British Tanks 1915-18,

Manufacture & Employment.

David J. Childs

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Glasgow University
Modern History Department

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Abstract

For far too long it was accepted that the higher echelons of the British Army, that is the War Office and GHQ, France, were reactionary, that they were anti-technology and cavalry oriented. In the past decade historians have gone some way to challenge this view, but not far enough. Much of the "traditional versus progressive" school of thought, in regard to the tactical employment of the tank, still survives. This thesis will attempt to continue the roll-back . It will not, however, confine itself to the tactical employment of the tank, but will instead suggest that to gain a more complete picture of the Army's support for the tank development programme in World War One we have to examine the manufacture of the tank too.

No one has acknowledged the role of the War Office in pushing for the creation not only of the first Tank Committee , but every subsequent committee thereafter. The original Tank Committee, the "New" or "Advisory" Tank Committee, The Tank Directorate and the Tank Board were all set up under the aegis of the War Office. True, the War Office had a great deal to gain in establishing these bodies in their attempt to wrest control of the destiny of the tank from "civilian" hands at the Ministry of Munitions, but it was these bodies, particularly the Tank Board (established in August 1918) that facilitated the crucially important liaison between the users of tanks in France, that is to say the Tank Corps, and the producers at the Ministry , the Mechanical Warfare Department (MWD). Without War Office involvement in this way (and, of course, the continued orders for more and better tanks from the War Office) it is inconceivable that the tank would have reached the level of technical sophistication, and therefore usefulness, that it had by late 1918. Ironically, if we persist with the "progressive versus traditional" scenario, we see that the "progressive" group, which consisted of the MWD and the Tank Corps, was in actual fact constantly at odds with itself over the design of the machines and the availability of spare parts for the whole period of the war. We can suggest, therefore, that the most damaging of the divisions that existed within tank circles in World War One lay not between the "progressive" and "traditional" camps, but across them, clearly dividing the "progressive" camp itself.

The continued existence of a struggle for control (note control and not survival) of the tank between the War Office and the MWD (which was at its most intense during 1917), and the constant "battle of the spares" waged between the Tank Corps in France and the MWD, further call into question the accepted wisdom that when Lloyd George handed over the reins of the Ministry of Munitions to Edwin Montagu in July 1916, he had largely resolved the nation's munitions problems. R.J.Q. Adams cites a tank pioneer who believed that" as Minister of Munitions he [Lloyd George] saved this country from dire disaster". Adams admits that such a claim was "extravagant" and that no one man "won the War ", but this thesis will suggest that the successful development and manufacture of the tank owed considerably more to his successors, particularly Addison, and to Churchill and support from the Army than it did to Lloyd George's own actions.

Finally, regarding the "reactionary" nature of GHQ, this thesis calls in to question the originality of J.F.C. Fuller's "Plan 1919", so often cited as the way forward in terms of the tactical employment of the tank, and suggests that by 1918 such plans were common currency among the upper echelons of the Army, and that Fuller's own scheme was but one of many. Further, there is sufficient evidence to suggest that GHQ had far-sighted plans for the employment of tanks once greater mechanical reliability had been achieved. But greater reliability was a matter of design and manufacture, not tactics. The role of the British tank on the battlefields of WorldWar One was, therefore, not dictated by the limited imagination of those at GHQ, but rather by the inevitable problems associated with developing and mass producing a highly complex and unique weapon at a time of total war.

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Abbreviations

ACMC..... Assistant Controller of Muntions Contracts

ASE ..... Amalgamated Society of Engineers

DMO ..... Director of Military Operations, General Staff

DMRS..... .Ministry of Munitions Department of Munitions Requirements and Statistics

CGS .....Chief of the General Staff

CIGS .....Chief of the Imperial General Staff

DCGS .....Deputy Chief of the General Staff

DCIGS .....Deputy Chief of the Imperial General Staff

TS Committee.....Tank Supply Committee

TS Department.....Tank Supply Department

MGC .....Machine Gun Corps

M of M..... *History of the Ministry of Munitions*

MPDB .....Manpower Distribution Board

MT .....Mechanical Transport

MWD .....Mechanical Warfare Department

MWSD..... Mechanical Warfare Supply Department

MW (O&A)D.....Mechanical Warfare (Overseas & Allied) Department

R,T&D..... Receiving, Testing & Department of Tank Corps Central Stores, France

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Introduction

Prompted by Robin Higham's [1] discussion of the peripheral status of the British rigid airship programme in the immediate years before, during, and after the First World War, this thesis will apply much the same criteria to the role and status of the British tank during 1915-18. The question is: was the tank a peripheral weapon ? That is to say, did it receive across the board support from both civil and military (Army) bodies ? Were significant resources allocated to it to permit mass production ? And was enough consideration given to the creation of a coherent doctrine of tactical employment ?

Structured in three sections, this work will address the first question in section one. Chapter one will discuss the organisation and function of the Mechanical Warfare Department. Chapters two, three and four will address the continuity of orders and production, the supply of steel and the availability of manpower.

In chapter one the administrative structure of the Mechanical Warfare Department (MWD) will be explored, highlighting the friction, or more accurately the growing pains, as both sides, civil and Army, came ultimately to a working relationship concerning the tank's development and manufacture. Initially both manufacture and tactical employment (early training and recruitment) were encompassed in the Landship Committee / TS (Tank Supply) Committee.[2] However, once the tanks were sent to France in late July and August 1916, the interests of the two halves (the TS Committee in England and the Heavy Branch in France) diverged and the two bodies quickly assumed their own identities and agendas. One was concerned with continuity of production, the other with performance. These goals were not, of course, by any means always mutually exclusive, but friction did arise as each body determinedly pursued what it thought was in the best interests of the tank programme. The so called "battle of the spares" is perhaps the best example of this.

During the course of this development the divergent paths followed by the two bodies led to a closer association with, for want of a better phrase, their "parent

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[1] Robin Higham., "The Peripheral Weapon in Wartime : A Case Study", in Gerald Jordan (ed) *Naval Warfare in the Twentieth Century.*

[2] To avoid possible confusion the TS Committee, the TS Department, the MWSD and the MWD are to all intents and purposes one and the same body. However the title given to this body will depend upon the context of the discussion, i.e. between February and July 1916 it will be referred to as the TS Committee; between July and October 1916 as the TS Department; between October 1916 and October 1917 as the MWSD; and between October 1917 and November 1918 as the MWD.

bodies ". In the case of the Mechanical Warfare Supply Department (MWSD) - formerly the TS Committee - it drew closer to and established stronger administrative links with the Ministry of Munitions (despite the resistance of Albert Stern). In the case of the Heavy Branch (later the Tank Corps) the years 1916-18 were to witness a growing integration of the new arm within the Army proper. These developments were in themselves sources of friction. The MWSD sought to retain a degree of independence under the Ministry's umbrella, while the Tank Corps pursued a comparable position to that enjoyed by the RFC (i.e., a semi-independent role within the Army with representation on the General Staff). Meanwhile, the "parent bodies" were far from total agreement with one another as to how, and indeed who was, to exercise most control of the new arm. The Ministry, prompted by Lieut-Colonel Albert Stern, as Director-General of the MWSD, and led at first by Lloyd George, was determined that matters of design, testing , transport, and experimentation should be firmly and exclusively in the hands of the MWSD. The Army and the Tank Corps on the other hand, as a matter of principle and, after the less than impressive performance of the MWSD, as a matter of efficiency, did not. The relationship between the MWSD and the Ministry was to become particularly estranged under succeeding Ministers as each sought to integrate the MWSD within the Ministry, a move strongly resisted by Stern. Stern's attitude was to set the MWSD apart from the other interested bodies involved in the tank programme, military and civil alike. However, inter-departmental and service rivalries could not be allowed to compromise the development of the tank programme. Efforts were made as early as the winter of 1916 to bring all sides together through the creation of a committee. This was finally achieved when the ill-fated Tank Committee was formed under the aegis of the War Office in May 1917. Although the Tank Committee itself was not a great success, it at least paved the way for greater co-operation in the subsequent "Advisory" or "New" Tank Committee of November 1917, and eventually in the Tank Board of August 1918.

Chapter two will discuss the extent to which continuity of orders and output were maintained. As mentioned above this was the major preoccupation of the MWSD. In order to find and hold contractors (against stiff competition from orders to manufacture other weapons and components) the department had to be able to offer long contracts for, as near as possible, fixed models (thereby reducing the possibility of hold-ups in production while jigs, etc., were changed, which could be costly for the contractor). But the rapid pace of evolutionary technical change and the War Office's quite understandable insistence on the most up-to-date models available severely compromised this ability. On the other hand poor organisation at both departmental and contractor level (which it must be said was partly due to the constant reorganisation as the whole tank programme continued to expand) and the MWSD's at times wildly optimistic delivery estimates did little to foster War Office confidence in their ability to

deliver. This was reflected in the size of their orders. But out of what must at first have appeared an unpromising situation there grew a mutual co-operation which saw the development and production of a quite remarkable run of continuous models reflecting the best in continuity and at the same time technical sophistication.

Regarding the supply of the most important material in the construction of tanks, that of steel, the tank did very well. Chapter four assesses the reasons why , at a time of supposed national shortage, mechanical warfare was never short of steel ; in fact it was in surplus.

The manpower situation was perilous, and again tank production had to compete for its share of the nation's finite reserve, particularly that of skilled labour. Contemporary evidence (Ministry of Munitions files containing letters from contractors and members of the Labour Supply Department) is limited and somewhat contradictory. On the one hand it suggests that the contractors were only intermittently inconvenienced by a shortage of skilled labour, and where this occurred tanks were not an isolated case (as in the spring of 1918 when due to the unforeseen demands made on the infantry by the German offensive, the "clean cut" had to be imposed not only on tank production, but on aircraft too). On the other hand, the contractors' own records suggest that they were short of skilled labour. There is, however, sufficient evidence to support the view that by late 1917 opinion in the War Cabinet had shifted toward a greater concentration of labour reserves in mechanical warfare production, and that, the anomaly of the events of the spring and early summer of 1918 aside, tanks would have received a greater share of the available skilled labour much earlier than they eventually did in the autumn of that year.

Before addressing the other main area of interest, that of a tactical doctrine of employment, the second section will explore the obstacles to efficient employment in the field. These will include the tanks' transport from Britain to France, and, once on the continent, their movement about the battlefields, the efforts to continue research and development in the field, the salvage of machines from the battlefield, and the creation of the Tank Corps itself.

The final section will examine the tactical employment of the tank. Were Haig and GHQ resistant to the introduction of the new arm ? Did they simply throw tanks away in "driblets" ? Or did they embrace them only to confine them to a rigid method of employment, so reflecting minds closed to the new tactical possibilities offered by the tank which were beyond the accepted norms of staff college training ? This final section will argue that there is sufficient evidence to cast doubt on the assumptions behind these questions. Instead it will suggest that not only were the upper echelons of the Army on the whole receptive to the tank, but also actually conceived of employing it in ways which went beyond the simple infantry support weapon. It was not only the "young bloods" of the Tank Corps HQ with their "Plan 1919" who could see the way

forward. Yet, as will have been shown in the preceding section, the operational difficulties served to limit the opportunity to exploit this thinking. Once the Hindenburg Line was broken and "open country" was reached the tank's vulnerability on soft ground, its inability to cross more than a small stream unaided, its reliance on the frequent supply of tons of spare parts and on considerable quantities of fuel and lubricants, and its poor top speed, all served to limit its role to that of an infantry support weapon - one which followed up the infantry rather than led it.

This thesis seeks to get away from the confrontational "traditional" vs. "progressive" picture which has so often been seen as representative of the nature of the struggle surrounding the development and employment of the British tank during the First World War. It is argued that the use of such terminology is very misleading since groups, such as the MWSD and the Tank Corps, who figured prominently amongst the "progressive" group, were constantly at loggerheads over the supply and design of spare parts and complete machines. It will be argued that the War Office and GHQ, those bodies which would, according to received wisdom, comprise the "traditional", reactionary group, were, on the whole, energetic in their pursuit and support of large numbers of technologically efficient tanks on the battlefields of France. The picture is, therefore, far more complex than has hitherto been presented. Both sides wanted the most technologically advanced tanks, and in the greatest number possible, but both sides did not always agree on how best to achieve this shared goal. Confidence and co-operation took time to establish, but at no time did this seriously threaten the future of the tank programme. This is not to argue that there were not pockets of active resistance or passive antipathy in both military and civilian circles. Clearly this would be wrong. But such resistance formed only a reactionary clique and did not reflect the overwhelming body of opinion which was generally supportive and often enthusiastic toward the new arm.

Section One

Organisation & Manufacture

This section will argue that there was no shortage of support for tank manufacture. The massive expansion of orders for the tank from 100 to over 6, 000 in three years must say something about the tank's importance and the enormous support and confidence that all those involved in its manufacture, both military and civilian, had in it. Despite conflicting priorities between user and producer, enough common ground was found to enable continuity of production to be established and the best machine available to be produced in large numbers. At a time of perceived steel shortages the MWSD was never denied sufficient steel to meet its programmes. True, there were specific specialised metals that it was either denied access to entirely, or given only limited amounts of, such as high tensile steel and aluminium respectively. But one should not forget that this was a very new weapon and for much of the war it was extremely vulnerable and unproven. Finally, a transformation had taken place which saw, by the end of 1917 and early 1918, just one year after entering full mass production, a significant shift in emphasis regarding the allocation of the nation's finite labour reserve toward tank production in particular and mechanisation in general. As a result, despite the confusion and inter-departmental / service wrangling, the tanks always had sufficient skilled manpower. Therefore, in terms of the support that it received from both civil and military bodies for research and development and manufacture the tank was not a "peripheral weapon".

[I]

The Mechanical Warfare Department

One can see a parallel between the evolution of the MWD and the tank itself. Just as the tank grew from a primitive " Heath Robinson" affair to achieve a relatively high degree of technical sophistication by November 1918, having passed along a chain of evolutionary models, spawning many off-shoots in design and variation, so too did the MWD.

The air of Edwardian amateur gentlemanly enthusiasm, which characterised the Landship Committee, gave free rein to the creative imagination and enthusiasm of its members. This state of affairs was vital to the early development of the tank, given, as we shall see below, the failure of the Army's own investigations. The transition from Landship Committee to Mechanical Warfare Department, over a period of some three years was, however, marked by a loss of this cosy individualism, and the subordination of its independence to the discipline of mass production and integration within the Ministry of Munitions . This transformation was not without its casualties. The most notable of which was Lieut-Colonel (later Sir) Albert Stern. As the first Chairman of the TS Committee after its creation on 12 February 1916 - when incidentally Lloyd George, the then Minister of Munitions, was cajoled into initialling a charter produced by Stern as "an act of good faith" guaranteeing the Committee "...the final decision in all matter connected with the manufacture and inspection of those machines [tanks]" - Stern set about shaping the department after his own ideas. But Stern's ideas concerning the development of the tank and the status of the department within the Ministry were not always compatible with those in a higher authority. Over a period of 20 months, from Chairman of the TS Committee to Director-General of the MWSD, he was an influential figure in the emergence of the tank , but as one of Lloyd George's men of "push and go" he was to fall foul of the War Office, the Tank Corps and successive ministers of the Ministry of Munitions.

Maj-General Stanley von Donop, Master General of Ordnance, was to comment on 19 October 1915 that :

> " I view with dismay the manner in which this subject [the organisation of tank production] is being dealt with. A War Office Committee was appointed for it, the C.I.D. is also dealing with it , a conference decides on what should be done, they are called Admiralty Landships, the personnel is to come from a naval organisation and I am asked for the provision of guns and ammunition [on] the patterns of which I have not been consulted." [1]

The general's comments reflect, for want of a better phrase, the mixed parentage of the administrative / organisational framework of the tank production body. More importantly one does not have to read too carefully between the lines to detect the antagonism which was to characterise much of the working relationship between the War Office and the MWD in its many guises, especially until Stern's departure in late October 1917. However, it should be stressed that this rivalry for control of production, and in particular matters relating to design, inspection and testing, was not characterised by support for the tank from the Ministry and the MWD on one hand and antipathy from the War Office and GHQ, France on the other. Both sides, with the latter more often than not being joined in opposition to the actions of the MWD by successive Ministers of Munitions, and also the Tank Corps personnel, shared a common goal ; namely the development and production of as many effective fighting tanks as was possible. The rivalry and frustrations stemmed more often than not from poor communications between the various bodies and differing interpretations as to how best to achieve that goal. The War Office may have been slow to seize the initiative in early 1915, but without its consistent efforts, not only to provide a constant stream of orders for new machines, but also to bring both sides, producer and user, together around the same committee table, there is no doubt that the tank programme would not have been as successful as it was.

Early days

The first organisational body to deal with the development of the tank was the **Landship Committee**. It was formed on 20 February 1915 from members of the Navy and in particular the Royal Naval Air Service (RNAS), whose early work with armoured cars in Belgium gave them an ideal background from which to approach the

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[1] *The History of the Ministry of Munitions* (hereafter *M of M*) Vol XII, Pt III, Ch II, p 29.

difficulties of mechanical warfare. Amongst the first committee members was Winston Churchill, whose brainchild the RNAS was, the naval architect and Director of Naval Construction at the Admiralty, Tennison d'Eyncourt (later Sir), and Squadron-Commander (later Major) T .G. Hetherington. Hetherington's initial ideas for an early version of the tank - an unwieldy monster of some 300 tons - led to the creation of the committee itself in order to explore further the possibilities offered by a combination of internal combustion engine, continuous tracks and armour plate as a means of overcoming trenches, barbed wire and machine guns.

While the Admiralty followed its own path, the Army also responded to the proponents of mechanical warfare. A trio of Lieut-Colonel M.P.A. Hankey (who was in fact a Royal Marine), Secretary of the Committee of Imperial Defence (CID), Major (later Lieut-Colonel) E.D. Swinton , who was enjoying something of a free role in France as the Army's official "Eyewitness", and a ballistics expert Captain T.G.Tulloch, presented their idea for a "Land Cruiser" to the War Office's Director of Fortifications and Works, Maj-General G.K. Scott-Moncrieff in January 1915. The following month Scott-Moncrieff established a **War Office Committee** to look into the feasibility of this "Land Cruiser." However, subsequent trials at Aldershot on 17 February and again in May were not a great success. The Navy on the other hand received continued support from Churchill as First Lord and his successor to that post, A.J. Balfour. The Army and the Navy thereafter combined resources under a new committee called the **Joint Naval and Military Committee** which came into being on 22 June.

Swinton's memorandum entitled "The Necessity for Machine Gun Destroyers" circulated around the upper echelons of both services in June and provided the first set of specifications for the new weapon. They were revised at the first meeting of the Joint Committee on 30 June, at which both d'Eyncourt and Scott-Moncrieff decided that experiments should continue. This research and development programme was to continue under the auspices of the Admiralty until full production of the first successful model was begun. The Landship Committee took its instructions regarding armament and armour from the War Office. By arrangement d'Eyncourt provided E.W. Moir of the Ministry of Munitions' recently created Department of Inventions with regular progress reports.

Both the Army and the Navy were instrumental in the early developmental work associated with the tank. However, it is fair to say that the Navy's contribution was more telling at this early stage. This was not because the Army was averse to new technology, but because it viewed the tank as a costly long-term project of uncertain success at a time when it was believed all available resources would be better devoted to winning a war which most thought would be over before a successful tank could be

developed. By late 1915 the solidification of the trench systems had convinced the Army otherwise.

To the Ministry of Munitions

The **TS Committee,** comprising members of the Admiralty and the Army, began its work with the Ministry on 15 February 1916, after the success of the "Centipede" [2] tank at the Hatfield Park trials. It was on the strength of these trials that the Army Council ordered its first 100 machines.

Tennison d'Eyncourt was appointed Chief Technical Advisor, while Lieut-Colonel Swinton became responsible for the recruitment and training of tank crews. Training was conducted at Thetford Park, Norfolk .[3] Volunteers were invited from anyone with an interest in mechanical engineering. The majority of the first crews came from the Motor Machine Gun Corps and members of Squadron 20, RNAS.

Major J.W. Wheeler, RA, Director of Artillery's Branch at the War Office, joined the Committee to advise on guns for the tanks, as did P. Dale Bussel, of the Admiralty's Contract Department, who was brought in to arrange contracts with the suppliers of components and the erectors of the tanks.

At first it was an advantage to have so few officers and personnel tied down to any one particular aspect of production : it enabled the full problem solving potential of the Committee to be focused on any difficulty encountered. However, as mass production proper began the *ad hoc* nature of the whole organisation steering the development of the tank became ever more apparent. Its unconventional structure which had functioned rather well when dealing with relatively small numbers of test machines, soon became suspect as a greater number of firms, mostly suppliers of components, became involved.

The Committee's name and structure were changed again in July 1916. The confusion surrounding the title Tank Supply Committee was obviated when **Department** was substituted for Committee. A Sub-Committee made up of d'Eyncourt, Bussel (contracts) and Stern was created to decide questions of design and policy. By October, however, the department's title had changed again, this time to the **Mechanical Warfare Supply Department**. This was due to the lifting of the veil of

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[2] The name "Centipede" was given to the first Mk. I prototype. This tank was also known as " Mother", "The Wilson Machine" and " Big Willie' (as opposed to "Little Willie", the first tank).

[3] The training of the first crews was conducted at Lord Iveagh's estate at Thetford, Norfolk. The Royal Engineers created a trench network intended to simulate condition on the Western Front. The public were, understandably, denied access to the park from mid-June. Training continued until mid- August when tanks and crews departed for France.

secrecy which had surrounded the early tank, now redundant following the tank's debut. Stern (now Lieutenant-Colonel) assumed the title Director-General of the MWSD. P. Dale Bussel and Captain Holden were made Deputy Director-Generals, while Tennyson d'Eyncourt remained as Chief Technical Advisor with Sir Charles Parsons as Technical Advisor. William Tritton, chief designer of Foster & Co., Lincoln (the first tank manufacturer and thereafter intensely involved in research and development), and Major W.G. Wilson were appointed Directors of Construction and Engineering respectively. [4]

Throughout the remainder of 1916 the department continued to expand, and separate sections dealing with finance, stores and statistics were created. A separate branch for the supply of equipment was added, as was an advisor on petrol engines. The inspection of engines was organised under an officer responsible for engine production. A chief draughtsman and a director of design were brought into the department. An inspection department was established and a head appointed on 25 December 1916.[5]

Early production problems

Two critical problems emerged to compound the organisational difficulties experienced by the department : continuity of orders and supply. Both of these issues will be addressed at some length in later chapters. Yet, it is necessary at this early stage to introduce them, however briefly, since they presented enormous tests to the efficient operation of the department. Continuity of orders and supply were always going to be difficult areas. The War Office had initially ordered 100 machines after the success of the February trials. This number was steadily increased during the summer until it stood at 250. After the tank's moderately successful debut a firm order for a further 1, 000 machines was placed on 14 October. However, the rate of increase in orders and the total numbers involved were deemed insufficient by the MWSD to allow continuous orders to be placed with the manufacturing firms contracted to supply components. As a result a " stop and go" situation began to develop.

There are several reasons for the War Office's diffidence - if one can describe an order for 1, 000 machines by the middle of October 1916 as diffidence. Prior to the tank's debut on the battlefield the War Office was understandably reluctant to order

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[4] *M of M* , Vol XII, Pt III, Ch III, p 40. Lieutenant (later Major) W.G. Wilson was previously of Wilson-Pilcher, pioneer motor car manufacturers. He was also involved with the production of armoured cars when with the RNAS.

[5] Ibid.

greater numbers since the tank had yet to be proved in battle. The subsequent stresses of battle revealed fundamental design flaws which needed rectifying. These were flaws which only became, and could only have become, apparent under battle conditions. Such was the enthusiasm of the research and development team working at Fosters that no sooner had one model been produced than it was superseded by an improved version. Between the first trial of "Mother" tank in February 1916 and February 1917 there were no fewer than four successive models produced. Given the continual and rapid evolution of the tank, which model was the War Office to order ? Stern and the department sub-committee expressed the wish that the first machines should not be used in September, but held up until January 1917, when they said they could deliver 350 machines which would have a much greater impact. As it happened, due to unforeseen difficulties in organising components, the MWSD was only able to deliver 150 machines during the whole of 1916. If the War Office had ordered in greater numbers they would have undoubtedly have ended up with large numbers of outdated tanks (if the MWSD had been able to meet its planned production targets), whilst the MWSD's designers, not to mention the tank crews, would have been deprived of the vitally important lessons of battle.

This leads us to the second of the difficulties which plagued the MWSD : that of supply, particularly of spares. As stated above, the experience of battle revealed many defects in the design and construction of the machines. This was inevitable since all concerned were on a very steep learning curve. The whole tank project had, until 15 September, been largely theoretical. However, many of these defects demanded hold-ups in production as parts were redesigned or changed completely. Production was also hampered by the lack of spares in France. To remedy this materials and skilled men had to be transferred to the production of spares at the expense of complete machines. What became known as "the battle of the spares" [6] was waged between the Tank Corps in France and the MWSD. The failure to introduce an efficient spares programme was due, in part at least, to the emergence of a "Catch 22 " situation. The lack of continuous orders led to a problem in the supply of components, since not knowing which model of tank to produce in large numbers necessarily led to doubts as to which, and how many, spares to produce. Failure to supply both complete machines and spares to the required number led to a breakdown in the continuity of orders, and so the situation worsened.

Whilst the Heavy Brigade Machine Gun Corps was training in England under Swinton, there remained a direct link between the MWSD HQ at 17 Cockspur Road, London (since October 1916) and the training camp at Thetford. However, once the

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[6] See chapter 8 for more on this.

Brigade went to France this continuity was stretched, and, if not entirely broken, was made so convoluted (channelled as it was through various War Office departments between France and MWSD HQ) that communication between the producer and user became very strained indeed.

In an attempt to ease the communication log-jam between France and the MWSD, London, General F. Gore-Anley was appointed GOC Heavy Brigade Machine Gun Corps in England, while Colonel (later Maj-General) Hugh Elles assumed the post of Officer Commanding in France.[7] Gore-Anley took offices close to Cockspur Road. He was made responsible for the requisition of spares and equipment for France directly from the MWSD, which then arranged for their supply and transport to the Brigade's HQ, France. An officer was appointed to liaise between Elles, Gore-Anley and Stern. However, Elles was soon voicing his frustration (21 December 1916) over the situation :

> " In France, the fighting organsiation is under a junior officer who, *faute de mieux* , has become responsible for initiating all important questions of policy, organisation, design and personnel through GHQ., France, and thence through five different branches at the War Office. In England, administrative and training organisation are under a senior officer located 130 miles from the War Office, with a junior officer (staff captain) in London to deal with the five branches above mentioned. The system is working now because headquarters in France have been free from the question of operations for most of the last six weeks, and have therefore, been in a position to deal imperfectly and at a distance with the larger aspect of the whole matter. In effect the tail in France is trying to wag a very distant and headless dog in England." [8]

The rivalry for control

Communication difficulties were further exacerbated by the uncase that existed between the MWSD and the War Office especially in regard to the demarcation of responsibility and authority.

The attempts of the War Office to gain hands-on control of tank production should not be seen as an isolated struggle for supremacy ; rather, it was played out against a backdrop of a much wider contest that had gone on throughout the latter half of 1915 between the War Office and the newly created Ministry of Munitions. R.J.Q.

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[7] "A Short History of Tanks in the Great War", Ch.V, A series of articles issued with "Weekly Tank Notes by SD7, War Office," published in The Tank Corps Journal, 1919, p 73.

[8] *M of M*, Vol XII, Pt III, Ch III, p 42.

Adams quotes Sir Hubert Llewelyn Smith (5 June 1915), General Secretary to the Ministry of Munitions (until October 1916), on the subject :

> "The fixing of designs and specifications , and the tests to be applied [he wrote to the Army Council], will remain with the War Office, as well as research and experimental work." [9]

To Lloyd George the Master-General of Ordnance, Sir Stanley von Donop, came to personify all that was most narrow minded, inefficient and reactionary about the War Office in particular and the military in general. The general's determination to retain control over the Royal Factories was matched by the new minister's equal determination to challenge the*status quo* . By 19 August Asquith had agreed to place the Royal Factories under the control of the Ministry.

With the help of Dr Christopher Addison and Sir Frederick Black, Lloyd George then set about making a case for the control of munitions design to be similarly placed under the Ministry's control. It was not until 22 November that the Prime Minster gave his consent. Adams cites Asquith, in a letter written the day before to the wife of his private secretary :

> " I went to the War Office where I had a succession of rather interesting (and exacting) interviews:...[among them, one] with Von Donop to whom I had to make the revelation that two or three of the remaining leaves of his attenuated artichoke are to be snapped off by Lloyd George. I handled him as well as I could, and I hope I broke his fall."[10]

Four days later was announced that from 29 November the War Office Inventions Branch and the Experimental Establishment at Shoeburyness would be under the control of the Ministry of Munitions. General von Donop had been outmanoeuvred by Lloyd George. This resulted in considerable ill-feeling between the War Office and the Ministry. The military's professionalism in matters relating to war, traditionally the domain of soldiers, was threatened by the new "push and go" civilians, and their business practice. This discord was to manifest itself again and again throughout the war, particularly in relations between the War Office and the MWSD.

Control of the tank programme became one such area of discord. While inventions and experimentation had been officially transferred to the Ministry of Munitions at the end of November 1915, the first prototype tank was not ready for trails

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[9] R. J. Q. Adams, *Arms and the Wizard* , p 134.

[10] Ibid, p 142.

until the end of January 1916. Was the tank therefore to be considered part of the transfer cited above ? From the contents of a letter from Lieut-Colonel E. Phipps,[11] Director of the Ministry's Safety of Factories Branch, on 24 October 1916, to Dr Addison, the War Office clearly hoped not. The letter concerned the status of the MWSD's inspection and design branches in relation to those of the Ministry.

"So long as the Tanks remain in an experimental stage, in which their design will be constantly changing and cannot be standardised there does not appear to be any advantage in either the D.G.M.D [Design] or D.G.I.M. [Inspection] taking responsibility for the tanks [sic] as a whole. D.G.M.D. will of course be responsible for the design of all guns and ammunition with which the tanks may be armed. These, together with any other stores, such as engines and optical instruments, which are obtained by the M.W.S Department through or in co-operation with the other Supply Departments of the Ministry, will of course pass through the procedure for design and inspection which is already established in the Ministry.

The War Office letter of October 4th asks you to agree that for the present all Tanks[sic], with their equipment, accessories, and spares should be manufactured and tested by the branch of the Ministry of Munitions under Colonel Stern. So the Army Council do not stipulate that Tank supply should come under the arrangements for design and inspection set up in the Ministry by agreement with the War Office, on the contrary, they suggest a special arrangement, at least for the "trial." We can therefore simply concur on that point ? Colonel Stern recommends concurrence in the four other recommendations of the "Conference."

The suggestion that the Army Council should be consulted on the "Specification" before it is approved, and that no change should be made without reference to them, is contrary to the principle of the division of functions between the Ministry and the War Office. I think we had better reply to that effect, but add, as Colonel Stern suggests in his minute of October 10th, that as long as the design of "Tanks" remains in an experimental stage the requirements and suggestions made by the Army Council will be incorporated in the design at the earliest opportunity."

This excerpt is revealing in several respects. First, it highlights the internal rivalry within the Ministry between the Design and Inspection Departments and the new MWSD. Second, outside the Ministry it suggests the extent of War Office / Army Council manoeuvring as it attempted to gain as much control over tank matters as it could. Clearly the War Office felt it was better at that stage to support the "independence" of Stern's department since this offered the best opportunity to influence the tank programme. Finally, it again highlights the experimental nature of the whole tank programme, not only in terms of the organisational structure of the departments and their relationships one with another, but also in relation to the tank itself. What they did not realise at the time was that this "experimental stage" would last for the duration of the war in both areas.

The War Office may have considered it expedient to lend its suport to the "independence" of Stern's department in late 1916, but its attempts to extend its influence on all matters concerning the tank programme were to gather pace as the year ended.

Under the terms of its charter the TS Committee had total control of tank design. Its remit also included control of the transport and testing (this section initially

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[11] Stern papers, 1 / C / 2.

included experimentation) of tanks which was combined in one section and carried out by men formerly of the Royal Naval Air Service (RNAS). However, both the War Office and the Heavy Branch thought that control of these areas properly belonged to them, or at least they expected to have a major input in decisions affecting them. The War Office took the initiative in November 1916 and began a series of conferences held to discuss the issues of design and testing. It was decided that in future, when an important issue arose concerning these or related matters, a meeting should be called in London with members of the War Office, Heavy Branch and the MWSD present. [12] It was further suggested by the War Office that a committee should be established to examine these areas on a regular basis to ensure "...that the design of tanks is developed in conformity with the tactical employment of those engines". (Design was always to remain under the control of the MWSD, although with a growing input from France in 1918). However, their preferred list of personnel for this committee would have tipped the balance in the War Office's favour. No further progress was made in establishing such a committee until May 1917.

The War Office was not the only body which was unhappy about its relationship with the MWSD. While Phipps's letter appeared to establish a working relationship between the Ministry proper and its new found semi-autonomous department, the Ministry soon came to the conclusion that the duplication of work done by Ministry departments, particularly inspection and contracts ought to be ended in the interest of both efficiency and saving manpower. In early 1917 it was clear that there were critical problems with the quality of inspection of components at the MWSD. A components section had been established at the MWSD in order to solve the problem of over-lapping orders. Initially there were only two firms involved in tank erection, Metros and Fosters, and they had placed their own orders with sub-contractors. However, now that the department had decided to expand the number of firms involved so as to meet production estimates, it was decided that the component section would organise the supply of components to each erector. This was to lead to an increased work-load for the department's inspectors.

Inspection was carried out by a small number of resident and divisional inspectors. They were organised at six large centres : Birmingham, Lincoln, Leeds, Newcastle, Glasgow and Manchester. However, they were severely stretched. Not only had they to inspect components, but they were expected to advise manufacturers on a wide variety of matters, including where they might obtain labour and parts, and how they might obtain priority rating. Needless to say, it was not possible to combine successfully the roles of both inspector of parts and progress officer. The subject of poor quality and / or incorrect assembly of spares is discussed in chapter six, but to

[12] *M of M*, Vol XII, Pt III, Ch III, p 41.

illustrate this point we need only refer to the experiences of Brig-General Glasgow, Commandant of the Training Camp, Wool, who in a letter to the MWSD on 28 April 1917 reporting that, after a routine inspection of a Mk IV which had been running for only a short period at the camp, it was found that the" Sprocket Wheels and Pinions [vital components in the tank's track driving gear] were not properly lined up, nor were these gears correctly opposite to each other...The trouble is", he continued :

> " by no means a new one as an inspection of the worn parts returned from this Training Camp will show...the trouble is undoubtedly due to bad fitting and careless inspection...I would request that the inspection of assembling and fitting of these parts be carried out by the inspectors." [13]

It was clear that the MWSD was hampered by an overly centralised structure. During the early part of 1917 Stern attempted to remedy this by recruiting Percival Perry, managing director of Ford in Europe, to reorganise the department on business lines. It was Perry's view that the department should be organised into 13 sections. Design, supply and inspection branches were organised in an inter-departmental way with direct access to the director-general. A production officer was appointed in February 1917. Thereafter every effort was made to order standard parts in bulk. Yet, one major weakness persisted. The supply branch, having no outside inspectors of its own, was entirely dependent on the inspection branch for information on the constructor's progress. This prolonged the earlier problem of a relatively small number of inspectors being swamped with both inspection and progress duties.

Whilst the emphasis under Perry's restructuring had been to de-centralise, under Dr Christopher Addison , the new Minister of Munitions (he succeeded Edwin Montagu on 11 December 1916), it moved to reverse Perry's de-centralising agenda and return to a more centralist policy. This was prompted by the poor performance of the inspection staff at the MWSD and the duplication of resources (the Ministry having its own Inspection Department). Addison wanted contract, finance and inspection branches to be brought under one central authority, merging them with existing Ministry departments. This was a further milestone in the integration of the MWSD within the Ministry - one of the actions which Stern saw as further undermining the unique, semi-autonomous role that he had championed for the TS Committee within the Ministry. However, it was realised that constant changes in the organisation of the department would have a serious impact on production efficiency. Changes were, therefore, delayed until late 1917, but it was thought prudent to appoint one of the

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[13] MUN 4 / 2791.

Ministry's top inspectors from the Inspection Department to assist and advise the MWSD's own inspection personnel.[14]

The inspection of tanks during their erection process was one thing, but the finished machines also had to be inspected and tested. This was done by a different branch of the MWSD. Tanks newly arrived in France from England, having already been inspected by MWSD personnel, were having to undergo anything from several days to several weeks fitting work in the Central Workshops at Erin before they were fit to fight. The MWSD had sole authority over the tanks until they were issued, and they conducted their own tests on new machines at various testing grounds established throughout the country but chiefly at Oldbury and Lincoln.[15] In late 1916 the MWSD had created a transport and testing section manned by officers and men formerly of the redundant Squadron 20,[16] RNAS, specifically to carry out this task. They were also involved in the newly created experimental section dealing with workshop modifications, which became a separately organised and independently equipped unit. However by early 1917 the work load had grown to such an extent that it was too much for these units to handle efficiently. This led, through a combination of poor communication and a lack of confidence between the various bodies, to a situation where there existed simultaneously three testing and experimental bodies operating independently of one another. The Heavy Branch developed its own experimental and testing workshops in France where they carried out their own tests and design improvements. At the same time the Tank Directorate at the War Office was conducting its own tests and problem-solving investigations at the training camps in England. Stern, anxious to maintain the "independence" of the MWSD, had written to the DMRS concerning the quality of inspection / testing of completed tanks in May 1917. [17] His letter was in answer to a long list of technical complaints received from the Heavy Branch, France, he wrote :

"I wish to point out that a tank can never be delivered in France ready

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[14] MUN 4 / 2791, Stern papers 1 / C / 4, and Stern, *Logbook* , p 63.

[15] Oldbury was near the Metropolitan Carriage,Wagon, and Finance Co. (Metros), Birmingham, the largest of the tank manufacturers. Lincoln was the home of Foster & Co. (Fosters). A ground was also established at Scotstoun for the planned tank production at Beardmore and the Coventry Ordnance Works.

[16] The Armoured Car Division , including the men and officers of Squadron 20, were given the choice (8 August 1915) by Commodore Murrey Sueter, Director of Air Department, as to whether they would join the RNAS or the Army. On the 13 August H. Llewelyn Smith, General Secretary to the Ministry, confirmed the transfer of work to the Ministry of Munitions. Six of the ten officers, led by Squad-Commander (who became Major) T.G. Hetherington, opted to join the Army and were transferred to work on tanks under the Ministry. Full details of the transfer can be found in ADM / 116 / 1339.

[17] MUN 4 / 2791.

> to fight until the Supply Department, has an establishment of its own in France, and at Wool, where these Landships with their many adjustable components can be finally tuned up and equipped."

Perhaps a rather cynical interpretation of Stern's motives might see in his recommendation another example of his seeking to expand the department's remit, this time to include France, at a time when efforts were being made by both the Ministry and War Office to confine the role of the MWSD to that of tank supply only.

Clearly, this situation could not continue. In line with the reforms which merged the MWSD inspection branch with the Ministry's own inspection department, Addison decided that in order to eliminate the duplication of test personnel, and because of the poor record of inspection and testing by the department, the Tank Corps should take responsibility for all testing done on MWSD testing grounds from late 1917. It is not altogether clear exactly when this transfer took place, and how successful such a division of responsibilities was given the state of non-co-operation that existed between the MWSD and the War Office for much of the second half of 1917. But the duplication of experimental units was to continue, probably because, unlike the testing sections, they were not officially recognised by the department. Even in late 1918 Lieutenant Shaw of the MWD's experimental section was writing to the Controller of the MWD, J.B. Maclean, to express his concern over the activities of the Tank Corps' Advanced Workshop (3).[18]

The relationship between the MWSD and the other major bodies was clearly not all that it might have been. The relationship between the MWSD and the Tank Corps was particularly strained as Elles's thoughts on the organisation of the MWSD,[19] recorded in the minutes of a conference held at the Ministry of Munitions on 7 November 1917, reveal :

> " ...is a matter which directly affects the fighting efficiency of the Army. At present... design, supply and inspection are in the hands of one man [Col. Stern], the acceptance of criticism and suggestions are also in his hands. Such a system is bound to break down if any progress is required design should not be in the hands of the Supplier, but in the hands of an independent organisation, the Supplier of course being represented...to place the power of veto or initiative in the hands of the Supplier is unreasonable and will not work better in the future than it has done in the past. The user must be in the main the initiator and suggester, and some independent body must weigh in between his demands which necessarily counsel perfection, and the objection of the Supplier who must clearly be for production of a standard type. [To date]...the opinion of the user has been disregarded according to the whim of the Supplier technical objections have outweighed technical

[18] Refer to chapter 6 for Shaw's letter in full, p 140.

[19] WO 158 / 859.

suggestions, and the arbiter of the whole affair has been the Supplier ."

He concluded his comments by saying that in his opinion the MWSD," as a commercial proposition ...would never have got rid of a single machine after the first hundred".

This was where the War Office was able to play its vital role in securing the continued development of the tank programme. It was not only responsible for providing orders for tanks, thereby assuring continuity of production , but through its attempts to bring together producer and user around the same committee table it enabled problems, some of which reflected the clash of lively and independent personalities, but a great many more were simply the result of poor communications, to be resolved. The first such meeting was suggested by the War Office in November 1916 , but was not finally established until May 1917. The **War Office Tank Committee** [20] was born of the need to correlate the experience gained in battle with workshop practice and future supply programmes. Its brief was to eliminate the waste in time, manpower and materials caused by the need constantly to re design and test machines, only to find that when employed in the field they often needed further modification. Such high hopes were never to be realised fully, but the formation of the committee was at least a start in the right direction.

By July 1917, The War Office Tank Committee had ceased to function . Attempts to control working design and general specification proved impracticable. Also, the absence of a representative of the Tank Corps prevented direct communication with the field. The Committee comprised five members, only two of whom were MWSD personnel. Stern wrote that by July both he and d'Eyncourt were no longer attending the meetings because they were constantly out-voted by the three War Office members. However, no sooner had Stern left the department (October 1917) than the Committee was re-born as the **"New" Tank Committee**, also known as the **Advisory Committee** (War Office).[21] The minutes of the first meeting of the reconstituted committee (26 November 1917) reveal an earnest attempt to encourage closer levels of co-operation between supplier and user. The new committee was to meet every fortnight alternately between England and France and was, importantly, to include General Elles, GOC Tank Corps, France.

The **Tank Directorate**, which had been formed by the War Office in May 1917, was to run alongside the new committee. It was responsible for the supply and training of personnel for the Tank Corps, detailing requirements for tanks and, in

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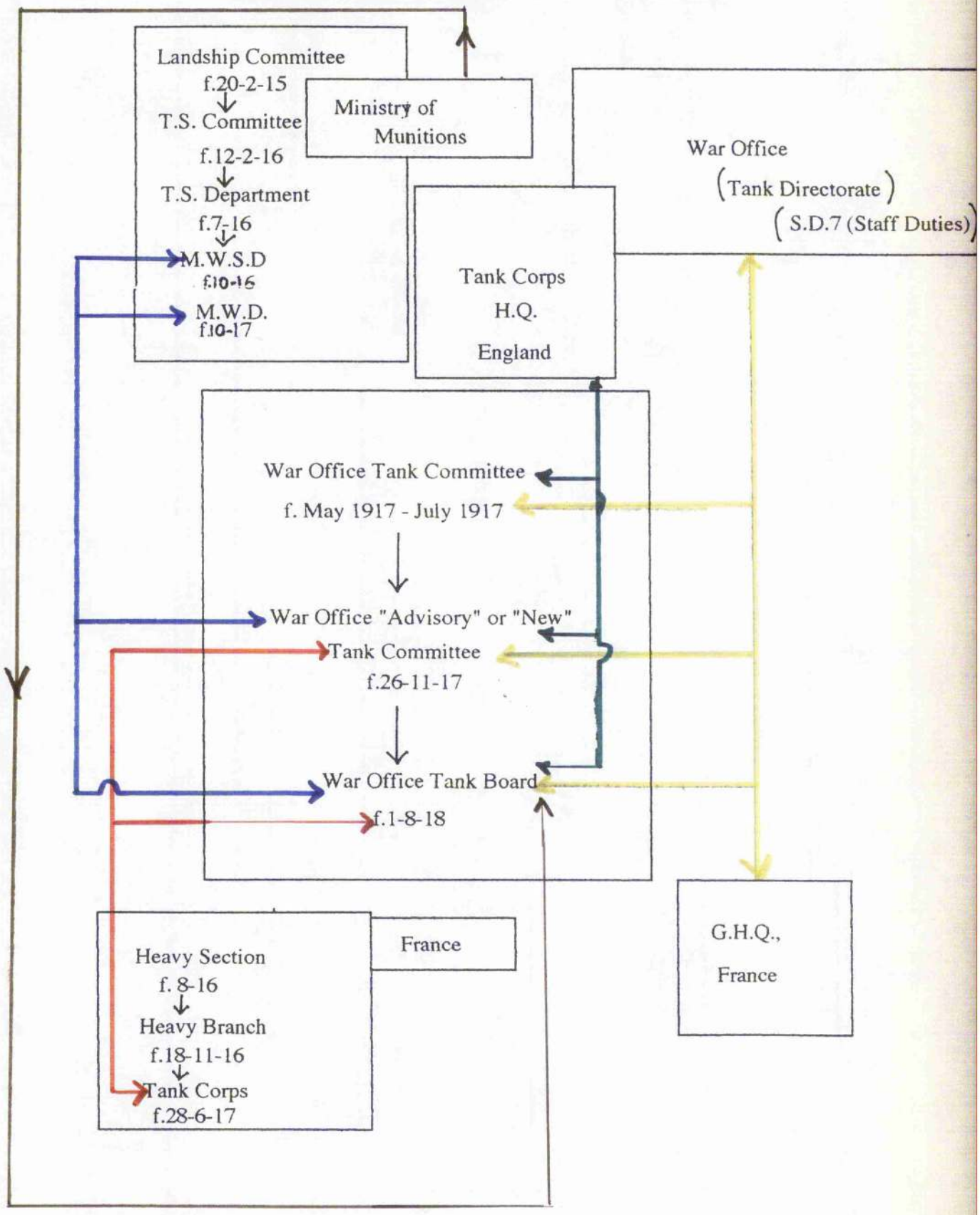
20 Stern, *LogBook* , p 144 and WO 158 / 867.

21 Stern, *Logbook* , p 160, refers to the creation of an "Advisory Committee", but WO 158 / 859 refers to the creation of a "New" Tank Committee.

Evolution & Relationship of the Tank Bodies



general, attempting to liaise between the MWSD and France. With the creation of the **Tank Board** in August 1918 (again under the aegis of the War Office) closer ties were established between the producer and user of the tank in line with the continued integration of the Tank Corps and the Army proper. Both the Tank Committee and the Tank Directorate were superseded by the new board. The Directorate had, in the words of Capper its Director-General,"...proved very useful...though something of an anomaly in the War Office... ". It was later replaced at the War Office by a sub-branch of the Directorate of Staff Duties called SD7 (Staff Duties). SD7 dealt with tank administration in general and the 1919 tank programme in particular at the War Office.[22]

Meanwhile the integration of the MWSD within the Ministry was continuing with the effect of further undermining the semi-autonomous role of the department. In July 1917 Churchill was appointed the new Minister of Munitions. In August he implemented a shake up of the Ministry's departmental organisation with the introduction of his Munitions Council.[23] This was deemed a necessary counter-measure intended to bring to heel Lloyd George's men of "push and go." Initially the introduction of business men to run departments within the Ministry proved successful in overcoming military bureaucracy. However, this tended over time to lead to a certain amount of "empire building" and inter-departmental rivalry which did, at times, prove counterproductive. The Munitions Council was intended to promote closer co-operation by organising the Ministry's seventy departments into ten groups organised along the lines of the Army Council and Admiralty. Each department head was responsible to a group leader who represented that group as a member of the Council. The transition had been swift. In August 1916 the Tank Supply Committee had been outside the departmental structure of the Ministry, having direct access to the Minister. One year later, as the MWSD, it had been absorbed within the departmental structure. By July 1918 it was to be grouped within Munitions Council Group "W" under Council Member, General J.E.B. Seely, along with other associated departments such as : Trench Warfare, Inventions, Mechanical Transport and the Overseas and Allied Mechanical Warfare Department. Yet, in 1917 the department, particularly in its relations with the War Office, was still something of a maverick, and in this it reflected its Director General's outlook.

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[22] WO 158 / 806. The end of the Tank Directorate also spelt the end of the role of Director-General of Tanks in England. Capper's adminsitrative role as head of tanks in England passed to Lieut-Colonel J.F.C. Fuller of the Tank Corps. In a letter to Sir Basil Liddell Hart on 18 February 1949, Fuller stated that Capper who was enthusiastic about tanks, "tended to be immersed in details, instead of seeing the big idea. He worried the War Office on minor points and put peoples' backs up; this was the resaon that they got rid of him... . " (Liddell Hart, papers, L.H. 9 / 28 / 59-62).

[23] *M of M*, Vol XII, Pt III, Ch IV, p 53. The MWSD was originally in Council Group " E" under Sir A. Duckham, before being transferred to Group " W", under Maj-General Seeley.

The removal of Albert Stern

R.J.Q. Adams wrote of Lloyd George's appointment of Stern to head the Tank Supply Committee, " The former banker, in Lloyd George's estimation, showed signs of being a man of "push and go" and , consequently, was judged suitable for Ministry service." [24] Stern required a guarantee of autonomy for *his* [italics mine] department and Lloyd George was required to initial a charter produced by Stern as "an act of good faith." In October, 1917 he stated that " The whole trouble with the War Office was that I pressed for a large programme of tanks - at least 4, 000 - for the fighting of 1918." He was told by Sir Arthur Duckham, council member for munitions group 'F' (of which the MWSD was part in late 1917), that three of the generals on the War Office Tank Committee had asked for his removal. There were accusations that Stern was "lumbering them up with useless Tanks at the front and wasting millions of public money." [25] Here is a reference to Stern's deliberate and planned over-production of Mk IVs of which more will said later. Stern was to claim that it was these tanks that had made the Cambrai offensive possible. This is a moot point. The surplus Mk. IVs were not delivered until early 1918, it was machines from the original 1, 000 ordered by the War Office that took part in the Battle of Cambrai.

Stern does seem to have ruffled some very important feathers. On 4 October 1916 Christopher Addison recorded in his diary that he had had "a discussion with Stern on the organisation of the Tank branch. He has not much notion of office method but he is a good hustler and will not be discouraged, I hope." [26] On 22 March 1917, he wrote that "Stern's Department has unfortunately put in too sanguine an estimate for immediate deliveries and has let us down rather badly." This comment was made at a meeting of the cabinet during a discussion on tank production. On 23 March he recorded that Lloyd George had been "...much impressed by the fact that Stern had let us down...and wanted to associate Winston with Tanks and Mechanical Warfare... ." The entry for 2 April 1917 reads, " I also saw Commander Basil Johnson, who has been in charge of Tanks at the Front . He was loud in his complaints of Stern & Company, and I arranged to have a full-fledged conference tomorrow on the whole tank position." The entry for the following day reveals that "...we had the conference arranged

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[24] Adams, *Arms and the Wizard*, p 162.

[25] Stern, *Logbook* , p 175.

[26] Dr C. Addison, *Four and a Half Years* (Vol II, June 1914 - January 1919) p 253.

yesterday with the officers from the Front who are concerned with Tanks. On the whole I think we managed considerably to clear the air and I left it to some of the men to hammer out the details. These harrowings will do Stern good." Here perhaps is a reflection of the extent to which Stern's and Addison's views on tank related matters differed, a difference which was reflected in the relationship between the Ministry and the MWSD. When Churchill succeeded Addison the rift remained. Churchill wrote to Lloyd George concerning Stern on 9 September 1917 to highlight the differences between the War Office, the Tank Corps and the MWSD, but he might equally well have drawn attention to the uneasy relationship between himself as Minister of Munitions and Stern as Director-General of the MWSD : [27]

> "Stern has rendered very good service in the past about Tanks, but I am sure he is not the man to carry this job further. It is in a very bad condition. The Tank Supply Department and the War Office are at loggerheads and this is particularly true of Stern and the soldiers. You know that I do not set undue store by their opinion , but I am sure that the development of Tanks is prejudiced at this stage, however much it may have gained in the past by Stern's methods and personality."

General Elles's pencilled notes on the minutes of the conference discussed above also reveal the extent of the antagonism which existed between Stern and members of the War Office and the Tank Corps. In addition to critical comments on the organisation of the MWSD, he concluded his notes with a recommendation that the department's organisation would be considerably improved if they were to "get rid of Stern." [28]

It was clear that the MWSD had outgrown Stern. He was replaced as Controller[29] of the MWD[30] by Vice-Admiral A.G.H.W. Moore at the end of October. In a letter to Lloyd George on 15 October 1917 he denied accusations put to him by Churchill that the MWSD under Stern's charge had amongst other things wasted money, neglected vital research and development, and overall had been instrumental in taking decisions that had squandered a year's lead in tank development. "We have", he said," never hesitated to stand firmly for what we considered to be real progress and

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[27] Martin Gilbert, *Winston S. Churchill* (Vol IV, 1917-22, companion), p 157.

[28] WO 158 / 859.

[29] To avoid the possibility of confusion it should be made clear that just as the title of the department changed over time so too did the title of its chief executive. It began as the Chairman of the TS Committee, became the Director-General of the TS Department and MWSD, and then became the Controller of the MWD in line with the restructuring of the Ministry departments as a whole.

[30] "Supply" was dropped from the department's title during October.

events have proved that we have been right in every case." He continued to see the War Office as the main obstacle to the tank's development :

> "...if the military Authorities are allowed to superimpose their War Office machinery on the technical side of the development as has been done for the last 5 months it will lead to complete chaos in production and design. This is a critical time to change after two and a half years the head of a Department who has made one of the successes of British Arms in this War."

But Churchill did not exclude Stern from all matters related to the tank programme. He felt that Stern's forceful personality would be an advantage in furthering the inter-allied tank programme. On 29 October 1917 Churchill appointed him Commissioner of the Mechanical Warfare (Overseas & Allied) Department - a move he was later to regret. It was Stern's brief to liaise with the U.S. Government representative, Colonel Drain, on a joint inter-allied tank building programme to take place at Chateauroux, France. From the beginning there were difficulties, particularly in obtaining materials and skilled labour . Ultimately the programme was to fail, and mass production of the Mk VIII / "Liberty" tank, of which 1, 500 per year had been planned, never materialised. With regard to this programme and Stern's part in it, Churchill was to be rather less than diplomatic. Writing to his wife Clementine, discussing the problems associated with the programme he referred to "...that foolish Stern...[and the]...possibility of an international scandal... ." [31]

Stern's departure to the inter-allied programme did not remove him from conflict with the War Office for long. As Director-General of Tanks Capper was responsible for a series of letters and memos on Stern's conduct as commissioner.

In a letter to General Seely, Deputy Minister of Munitions, dated 16 July 1918 Capper suggests that Stern was empire building (not an unreasonable assumption given, as we have seen, Stern's possessive hold on the reins as Director-General of the MWSD) which alarmed the general. He was particularly concerned about Stern's expressed intention of gaining control of the proposed Central Training Ground for all allied tank forces in France. He asked that Seely relieve the Overseas and Allies Branch of all its duties " other than those concerned with the arrangement necessary for the assembly of the 1500 Tanks, a work of considerable magnitude, which should suffice to absorb all its energies." [32]

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[31] Gilbert,*Winston S. Churchill* (Vol IV, 1917-22, companion), p 136.

[32] WO158 / 859. There is no proof that Stern's unpopularity with the War Office had any anti-semitic basis, although it is not unthinkable. It is more probable, however, that it was motivated by his civilian background. He came form a very successful family of merchant bankers whose family firm was originally founded in Frankfurt in 1807. He was educated at Eton and Christ Church and later studied banking in both Frankfurt and New York. If this was not sufficient cause to alienate him from the

Clearly, " its " should also be read as "his", meaning Stern. Capper's suspicion, even dislike, of Stern is evident in the following extract from a memo regarding Stern. The memo is undated but probably dates from mid-1918. Again Capper takes issue with the roaming brief assumed by Stern :

> "...his duties in that Branch [inter-allied] are definitely laid down in an encloseure to letter (Ia) and concern the manufacture and supply of Tanks ...I have previously given my views as regards ... Stern's fitness for the post he holds. It appears to be impossible for him to confine himself within the limits of his appointment and duties whilst the nature of his duty allows him great facility of movement." [33]

Capper went on at some length to outline how Stern had approached General Henri Petain and M. Loucheur, minister in charge of French tank production, and, having gained their support for the Central Training Ground, he further succeeded in gaining their recommendation that he was the person best fit to command it. Capper wrote:

> "I consider it eminently undesirable that any officer who is not properly accredited by the Military Authorities for the purpose, should be allowed to approach the High Command of our Allies on military matters... ."

Several months earlier, this time in connection with a memo on the subject of the standardisation of design and its effect on productivity , Capper complained :

> "Lieut. Col. Stern's [production estimates] in comparison to the MWD are quite valueless and most unreliable...To take only one item, the supply of gearboxes, the arrangements for the supply of which had to be entirely recast by his successor owing to the unsatisfactory prospects of delivery... ."

Writing to General Harington, DCIGS, on 16 July 1918, Capper declared that :

> "...It is my considered opinion that ... Stern has not the qualifications or temperament for an official holding the position he now occupies, and I earnestly request that he may be removed from his appointment." [34]

When J.B. Maclean came to the post of Controller in August 1918 he found things far from perfect. Admittedly this was a situation that he had inherited from Admiral Moore and not Stern, but Moore had been at the helm for only one year and he had inherited it from Stern who had personally shaped it after his own ideas. Moreover,

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professional and very conservative elite of the British Army officer corps, then Stern's first commission with the Royal Naval Air Service probably tipped the balance.

[33] Ibid.

[34] Ibid.

given Stern's continued tendency to empire-build, it is not unreasonable to suggest that Stern was, by 1917 if not before, something of a liability. Of course, this should not detract from his considerable achievements during the early stages of the tank's evolution when someone of Stern's forceful and single-minded determination was essential to press the new weapon's case. Stern was replaced as Controller of the MWD by Vice-Admiral A.G.H.W. Moore in October, 1917, to facilitate greater co-operation between the military and the MWD ("Supply" had been dropped from the department's title during October).

Growing co-operation

All requests were now to go through the MWD to other departments of the Ministry and not via the War Office. All correspondence in regard to design and complaints from France or Wool was to be sent in duplicate to the War Office and MWD. Also, the MWD was to send a technical advisor to sit on the War Office Tank Directorate.

Falling production figures in early 1918 prompted still further reorganisation, this time of the supply branch. It was decided to divide it into six sub-sections which were sub-divided again into groups. Each group, under an officer, was responsible for a particular job. The Ministry's newly created engineering department was available to assist the department's own small band of progress officers. On the 4 August 1918 Vice-Admiral Moore was replaced as Controller of MWD by J.B. Maclean.[35] As part of this shake up the War Office Tank Directorate was dissolved, and replaced with the **Tank Board** (sanctioned by the Cabinet on the 8 August) which held its first meeting one week later. Under its president, Maj-General Seely, the board's main function was " to consider the vital necessity for speeding up production with the improvement of existing types and development of new types of Tanks." Where it differed most noticeably from previous joint committees was the extent to which the members were drawn from all the interested bodies. These were Sir Percival Perry as Director of Traction ; Stern now as Commissioner of the Mechanical Warfare (Overseas and Allies) Department (MW(O&A)D) ; the Controller of the MWD (Moore), representatives of the General Staff, the War Office and G.O.C. Tank Corps, France; the Master General of the Ordnance, the Controllers of the Munitions and Inventions

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[35] Maclean had enjoyed considerable success with the Ministry. He became Deputy Dir-General of Gun manufacture (8 July 1917); Controller (20 August 1917); Controller of Engineering Department (6 March 1918); before assuming the post of Controller of MWD.

Departments ; and d'Eyncourt, who was given special duties involving the design and re-design of tanks. [36]

The Board was to meet at intervals of not less than once per week. At its fifth meeting on 12 September 1918 the board arranged for the engine designer, Harry Ricardo, to act as technical advisor to the department . It was also decided that Major W.G. Wilson should be given additional responsibility for ensuring the serviceability of newly arrived machines in France, which was still posing problems even at this late stage. [37]

Maclean found it necessary to drastically reduce tank production estimates for the 1918-1919 programme. His report of August 1918 is scathing in its criticism of nearly all aspects of production. Along with criticisms of and proposed remedies for the general problems such as material and labour shortages, which will be the subject of detailed discussion in the following chapters, there were problems which were particular to the department and its organisation and function.

He highlighted the lack of outside production officers whose job it was to supervise and report on the contractors' progress. They simply "did not exist", though, he said, " every other Supply Department has found it absolutely necessary to operate such posts". They were especially needed to supervise local contractors. He cites two examples where the absence of such staff led to major hold-ups in production. Wm. Beardmore, Glasgow and the Miris Steel Co., Sheffield, had both undertaken to machine their own plate, but both firms had been allowed to undertake orders far in excess of their actual machining capacity. The result of this was that at the time of writing his report some " 5, 000 tons " of armour plate was "lying about the Country" waiting to be machined :

> "It is quite evident that the MWD did not take anything like adequate steps to deal with this serious matter...The utterly unreliable promises of Beardmore and Miris seem to have been accepted without investigation."

He went on to cite the poor communications between the MWD and the Forgings Stampings and Castings Department of the Ministry. Before April 1918 it had been the practice of the MWD to deal directly with the contractors and suppliers of engine and transmission gears. After April the MWD had involved themselves in an :

> "elaborate procedure...[which had to be gone through]...before fresh orders for stampings could be placed...Under the most favourable circumstances...this procedure took 10 to 14 days to complete, but as frequently occurred...as much as four weeks has been necessary to get

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[36] *M of M* , Vol XII, Pt III, Ch V, p 67, Stern, *Logbook* , p 219 and WO 158 / 867.

[37] Ibid, *M of M*, p 67.

continual re-allocation of stamping resources before supply was assured."

Some greater control over the contractors was essential because some contractors were apparently unable, or reluctant to work to the exacting specifications demanded. He found it necessary to order large quantities of new plant "to cope with even the amended figures" for engine and gearbox production, such was the poor state of organisation.

Both Stern and Moore had realised the importance of reorganising the design section. However, Maclean still encountered huge problems due to the shortage of fixed drawings. It has been argued above that with so many new models and so many alterations and modifications resulting from practical experience in the field, it was inevitable that fixed drawings were going to be at a premium. Yet, Maclean found room for fresh criticism. In many cases :

> "preliminary drawings were not produced early enough." "I find it still necessary to send out prints which are altered solely on account of errors made in drawings prepared months ago, and which were not properly checked."

"The methods adopted by the Contracts Department", he wrote," have produced a chorus of protests from Contractors." These protests were occasioned by the procedure adopted by the contracts department of issuing letters to proceed with manufacture stating that "prices will be settled later." "This sets up", he reflected," very difficult conditions for the contractor who has to place sub-contracts, as his sub-contractors always insists on his price being fixed."

All of these problems - failure to ensure sufficient manufacturing plant for vital engines and transmissions, the overly complicated departmental arrangements for the supply of components, the poor organisation, or total lack of local production officers to ensure that contractors kept to their contractual commitments, and the unhelpful practice of the contracts department - were individually capable of holding up the production programme. Taken together and compounded by the immense problems caused by a national shortage of materials and labour they represented an enormous task for any Controller, and a serious obstacle to efficiency. But Maclean managed to end his report on an upbeat note, commenting on the staff of the department :

> "I find the staff, speaking generally, very efficient and have selected Major Wilson , Captain Gelder, Lieut. Spinney, Commander Mc.Grath. Lieut. Shaw and Mr. Lately , for the higher administrative posts. Captain Bussell has made excellent work with reference to transport. There is a very great shortage of staff, however, and I am glad to say that after speeking to Mr. Dulanty and Mr. Geake, of the Establishment Branch, I have had everything which I required granted immediately, and

> the generous treatment which has now been given the department has resulted in an entirely different atmosphere being created." [38]

This chapter has sought to outline the organisation and function of the MWD Obviously, there were personal failings and shortcomings which led to a great many problems, but these should be seen in the context of the enormity of the task. No precedent existed upon which to model even the organisational structure in regard to organising contractors, ensuring an adequate supply of such a wide and diverse number of component parts for the mass production of a machine which, in its early stages existed only imperfectly in the collective minds and drawings of a few, in the best sense of the word, amateur enthusiasts.

Despite the very obvious friction between personalities and bodies, civil and army, over the control of all matters relating to the tank, it is clear that both sides shared a common goal, namely the success of the tank. The rivalry was not over whether to develop the tank, but how.

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[38] Maclean's report in MUN 4 / 1374.

[2]

Production &Continuity

The War Office placed its first bulk order for 100 machines (Mk I tanks) after the first successful trial at Hatfield Park in February 1916.[1] Problems of continuity of orders and supply, which were apparent even before this order, now arose to present formidable obstacles to successful production. (see table 1). An order for 100 machines was simply not enough to guarantee continuity of supply. Contractors would not, and could not, give over sufficient manufacturing capacity to such a short term order. On 21 April, in order to alleviate this situation, the Army Council increased its order to 150. These were to be, as near as possible, half female and half male tanks.[2] The Chairman of the TS Committee, Sir Albert Stern, was confident of being able to supply this order ready for transportation to France by the end of July 1916. [3]

However when Colonel Swinton , Director of Staff Duties, Heavy Branch Machine Gun Corps, wrote to Maj-General J.T. Burnett-Stuart, GHQ, on 1 July regarding the tank supply situation, he had to confess that his earlier confidence, which had led him to assure Maj-General R.H. Butler, DCGS, on 14 June that he " did not see any reason why ...we [TS Committee] could not keep to the approximate estimate of output, was misplaced. "Snags ", he wrote," are bound to occur in such a complicated matter... Deliveries quoted by me will have to be put back two weeks." [4]

Burnett-Stuart wrote to Swinton on 10 July stating that in answer to the Committee's request for more orders :

> " It is hardly possible to decide now, with the knowledge at our disposal, whether more Tanks should be ordered or the type changed...Before any

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[1] Fosters received an order for 25 and Metro for 75. Hatfield Park mentioned in variety of sources including : Chamberlain and Ellis, *British and German Tanks of World War I*, p.24, Stern, *Logbook* , p 65.

[2] Male tanks were armed with two 6-pdr guns together with four Hotchkiss machine guns. Female versions were armed only with machine guns: four Vickers and two Hotchkiss.

[3] *M of M.*, Vol XII, Pt III, Ch III, p 34.

[4] WO 158 / 833.

> judgement can be formed it will be necessary to see at least 20 Tanks fully equipped and manned, functioning in accordance with some definite tactical scheme. It will also be necessary to view the French experiments, which they have informed us that they propose to hold shortly with their Tanks.
>
> Can you say, please, for how long a decision may be deferred without endangering the continuity of manufacture ?" [5]

Swinton's reply, that the manufacture "is a question of engines, guns, gun mountings, gun ammunition and various small parts", revealed the enormous difficulty of organising and bringing together the wide variety of component parts necessary to complete a tank. Swinton went on to state that "The absolute continuity of supply is, as a matter of fact, already broken." [6]

By mid-July it was realised that the tanks would not be ready until the end of September. To further ease the continuity problem the Army Council increased its order by 50 on 25 July, and on the intervention of Montagu, Deputy Minister of Munitions, it was increased by another 50 to a maximum of 250. [7]

However, the sub-committee (chaired by Stern) of the TS Department urged the War Office not to introduce the tank in the autumn of that year, as it planned, but instead to postpone its debut until the following January when the TS Department assured the War Office it could have some 350 machines ready for operation.[8] Burnett-Stuart expressed the War Office's dilemma. He appreciated that it was in the War Offices's own best interest to preserve continuity , and the relationship between continuity of orders and continuity of supply was clearly understood. Yet, at the same time the Army wanted the best machine available, and at this time it was not convinced that the Mk I fitted the bill. No machine at this time had tackled anything more demanding than simulated battle conditions, a poor substitute for the real thing.[9]

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[5] Stern papers, 1 /C / 3, and Stern, *Logbook* , p 84.

[6] Ibid.

[7] *M of M.*, Vol XII, Pt III, Ch III, p 35.

[8] Stern, *Logbook* , p 87.

[9] No effort had been spared in attempts to replicate accurately the German trench systems that the tanks would encounter in France. WO 158 / 831 reveals detailed reports and plans compiled by GHQ on the nature of the construction of the German trench systems. However, as many agreed at the time (including J.F.C Fuller, one of the harshest critics of GHQ's tank tactics), nothing revealed design and manufacturing defects so effectively as actual battle conditions.

Production programmes

The TS Committee did not get its way. The first tank made its debut at Flers-Courcelette on 15 September 1916. Following this relatively successful debut the Army Council ordered a further 1, 000 machines, but on the proviso that they could be supplied with sufficient spares. A failure on the part of the TS Committee to give this reassurance led to the order being withdrawn on 30 September. However, the *History of the Ministry of Munitions* clearly states that a contingency order of some 600 machines was placed in order that continuity should be protected.[10] The delivery of this order was promised by the TS Department for the beginning of January 1917. On 14 October the War Office renewed its order for 1, 000 - that is from 600 to 1, 000, which included the earlier order for 250.

Was this the result of pressure from Lloyd George ? It is suggested by some historians, and by Lloyd George himself, that upon hearing of this cancellation, he "cancelled the cancellation", thereby protecting the future of the tank from those who would see its production discontinued. In his memoirs he recalled :

> "...I ordered [September, 1916] 1, 000 tanks to be manufactured. Sir William Robertson countermanded the order without my knowledge. Thanks to Sir Albert Stern I discovered this countermand in time, and gave peremptory instructions that the manufacture should be proceeded with and that the utmost diligence should be used in executing the order." [11]

No one would seek to deny that the tank had its opponents within the War Office, yet clearly there were also many supporters in high places, among them the Commander-in-Chief. After all an order for 600 hardly suggests a lack of interest on the part of the military authorities. Its diffidence, if as suggested above an order for 1, 000 can be viewed as such, was arguably due to a lack of confidence in the department's ability to deliver on time. Army Council minutes (1915-16) for 27 September 1916, under the heading "Provision of Tanks" state that it had been decided that "the programme for the provision of "Tanks" at the rate of 3 a day should be adhered to for the present. Accordingly the proposed order for 1, 000 Tanks should be held up pending further

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[10] *M of M.*, Vol XII, Pt III, Ch III, p 37.

[11] Stern papers, 1 / C / 5, and Lloyd George,*War Memoirs* , Vol II, p 1456. It seems a little strange that some three weeks later Haig was in London where he met with Lloyd George who, according to Haig's Diary (entries for period 3-7 November, 1916, Vol 12), was most anxious to help the Army all he could. There is no mention here of any disagreement or ill-feeling that one might have expected after the "cancellation" of the cancellation a few weeks earlier. Liddell Hart also questions the whole "cancellation" episode and his papers suggest the he too was unclear as to what exactly was going on (L.H. 9 / 28 / 59-62].

investigation as to the utility of those now employed, and as to the possibility of improvements." [12]

Which was the more realistic, Lloyd George's insistence on 1, 000 machines of a model which, though it had proved itself useful, was to all intents and purposes still a proto-type requiring significant modification, or the Army Council's ponderous but essentially pragmatic view ?

Further, on 30 September there were 49 machines in France, of which some 36 had taken part in the Somme. In England there were only in the region of 40 machines nearing completion.[13] Simple arithmetic suggests that of the original order for 250 there were still 161 to be completed. These, after the experience of 15 September, were to be modified with a bomb-proof roof, or at this early stage a construction of chicken wire and wood to keep German hand-thrown "bombs" (early hand-grenades) from severely damaging the roof. They were also to have their gun-mountings, tracks and track mechanism altered.[14] A revised delivery estimate for the second week in November was given for these "new" models (Mks II and III) with production estimated to rise to 40 per week by 1 January 1917. If we give the TS Department the benefit of the doubt, and assume that they could have met this deadline (there is little evidence to suggest that they would have), such a delay would have denied the designers, manufacturers and tank crews the experience of battle, in effect putting the evolution of a truly effective fighting tank on hold for six months.

Both the Ministry and the Army Council were expressing some doubt over the value of the tank at this time. Pressure was mounting to expand erection facilities and increase plant but the War Office and the Ministry were reluctant to provide funding while the " capacity for the Supply Department to meet the existing programme was not yet established."[15] It was also discovered at this stage that there were not enough firms, who were not already producing other forms of munitions, available to produce complete tanks. So, rather than spread the workload over a large number of firms as the Committee had first intended, it was now decided to establish a network of suppliers to the main erectors, relieving them of the need to produce their own components. This not only speeded up production but began the move to standardising components. In December 1916 Edwin Montagu was able to confirm that production rates of Mks II and III machines were such that 100 would be available by February 7 and that 80 more

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[12] WO 163 / 21.

[13] *M of M.*, Vol XII, Pt III, Ch III p 37.

[14] Chamberlain and Ellis, *British and German Tanks of World War 1*, pp 26-28.

[15] *M of M.*, Vol XII, Pt III, Ch III, p 43.

would be produced by the end of the month, with a total of 420 by the end of May. [16] Events were to supersede this estimate with only 100 being built before the switch to the Mk IV.

Strikes and delays in orders during the first half of 1917 saw production figures tumble. This decline was further exaggerated by the almost continual, though necessary, reorganisation of the MWSD. The absence of outside production staff overstretched the inspection branch, and the reorganisation of the design branch, which resulted in a more centralised body, led to enormous backlogs of work. The detailed redesign work on the Mk IV, a result of the feedback from France, and the new Mk V (in both cases it involved the lengthening of the tanks to cope with wider trenches), together with design work for the new Mk VIII for the Mechanical Warfare (Allied & Overseas) Department, meant that design work for the Mk V* and Med 'B' had to be transferred to their place of manufacture, i.e. the Metropolitan Works, since neither the room nor the staff were available at the MWD. The rapidity of the evolution of tank models reflects the state of flux in tank design and the inevitable continuity problems.

Meanwhile, production of the Medium 'A' "Chaser"[17], which began in October 1917, was hampered by difficulties in obtaining ball-bearings. Manufacturers were also falling behind in deliveries of both gear boxes and epicyclic gears. Eventually the Ministry had to issue a revision of estimated output for 1918. Churchill was later to intervene personally with the manufacturers after which they undertook to produce 660 Mk V and Mk V* by the end of June 1918.

By far the largest of the tank manufacturers was the Metropolitan Works, Birmingham, who received orders from the MWSD for 1, 400 Mk V, Mk V*, Mk V** and 450 Med 'B's. The remainder of the work was distributed to a growing number of firms including : Fosters & Co., Lincoln ; Marshalls of Gainsborough ; Coventry Ordnance Works, Glasgow ; Brown Bros, Edinburgh, (see table A).[18] Early 1918 saw the Railway Materials Department, of the Ministry, ease restrictions on the use of locomotive workshops for the erection of tanks. As a result North Britsh Locomotive, Glasgow, West's Gas Improvement Co., Ltd, Manchester, and Kitson & Co., Leeds, were contracted to build complete or part tanks. [19]

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[16] Production ended in February 1917, and not May when the new Mk IV came into production.

[17] The Medium 'A' "Chaser" was also known as "Tritton's Light Machine". It was an attempt to create a cavalry, light or medium tank as opposed to the heavy tank.

[18] See table A for a list of the principal manufacturers. This list is by no means exhaustive. Also see Maclean's list in chapter 3.

[19] *M of M.*, Vol XII, Ch III, Pt IV, pp 63, 65, 68 and Pt V, pp 27, 35. WO 158 / 867, MUN 4 / 6400 and 5200, also the Weir Papers , 17/49, Archives, Glasgow University.

TABLE OF MAIN DIMENSIONS AND PARTICULARS OF TANKS. 1918

Type of Machine	Dates of Design, &c.					Weight.			Pressure per square inch in lbs.					Length and Width of Track in Ground Contact.			
	Date of Commencement of Design.	Builder of First Machine.	Principal Manufacturer.	Date of First Standard Machine.	Number of Machines produced up to December 31, 1918.	Total Weight in Fighting Trim in Tons.	Weight per horse-power in pounds.	Horse-power per Ton.	Number Sinkage.	2-inch, Sinkage.	4-inch, Sinkage.	6-inch, Sinkage.	Sunk to Belly.	Width of Track Plates.	Length of Track on each Side in Ground Contact, No Sinkage.	Length of Track on each Side in Ground Contact when Sunk Belly and Machine at Rest.	Length of Track on Each Side in Ground Contact when sunk Belly and Machine in Motion.
						lbs.		h.p.						in.	ft. in.	ft. in.	ft. in.
Mark I ..	Oct., 1915	Foster and Co., Ltd., Lincoln	Metropolitan Carriage and Wagon Co.	Dec., 1915	Male, 75 .. Female, 75	Male, 28 .. Female, 27	597	3·75	27·8	24·6	16·9	13·0	11·6	20½	4 7	17 0	11 0
Mark II ..	Feb., 1916	,,	,,	Jan., 1917	Male, 25 .. Female, 25	Male, 28 .. Female, 27	597	3·75	27·8	24·6	16·9	13·0	11·6	20½	4 7	17 0	11 0
Mark III ..	Feb., 1916	Metropolitan Carriage and Wagon Co.	,,	Jan., 1917	Male, 25 .. Female, 25	Male, 28 .. Female, 27	597	3·75	27·8	24·6	16·9	13·0	11·6	20½	4 7	17 0	11 0
Mark IV ..	Oct., 1916	Foster and Co., Ltd., Lincoln	,,	Mar., 1917	Male, 420 .. Female, 595	Male, 28 .. Female, 27	597	3·75	27·8	24·6	16·9	13·0	11·6	20½	4 7	17 0	11 0
Mark V ..	Oct., 1917	Metropolitan Carriage and Wagon Co., Ltd.	,,	Jan., 1918	Male, 200 .. Female, 200	Male, 29 .. Female, 28	450	5·2	28·7	25·0	20½ inch 17·0	tracks. 13·0	12·0	20½ and 28½	4 7	17 0	11 0
Mark V* ..	Feb., 1918	,,	,,	May, 1918	Male, 290 .. Female, 432	Male, 33 .. Female, 32	499	4·28	23·2	19·4	26½-inch 13·2	tracks. 11·0	9·8	20½ and 28½	10 7	22 0	17 0
									14·2	—	20½-inch —	tracks. 12·0	8·9				
Mark V** ..	May, 1918	,,	,,	Dec., 1918	1 made ..	Male, 35 .. Female, 34	343	6·4	11·6 28·3	— —	26½-inch — 21·2	tracks. 9·3 13·2	6·6 9·0	20½ and 26½	5 0	28 5	17 6
Mark VII ..	Dec., 1917	Brown Bros., Edinburgh	Brown Bros., Edinburgh	July, 1918	3 made ..	33	493	—	25·0	23·0	15·2	12·3	10·8	20½	4 7	16 0	12 6
Mark VIII ..	Dec., 1917	North British Loco. Co., Ltd., Glasgow	North British Loco. Co., Ltd., Glasgow	Oct., 1918	7 made ..	37	270	8·0	18·6	—	—	15·3	6·3	28½	7 6	—	21 0
Mark IX ..	Sept., 1917	Armstrong, Whitworth	Marshalls, Gainsboro'	June, 1918	25 made ..	27, unloaded 37, loaded	550	4·05	28·0	—	19·0	13·7	6·9	20½	6 0	—	24 0
Gun-carrying tank	July, 1916	Metropolitan Carriage and Wagon Co., Ltd.	Kitson & Co., Leeds	Jan., 1917	45 made ..	27, unloaded 34, loaded, With gun and ammn.	576	3·9	29·2	20·0	11·5	10·7	7·6	20½	11 7	—	19 0
Medium Mark A whippet	Dec., 1918	Foster and Co., Ltd., Lincoln	Foster and Co., Ltd., Lincoln	Oct., 1917	200 made ..	14	345	6·43	16·8	—	12·6	9·8	4·5	29½	4 9	17 0	14 0
Medina B ..	June, 1917	Metropolitan Carriage and Wagon Co., Ltd.	North British Loco. Co., Ltd., Glasgow	Sept., 1918	45 made ..	18	403	5·5	14·3	14·0	12·4	9·3	5·3	22½	5 0	—	14 0

Total number of tanks constructed, 2,633.

Kitson's received an order for 36 Mk VII machines on 25 March 1918, and Wests an order for 1, 500 Mk VIII hulls on 7 March. Both firms became centres for tank erection groups established in their regions. These groups represented an attempt to decentralise and devolve the production of complete machines taking advantage of the new capacity freed by the relaxation of the restrictions on locomotive builders. The South Lancs Group, established in February 1918 under Mr West of Wests Gas Improvement, was to produce 300 h.p. engines at a rate of 320 per month for the Mk VIII. The Yorkshire Group, established in April and centred around Kitsons , Leeds, received orders for 200 Medium 'C' tanks. Both groups were to merge to form the North of England Group under chairman Captain A.E. Gelder, Assistant-Controller, MWD. [20]

The Scottish Tank Production Committee was intended to perform a similar function north of the border. This group which included North British Locomotive (NBL), Cardonald and Beardmore, became fully organised under its chairman Fred Noblitz, Director-General of Munitions in Scotland, in October 1918. [21]

Concern over the well being of locomotive production soon led to a revision of the use of these facilities for tank erection. This pressure, together with shifting priority status in regard to mechanical transport, rail and tanks (Army Council placed them in this order in March, but revised it again in favour of tanks later in the year), saw Kitsons receive fresh orders for locomotives, but they were to finish their tank programme first. NBL also received an order for 130 locomotives in November which, Maclean calculated, would mean a reduction of over fifty per cent in Medium'C' output .[22]

Both orders for tanks and estimates of delivery were liable to fluctuate with the inevitable negative effect on confidence and continuity. For an example of just how widely War Office orders fluctuated we have only to follow the course of the Mk V heavy tank and its variants (V* and V**) [23] for the 1918-19 programme.

Fluctuating orders

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[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] Mk.s V* and V** were lengthened versions of the MkV. The Mk V* was a MkV with three additional panels added in the middle to give it extra trench spanning capability. The MkV**, which never went into full-scale production, was a purpose built MkV*, as opposed to a MkV with additional panels.

In an interdepartmental communication from H.G. Fleming to W.T. Layton, secretary to the Ministry's Department of Munitions Requirements and Statistics (DMRS) dated 21July 1917, Fleming stated that in a conversation with Stern he had been informed that the heavy tank component of the 1917-18 tank programme would be 540 machines to be ready by 1 May 1918, with replacements running at 108 machines per month making a total, by September 1918, of 972 tanks. Nearly one month later on August 17 a communication between the same two members of the DMRS suggests that Fleming understood that"unofficially" (reflecting the degree of uncertainty as to what the War Office wanted) this component had now increased to 700 Mk V machines, rising to 1, 600 by September 1918" by the addition of 108 per month". [24]

On 24 August Stern wrote to the DMRS stating that he had arranged for the "laying down of 800 Mk V machines". Of which he said " no production of this type can be anticipated before January next and whilst plans are being made for an output of 160 per month it will not be possible to reach this figure for some time after the commencement of production." [25]

As stated the Metropolitan Works were the only firm engaged in the production of the Mk V tank and its variants. Records show that they received orders from the MWSD for 700 Mk V* and 900 Mk V** on 22 September 1917, but there was no mention made of the Mk V.[26] Perhaps we are to take it as read that this order was for machines over and above the existing order for the Mk V. It would seem logical to assume this.

Having recently succeeded Stern as Director-General of the MWSD, it now fell to Admiral Moore to answer the DMRS 's query regarding tank estimates for the 1917-18 programme. On 25 October he wrote informing them that he estimated that 600 Mk Vs would be available by 1 June. He concluded this statement on a wishful note," provided design is not altered." [27]

In a precis to the minutes of the second "New" tank Committee meeting of 7 January 1918, Moore advised Sir Arthur Duckham, member for Council Group 'E' (Engines), of a requirement from the Director-General of Tanks (Capper), for the late addition of 300 Mk VIII tanks to the production programme.[28] On 27 February 1918,

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[24] MUN 4 / 2801.

[25] Ibid.

[26] MUN 4 / 6400.

[27] MUN 4 / 2801.

[28] WO 158 / 859.

in a report to Duckham, Moore stated that there were still some 1, 400 Mk V, V* and V** machines outstanding from the 1917-18 programme.[29] These figures (400, 700, 300 respectively) then reappear as the number of machines ordered from the Metropolitan Works for the new programme produced by the Ministry on 7 March indicating the distribution of production for the "1918 (1 February to 31 March 1919) Programme". [30] The *History of the Ministry of Munitions* records that in May the War Office placed orders with the MWD for some 6, 940 machines of which 900 were to be Mk V** (confirmed by Maclean's report written in August) and 900 Mk VIII (plus the 1, 500 Mk VIII "Liberty" tanks to be produced by the joint Anglo-American venture at Chateauroux). [31]

On 17 September the War Office issued a revision of the tank production programme stating that they required some 3, 600 fighting machines (including one hundred per cent reserves) of which between 1, 200 - 1, 800 were to be Mk V* or V**. There is no mention of the new heavy tank, the Mk VIII, which, after its less than successful trails at Glasgow,[32] seems to have been dropped from the programme. Finally, at a Tank Board meeting (31 October 1918) the General Staff indicated by letter that the delivery of 4, 000 machines by 1 January 1919 was to have high, but not absolute, priority.

Over a period of some fifteen months (July 1917 - November 1918) there was a considerable fluctuation in both the numbers and the models of machines ordered. Numbers varied from some 540 in July 1917, to 700 in August and the 800 laid down by Stern [33] in the same month. The War Office would not sanction a larger order for Mk Vs for the same reasons as those which caused it to hesitate when facing pressure from the MWD to order more Mk Is - the rapid evolution of technical change. They had no intention of being "lumbered" with large numbers of obsolete machines as they had been with the Mk IV.

True to form, by September attention had shifted from the Mk V to the Mks V* and V**. Both were variations on the Mk V theme arising out of experience in the field. However, because of the War Office's cautious approach to placing firm orders

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[29] MUN 4 / 2801.

[30] WO 158 / 859, and MUN 4 / 2801.

[31] MUN 4 / 1374, and *M of M*., Vol XII, Ch III, Pt IV, p 65.

[32] See the section on the MkVIII tank, below.

[33] MUN 4 / 6400.

for the Mk V, the laying down of plant was delayed from January until August. As a result its first trails were not conducted until January 1918 by which time the War Office, in keeping with the pace of technical change, had shifted its attention to the V* and V**.

By the end of March the Ministry's programme showed that the original order for the Mk V had been reduced by some fifty per cent. Production was ceased when this figure was met at the end of June. Meanwhile production of the Mk V* was moving apace, with 214 machines produced by the end of July, a figure which had risen to 579 [34] by the Armistice and 632 by December. However, not a single Mk V** left the erection shop before the end of the war.

May saw the programme change once more. This time the Mk V* was out of favour, replaced by the new Mk VIII. Yet, with the failure of the Mk VIII in the September trials at Glasgow (see below), the Mk V* was once more back in favour.

It is hardly surprising that with orders in such a state of flux continuity and confidence within the MWD and its contractors were undermined. But, as orders fluctuated, so too did delivery estimates. Of course, estimates are bound to change in line with orders, and there was also a sense that the MWD had to inspire confidence in the War Office, but this does not explain some of the overly optimistic estimates given by the MWD, which, if anything, did a great deal to undermine that confidence.

Delivery estimates

Stern had concluded his report to the DMRS of 24 August 1917 with a brief description of the difficulties facing the MWSD :

> "It is impossible to forecast with any degree of certainty the productive capacity of the contractors to the Department...The contractors are dependent upon many extraneous circumstances, concerning which it is not wise to prophesy...Scarcity of raw material, shortage of labour, difficulties in obtaining tools, and other extraordinary conditions, have to be taken into account...Consequently my anticipation must be conservative and it must be distinctly understood that where improvement of the delivery dates can be obtained, every effort will be made in that direction." [35]

Stern did not do himself or the department any favours when he described his best estimated output of 160 Mk Vs per month as a "conservative" estimate. If we take

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[34] This figure was supplied by David Fletcher, Librarian, Tank Museum.

[35] MUN 4 / 2801.

the 400 Mk Vs produced between January and the end of production proper in June and add to this the 579 Mk V*s (refer to footnote 27) produced by the Armistice we have a total of 979 machines. If we divide this figure by the nine months of production this gives us an average of 109 machines per month. Stern would have been better advised to have described his estimate as optimistic.

J. B. Maclean, in his report on the state of the MWD, was critical of these ever changing and at times overly optimistic estimates of production. As the estimates for early 1918 had to be revised, so too according to Maclean's report did the estimates for late 1918 and early 1919. The following table shows the estimates for the delivery of complete tanks between September 1918 and April 1919. The first line represents the estimates that were current when Maclean assumed the position of Controller and were compiled under the supervision of Admiral Moore. The second line of figures is the result of an investigation carried out by Sir Percival Perry during the first days of Maclean's tenure, and the third the result of Maclean's own calculations.

	Sept.	**Oct.**	**Nov.**	**Dec.**	**Jan.**	**Feb.**	**March.**	**April.**
(No.1)	203	315	378	549	700	708	734	747
(No.2)	190	248	322	490	720	800	800	800
(No.3)	145	172	215	113	228	378	496	573

[36]

He makes it clear that the figures in the third line do not include " deliveries of hulls and sets of track shoes for the Chateauroux Programme ", which he estimated separately :

Nov.	**Dec.**	**Jan.**	**Feb.**	**March.**	**April.**	**May.**	**June.**
40	120	160	240	280	280	280	100

He also states that these figures (third line) were, unlike the others, compiled after consulting the supply officers of the department "dealing and conversant with" the firms manufacturing the main component parts. He then sets out to compare the estimate in line number two with a table showing the vital component parts available at the time. The estimate (No.2) was made on the 7 August , while (table B) [37] was based on stocks available on 10 August.

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[36] MUN 4 / 1374, Maclean's report.

[37] **Column 1.** Shows the complete stock at August 10.
Column 2. Shows rate of monthly production at that date, and indicates whether it was rising or falling.

"It is an elementary deduction ", wrote Maclean, " from this table that the September estimate of 190 tanks could not be obtained. Hulls, Armour Plate, and Sponsons, were well under that figure." Moreover, the fact that the actual rate of output of the main components such as armour plate, engines and sponsons was falling meant that the rapid rate of increase of estimated output was " unduly and considerably optimistic". Maclean provides one further table (table C) which, to quote him, " brings to light some more astonishing results".

Table B

	Stock	Rate of output per month		Time lag.
Hulls	139	136	Falling	6 Weeks
Sets of Armour Plate	154	130	"	6 "
" " Bomb Proof Plate	229	165	"	6 "
" " Sponsons	92	85	"	6 "
" " Track Shoes	444	278	Stationary	6 "
" " Engines	359	184	Falling	4 "
" " Gear Boxes	473	177	"	4 "
" " Clutches	270	202	Stationary	4 "
" " Epicyclics	286	226	"	4 "
" " Radiators	205	233	Falling	4 "
" " Chains	217	178	Stationary	2 "
" " Tanks (oil etc.)	203	186	Falling	4 "
" " Fans	699	353	"	2 "

In September 1917 the War Office placed an order for 900 Mk V** heavy tanks. Yet, the table shows that on 10 August not one complete set of components was in existence. Further, 1, 500 Mk. VIII hulls (order placed with West's Gas Improvement Co., Leeds) were ordered for Chateauroux on 7 March 1918, but again on 10 August, apart from one sample tank, there was not one complete set of components.

Table C

	V*	V**	VII	VIII	VIII	IX (O&A)	B	C
Hulls	120	-	3	2	0	13	0	1
Armour Plate (sets)	77	-	2	-	-	75	0	-
Bomb Proof "	60	-	2	20	-	147	0	-
Sponsons "	89	-	1	2	-	reqd	-	-
Track Shoes "	112	-	9	20	-	126	96	-
Engines "	176	-	37	1	-	25	7	13
Gear Boxes "	397	-	60	-	-	16	0	-
Clutches ....no difficulty	163	-	-	25	-	25	44	13
Epicyclics	210	-	-	1	-	68	7	-
Radiators " "	62	-	22	2	-	57	54	8

Column 3. Gives the time, before the completion of the tank, by which the component should come into the hands of the erector.

Chains	71	-	8	30	-	45	63	-
Petrol Oil Cans	102	-	23	-	-	73	5	-
Fans (sets)	332	-	28	2	-	187	150	-
Totals	1971	-	195	105	-	857	506	35

Exactly the same can be said of the Med 'B' machines, 250 of which were ordered on 22 September 1917, and of the order of 200 Med 'C' placed on the same date. Finally, although stocks for the Mk VI and Mk IX tanks looked healthy enough, they were, Maclean suggests, quite inadequate to enable the two firms concerned to utilise their full erecting capacity. Any temporary hold up, such as a bad batch of armour plates, would inevitably have led to a fall in output due to the limited stock available.[38]

Fixed drawings

Improvements in output during the first quarter of 1918 could not be sustained. This was due in part to an influenza epidemic which struck the West Midlands, and was exacerbated by labour force reductions following the introduction of the"Clean Cut".[39] Moreover, the design branch was still over extended.

In his report Maclean stressed the inaccuracy of some of the final drawings, which he attributes to error on the part of the draughtsmen.[40] Yet the most daunting task facing members of the design branch was the enormous number of technical changes which had to incorporated. For example, between February and July of 1918 some 1, 755 alterations had to be made to working drawings sent to contractors.[41]

" February, 1918,	.....	51	alterations	sent	to contractors.
March,	"	61	"	"	"
April,	"	...429	"	"	"
May,	"	, ..555	"	"	"
June,	"	, ..325	"	"	"
July,	"	, ..334	"	"	"
Total,....		1,755			

[38] Ibid.

[39] The "Clean Cut" was means by which men of a certain age were conscripted en masse from the workforce. It was imposed in early 1918 to meet the demands of the German spring offensive.

[40] MUN 4 / 1374, Maclean's report.

[41] MUN 4 / 2809 contains details of the many hundreds of alterations submitted each month.

" As any one alteration above", wrote Maclean," may have applied to several firms, the alarming progression of the figures in obvious." He further pointed out that :

> "It would be an interminable story to show why drawings had never been fixed, but it will suffice to say that for the whole of the types of tanks on programme , the drawings, when I took over, were still in a state of flux. I found that in some cases the firms were responsible for the designs, in others, the MWD, and in one case a Committee.
>
> Prolonged discussion as between the Department and France was in operation regarding points in design and meanwhile production was side-tracked or material produced which was ultimately useless."

Difficulties surrounding the Tank Corps' sense of isolation in regard to fixed drawings and design input were not confined to 1918. On 24 March 1917 Lieut-Colonel Searle, a technical advisor to the Tank Corps, wrote a detailed letter to Elles outlining several areas of difficulty, one of which was the gulf between producer and user particularly apparent in matters of design :

> " It is not possible for agreements as to design to be come to [sic] when the designers for the production of a satisfactory Tank do not visit the scene of operation, and it is a fact that those responsible for design have not been in France for the past four months....No modification in design should be made without consultation with France, and when the modifications are produced, after machines embodying such modifications have been tried in England, they should immediately be sent to France for further test." [42]

Elles later raised the subject at the fourth meeting of the "New" Tank Committee on 4 February 1918 when he said that he had been denied access to drawings." I find myself", he said," within a few weeks of the arrival of an entirely new type of machine for which I have to train several hundred men and on which instruction, maintenance books, spare part calculations, arrangements for repairing and workshop details all have to be made without a single drawing of the weapon with which I am going to fight. This is a great handicap... ." He continued stating that he fully understood the MWD's objections to having to submit every drawing to the scrutiny of France before progress could be made and assured the Committee that this was not his intention ; but, he said,"...when drawings were passed for manufacturers, such drawings should be automatically sent to France." Any changes that France might wish to instigate should, he suggested, "...be introduced after the production of a certain

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[42] WO 158 / 838.

number of machines", so as not to hold up the initial production run.[43] Admiral Moore consented to these plans being sent to France but made it perfectly clear that no changes to final drawings would be permitted until a later, and more convenient, date.

At first sight Searle may appear more determined than Elles that France should have been involved in questions of design, and, therefore, the "fixing" of technical drawings, but this is a reflection of the context from which the quotes were taken, rather than any major difference of opinion on the matter : Searle's came from a confidential letter, while Elles's came from the official minutes of a major board meeting. The point is clear that theTank Corps felt aggrieved by the MWD's monopoly of tank design. However, in the interests of continuity, in the light of the enormous numbers of technical changes in design suggested by both the department's own experimental and testing body and from France, it is entirely understandable that the MWD should have sought to cap the level of design changes.

The Mk IV and Mk V III tanks

Overall deliveries in May were 33 per cent down on estimates submitted in March. It was estimated that there would be a deficit of some 3, 000 tanks on the War Office programme to June 1919. Both the Mk IV and the Mk VIII tanks provide excellent case studies highlighting the enormity of the task of establishing and maintaining continuity of production.

The Mk IV

The pace of technical change soon rendered Mks II and III obsolete. Yet, the MWSD was still delivering these models in August, 1917, although in February 1917 the new improved Mk IV was ready to enter mass production. In February the War Office stated its requirements in regard to the Mk IV and the new Medium 'A' Chaser. Orders were placed for 1, 000 (648 first line, with 352 as reinforcements) and up to 200 after the end of June, respectively. Until this time the Mk IVwas to have priority.[44]

The Mk IV was a significant improvement on earlier models, incorporating many of the lessons learnt in France. Its armour was marginally thicker, offering improved protection from German armour-piercing ammunition. It had fixed sponsons

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[43] WO 158 / 859.

[44] Priority status was a crucial factor in the distribution of the limited supply of skilled labour and raw and finished materials, including engines / transmissions and armament. Mechanical warfare faced severe competition form the more established rivals, namely : the Admiralty, including the Royal Naval Air Service, the RFC and the Army, including mechanical transport and railways.

which could be pushed in to the tank making it significantly easier to transport. The cumbersome tail of the earlier marks was removed reducing the weight and the vulnerability of the tank to artillery fire. The tracks were improved and the petrol tank was placed outside and behind, minimising the risk of fire. It was understood that some 300 hundred of these tanks would ready by the end of May. If erection capacity had not been given over to finishing earlier and now obsolete machines, this figure might have been significantly improved upon. But this, of course, does not allow for difficulties of continuity.

Once again delays in manufacture meant that estimates had to be altered. Revised estimates for the initial three month production run now allowed for the production of 200 not 300 as originally planned. Stern suggested that the delay was due to the removal of first class priority status by Haig, resulting in labour being taken for aircraft production which now commanded a higher priority, and the large number of design changes coming from France. However, this conceals the truth of the matter. Haig had arranged for tanks to receive first class priority status until 11 February, when production of the Mk IV should have already begun. It was anticipated that the production of the Mk IV would be running and fully manned by this date. However, as stated above, the production run was delayed and so on 21 March Stern found his manufacturers short of labour.

There were further problems in Scotland. Wm. Beardmore and the Coventry Ordnance Works were contracted to produce some 400 Mk IVs. Whilst Coventry Ordnance continued production, Beardmores could produce only 50 before demands by the Admiralty for destroyers and submarines [45] meant that production had to be stopped. These 50 tanks produced in early 1917 were the last complete tanks to emerge from the Beardmore works. The onus then fell on the three remaining firms, Metropolitan, Fosters, and Armstrong-Whitworth, to meet the demand. By May the production of Mk IVs was in full swing, with 80 produced in April, 100 in May and 120 in June. There were 19 Mk IVs in France by mid-April. Yet, as before, things were not in order. Heavy Brigade inspectors in France found that the newly-arrived machines, despite passing inspection tests in England prior to shipping, were not fit to fight. It was as a result of this that Haig asked for the creation of the Tank Committee.

Production of the Mk IV, particularly the ensuing confusion over the exact number of machines ordered, serves as an excellent example of some of the key issues surrounding tank production. The War Office's order of 1, 000 machines was enlarged

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[45] Sir William Beardmore's reply to Lord Weir's tribute to Beardmore's role in munitions supply during the war. Both speeches were given at a "Victory Dinner", and were reported verbatim in the Beardmore News, 14 May, 1919.

Some of the 50 Mk IV tanks erected at Wm. Beardmore's Parkhead Works, Glasgow, in early 1917.

by Lieut-Colonel Stern who set in motion a production run for 1,400 machines.[46] Evidently there was a serious lack of communication between producer and user. But it also reflects Stern's dogged determination and forceful character. He was certain of the Mk IV's success, and keenly anticipated an expanded order over and above the original 1, 000. In this he was to demonstrate a lack of foresight. As we have seen, the earlier Mks I to III had very quickly been rendered obsolete by practical experience. Why assume that the Mk IV would not be superseded by new models ? In fairness, Stern may have been guilty of nothing more than an earnest attempt to overcome the enormous difficulties of continuity. The efficient production of machines and spares, making best use of labour and materials and floor space, could only be achieved if a continuous production run could be relied upon. Such an enthusiastic and concerted drive for continuity was to lead to the accusation that Stern had only succeeded in "lumbering" up the front with useless tanks.[47] In a letter to General Gore-Anley, G.O.C. Heavy Brigade (23 April 1917) General Elles commented on the efficiency of the Mk IV:

> "Mark IV machines will not do what we want; this has become quite plain from the Arras Battle. Our casualties in Tanks have been, as far as I can make out, ninety percent due to the Tank being hit while stationary, to stop and swing and turn. I am very strongly of the opinion that we must have something faster and handier which can be driven by one man instead of four, and will not stop in heavily shelled ground. The wear and tear on men digging out Tanks has been very great, and there has been a large percentage of casualties caused to men outside the Tanks."

He wrote that the MWSD was producing more Mk IVs than the Brigade could use, and that he had, in the presence of Stern, told General Butler that the Mk IV should be scrapped as soon as the Mk V could be produced. The intervening period should be devoted, he thought, to eradicating the considerable number of faults on the Mk IV so that they could be later used for "subsidiary services", principally as supply tanks to save the " tremendous labour of carting thousands of sprocket pinions about the country." [48]

He wrote to Gore Anley again at the end of May. This time Elles asked for the "export" of Mk IVs to be discontinued " until they can be sent out in the minimum condition for fighting." He expressed the wish that they be sent instead to the training camp at Wool where he asked that crews be instructed further on the differences

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[46] WO 158 / 826 (General Capper's memo), also *M of M.*, Vol XII,Ch III, Pt IV, p 53.

[47] Refer to chapter one and "The removal of Albert Stern".

[48] WO 158 / 814.

involved in the "pressure system of petrol feed". Here Elles was referring to the introduction of the "Auto-vac" petrol feed system which was fitted for the first time to the new Mk IV, replacing the gravity feed system employed on the previous models. The coversion to the new system was crucial, as was the training of the crews on its operation. Without this he said " I cannot cope out here".

This letter highlights the problems of inspection and design in regard to efficient functioning of the petrol feed system. It also, very clearly, demonstrates the isolation of France from immediate influence in areas of output, design, production and inspection. As suggested in chapter one the creation of the War Office Tank Committee was intended to alleviate this situation by bringing together producer and user. However, as stated above, the Tank Committee never succeeded in arranging an amicable and productive meeting of the various bodies.

Of the 1,400 tanks ordered for the 1917 programme, 769 had been delivered by the end of September. It was decided that no more than 800 in all would be needed for France.[49] The delivery of these machines makes a nonsense of Stern's explanation for the original expansion of the Mk IV order. He maintained that it was only by increasing the size of the order that there were sufficient tanks in France to equip Elles' forces for the Battle of Cambrai. There were between 380 and 450 tanks used in this battle, only half of the machines in France a month earlier. A further 150 would be accepted for training in England and for demands from other theatres. Of the remainder, 216 would be converted for use as tender and supply tanks. The contracts for the remaining 234 were cancelled.[50]

On 11January 1918 Tennyson d'Eyncourt, (third meeting of the "New " Tank Committee) stated that it would be " a very serious matter indeed if an enquiry happened to be held and it came out that we were using labour and material in producing poor machines which we did not want." [51] He was talking here of the Medium 'A' tank, but he could just as well have been referring to the Mk IV. The Medium tanks had not proved a great success . Admiral Moore thought that the Medium 'A' would be best employed in "hauling up field guns", and that he had witnessed this being done during trials" over ground in which a team of horses would have been bogged." [52] Did this constitute fit and proper use of labour and materials for

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[49] Ibid.

[50] *M of M.*, Vol XII, Ch III, Pt IV, p 55.

[51] WO 158 / 814 contains Elles's discussion on alternative uses for the Mk IV. Of the 1, 400 laid down only 1, 015 were produced. Foster's records (Rigby, Vol II, Lincoln Archives) and The Lincoln Tank Group, *Tank Papers* .

[52] WO 158 / 859.

tank production ? The answer must be no. Especially given that the production of tractors was being planned to fulfil this particular role at a considerably lower cost. [53] It could only really have been justified as a means of maintaining badly needed continuity. The Medium 'B' (which was a very unsuccessful model of which only 45 were ever built) was to be continued until the new Medium 'C' could be produced.

The Mk IV was superseded by the Mk V which went into production at the end of January 1918. However, in order to ease a shortfall in Mk V production under the 1917-18 programme, as outlined above, it was suggested that Mk IVs might be adapted to take their place. It was anticipated that some 200 might be altered to receive the new Ricardo 150. h.p., 6 cylinder engine and the epicyclic gear [54] destined for the new Mk V.

A discussion at the third "New" Tank Committee on the tests conducted at Dollis Hill testing ground revealed that the Mk IV's would have to be fitted with "tadpole" tails in order that they might be able to cross the wider German trenches being encountered. It was estimated that some ten machines could be converted per week at Fosters.

Attention now focused on the Mk V. Its new engines and epicyclic gears afforded a considerable increase in speed and manoeuvrability over the Mk IV. It was also fitted with a turret, increasing the observer's visibility. Perhaps the chief improvement came with the adoption of the epicyclic gears. Previously the driver worked with two gearsmen and a third man required to operating the brakes. With the new arrangement it took only one man to operate gears and brakes. But once more the pressure of technical change was felt. The order for 800 Mk V was not to be expanded before June1918 in the expectation that by this time a new, improved model would be awaiting production.

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[53] Produced by the Agricultural Machinery Branch of the Ministry, (Group"W", same group as Mechanical Warfare), under H.C.B. Underdown. Percival Perry, Deputy-Controller MWD, from March, 1918, was one of the chief motivators behind this project.

The new tractor was intended to replace supply tanks. It would use caterpillar tracks and commercially available engines and transmissions avoiding the necessity of costly specialised plant and competition with tanks. However, production came too late for the war. Yet, the point is still valid since Fosters had been manufacturing large tractors (the basis for the "Big Wheeled" machines) for the Army to tow artillery since 1914 (Lincoln Tank Papers et al).

[54] See chapter 4 for more on Ricardo engines. It is perhaps worth mentioning that Wilson's epycyclic gear would have been ready for introduction to the Mk IV had Stern not insisted on holding a competitive trials at Oldbury on 3 March 1917, in which Wilson's creation out-performed all its rivals. But had Stern adopted Wilson's gearing without a trial and it had been found wanting he might have delayed the tank programme even further. It will remain one of those interesting points of discussion. See David Fletcher's, *Landships, British Tanks in the First World War*, pp. 22-23.

"Tadpole Tails" were yet another creation to emerge form Fosters, They consisted of adding nine foot extensions to the tails of Mk IV and Mk V in order to improve ground contact thereby improving trench spanning ability. However, they were not successful and were phased out *in* preference for the Mk V* .

The MkVIII

The Mk VIII was the first supertank. Larger and more powerful than previous models it carried the hopes and expectations of a great many. Had the war continued into 1919 either it or the Mk X would conceivably have comprised the fleet of heavy tanks J .F. C. Fuller envisaged in his " Plan 1919". [55]

At the sixth meeting of the "new" Tank Committee on 14 April 1918 the future production of the Mk VIII was discussed.[56] With the relaxation of restrictions on the manufacture of tanks at locomotive works, it was decided to base the initial production and trials of the first machines at the North British Locomotive Works, Glasgow. However, orders were placed with a wide variety of firms for the erection of both complete machines and hulls. The laying down of plant was begun during the early part of the year with the hope that production of the first machines would begin in August. This was an act of either supreme confidence or desperation by the MWD since the Mk VIII, unlike the Mk V, V* or V**, was a complete departure from previous models, with many unique features.

The Mk VIII posed problems from the start. Such a large tank required a very powerful engine. It was decided to use a new Ricardo engine of 300 h.p.[57] However, this entirely new engine was still undergoing trials on the test bed; it was not at all clear whether it would be ready in time for the first machines. Other problems came thick and fast. Included in the minutes of the above meeting was a letter from France which was very critical of a decision taken at the meeting regarding the number of gears that the Mk VIII would have. The Tank Corps irritation was roused by the phrase " if found necessary". It suggested some back-tracking on decisions taken at an earlier meeting by the Committee and the MWD regarding the number of gears. The Tank Corps believed that it had been agreed upon by all concerned that the Mk VIII would have four gears. The Corps was of the opinion that four gears were absolutely vital if the tank was to perform to the best of its ability. However, production problems led the authorities in England to propose a reduction in the number of gears to two, with a proviso that "if found necessary" [58] they would be increased to four. To wait, they argued, for the four-

[55] "Plan 1919" was, of course, the product of several young tank pioneers at the Tank Corps H.Q, and not wholly the work of Fuller. The plan called for a massed tank offensive combining medium and heavy machines with mechanised infantry. See chapter 10 for more on plans for 1919.

[56] WO 158 / 859 and 867.

[57] See Steel section below for a discussion on difficulties encountered with the 300 hp engine.

[58] WO 158 / 867.

gear mechanism to be perfected would entail a considerable delay in production. The first 700 - 1, 000 machines, they said, would have to be of the two-gear variety.

The whole debate became rather academic when some three weeks later, on 5 September, the first reports came back to the recently-created Tank Board on the first trials of the first Mk VIII prototype. Maclean, having witnessed the trials at first hand, had to report that "the heavy weight of the Tank and the larger area of contact with the ground had apparently set up an entirely new set of conditions. The track was very badly fouling at various points and probably 30 per cent of the power was being used in over coming track friction." The situation was to get worse. He had to report that the gearbox was " unsatisfactory even with the 100 h.p. engine instead of the 300 " [which still was not ready]". The armour plate", he continued," was on new lines which renders the old gigs [perhaps jigs ?] practically useless". He finally concluded a dismal report with the statement that there was no guarantee that the new 300 hp engine " would prove satisfactory". [59]

In light of the disappointing test results it was suggested that perhaps the Light to Heavy ratio [60] of tanks produced, hitherto always in favour of the latter, might be shifted to favour the former. It was further suggested that since the new Med 'C' "Hornet" [61] tank was, in reality, only slightly lighter than the current Heavy machine, the Mk V, it would be no great loss, and would alleviate the Mk.VIII problems until such time as they could be corrected. However, Maclean had more bad news. He had to inform the Board that the new gear box for the Med 'C' was unsatisfactory, and would have to be redesigned. Two weeks later he was able to inform the Board that the new gear box was on the test bed. However, even if successful, it would be January 1919 before it could go into production. In the light of the failure of the Mk VIII it was decided to continue production of the Mk V* and V**.

A report dated 10 September 1918, just five days after Maclean informed the Tank Board of the disappointing test results, reveals the Board's decision to continue with the development of the " two" Mk VIII "sample" tanks until the machine was completely successful with the 300 hp Ricardo engine. It was also decided to continue building up stocks of material for the Mk VIII until plant for the Medium 'C' had been laid, and it was ready for production. At this point Mk VIII material was to be transfered to Chateauroux for the inter-allied programme. "It is believed", the Board

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[59] Ibid.

[60] In order to avoid any possible misunderstanding all tanks including and after the Mk IV were designate either heavy or light . The latter class comprising the medium machines.

[61] The Medium 'C' "Hornet" came into production at the very end of the war. Figures vary as to how many were produced. Its design was influenced , more than any previous tank, by the Tank Corps, and was rated as potentially one of the best machines to emerge from the war.

said (why were they not sure of this ? This is particularly important in the light of Stern's comment below regarding tracks), " that 80 per cent of these components will be suitable for this programme." [62] It transpired that only seven Mk VIIIs ever came off the production line at the North British Locomotive Works, six of these after the Armistice. The United States government was eventually to build 100 machines after the war.

At the meeting of the Tank Board when Maclean announced the results of the test, Stern said that the inter-allied version of the Mk VIII used different track links from the British version, so he did not think that it would be susceptible to the same difficulties revealed by the Glasgow trials. This is interesting because it immediately raises the question as to why were the two tanks using different track systems ? Both tanks, the United States "Liberty" [63] and the Mk VIII, were supposed to be compatible. And if the inter-allied model's tracks, supplied by the United States, were superior, why then were they not used on the British version ? The lack of co-operation and communication between departments, even in the same Munitions Group, was truly remarkable. Of course, the faulty track system represented only one of several major obstacles to successful production.

In chapter one it was stated that Stern was appointed Commissioner of the MW(O&A)D in joint charge of the inter-allied tank production programme, with Major J.A. Drain representating of United States Army.[64] On 4 December 1917 the Mk VIII was chosen as the model to be produced with details of design left in the hands of the joint Anglo-American Committee, with the proviso that any alteration

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[62] WO 158 / 867.

[63] So called because it was to be powered by the modified US Liberty aircraft engine. It was noted in the minutes of ninth Tank Board meeting (10 October 1918) that members were not only concerned about the regular and prompt delivery of this engine from the US, but also over whether the provision of aviation fuel 1919 might pose logistical problems. (MUN 4 / 6400).

[64] The factory at Chateauroux was intended to have sufficient capacity to produce some 300 complete tanks per month, with an option to expand to 1, 200 machines per month.

It was initially decided to produce 1, 500 tanks in 1918. The United States was to provide the engines complete with starter, clutch, fan and piping, silencer, electric lighting, dynamo, battery, propeller shaft, the complete transmission, including the main gear box, brakes, roller sprockets, gear shifting and brake control, track links and pins, rear track sprockets, hub and shafts, front idler hub and shafts, track roller, track spindles and bushings. Britain agreed to provide the armour plate, hulls, track shoes and rollers, guns, machine guns and mountings, ammunition racks and ammunition.

Unskilled labour for the erection of the factory was to be provided by Britain. The responsibility for the provision of skilled labour for both the factory and for the construction of the tanks was to rest jointly with both governments and priority was to be given to allow construction to proceed in the " most expeditious manner". The machines provided were to be divided amongst the two governments and the French authorities, the first 600 going to the United States Army.

The cost of the programme, including that of construction of the factory and of materials for the production of the tanks, was to be met jointly by the two governments. The value set on each tank was to be £5, 000. The United States government agreed to replace the armour plate used by the British with ship plates on the basis of ton per ton. MUN 4 / 2801.

affecting general design had to be approved by the Tank Committee. In the end the agreement came to nothing. The factory at Chateauroux did not begin production before the Armistice.

The manufacture of tanks was always about more than just the production of complete machines. To reiterate Swinton's point made above, continuity was also dependent upon the manufacure of " various small parts". Some component parts were common to a succession of models. However, not all parts were interchangable. Given the rapid evolution of models the decision as to when to end the production run of a certain part and begin the production of a new component, bearing in mind that skilled labour and machining facilities were in short supply, was a very delicate task. The production of spare parts was therefore hugely significant for the maintenance of machines in the field, and continuity of production at home. The production of spares, as will be discussed later, was a cause of much frustration between the producers and the users.

Despite what at times seemed like chaos characterised by muddled communication and misunderstanding between and within the civil and Army bodies, it is clear that all concerned had but one goal in mind, namely the production of large numbers of the most effective fighting tanks possible. But how best to go about it ? The conflict between the best machine available and its production in significant numbers remained a problem which was still not entirely resolved by the Armistice. However, relations between the MWD and the War Office grew steadily better from the end of 1917, and by mid-1918 an efficient structure for the ordering and production of tanks, with input into design from both producer and user, was established and focused in the Tank Board. One has only to examine the extent to which the Mk I -V** models evolved from one to another to see that both sides, civil and Army, recognised the need for continuity combined with technological advancement. Moreover, the number of new models, the Mk VIII, Mk X and Mk VI to name but three, indicated that both sides were willing to support further development in new and untried machines.

[3]

Production &Manpower

When the War Office placed an order for 1, 000 machines after the "success" of 15 September, it signalled the beginning of mass tank production in its full sense. Unfortunately for the MWSD the beginning of mass production coincided with the imposition of more active government control over the supply of labour in general, and skilled labour in particular. At this stage of its development the tank faced the twin obstacles of not only obtaining an adequate supply of skilled labour against stiff competition, but in retaining it in the face of ever shifting production priority ratings, and the need for more men for the Army - a problem with which it would struggle until the end of the war. This situation was further complicated by the fact that the tank, because it did not enter mass production until late1916, had arrived too late on the scene to stake its claim to materials and men and had, therefore, to compete with the traditional and more firmly rooted demands of the established arms (see table 6).

Background

The need for regulation of the labour supply had been apparent for some time. By the autumn of 1916 a means of controlling the distribution of the nation's finite labour force could wait no longer. As a result the Man Power Distribution Board (MP DB) was created on 22 August 1916. Austen Chamberlain accepted the position of Chairman and Lord Midleton that of Vice-Chairman. The board, which was finalised one month later, comprised : Arthur Balfour, George Barnes, Stephen Walsh.[1] Its brief was to act as a court of appeal to which the services and departments could put their individual cases for labour requirements. Beyond this it was decided that at this early stage it was best to let experience define the exact role of the board, and where it was most needed. The creation of the board was not greeted with unanimous enthusiasm. Edwin Montagu and his deputy at the Ministry of Munitions, Dr. Addison, were far

[1] Keith Grieves, *The Politics of Manpower, 1914-18*, p 40.

from certain that yet another body was needed. They suspected that it could only harm arrangements concluded with the trade unions in early 1915.[1] Particular care had been taken in choosing the members of the board, yet the balance between those who took a strong and supportive stance on military recruitment, and those who placed more emphasis on the importance of maintaining the labour supply for munitions industries at home, was a difficult one to achieve. The board, and indeed its successors, the Department and later Ministry of National Service, succumbed, albeit to different extents, to internecine wrangling between the major departments and services, each with a vested interest in influencing the division of the national labour reserve.

The MPDB was succeeded by the National Service Department in January 1917. However, early hopes that this body would be able to inject a sense of patriotic urgency and much needed central control over the labour issue proved ill-founded. Poor organisation, uncertain status vis-a-vis other departments, and a lack of support from the those bodies and departments with a vested interest in labour supply, once it was discovered that they could not unduly influence the distribution process, led to Neville Chamberlain's resignation as Director-General in August.[2]

The new Ministry of National Service under Sir Auckland Geddes came into being in September. In conjunction with the National Labour Priority Committee and the War Cabinet, it was to decide on all matters relating to the distribution of labour.[3] It differed significantly from its predecessors in that it had the task of providing men for the Army, whereas previously the Army had control of its own recruitment. It decided on matters such as the physical fitness of potential recruits and their substitution (with male or female workers). The end of 1917, therefore, marked a watershed in civil-military relations and signalled that the government would no longer automatically sanction the replacement of troops lost on the Western Front.

Within the Ministry of Munitions itself control over the distribution of labour rested in the hands of the Labour Supply Department. Before Churchill created the Munitions Council the Labour Department consisted of two main divisions : labour relations and labour priority and supply. Under the Munitions Council arrangement labour was controlled by Group "L" ("L" stood for Labour), under Council member Sir Stephenson Kent, comprising : Labour Regulation, Labour Advisor's Department, Labour Supply (Civil) and Labour Supply (Military).[4] The Department was free to decide the distribution of its own mobile labour force subject to national priority.

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[1] Ibid, Vol IV, Pt I, Ch I, p 4 .

[2] Grieves,*Politics of Manpower* , p 119.

[3] *M of M.* , Vol VI, Pt I, Ch I, p 18.

[4] *M of M.*, Vol II, Appendix V, pp 246-7.

Having very briefly outlined the organisational framework governing labour distribution we can now address the issue of the supply of labour for tank manufacture and maintenance. Manpower for the maintenance and operation of machines in France will be discussed along-side manufacture since deficiencies in production and a shortage of manpower in Britain led the Heavy Branch (later the Tank Corps) workshops and tank crews into *ad hoc* arrangements for the maintenance and repair of machines, and even into the production and alteration of spare parts in the field. For this reason, given the growing interchangability of much of the manpower involved with tanks, whether in terms of manufacture or operational employment, it would be artificial to separate the two.

Confusing signals

Beyond a few isolated examples it is difficult to determine, with any real accuracy, the effect that the struggle for labour had on the tank production programme. In relation to other much larger areas of munitions manufacture tank construction employed only a small number of workers, and in many instances tanks were built in workshops which sat along side, and were very often dwarfed by, much larger engineering projects (see table 6).[1] On the Clyde two of the largest manufacturers of tanks and, more importantly, tank components were North British Locomotive and Wm. Beardmore. The former only entered tank production in 1918 and was chiefly employed, as its name would suggest, in the production of locomotives and rolling stock. Beardmore on the other hand played a vital role in tank component manufacture, but this activity was overshadowed by the firm's much greater role in naval construction. The higher priority given to naval construction and, in particular orders for destroyers and submarines in early 1917, coupled with a shortage of riveters meant that Beardmore abandoned tank construction in favour of new Admiralty orders.[2]

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[1] Whilst it is inevitable that tanks should loom large in our thoughts, it is essential that we are able to see them in the context of their relative importance, particularly in regard to labour. By examining the figures given in Table 6 it can be seen that of the total labour force employed in the production of tanks and its three main rivals in January (viewed in terms of the rivalry for priority status in 1918), only 5.2 per cent of the available labour force was involved in tank production. Compared to the other "new" weapon (aircraft) 92 .6 per cent of labour available for both was deployed in aircraft and aircraft component production.

By September each of the four competitors had received a percentage increase in their labour allocation. Aeronautics enjoyed the largest increase of 15.6 per cent. Tanks received 12.8 percent, mechanical transport a much smaller increase of 4.9 per cent and rail the smallest of all at 2.2 per cent. Whilst these figures may be taken to reflect the growing importance of the tank as the year progressed, it must still be remembered that although rail transport, the next smallest competitor, was granted such a relatively small increase it could still command a workforce 32 per cent larger than that allocated to tank production.

[2] Beardmore News , 14 May, 1919.

On 10 March 1917 the Ministry of Munitions held a meeting to discuss the labour situation regarding tanks. The minutes reveal that the skilled labour shortage was acute." The most important section of labour engaged on tanks is the labour on the engines, and in this respect tanks compete with aircraft. It is admitted that aircraft need priority over tanks, and that there is a shortage of skilled labour." On the same day a copy of a letter from the Secretary of the War Cabinet was forwarded to Stephenson Kent by Stephen Leake, DMRS. It noted that both Haig and the DCIGS recognised that " the supply of labour , materials and engines required for Tanks would be given the highest possible priority, but the urgency for the need of other munitions - aeroplanes, railway materials, mechanical transport, etc. - rendered it impossible for Tanks to continue to receive absolute priority" - tanks had been in receipt of absolute first class priority since 20 November 1916. [1] This gives some indication of the extent of the confusion surrounding labour supply for tank production. The subtleties of the balance between the rival arms proposed by the War Office, although well meaning, were, almost inevitably, blurred by the realities of practical application .

Working in the dark

Until September, 1916 the secret nature of the whole programme often resulted in the men working in tank manufacture coming under considerable social pressure to" join up" since they were not thought to be engaged in work valuable to the war effort. The effect on their morale is not hard to judge.[2] While this particular problem ceased to exist by the winter of 1916 other problems associated with the experimental nature of much of the work involved in tank production lived on. With its stop-go nature and subsequent dislocation of production men were often left standing idle while machinery for new models was installed or production lines were disrupted as parts were redesigned. This often resulted in a drift of labour, as men sought more regular and officially recognised work, and in some instances led firms to eschew all tank work.[3]

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[1] MUN 4 / 2791.

[2] In late 1915 the War Badge Department refused to grant men working on tank erection at Fosters exemption badges, rendering them liable to call-up for military service. The day was saved apparently by Albert Stern :

"Foster's work men were leaving the firm. It had frequently applied to the government for war badges for them, but had never been able to get them owing to the secrecy of the work on which the men were employed, their comrades thought that they were not doing war work. I found it impossible to obtain war badges, until at last I went to the offices of the War Badge Department in Abingdon Street and threatened to take them by force with the aid of Squad 20. Thereupon a sack of badges was delivered."

[3] Admiral Moore highlighted just such a situation when, in a letter to the DMRS on 29 October, 1917, regarding production of the Medium 'B' tank, he wrote:

This was always a problem for tank production since the tank drew on so many diverse areas for its construction : steel plate, armour plate, mechanical engineering for its engines and tracks, both small calibre artillery, much of which was still in the early stages of development, and machine guns.

In a statement prepared with the collaboration of Sir E. d'Eyncourt, J.B. Maclean argued as late as August 1918 [1] that the falling supply of labour was the direct responsibility of the department itself for failing to take "proper steps" in maintaining material stocks. "Without material", he said," the men are either paid off or leave immediately." Perhaps this is a little harsh since it takes no account of the continuity problems posed by the unreliability of the machines themselves, but it does at least suggest that the difficulties were not all on one side. This to say, it was not entirely the fault of the contractors, nor indeed the workmen, when tank production did not flow as smoothly as some would have hoped.

Labour shortages and the problem of regulation

Wests Gas Improvement Co., Leeds, wrote frequently to Macleanin 1918 urging that action be taken over their shortage of skilled labour. On 22 October they stated that " unless the necessary men are released from the Colours, progress of work [the construction of Mk VIII hulls] will be very seriously handicapped." Further, on 10 October Mather & Platt Ltd., who had been contracted to produce Medium 'C' tank gearboxes, asked the advice of Major Irving, the Ministry representative, as how best to go about securing their existing skilled men from being called up for military service.[2] This is strange given the fact that at this time all tank work had been granted first class priority status and men were being returned from the colours for tank work. But again this graphically illustrates the considerable confusion which surrounded tank manufacture, when vital materials and skilled labour were in such short supply and the means of organising them still so new.

But it was not always the fault of overly officious Ministry representatives. It would seem from an internal letter to F.G. Kellaway of the Labour Supply Department from T.M.Taylor that both Stern and some of the contractors were not above exaggerating their claims for skilled labour and submitting false reports. In his letter

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"I am assuming that the manufacturers who were in a position to accept contracts six weeks ago...have not in the meantime filled their workshops with other work." (MUN 4 / 2801).

[1] Appendix A, Maclean's report.

[2] MUN 5 / 204.

Taylor made it clear that he was upset and annoyed at some of the allegations made about his department. "You may be interested to know the facts in connection with the labour supply to the Tank Department in view of the complaint voiced by Colonel Stern at the Minister's meeting this afternoon" (27 February 1917). The MWD had apparently asked for an extra 2, 000 men and received only 200. Taylor admitted that :

> "...it is true that in October [1916] a minute was sent to us showing labour demands for something over 1, 000 men for each of the two firms[Metro and Daimler but] these demands were not existing demands for labour ; [Metro] ..expressly stated that their demand was prospective without giving any date when it would mature; the Daimler Coy spread their demand to the end of April. It is clear, therefore, that to say they have asked for 2, 000 men and have received only 200 odd is not a correct statement of the facts."

He then went on to explain in detail what he felt was a clear case of misrepresentation on the part of both firms :

> "The case of [Metro] is perhaps more serious still. They put in a prospective demand for something over 1,000 men in October. They were placed immediately on a special priority list. They had practically no demands registered at the Employment Exchange at all. Early in December we had a demand for 45 man for their Saltley Works and on 6th January we received a report that two of these vacancies had been filled, and the remaining 43 cancelled. On 19th January when a report was prepared and sent to us there were no demands for labour at the Saltley Works at all. On 5th February when we made a further enquiry the only demand existing in respect of this Company was for 28 man at the Oldbury Branch. It is clear from this that the figure of 1,000 men for [Metro] is a purely fictitious one, and that there are comparatively few actual existing vacancies in their works. When I last got out the figures of outstanding demands as requested at the local Exchange on Saturday last they showed a total demand of 48 men for Saltley and 36 for Oldbury."[1]

If there was some doubt over the extent of the skilled labour shortage at Metros in 1917, there can be little doubt that there was a real sense of crisis in early to mid 1918. On 17 April 1918 Churchill sent a telegram to Dudley Docker asking him to :

> "Explain to the them [the workforce] that during the uncertainty of battle and its intense fierceness, it is not possible for the Tank Corps to make deliveries regularly. The roads are congested, depots are moving, everyone is involved in the fight. When the lull comes there will be a general refitting and that is the moment for which we must have ready the largest possible numbers ...they [the workforce] must not be put off their efforts if tanks accumulate temporarily...let there be no misunderstanding therefore but only confidence

[1] MUN 4 / 2791.

and full steam ahead."[1]

Clearly the effects of the German offensive were causing backlogs in the delivery of new tanks to France, which was having a knock-on effect on the morale of the workforce at Metros. Dudley Docker and Hugh Reid of North British Locomotive both told the Tank Board on 20 June that tank output had declined due to the recruitment of labour from their works by the Army. [2]

At a War Cabinet meeting on 26 June Churchill "pleaded for equal treatment for all Departments" it was reported in the same Cabinet Minutes that he had received:

> "A resolution...from the Metropolitan Carriage, Wagon and Finance Company (Limited), which was the firm most responsible for turning out tanks, in which a protest was recorded against the young men being taken before suitable men had been provided to take their places. In this firm there were from 200 to 300 men involved, and the effect of taking these men would be that the output of tanks would be reduced from 50 to 15 a week."[3]

This excerpt from the minutes reveals the extent to which, by the end of June 1918, the Ministry of National Service was prepared to go to enlist all available recruits, such were the pressures resulting from the German spring offensive. After discussing at some length the detrimental effects of withdrawing men from the mining, chemical and optical instrument industries, Churchill turned his attention to the case of the tank, which he found to be "most remarkable of all" :

> " A programme was approved at a special meeting of the War Cabinet presided over in February by the Prime Minister, for the urgent construction of tanks. That programme represented what I considered to be the maximum effort we could make in this field. It is rapidly falling into arrears. Meanwhile, however, the War Office, on urgent demand of the army in the field, have demanded 400 additional tanks ...[and]...still larger increases will be required. The only thing that has been done to assist me in this matter has been to take hundreds of men from the manufacture of tanks, thus dislocating the whole of the Metropolitan works, with the result that for the sake of getting enough men to make a couple of companies of infantry, the equipment of perhaps four or five battalions of tanks will be lost." [4]

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[1] Gilbert, *Winston S. Churchill* (Vol IV, 1917-22, campanion), p 303.

[2] MUN 4 / 6400.

[3] Gilbert, *Winston S. Churchill* (Vol IV, 1917-22, campanion), p 334.

[4] Ibid, p 343.

The War Cabinet Minutes of 19 July 1918 recorded that Churchill was still struggling in the face of the continued demand for more men from the Ministry :

> "The Minister of Munitions said that it was really impossible for him to release more men from his Department, except slowly by dilution. ...he mentioned that at the present time the output of aeroplane engines was approximately 55 per cent of the programme arrange [sic], and the out-put of tanks had fallen by one-half." [1]

The MWD was not, it should be said, being singled out for unilateral treatment ; it was not being victimised. The aircraft industry also suffered the loss of vital men which saw its output figures drop in line with those of mechanical warfare, that is by some 50 per cent.

In late 1918 in response to the continued departmental and service rivalry the Joint Priority Board was appointed to act as a common service department for all government departments. But rivalry persisted. Five out of every six persons employed in the munitions industry were engaged in work for the Ministry of Munitions; but the Admiralty had absolute labour priority, and owing to a huge merchant ship building programme constantly demanded more. For example between March and November of 1917 the Ministry released 53, 000 general service men, compared to just 700 released by the Admiralty.[2] It must be remembered, of course, that these figures reflected the vital importance of the ship building programme in response to the German submarine campaign of 1917.

The problem of a shortage of skilled labour was not confined to the shop-floor. It was also acutely felt at the organisational end of production, i.e. within the MWD itself. As discussed above, the inspection branch was under-manned. The total number of staff engaged in this department for 1918-19 was only 380. In relation to the employment of some 4, 000 contractors and sub-contractors this was a wholly inadequate figure. [3]

The minutes of a Tank Board meeting (31 August 1918) reveal Maclean's concern over the shortage of qualified draughtsmen in the Design Branch. Again, if we refer to chapter one we shall see that the back-log of work caused by the enormous number of alterations to drawings was another major cause of delays in production. Maclean suggested to the other members of the Tank Board that they should consider employing architects to fill these vacancies. [4]

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[1] Ibid, p 355.

[2] *M of M.*, Vol II, Pt I, Ch IV, p 82.

[3] Ibid,Vol XII, Pt III, Ch VI, p 78.

[4] MUN 4 / 6400.

It was stated at the beginning of the chapter that by 1916 the labour situation had become so critical that tough regulatory action had to be taken in order that vital munitions and indeed civilan industries did not cease to function all together, while at the same time ensuring that Army recruitment did not suffer. Whether by issuing War Badges , which clearly identified munitions workers exempt from conscription , or by taking men of only a certain age by imposing a"clean cut" [1] through out the workforce, the means of regulatory control gave rise to serious difficulties, both in terms of effective administration, and in the negative effect that such actions had on relations with the trade unions.

The failure of regulatory control to recognise the importance of tank manufacture, despite the priority given to it by the War Office, was reflected in an internal letter to Stern. On 10 March 1917 A.Griffiths described the labour supply situation as it affected the department's contractors stating that :

> " for the next 3 months, in order to reach an output of 40 machines, Mark 4, [sic] per week, ...2,150 [men of whom 1, 650 were skilled men, mostly millwrights, machine hands and fitters would be required]...[However, this]... number [is] based on the assumption that none of the men actually employed will be taken by the Military Authorities."

He went on to argue that it was extremely difficult to "give [an] accurate forecast of the total labour and type of labour required...much depends on the delivery of various machine tools, and the possibility of some firms employing women." Regarding the latter he said that a "dilution of 1 woman : 4 / 5 men may be reached shortly." The uncertainty of the whole labour situation is further revealed when Griffiths stated that it was extremely difficult to accurately estimate the number of men between the ages of 18 and 20 who are liable to be called up by the Army. Finally, echoing the state of affairs some fourteen months earlier at Fosters, he concluded his letter by saying that:

"the fact that all the men have been de-badged has had a very bad effect

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[1] Metros were losing men of "19 & 20" through the imposition of the "Clean Cut " scheme in early 1918. The scheme was first suggested by Neville Chamberlain in January 1917 in answer to the Army's announcement that its recruitment figures for 1916 were down by 305, 459 on the 470, 000 men fixed for general service by the Cabinet for the period up to April 1917. However, it was felt at the time that it would prove too great a dislocation of production and provide too few recruits to justify its introduction. It was revised in January 1918, in the hope that by imposing a "Clean Cut" of 19 and 20 year olds (figures were to vary between 18 and 23 during 1918), revising the Schedule of Protected Occupations, and a cancelling the agreement reached with the Amalgamated Society of Engineers (ASE) some 100, 000 category I men could be raised. The scheme led to friction with the trade unions who thought that it was both unnecessary and contrary to the Prime Minster's assurance to "skilled men" of 1916 : "...men who from natural ability, or training , or a combination of both, have special aptitude for particular and indispensable kinds of national work here at home) ought not to be recruited for national service". The "Clean Cut" was always difficult to implement for the reasons stated above and because the age group contained so many pivotal men without whom the munitions industry would have been particularly badly hit.

> on these men, who have come to the conclusion that, since their badges were taken away , they would sooner or later, be called up...This has resulted in slackness among the men, loss of time, etc." [1]

One of the most divisive methods of filling Army recruitment demands whilst at the same time attempting to ensure the maintenance of the nation's industrial base was through a process known as dilution. Embodied in the terms of the Munitions of War Act of 1915, it was at the root of much of the industrial discontent during the war. On the Clyde, always a hotbed of industrial discontent, workers affiliated to the Amalgamated Society of Engineers (ASE) threatened industrial action if the Ministry imposed the conditions of the act and employed women on repetitive lathe and machine work.[2] The Ministry of Munitions backed down and withdrew its recommendation. When, on Christmas Day, Lloyd George, in his capacity as Minister of Munitions, addressed a body of engineering shop stewards, in an attempt to put the case for dilution and an all-round national effort, he was met with a chorus of disapproval.[3] As a concession to the militant stand taken by the workers on the Clyde they were given a Dilution Commission (appointed in January 1916). The Commission's brief was to act as arbiter between the unions and employers. Despite early industrial action over the dilution issue in January, March and April (which included Beardmore's Parkhead steel plant where armour and bomb proof plate was produced for the early tank programme and also the pedrail shoes for the tank tracks), the commission made an impact. From one thousand conferences between unions and employers between January and April the figure fell to just forty during the following two summer months.[4]

The case of "John Cairey v Beardmore & Co. Ltd," brought before the local industrial tribunal in early 1917, is but one example of the hundreds of similar cases caused by the imposition of dilution. Since he was employed by Beardmore's at Dalmuir (where Beardmore's erected fifty tanks in early 1917) in a situation where he was doing a skilled turner's work. Cairey claimed, as a right, those conditions of work and wages enjoyed by turners. However, as the appeal transcript argues "he was only a dilutant, doing work of a class which prior to the war was customarily undertaken by a turner ", and was, therefore, not entitled to wages or conditions of employment enjoyed by time-served turners. [5]

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[1] MUN 4 / 2791.

[2] Figures do not seem to be available for the number of women working on tanks in individual firms. Table D does, however, give the total number of women working in tank manufacture during 1918.

[3] J. Cunnison and W.R. Scott, *The Industries of the Clyde Valley During the First World War*, p 144.

[4] Ibid, p 153.

[5] *Munitions of War Acts, 1915-16 : Scottish Appeal Reports 1916-20*, pp 102-8.

(NUMBERS IN THOUSANDS.)

	JANUARY.			APRIL.			JULY.			AUGUST.			SEPTEMBER.		
	Males.	Females.	Total.	Males.	Females.	Total.	Males.	Females.	Total.	Males.	Females.	Total.	Males.	Females.	Total.
Ministry of Munitions—Gun Ammunition—															
Manufacture	189·6	190·6	380·2	189·3	183·5	372·8	186·7	186·3	373·0	187·6	185·2	372·8	189·6	186·1	375·7
Filling	28·5	63·3	91·8	27·8	55·8	83·6	29·7	66·7	96·4	30·1	68·8	98·9	30·0	69·6	99·6
Total	218·1	253·9	472·0	217·1	239·3	456·4	216·4	253·0	469·4	217·7	254·0	471·7	219·6	255·7	475·3
Ordnance	69·0	19·4	88·4	68·4	18·2	86·6	67·6	19·6	87·2	66·8	19·4	86·2	67·3	19·0	86·3
Rifles, Machine Guns, etc. ..	32·4	8·4	40·8	32·4	9·0	41·4	32·7	9·1	41·8	32·5	9·5	42·0	33·9	10·0	43·9
S.A.A.	16·7	27·5	44·2	15·9	27·5	43·4	15·5	31·9	47·4	15·3	30·7	46·0	15·2	31·1	46·3
Trench Warfare (other than chemical substances) ..	22·8	24·5	47·3	22·6	24·7	47·3	21·6	22·7	44·3	21·5	22·4	43·9	21·7	23·4	45·1
Explosives and Chemicals ..	92·9	44·9	137·8	82·6	38·0	120·6	77·9	36·2	114·1	78·7	36·4	115·1	79·3	37·3	116·6
Aeronautical Supplies	122·3	52·3	174·6	125·5	58·2	183·7	129·8	63·8	193·6	131·4	64·2	195·6	134·9	67·1	202·0
Mechanical Warfare	11·2	2·8	14·0	12·3	3·3	15·6	11·9	3·8	15·7	11·6	3·9	15·5	11·7	4·1	15·8
Railway Materials	19·9	2·9	22·8	19·5	2·8	22·3	19·4	3·1	22·5	19·5	3·4	22·9	19·7	3·6	23·3
Optical Munitions and Glass ..	6·0	3·0	9·0	6·1	3·4	9·5	6·2	4·0	10·2	6·3	4·1	10·4	6·4	4·3	10·7
Mechanical Transport	41·2	17·0	58·2	41·5	18·3	59·8	41·2	18·9	60·1	41·3	19·1	60·4	41·5	19·6	61·1
Iron and Steel	188·5	26·4	214·9	189·5	28·1	217·6	186·2	31·2	217·4	186·2	31·6	217·8	187·1	32·4	219·5
Non-Ferrous Metals	35·6	8·3	43·9	34·8	9·5	44·3	34·3	10·5	44·8	34·3	10·5	44·8	34·4	10·9	45·3
Constructional Engineering, etc.	81·3	25·4	106·7	82·0	25·5	107·5	80·4	27·3	107·7	80·4	27·4	107·8	82·3	28·3	110·6
Gauges, Tools, Screws, etc. ..	34·5	19·4	53·9	34·9	20·4	55·3	34·1	21·8	55·9	33·8	22·0	55·8	34·4	22·8	57·2
Machine Tools	22·8	6·2	29·0	21·6	6·3	27·9	20·3	6·6	26·9	20·7	6·7	27·4	20·8	6·7	27·5
Inspection	17·5	41·1	58·6	17·0	40·0	57·0	17·0	40·7	57·7	17·1	39·8	56·9	17·1	39·9	57·0
Total, Ministry of Munitions	1,032·7	583·4	1,616·1	1,023·7	572·5	1,596·2	1,012·5	604·2	1,616·7	1,015·1	605·1	1,620·2	1,027·3	616·2	1,643·5
Admiralty	746·6	102·6	849·2	766·5	105·9	872·4	764·4	113·5	877·9	766·9	115·0	881·9	772·7	117·5	890·2
War Office, Miscellaneous ..	96·2	56·6	152·8	95·6	58·7	154·3	93·6	60·4	154·0	92·4	60·0	152·4	93·8	61·7	155·5
Other British Government work	122·2	35·8	158·0	122·0	36·5	158·5	120·1	38·4	158·5	119·7	38·4	158·1	121·2	38·9	160·1
Allies	37·9	5·5	42·5	36·7	5·5	42·2	36·1	5·7	41·8	36·1	5·8	41·9	36·3	5·9	42·2
Grand Total ..	2,034·7	783·9	2,818·6	2,044·5	779·1	2,823·6	2,026·7	822·2	2,848·9	2,030·2	824·3	2,854·5	2,051·3	840·2	2,891·5

The figures for each month refer approximately to the end of the month.

All the main industrial centres in England were sorely troubled by the same militancy. Engineering works in Birmingham, Coventry, Sheffield, Leeds and Manchester amongst others were affected. From the point of view of tank manufacture these centres were central to the whole national programme, as was the Clyde. The direct results of industrial action on the output of tanks is difficult to assess. The DMRS wrote to Stern on 8 May 1917 informing the MWD that they (the DMRS) in turn had been informed by their inspectors that as a result of the industrial action in Sheffield and Manchester "output from [those] districts will be very seriously interfered with and the delivery of tanks delayed." [1]

The confusion continued into late 1918. On 26 September Crossley Brothers wrote to Maclean complaining of the" overly stringent labour embargo" that had been placed on them by the Dilution Department of the Ministry of Munitions. Essentially this prevented them from freely engaging skilled labour (the Dilution Department issued them with a licence which acted as a quota) until they had " diluted" their workforce to a prescribed level. Crossleys had an order for 2, 100 150 hp tanks engines and claimed that the trade union representative at the plant refused to let dilution take place until the embargo had been lifted. A.C. Buckmaster, the North West area superintendent engineer, told Maclean that in his opinion that Crossley's problems were "almost entirely [due] to the [company's] extremely poor internal organisation." On 9 October, after another investigation by a representative of the Dilution Department, Crossleys once more wrote to Maclean informing him of their willingness to co-operate with the dilution plans laid down by the department . But "even with the embargo lifted," they wrote :

> " it would naturally take some time ...before dilution can be carried out...Serious delays have already been caused...at the present time there is considerable inconvenience caused by the necessity of having to apply to the local Ministry for licence to engage skilled men. The fact that we have agreed to carry out dilution as early as possible, and that our works are open to continual inspection, in this respect is sufficient to safeguard the Ministry's views." [2]

This was followed with what seems like a barely veiled threat to take the matter to a higher authority if the embargo was not immediately lifted, " but if not we shall have to put the matter forward as a separate report ". This letter clearly reveals the friction between contractor and Ministry over this subject - not an uncommon cause of complaint. Nevertheless, the embargo against Crossleys was lifted on 10 October. The delicate balancing act, meeting the demands of both Army and industry, was to prove a

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[1] MUN 4 / 2791.

[2] MUN 5 / 204.

constant trial to the authorities. But it was not only in the workshops of Britain that the labour shortage was felt.

France

By the winter of 1916-17 it was becoming clear to all involved that it was impossible to have the nation's skilled mechanics both in the field and in munitions at home. The answer, as far as maintenance and routine repair was concerned, was to increase the level of technical training given to the tank crews. Yet, these crews were drawn from an ever more divergent variety of backgrounds, the great majority of them non-technical. However, such was the need for extra crews that training periods were as short and intense as possible. This inevitably led to a decline in standards.

Brigadier P.C.S. Hobart said that the "material to be trained consisted of batches of men sent down from the fighting line from all regiments very few of whom had any mechanical experience...By the time of Cambrai", he said," there were four veteran Bns, each a year old, and two more who had fought during 3rd Ypres, the remaining were as yet untried." [1] However, Captain D.M.F. Sheyer, 6th Battalion, had only praise for those who crewed his tanks, "the mechanical ability of the average tank crew was remarkable. There were some really very fine feats of salvage and maintenance done by these people." [2]

Donald G. Denison, a tank crew member in the 10th Battalion, was transferred from the Artillery to the Tank Corps in mid-1917. " What a change from horses to motor engines. None of us had any experience in motor vehicles. Talk about a Jack of all Trades, this was it." This must have been a fairly typical reaction to what was for the majority an entirely novel experience. It is also probably fair to say that Denison's description of the training course was also fairly typical :

> " What they expected us to learn in 6 months training was unreasonable. We was [sic] expected to know everything about the 105 h.p. Daimler engine, all 8 positions [tank crews jobs were expected to be inter-changeable unlike the specialised training given at the beginning of the war] and duties on the tank. All repair work including broken Caterpillers Tracks [sic], naval Gunnery [sic], which included a week at sea [because tanks pitched and rolled like a ship], all types of machine gun, revolver firing, signalling, pigeon flying, driving, etc., etc. All very interesting work, [but] the big drawback to it all, was the food,

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[1] Brigadier P.C.S. Hobart, " Cambrai : The Complete Narrative", The Tank Museum, p 1.

[2] Captain D.M.F. Sheyer, "War Experiences" , The Tank Museum.

hungry every day." [1]

As a pharmacist in civilian life J.E. Mossman naturally enlisted in the Royal Army Medical Corps when he joined up in 1915. However, by late 1916 he, in his own words, " got fed up with the R.A.M.C.", and so applied for a transfer to the Heavy Branch", which his friend, who went with him, had said," sounded a long way back...We were," he said, " a rag-tail lot drawn from every regiment of the British Army." [2]

The learning curve was as steep for the workshop personnel as it was for the tank crews. Major E.R. Parsons, who in September 1916 was a lieutenant and in command of a tank in 'D' Company was, by November of that same year, second in command of the 'B' Battalion workshop company. He recalled how in November, after the re-organisation of the Heavy Section, he was posted back to the Tank Corps Central Workshops at Erin as a workshop officer where :

> "I spent a few weeks taking tails off the tanks and fitting sponsons, and teaching new officers the rudiments of driving, the mechanical construction , jacking up, etc. Towards the end of the month I had the job of bringing a few dud [sic] tanks form Wavrans to Piedmont.
>
> This experience was invaluable to me and I might say that up to December I knew nothing of a tank, but by the end of that month I thought I knew everything, so much had I gained by teaching others what little I knew and then having the practical job of moving those dud tanks... ." [3]

This experience, together with several small classes on sprockets, rollers, radiators and the Daimler engine, were all that were deemed necessary for Lieutenant Parsons to take up his position at 'B' Battalion workshops.

At the end of January 1917 he and three other officers were returned to Bovington Training Camp, England, where he was posted to the 8th Battn to help in starting workshop companies. He recounted how they started with about " 30 or 40 men, nearly all new recruits and most of the day we spent on drill and Technical Lectures and in the evenings we had squads working on the Tanks that had been used during the day for training." "This", he said :

> "was very hard and unsatisfactory work. We could never start before 6 p.m. by which time the stores were shut up and it was very difficult to get the tools and spares we wanted. ..Only one or two of the men

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[1] Donald G. Denison, "Personal Reminiscences of a Tank Crew Member", TheTank Museum.

[2] J.E. Mossman, "Tank Corps War Experiences", The Tank Museum.

[3] Major E.R. Parsons, "Personal Experiences, 1916-18", pp 1-6.

> had done any fitting before. In fact their only claim to be called fitters was in a large number of cases, the fact that they had done two or three months repetition work in a Munitions Factory. However, some of them got on quite well and became very useful."

At the end of March, he was on the move again, this time to the Metropolitan Works at Birmingham to help with tank construction because " they were short of men." He and another officer each took half (some fifty men) of the new workshop company (8th Battn) with them. There they remained until the company left for France arriving at Le Havre on 22 August .

Parsons stated that because the battalion was "quite new and inexperienced" they were not allowed enough time for each tank commander to check and stow away all his tank's gear. As a consequence " several items were found missing or damaged " when they arrived at Blangy (base). The battalion later entrained for Wailly, where, he said, " the crews had invaluable training fitting several new engines, differentials, secondary gears, radiators, etc.". These were fitted without the aid of cranes and maintenance tools. "This", he commented," is where our men profited by their time spent at Birmingham." [1]

Parsons goes on to recount how for the remainder of 1917 the company saw action at both Ypres and Cambrai where it seems that his fitters were constantly in action fitting and re-fitting the same tanks time after time. Predictably the Salvage Companies also had problems in recruiting skilled personnel. Captain R.P. Butler, recalled that :

> "After we started the salvage of tanks we received several additions to our personnel, both of officers and of other ranks. Generally a unit was ordered to send us a certain number of men, and they naturally sent us those that they did not want. Some who came were very good, others were of little use. We asked for some fitters and they arrived in due course, but we found that they were gas fitters - experts in fitting up chandeliers , but completely ignorant of i.c. engines. We asked for ex-R.E's, thinking that in them we should find engineers accustomed to working in the field, and some were sent, but it turned out that they had been in what was called the "Special Section, R.E." - purveyors of frightfulness, who dealt with flame-throwers, poison gas and such things, and knew nothing of engineering of any sort." [2]

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[1] A possible explanation for the posting of workshop personnel to Metros can be found in the fact that the new company was not yet fully manned, and until the extra men required were available it was the best form of continued training, as Parsons later pointed out, to allow the men to participate in tank manufacture.

The seemingly never ending cycle of changing the same key components time and time again is a point to which we will return in the discussion of tactics, and of the tank's ability to inspire confidence in those who used them.

[2] Captain R.P. Butler, "Reminiscences of Salvage Work, The Royal Tank Corps Journal, June 1932, p 59.

On 23 February 1917 Butler managed to enlist the help " more or less permanently" of 25 Australians from the 29th Battalion A.I.F. " Some of them", he said," had been mechanics in civil life, and all were excellent fellows and good workers." However, Army regulations finally caught up with him and the A.I.F asked for their return after nearly six months.

The situation at the Central Workshops was no better. In January 1917 Major S.G. Brockbank took command of what was then the Central Repair Shops. It had an establishment of 13 officers and 394 other ranks. By the middle of January he had received a number of men which he said came from " 37 branches of the Service." He stated that they had " great trouble and difficulty obtaining skilled riveters." A few were drawn form other branches of the Army, but in general they had to rely on training men themselves.

Engine repair was also to prove troublesome. "In the whole of Central Works only 2 men could be found who had any knowledge of petrol engines or their repair." However, Brockbank was able to overcome this skill deficiency by retraining existing personnel with the result that a functional "Engine Shop" was soon established. A shortage of personnel was also a factor in both the Receiving, Testing and Despatching (R,T&D) and Railhead Sections of Central Stores. Created at the end of 1917, they drew men from the old battalion workshops (workshops were first allocated one to each company, then on a battalion, and finally on a brigade basis as the number of technical personnel available to the Tank Corp declined) and a limited number for the Central Workshops themselves. In late 1917 the R,T&D assumed the responsibility for fitting up new machines delivered from England. On average they spent some 90 man hours on each. It was a source of constant irritation in France that time and resources had to be spent, in effect, doing the same job twice.

Between October and December, 1917 the Central Workshops repaired for re-issue to battalions 127 machines requiring approximately 120 man hours each. This was exceeded between April and June 1918 when 104 Mk V machines were received from Bovington training centre which required an average of 200 man hours each before they were ready for issue.[1] It should be said, however, that these machines were not new and had been subjected to considerable use before they were despatched at short notice. Yet, this does not disguise the fact that fitting and repairing machines was a heavily labour intensive exercise at a time when skilled labour was at a premium. As 1917 progressed it was obvious to all concerned that the supply of technical personnel was all but exhausted. The brigading of the workshops helped free badly needed skilled men for the newly expanded Central Workshops, but still more skilled labour was

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[1] Major S.G. Brockbank, "War History of the Central Workshops", The Tank Museum, Ch II, pp 3-18.

needed. However, while there was an undoubted shortage of skilled labour, contemporary evidence would suggest that it was subject to fluctuation.

A report into the efficiency of the Tank Corps workshops in France, commissioned by General Capper and conducted by Lieut-Colonel Simpson, did not mention a shortage of skilled labour when it listed the difficulties faced by the maintenance units. One would have thought that this would have come top of his list, which included machine tools and space, if it had been seen as a problem at the time. Later in the year, on 14 November, Capper wrote a letter to Elles regarding not the under-manning but the over-manning in the Tank Corps' workshops in France. This does not suggest a continual shortage of technical personnel. Clearly manning levels fluctualted. It also suggests that occasionally double standards were applied. On 31 March 1918 Churchill had roundly condemned what he termed the "luxurious" use of manpower in the RNAS. [1] Yet Capper's letter to Elles reveals the equally "luxurious" use of manpower at the Tank Corps workshops. But the Navy and the Tank Corps were not the only services juggling their manpower requirements. The Air Council was also demanding more men claiming that they "needed" fifty men per aircraft .[2] All the services, branches and departments were attempting to out-manoeuvre one another over this issue. Finally, regarding Capper's letter to Elles, it is not difficult to imagine, given the acrimonious relations between Capper and Stern, that the gently chiding tone with which Capper admonishes Elles, would, perhaps, have been a little sharper had Stern been the culprit :

> "It has been pointed out that the establishment of officers [in Central Stores and Workshops] is very extravagant compared with those in [the] big Ordnance Shops at Havre and Boulogne and certainly ...as compared with any commercial business.
>
> As regards the Establishment of Artisans, to take one item only - Riveters -100 are put down. I find that [the] Metropolitan Works with a turn out of 15 Tanks per week only employs 30 Rivetters, but, of course, they have a great deal of good machinery. But they also have a great deal of rivetting to do, far more than could possibly be done in the shops.
>
> Similarly in the Store department, the main stores of the MWSD at Leicester which deals with a very large quantity of material and keeps all the accounts of distribution to manufacturers, etc., employ only a fraction of the numbers asked for by you.
>
> The position as regards man power being that the total requirements of the Corps are now 2, 000 above the allotted, it is all the more necessary that the utmost economy of men should be insisted upon." [3]

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[1] Gilbert,*Winston S. Churchill* (Vol IV, 1917-22, companion), p 290.

[2] Secretary of State for Air to the Prime Minister, 9 April 1918, DC96 / 17/ 57, Weir Papers, Glasgow University Archives.

[3] WO 158 / 816.

Despite these anomalies, the availability of skilled labour, was undeniably acute. It was apparent in the need constantly to revise the organisation of the workshops throughout the period 1916-18, in order to best utilise the limited pool of skilled labour. It was also evident in the perceived need to train the tank crews themselves to conduct ever more complex maintenance tasks in order to relieve the pressure on the repair workshops. A partial solution to the problem came from a somewhat unorthodox quarter, Chinese labour. The use of Chinese labour in relatively large numbers is perhaps the best indicator of the seriousness of the overall problem. Had the skilled labour situation not been dire enough to demand such a departure from the normal all "white" workforce, it is difficult to imagine that the Chinese would have been employed in any capacity other than that of manual labour. This is not intended to be racially offensive, but the degree of condescension, in Brockbank's account of the operation of Central Workshops, toward the" Coolies " is difficult to over-look.

The 51st Labour Company was the first detachment of Chinese labour to be employed at Central Workshops, arriving on 8 August 1917. It consisted of 4 officers, 12 NCO's and 200 tradesmen. On the 26th an extra 270 labourers arrived. Of the first batch of Chinese "tradesmen" many failed to meet the required minimum standard. But there were those who did show promise and steps were taken to train them. In the event, more than half of the Chinese labour allocated to mechanical warfare was detailed for other duties elsewhere in the Tanks Corps area by Labour Group HQ.

A great deal of Chinese labour was employed in late 1917 in the creation of the fascines used by the tanks at Cambrai in November. This was a considerable task. Some 220 trucks containing 21, 500 bundles of wood were unloaded at the Central Workshops. Each had to be chopped to a definite length - at one time it was reported that some sixty axes were in use simultaneously. Between 60 - 10 bundles were bound together to make one fascine. And it took 18 tanks with special fixtures made at the shops to tighten the bundles, each of which weighed approximately 1.75 tons. Just moving a finished fascine required some 15-20 Chinese labourers .

It was " very soon discovered", said Brockbank , " that the average skilled Chinaman excelled"in the engineering environment. Chinese labour was particularly suitable, he believed, for salvage work and rough fitting on manufactured articles. It was also discovered that selected individuals, if paired with skilled men, could soon produced "satisfactory" work. In the Engine Shop one"Chinaman" was given the opportunity to try " bedding in" big- end bearings. He proved so successful that others were drafted in working as mates to this first Chinese tradesman, eventually taking on the job themselves.

However, work in the tank repair section was found to be more difficult until it was decided to train a squad at one particular job, such as de-tracking, de-rollering,

dismantling and assembling sprockets and pinions. These squads when trained worked from one machine to another " and their worth became evident." Chinese labour proved particularly useful at riveting where the " four gap riveting machines" were entirely run by them. They were able to produce a monthly average of 4, 700 plates. After the move to Teneur, where six machines were in use, this figure rose to 7,480. An increase in pay to 50 centimes per day appeared by all accounts to have filled classes on pneumatic riveting. It was also decided to introduce a scheme whereby the officers of the 51st Labour Company, who had hitherto been engaged on administrative duties only, were employed, after a short period of technical training, as supervisors for individual sections of Chinese workers.

No. of skilled Chinese employed at Central Workshops (March 1918)

	No. 1Section	No. 2 Section	No. 3 Section	Salvage	Total
Fitters	35	41	16	1	93
B / Smiths	1	4	6	1	12
Riveters	27	9			36
Track breaker				18	18
Radiator fitters			14		14
Sprocket fitters			13		13
Strikers			22		22
Tinsmiths			4		4
Carpenters			33		33
Electricians			3		3
	63	54	111	20	248

Employing Chinese labour on semi-skilled jobs such as track breaking was "most profitable." It was the only source of supply to meet the extra demand for plates required by the track riveting shop who at the time were turning out 1, 200 plates a week. As a result the track riveting workshop was never held up for lack of plates. Its output for 1918 stood at some 81, 340 plates or over 900 tracks.[1]

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[1] Major S.G. Brockbank," War History of the Central Workshops" (Chinese Labour section), pp1-4. They were employed to offset a shortfall of 225 man at Central Workshops in January, 1918. The alternative would have been to reduce the number of tank crews to make the difference.

It would seem that the Tank Corps workshops, whilst not the only units to employ Chinese labour in France (both the MT and RFC did so), they were the only units to employ them in skilled positions. The RFC used them in unskilled positions under strict supervision - this did not include air frames or engines. The same can be said of the operation of the Mechanical Transport workshops.

Perhaps the answer as to why Chinese labour, albeit in limited numbers, was employed in skilled positions by the Tank Corps can be found in the fact that tanks arrived rather late on the scene in

The whole of the Central Workshop's output of repaired sprocket wheels and radiators was entirely produced by Chinese labour. Apart from a few examples in No. 2 Section, there were no mixed working sections. After the move to Teneur it was decided to allocate one entire hangar to the Chinese. In it they tackled the exact same tank repairs as the "white" repair shops. The output from this hangar was believed to have compared very favourably with the other hangars. However, it was noted that, whilst Chinese labour worked very efficiently on the Mk IV, the conversion to the Mk V led to a sharp decline in output from this hangar. In light of this they were given the job of converting Mk V male and female machines into "composite" [1] machines. A job which, it is said, they thrived on.

Chinese labour was able to fill a considerable gap in the skilled labour market for tank repair in France. However, contemporary observers suggested that they could not be relied upon to finish off machines. The fine details, odd nuts and bolts, were left off or missed, and screw drivers were poked through radiators without an understanding of the consequences.

The tide turns

Late 1917 marked something of a watershed in manpower organisation and distribution. As Keith Grieves pointed out, it was the failure of the Third Ypres and the inability to hold on to the gains made by the tanks at Cambrai that suggested to many in influential positions in Britain that the strategy of attrition long waged on the Western Front was bankrupt. Britain simply did not have the manpower reserves to continue to replace in 1918 the huge numbers of casualties experienced in 1917.[2] This came at a time when the tide of opinion was beginning to shift decisively in favour of the new technologies as a means of off-setting the critical manpower shortage. It was reflected in the growing trend toward the release of men from the colours for work in vital war munitions including tanks. It was anticipated that by allocating a greater role to mechanical warfare (which required fewer men without a reduction in offensive capability) the number of men needed by the Army could be reduced. This issue was

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regard to receiving their share of the nation's resources. In the Autumn of 1915 under the Derby recruiting campaign skilled volunteers were enticed into the RFC / RNAS by relatively high rates of pay offered in an intensive advertising campaign. This is not to suggest that the RFC (later RAF) was never short of skilled labour, just that they received a very much larger share at a much earlier date than did the Tank Corps and were therefore never in the position of having to "scrape the bottom of the barrel."

[1] Ibid, p 5. "Composite" machines were armed with one 6-pdr gun as opposed to the two on a "male" tank and none on a "female" tank.

[2] Grieves, *Politics of Manpower*, pp. 166-7.

first raised as early as 23 November 1916 by the Commander-in-Chief, Douglas Haig, during a conference at which it was decided to release some 300 men to assist in tank production.[1] However, it was not until the summer of 1918 that the Government officially sanctioned the return of men from the colours in large numbers for tank production, stampings and forgings, and blast furnace work. [2]

Evidence of just how active the discussion over the Army's future manpower needs had become by late 1917 and early 1918 can be gleaned from the continuing debate in the War Cabinet and at the SupremeWar Council, Versailles.

At a Cabinet Committee meeting, held on 10 December 1917 to discuss the BEF's manpower deficiency of 100, 000 infantry, 41, 000 artillerymen and 40, 000 men for the RFC, Lloyd George declared that it " was essential that we should do all in our power to husband our reserves...to adopt every means, consistent with active defence, for reducing our present rate of casualties." Lloyd George observed that the Germans and the French had decreased the proportion of infantrymen to guns and mechanical power in their divisions. A French Army memorandum cited in the Cabinet Committee on Manpower, dated 16 December 1917, said that :

> "...It is probable that in 1918 the increase in our armaments and of mechanical contrivances of all kinds will permit us to modify certain methods which have hitherto been in practice and which will increase our advantage." [3]

Lloyd George asked the War Office representatives whether they had considered following suit. However, as stated, Haig had first raised this issue in late 1916, but the tank's poor performance militated against a major shift to mechnical warfare. A memorandum on 28 September 1917 clearly indicated that the subject was "still in the air". It is not clear who wrote this, but given its pro-tank bias it probably came from Tank Corps :

> "The cost [it says] of a large fighting Tank is taken at £5, 000. The average cost of a Tank, including all sorts may be taken as £3, 500.

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[1] *M of M* , Vol XII, Pt III, Ch III, p 44. Also a reference to this decision can be found in MUN 4 / 2791.

[2] MUN 4 / 2801 contains several such letters concerning the return of man from the Army to tank manufacture. The figures range from 325, 173 to 152 men who seem to have been *accidentally* [italics mine] taken by the recruiting officers from their civilian occupations.

General Furse, War Office representative on the Tank Board, pointed out on September 29, that the Ministry of National service had stated that owing to the recall of tradesmen from the Army (men taken in the spring by the "Clean Cut"), "there would be no more tradesmen of any kind available for the Army". (WO 158 / 867).

[3] CAB 27 / 14.

Taking 20 per cent of the total cost as Contractor's profits. interest on capital , cost of machinery, buildings, etc., which exist and do not absorb manpower , the net cost of labour and materials will be about £2, 800.

Wages of the Mechanic and Labourer may be roughly taken as an average of £3 per week whether he is employed in the production of raw materials or the finished article. Therefore the manpower on the Tank may be taken as 2, 800 divided by 3 = approximately 933 man weeks or 216 man months.

But a certain amount of the work of production is done by women and boys, who do not count against manpower.

We may safely reduce the manpower absorbed in the production of one Tank as not more than 200 man months :-

1, 000 Tanks will absorb 200, 000 man months
8, 000 " " " 1, 600, 000 " "

Allowing for the sake of argument that an Infantry soldier can be made efficient in four months from the date of enlistment, a programme of 8, 000 Tanks will absorb no more manpower in construction than is taken in training 400, 000 Infantry soldiers." [1]

However, their were still voices which urged restraint. One could not characterise Maj-General Guy Dawnay's (General Staff) comments to the Supreme War Council as being in any way anti-tank , but they do reveal a strong hint of pragmatism (particularly understandable when it is remembered that he was speaking at a time when the Mk IV was the main battle tank and its severe limitations were recognised by all, including Elles and Fuller). He said on 26 May 1918 that "at present...its seems to me indisputable that we have not got anything like enough to go on to make it reasonable for us to go all out and gamble and put large resources in manpower and materials into the construction of Tanks on a large scale." [2]

However, by July the new and much improved heavy tank, the Mk V, had made its debut on 4 July at the battle of Hamel. The Tank Corps now had a very useful main battle tank , and one that was arriving in France in great numbers. Mechanical warfare could now begin to repay the faith and support that the Army, and Haig in particular, had shown it, not only as a means of maintaining the offensive by virtue of its improved performance as compared to its predecessor, but also by making good the increasingly urgent deficiencies in infantry numbers.

The minutes of the Supreme War Council held on 9 July discussed "Mechanical Warfare and Manpower." Lieut-Colonel Buzzard, General Staff, stated that :

" indications that in the struggle to obtain Army personnel in England the output of the Country in war products, munitions, tanks, etc., will suffer...It is reported that our tank output is being seriously affected by "combing out". If so we are proceeding on false lines. We have in America unlimited

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[1] WO 158 / 819.

[2] CAB 25 / 12.

personnel which needs to be transported and equipped." [1]

Two days later Lieut-Colonel J.W. Macardy, General Staff, addressed the Council in the same vein :

> "The more men we use, within reason, in producing coal, ships, aeroplanes, tanks, machine guns, the more we shall get from America, and the sooner we shall be able to take the offensive. If 100 [men] build 10 tanks in 3 months, 3 or 400 Americans will be sent to use them every 3 months who will otherwise stay in America next year."

On 3 September Buzzard was once more addressing the Council on this issue :

> "The fact must be emphasised that even if the Allies have sustained large losses in tanks, there has been a proportionate saving in the personnel of the Infantry, and moreover we have found no substitute for the tank. If we relinquish their employment, we must revert to more elementary methods, extensive bombardments and primitive cavalry and infantry tactics, which have hitherto proved costly and unsuccessful." [2]

But as we have seen above, despite the best intentions, there still remained an element of confusion and lack of co-ordination in regulating the labour supply. At the fifth meeting of the Tank Board on 12 September Maclean complained that the local recruiting authorities had "apparently" not yet received instructions communicating the War Cabinet's decision that no more men should be taken from tank production . He also said that they were having difficulty in getting some "200-300" men who had already been called up, and which the War Cabinet had decided should be released to tank manufacturing firms. [3] By 26 September (the seventh meeting of the Tank Board) Maclean was able to report that he had come to a satisfactory agreement with W.T.Layton (DMRS) that no men who were"wholly employed on tank work would be taken for the Army, [and] men partially so employed would only be taken after consultation with (MWD) Divisional Inspectors." Further, reflecting the growing importance of tanks, General Furse pointed out at the same meeting that the Ministry of National Service had stated that owing to the recalling from the Army of the tradesmen recruited by the clean cut in March there would be no more "tradesmen" of any kind available for the Army. This presumably meant the Tank Corps too.[4] The close

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[1] CAB 25 / 93.

[2] Ibid.

[3] WO 158 / 867.

[4] Ibid.

relationship between the manufacturing base in Britain and the maintenance and operation side of the mechanical warfare equation in France has been stressed. A very delicate balancing act had to be observed when decisions concerning the allocation of available skilled labour to one side or the other. Here manufacturing seems to have been getting the better of it. However, on 9 September Churchill wrote to Lloyd George regarding the expansion of the Tank Corps :

> " ...up to present there have only been about 18, 000 men in the Tank Corps, and they have only had 600 or 700 Tanks to use in action. It is universally admitted out here [he was writing from Chateau Verchoeq]that they have been a definite factor in changing the fortune of the field and in giving us that tactical superiority, without which the best laid schemes of strategists come to naught . No exaggeration ...these 18,000 men are the most profit bearing men we have in the Army.
>
> It has now been settled to raise the Tanks to 55,000 men. This is only about half of what we shall need for the Tanks I shall actually have ready by the summer next year [1919]." [1]

A typical piece of Churchillian optimism perhaps, but this once again demonstrates the growing emphasis placed on the importance of the tank. Of course the Tank Corps (and the Heavy Section and Brigade before it) had expanded at much the same rate and often in parallel with MWD. On 18 November 1916 the four companies which comprised the Heavy Section were first expanded to four battalions and then, with the creation of two new battalions at Wool in Dorset, they were then formed into three Brigades, each of two battalions. The experiences of the Battle of Arras in April 1917 led to the further expansion of the Heavy Branch to six brigades of three battalions each. However, because of manpower shortages this expansion was not given official approval until November 27, and not finally implemented until the summer of 1918 - owing to the manpower shortage and chaos created by the German spring offensive.[2]

On 26 September Maclean told the seventh meeting of the Tank Board that the total demand for extra labour for tank manufacture (including a demand from Dudley Docker of Metros for about "1, 000 extra men " whose release had already been approved by the War Cabinet) amounted in all to some 3, 500 men.[3] Here he was reiterating what he had earlier stated in its report of August that year, when he had told the War Office that their revised programme for 1919 could not be met with the labour then available to the manufacturers. The programme had been revised upward in May

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[1] Gilbert,*Winston S. Churchill* (Vol IV, 1917-22, companion), pp 389-90.

[2] War Office (SD7) issued with Weekly Tank Notes, "A Short History of Tanks in the Great War" , The Tank Corps Journal, 1919-21, pp 73-4.

[3] WO158 / 867.

to 6, 940 machines. He made it clear that, with an additional 3, 500 men, nearly all of whom would need to be skilled, tank production could be increased to 6, 338 by September 1919. Without this increase output would be no more than 4, 256 by the same time. These figures can be broken down as shown in the table below (Table E).

> "...the release of 3, 500 men is worth an additional 2, 082 tanks which can be produced in the time interval ending 30th September 1919. This is actually at the rate of 1.7 men per tank per annum, the real requirement being practically 2 men per heavy tank and 1 man per light tank per year. It should be recognised that this principle cannot be extended much above the figures given in the second column of the table; any increase here would require additional shops, foundries, additional stamping facilities, and large numbers of machine tools." [1]

Table E

	With present labour	With increased labour
October, 1918,.....	172	172
November, "	215	215
December, "	113	113
January, 1919, ...	228	228
February, "	378	378
March, "	450	496
April, "	450	573
May, "	450	703
June, "	450	863
July, "	450	873
August, "	450	873
September, "	450	851
Totals.....	4, 256	6, 338

However, on 11 October G.F. Davidson, ACMC, wrote to Major Dewar, Controller of Statistics and Progress, suggesting that Maclean's figures were wrong. He argued the achievement of an increase of 100 machines per week would require an extra 10, 000 men not 3, 500 as Maclean had suggested. He stated that 3, 500 skilled men could account for an increase of only 35 machines per week.[2] Yet the list below [3] (which was still incomplete because several firms including Fosters and NBL had not completed their returns and one important firm , Wm. Beardmore, Glasgow, was

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[1] Maclean's report, Appendix A.

[2] MUN 4 / 2804.

[3] MUN 4 / 5204.

missing), compiled by Maclean for the Secretary of the Ministry of Munitions on the same day (11 October 1918), reveals skilled labour demands consistent with Maclean's earlier predictions of " some 3, 500 in all" in order to come close to fulfilling their contracts for the 1919 programme.

" Provisional list of most of the contractors engaged in tank manufacture"(11 December 1918)

	Skilled		Unskilled	
	No. of men employed	Extra needed	"	"
1] Bellhaven Ltd., Wishav	10	18		
2] Bell Bros., Ravensthorpe	6	44		
3] British Westinghouse, Manchester	105	175		
4] P. Brotherhood, Peterborough	90	84		
5] Browett Lindley, M'ster	104	24		
6] Brown Bayley, Sheffield	108	20		
7] Brown, Bros., Edinburgh	48	60		
8] Caledon Motors	35	8		
9] Clayton & Co., Macclesfield	8	0		
10] Coventry Chain, B'ham	92	25		
11] Coventry Ordnance Wks, Glasgow	130	75		
12] Crabtrees, Leeds	61	91		
13] Crossleys, M'ster	600	200		
14] Dobson & Barlow, Bolton	0	22		
15] Firth & Co., Sheffield	14	14		
16] Foster & Co, Lincoln	?	32		
17] L. Gardner & Co, M'ster	440*	40		
18] Halleys Industrial Motors, M'ster	112	64		
19] R. Hoe & Co, M'ster	96	11		
20] Kitson & Co, Leeds	227	53		
21] Mather & Platt, M'ster	0	150	200	

22] Marshall & Sons, Gainsborough	92	10	
23] Metropolitan Co, B'ham	2000	1227**	
24] Mirrless, Bickerton & Day	250	30	
25] Mirrless, Watson, Glasgow	70	34	
26] Mitchell Shackleton, M'ster	19	9	
27] National Gas, Ashton-under-Lyne,	97	50	
28] National Projectile Factory, Glasgow	0	0	
29] Newton Harper, Rochdale	12	50	
30] North British Loco, Glasgow	1960	?	
31] Perkins Engineers	103	10	
32] Hans Reynolds	5	11	
33] Rover Motor Co, Coventry	0	0	
34] Ruston & Hornsby, Stockport	185	90	
35] Ambrose Shardlow, Sheffield	177	10	
36] Star Engineering Co	190	75	
37] Tilling Stevens, Maidstone	15	?	
38] Tangyes, B'ham	100	50	
39] Urquhart Lindsey, Dundee	96	30	
40] Wests Gas Improvement Co,	450	465	
41] E.G Wrigley & Co, B'ham	176	20	
42] Goodall Clayton	?	5	
43] Greenwood & Batley	?	35	65 (semi)
44] Hudswell Clarke	0	1	
Total	8, 283	3, 421	

* Includes semi skilled.

** The list made it clear that this figure did not include their request for skilled men and apprentices made the previous day which brought their labour requirement up to 1, 370 mainly skilled men and apprentices.

(MUN 4 / 5204)

[4]

Production & Steel

From the outset the tank programme faced intense competition for its most essential building material, steel. As part of the Ministry of Munitions, the MWSD faced particular resistance to its demand for an ever increasing share of the nation's steel budget[1] from the Admiralty (the Navy was allocated its own steel budget independent of that controlled by the Ministry of Munitions) which was determined to maintain its first class priority status in regard to steel supply. Churchill, having so recently been First Lord, was in a unique position when, as Minister of Munitions in August 1917, he championed the cause of the tank, highlighting the profligacy of the Navy's demand for ever more steel. Mechanical warfare had not only to compete with the Navy, but also in areas where its interests clashed with those of rail transport, mechanical transport and aeroplane production, i.e. steel component parts, such as engines, track-links, and guns. In sending his " Circular to Steel Works " in September 1917 Churchill, as Minister of Munitions, acknowledged the importance of steel to the British and allied war effort . The war had become, in his words, very definitely a "Steel War". [2] The decision to produce 100 Mk I tanks after the tank's successful showing at the Hatfield trials in January 1916 made the issue of steel supply crucial. Steel was, of course, essential as a raw material from which to shape the basic hull. But an adequate supply was also vital to the manufacture of engines to propel the tanks, guns to arm them, and armour-plate to protect them. How successful was mechanical warfare in enlisting support for its claim to a share of the steel budget ? Failure would have rendered the tank a "peripheral weapon".

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[1] The first " Steel Budget" was prepared in January 1918 after it became obvious that a reduction of imports seemed inevitable. As a result the Shipping Controller reduced the available shipping tonnage for steel for munitions purposes from 15, 000, 000 to 10, 000, 000 tons. In the event these reductions were to have little effect on the availability of steel since the original steel allocation of 15, 000, 000 had been very generous, and the shipping situation was not as poor as had been anticipated. This, however, did not become apparent until December. In January the Ministry was still anticipating reductions.

[2] Gilbert,*Winston S. Churchill* (Vol IV, 1917-22, companion), p 160. Also Carr and Taplin , *History of the British Steel Industry*, p 299.

The supply of engines

Tank engines, unlike most other heavy transport engines, were called upon to run under very heavy loads at high revolutions for a long period of time and over very rough terrain. The average load factor for a tank engine was in the order of over eighty per cent compared with that experienced by transport lorries of 34-35 per cent. The engines ran at a more or less constant speed governed mechanically at 1, 200 - 1, 350 rpm . Tank engines were further disadvantaged by the considerable quantities of dust or mud constantly thrown up by the tracks which inevitably then found its way into the interior of the tank, and which made the job of designing and fitting breathers or filters to the engine very taxing. Moreover, tanks were often asked to run on inferior fuel for long periods of time and, despite the best efforts of the Field and Central Workshops, received in many cases only very basic maintenance.[3]

It was not uncommon for tanks to have to operate at angles over 35 degrees to the horizontal whilst traversing a steep trench system. This placed considerable demands not only on the fuel system which had to ensure an adequate supply of petrol to the engine at all times, but also the engine's lubrication system which demanded that oil be present in all of the engine's vital parts whatever the angle of the machine.

As the tank entered an era of mass production the engine followed suit. At a meeting on 25 November 1916 P. Martin of Daimler & Co. undertook to deliver 105 hp engines as follows : [4]

January, 1917 .....20 per week
February, " .....28 " "
March, " .....35 " "
April " .....40 " "

In all rising to 60 per week in May. However, it was soon realised that this output would be insufficient to meet future tank orders (Stern's keenly anticipated orders) and that the 105 hp engine was simply not powerful enough to provide the performance required.

Daimler were at this time committed to aero-engine output and could neither expand their production nor produce a larger engine. However, the contracts branch,

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[3] H. Ricardo, *The Internal Combustion Engine*, Vol II, p 333.

[4] Stern, *Logbook* , p 115.

MWSD, and the engine designer, Harry Ricardo, were able to locate five firms [5] in the Manchester area, which had been rejected by the Air Ministry as being unsuitable to build aero-engines. With characteristic impetuosity Albert Stern placed an order in October for 700 105 hp engines with this group of manufacturers, and, despite resistance from the Ministry and the War Office, placed an order for a further 700, making 1, 400 in all (in keeping with his order for 1, 400 Mk IV machines).

Harry Ricardo, meanwhile, was working on the research and develoment programme for the next generation of tank engines. In late 1917 the first of a series of Ricardo engines (150 hp) went into production. A programme (November 1917 - July 1918) for 5, 342 engines was embarked upon, with orders for the period being placed with nine different engine manufacturers. [6]

Ricardo continued to design bigger and more powerful engines. The 225 hp and 300 hp each came from the same drawing board. Designs for the 225 hp were complete in September 1917, but the engine did not go into production until January 1918 due, it is said, to delays in placing contracts. Approximately 800 of these engines were produced, but delays in tank production meant that none of these engines saw any fighting. [7]

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[5] Ibid, pp 123-4. Stern said that the Air Department had found the five firms concerned "Unsuitable" for aero-engine production. This statement is somewhat at odds with the *History of the Ministry of Munitions*' version which suggests the output of the five firms was not immediately available for tanks because they were still engaged in aero-engine work (Vol XII, Pt III, Ch III, p 43).

The severity of the situation regarding manufacturing capacity for all arms was further indicated by a letter from the Controller of Aeronautical Supplies to the DMRS (13 August 1917) which came in answer to an enquiry from Dr Addison regarding the reduction of possible manufacturing overlap. In the letter the Controller of Aeronautical Supplies said that :

> " as a rule...[tank workshops were]...not very suitable for aeroplanes, but as a matter of fact,...[Metros]...are now going to devote some shops to aeroplane construction, but I am given to understand that this will have no influence on tank production.
>
> "With regard to aero-engine production I note you have already enquired from Mr. Martin [Dir-General of Mechanical Transport Supply and Petrol Engines], who will doubtless report that facilities for making tank engines could under certain conditions be used for making aero-engines, and that he has fully considered this matter and arranged for the minimum of [production] overlap."

But it should not be overlooked that during the war tanks would do their fair share of impinging on the manufacturing base of the Aeroplane industry and Mechanical and Rail Transport Departments - turn and turn about !

[6] Tangiers Ltd; Browett Lindley & Sons; British Westinghouse Co. Ltd; Mirrlees, Bickerton & Day; National Gas Engine, Ltd; Williams & Robertson; Crossley Bros Ltd; Peter Brotherhood Ltd; Perkins Ltd; L.Gardner & Sons Ltd; Ruston & Hornsby. This list is taken form Maclean's report of August 1918.

[7] Delays in placing contracts could suggest that there were not enough firms, reflecting the intense competition, especially with the Air Department. However, the fact the MWD was not only able to establish, but increase its tank engine construction group to nine members by late 1917, before the return of first class priority status, would tend to suggest that tanks were doing reasonably well in the competition for resources.

With the emergence of the all new Mk VIII "supertank" in 1918 an even more powerful engine than the 225 hp was needed. The 300 hp engine was of twelve cylinders as opposed to the earlier models which were of six cylinders. It received clearance to enter production in September 1917. However, as discussed in chapter two, its numerous teething problems delayed full scale production. In fact only six engines were produced before the Armistice. The United States authorities were also having problems with their version of the 300 hp engine. These problems were linked with the development of the 300 hp Ricardo engine.

On 25 June 1918, at the ninth meeting of the "New" Tank Committe, Moore stated that, because the United States authorities were experiencing difficulties with the development of the Liberty aero-engine for the American version of the Mk VIII, he had been asked by the United States government to supply Colonel Drain with drawings for the 300 hp Ricardo engine for possible manufacture in the United States.[8] Doubts had been voiced at an earlier meeting of the "New" Tank Committee on 11 January over both the technical problems of converting the Liberty engine for use in tanks and the reliabity of the supply of engines from the United States, given their exposure to the German 'U' boat threat.[9] On 3 October, the eighth meeting of the Tank Board discussed the technical and supply problems which were still being reported by the United States government since priority in the United States was given to aircraft before tanks. Colonel Drain, however, assured the Board that the problems were not "insuperable".[10] For the whole of 1918 the debate continued over possible reliance on the Liberty engine with obvious questions still to be resolved regarding the future of engine supply for the Inter-Allied programme - British or American ? Moreover, if the Liberty engine was successful, and the problems with the Ricardo could not be easily solved, would the MWD manufacture the Liberty engine in Britain for the British Mk VIII and other such "supertanks" like the Mk X ? However, the Armistice interceded and only six Ricardo engines were produced before November.

Armament : 6-pdr, 2-pdr and machine guns

Heavy tanks were, for the most part, built in equal numbers , male and female - the former differing from the latter in that they were armed with 6-pdr, .40-inch calibre

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[8] WO 158 / 859.

[9] Ibid.

[10] WO 158 / 867.

guns (the Mk IV and subsequent models were armed with a short barrelled 6-pdr gun of .23-inch calibre). The female models were armed only with machine guns, six in total compared to the male's four.

Inevitably the gun programme varied in response to the fluctuations in the overall tank programme. Figures produced by the MWD to meet the War Office demand of 1 January 1918 show that in February 100 6-pdrs would be required to meet the existing tank programme, together with 769 machine guns. These figures were intended to increase to 190 and 1, 290 respectively by December. Yet, that very next month , in order to meet the new revised tank programme of 8 March, this requirement had to be amended. In March they rose to 350 and 1, 304 respectively, finally peaking at 790 and 2, 802 during April through July, tapering off in the latter half of the year to 190 and 1, 290 in November. Such was the rate of change which affected all tank production. Realising the need to forewarn the gun manufacturers of this, in July General Seely, member of Munitions Council group 'W' ('W' stood for Weapons after Churchill had reorganised the Ministry of Munitions in late 1917) and Deputy Minister of Munitions, warned the Controller of Gun Manufacture, Captain V.B. Stewart, that he would be wise to bear in mind that new " demands...may be made upon his resources, very soon". He was specifically referring to the new quick firing "Pom-Pom" type of gun to be mounted in tanks and used for the destruction of German tanks. As with the development of new engines, the development and production of new guns for tanks was the subject of an on-going debate throughout 1918.[11]

On 11 January General Capper stated that the output of both the 6-pdr and the new 2-pdr guns was likely to be subject to considerable shortages due to problems of steel supply and machining.[12] The 6-pdr (.23 calibre) [13] was already firmly established as the tank's main weapon. However, anticipated tank v's tank confrontations gave the spur to research and development of lighter guns, which with higher muzzle velocities would give, in theory at least, greater penetration, range and accuracy Yet, early work was not a success. In its original format the 2-pdr failed to meet the performance criteria, particularly in regard to penetration tests where it failed even to match the existing 6-pdr.[14]

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[11] MUN 4 / 2801.

[12] Ibid.

[13] The .23 calibre 6-pdr replaced the .40 cal gun after the Mk I because the barrel length of the latter tended to make guns and sponsons difficult to transport with their inherent risk of damage so much higher than the shorter barrelled .23 calibre gun).

[14] WO 158 / 867.

The situation in regard to the tank's other weapon, the machine gun, was more straight forward than the main gun, although it too was affected by muddled thinking and competition for resources.

The first machines, Mks I-III, were armed with Hotchkiss and Vickers machine guns , the former being the most numerous. This was to remain the situation until the introduction of the Mk IV in February 1917. The War Office then abandoned the Hotchkiss in favour of the Lewis Gun. The production of the Hotchkiss was, however, continued on a reduced scale in order to provide weapons for the Allies.

It is difficult to discover exactly why the Hotchkiss was abandoned. Albert Stern suggested that it was changed at the insistence of a high ranking Tank Corps officer who had " once been in charge of a Lewis Gun School at St Omer."[15] The officer concerned was Colonel C. B'A. B.S. Baker-Carr. In post-war correspondence with Sir Basil Liddell Hart, General G. Le Q Martel (a Captain in the Tank Corps in late 1916), said that Baker-Carr had" originally sold the Lewis gun to the Army on behalf of his American friends".[16] Clearly, Martel was suggesting that Baker-Carr, in pressing the case for the adoption of the Lewis gun for use in tanks, was deliberately furthering the cause of his civilian associates over the interests of the tank programme. This is one view. However, it could be argued that it was motivated by the perceived need on the part of the War Office to streamline machine gun production. The Ministry was, at the time, producing three different models : Vickers, Lewis and Hotchkiss. The Vickers and Lewis guns were produced in far greater numbers than the Hotchkiss and enjoyed considerable support from both the Army and the RFC. This was particularly so of the Vickers which , unlike the Hotchkiss, could be fitted with an interrupter mechanism enabling the gun to be fired through the propeller of an aircraft. Yet, the continued manufacture of the Hotchkiss, albeit at a reduced level, surely negates this argument since it did not allow for the redistribution of valuable skilled labour or machine plant which, as we have seen, was of critical importance in the manufacture of both guns and tanks. [17]

The practical effect of changing from one to another was damaging both to continuity of production (as different mountings had to be produced) and more importantly to the efficiency and morale of the tank crews. However, the Hotchkiss did not lose favour for long. Barely one month had passed before the War Office reinstated

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[15] Stern, *Logbook* , p 114.

[16] Liddell Hart papers, L.H. 9 / 28 / 59-62.

[17] The Hotchkiss machine gun was a weapon of French design and was built in this country under licence at Coventry by Societe Hotchkiss. It was not a controlled establishment which meant that for much of the war the Ministry had could exercise little contol over it - dilution of labour, etc.

the Hotchkiss as the tank's main machine gun.[18] The Lewis gun had been found wanting in several areas. The barrel's outer jacket was easily punctured by small arms fire. It proved too cumbersome to fit into the loop-holes fitted in the tanks from which machine guns were to be fired. Moreover, it was also unable to be fired at extreme angles to the horizontal due to its circular magazine jamming in this position.

Speed and protection

To paraphrase Lord Fisher, speed is armour; armour without speed merely produces a target.[19] In the very early days of the development of the tank, when some rather weird and wonderful designs were being proposed, there was still a belief that tanks could be made to withstand artillery fire as well as that from small arms. However, it very quickly became clear that Fisher's dictum applied equally to "land ships" as it did to the those on the high seas.

Absolute protection from artillery fire was never a realistic goal; nevertheless, this did not prevent continued experiments in this field. Albert Stern described one such experiment :

> " On June 19th it was decided to build a tank capable of resisting field guns. Mr. Tritton had already got out certain designs , and experiments were carried out at Shoeburyness with Beardmore plates of 1", 11/2" and 2" thickness."

Stern again ;

> " It was discovered that a 3/8 inch plate, with half the metal stamped out, giving the weight of a 3/16-inch steel plate and placed one foot in front of the ordinary plate of the Tank , would detonate a German high explosive shell and prevent any damage." [20]

Early experiments continued in the hope of developing a model resistant to high explosive based on the Mk I. As indicated above experiments revealed that a minimum

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[18] Alexander Duckham, Dir-General of Small Arms and Machine Guns, wrote on 6 May 1917 to the DMRS, "This is very annoying, in view of the fact that such a comparatively short time has elapsed since Hotchkiss guns were condemned for Tank purposes."

The following day the War Office stated that it was the Army Council's recommendation that the Lewis gun be replaced by the Hotchkiss which they thought to be "too cumbersome and very unwieldy to be operated effectively inside a Tank."

[19] A.J. Smithers, *The New Excalibur, The Development of the Tank, 1909-39*, p 42.

[20] Stern, *Logbook* , p 68.

thickness of some 2-inches was necessary. It was estimated that following these dimensions would dictate a weight of aproximately 100 tons. William Tritton at Fosters intended that this machine, known unofficially as the "Flying Elephant", should be driven by two 150 hp engines. The design utilised"two auxiliary tracks set inboard and slightly higher (6-inch) than the main tracks."[21] They were not intended for normal driving but were capable of being engaged to give extra traction over rough ground.

The prototype received approval in June 1916, but the project was cancelled just short of completion at the end of the year when resources were focused on the mass production of the basic Mk I. Until the introduction of the Mk VIII at a comparatively modest 37 tons, the cancellation of this project signalled the end of the search for a "super tank." With it died the idea that tanks could be proof against high explosive. Making machines proof against armour-piercing small arms ammunition and German anti-tank rifles was to prove challenge enough.

The search for an ideal balance between speed and protection was to continue throughout the war spurred on by continual developments in German anti-tank defences. The minutes of the Supreme War Council (British Section) for September and October 1918 make frequent reference to the need for or the occasion of new developments in armour plate for tanks. Some of these developments were clearly more practical than others. For example a discussion was held on 21 September regarding the merits of a new system of tank armour which was intended to do away with the weight and bulk of traditional plate, thereby lessening the overall weight of the tank and therefore improving its manoeuverabilty, but without sacrificing the protection from direct hits from small arms fire or glancing hits from artillery which the heavy plate offered. This system was called " Venetian Shutters".[22] Detailed drawings were provided which gave a scaled lobster effect to the tank. As with many new ideas connected with the tank, however, the gulf between innovation and the production line, particularly given the concerns over continuity, was insurmountable.

In an informal letter to General Sackville-West, dated 7 October 1918, General Harington, DCIGS, mentioned the "Venetian System", but dismissed it as "unworkable." He did, however, go on to suggest that the addition of extra armour plate to the Mk.V, in "order to counter" improved German ammunition, was feasible. His reasoning was that "This would not necessitate a very great increase in weight. It is not

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21 P. Chamberlain and C. Ellis, *British and German Tanks of WorldWar I*, p. 44. See also David Fletcher, *Landships, British Tanks in the First World War*, p .23.

22 CAB 25 / 12.

generally known that though the Mark.V tanks weigh some 27 tons the actual armour plate used on them weighs under 5 tons." [23]

It seems Harington may have had a point . One would have thought that the relationship between engine power and the weight of the tank would have been very carefully worked out and if extra weight-carrying capacity had been available on the Mk V, without sacrificing the manoeuvrabilty of the tank, surely this would have been utilised with a greater weight of armour from the beginning. But if we examine the table below it would suggest that there was an extra four tons of carrying capacity, as it were, going spare.

Mk. V..... (Male) 29 tons.....4.6 m.p.h.....150 h.p. engine.[24]
Mk.V*..... (Male) 33 tons.....4.6 m.p.h..... 150 h.p. engine
Mk.V**..... .(Male) 35 tons.....5.2 m.p.h.....225 h.p. engine.

The Mk V*, which was only an *ad hoc* extension of the Mk V engineered by the addition of three extra side panels, seems to have been able to carry this extra four tons with the same engine without loss of speed or manoeuvrabilty (although this does not take into account turning capability, which must have been impaired by the extension in length - 6 feet) and with an increased trench spanning capability of three feet. However, with the introduction of the Mk V** (a purpose built version of the Mk V* as opposed to an adaptation of the Mk V) at the close of the war, the argument became hypothetical.

At the eleventh meeting of the Tank Board, held on 24 October 1918, the problem of additional plate and its effect on manoeuvrability was again being discussed. Maclean suggested additional armour plates capable of being fitted by the tank crews in twenty-four hours, as a means of counteracting improved German armour-piercing ammunition. It was hoped that these would be ready by March 1919. This represented another compromise between manoeuvrability and strength. The "readily" detachable extra plates would reduce the weight carried by the tank, and therefore theoretically the extra wear on component parts, as the tanks made their way to the forward line. It also had positive advantages in terms of availability of materials since plates could be more easily salvaged and only tanks going into battle needed to be fitted, i.e. reserve machines need not necessarily have been so equipped.[25]

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[23] Ibid.

[24] Technical specifications are taken from several sources : The Tank Museum technical manuals, Chamberlain and Ellis, *British and German Tanks of WW I* , pp 74-75, and Sir E. d'Eyncourt, "Account of the British Tanks used in the War", Engineering, 12 September 1919, p 337.

[25] MUN 4 / 6400.

The Board also discussed the topic of defence against German anti-tank mines. Designers had now not only to counter small arms and high explosive but also the recent German practice, described at the meeting by Lieut-Colonel Frank Searle, of burying 6-inch shells "covered with wooden battens, which when crushed by the weight of the tank, detonated the shell". It was decided to follow Searle's suggestion of fixing rollers to the front of the tanks which would detonate the mines in front of the tank . This must have been discussed at an earlier meeting, or perhaps informally between the main members, because work on the development of these rollers was already in hand. Maclean was able to inform the Board that a roller system was now ready for trial. All this, of course, would add still further weight (since the roller would have to be a significant weight in order to detonate the mine) to the tank, further reducing its manoeuvrability.

The weight of a tank not only affected its manoeuverabilty, but could also have a detrimental effect on its reliability and durability, since it could hasten the wear and tear on component parts designed for lighter machines. This was one of the draw -backs of the search for continuity which saw a direct evolutionary path from the Mk I to the Mk V** with an increase in both speed and weight in the later model. An alternative was to design a purpose-designed model from scratch. But this too could have its negative side. The length of time for research and development, the extra materials involved and construction space given over to a new design often outweighed the potential advantages, particularly given the condensed time period that we are talking about here. The Mk VIII is an excellent example of this. Its under-powered engine (the prototype was fitted with a 150 hp engine for test purposes while its intended engine of 300 hp was still under development) and increased weight led to severe technical problems, particularly with the tracks, which prevented it from going into production in late 1918. But in the end it was the power of the available engines which dictated that mobility must win out over protection in the struggle to improve the tank's defences.

Competition :

Aside from the many technical and design problems that mechanical warfare faced in developing sufficiently powerful and robust engines, and in arming and protecting the tanks, it also faced stiff competition from rivals in mechanical and rail transport as well as aeroplane manufacture for production capacity and certain scarce metals. The Navy jealously guarded its first class priority status guaranteeing its supply of steel materials, however unreasonable that may have seemed to some at the time.

The Navy's demands for steel for the manufacture of shells and to erect airships and airship hangers was a focus for Winston Churchill's criticism during 1917-18. They were, he maintained, examples of conspicuous waste on the part of the Admiralty.

On 26 July 1917 Churchill wrote to Lord Curzon, Deputy Minister of National Service, stressing the profligacy of the Navy's shell steel orders. Whilst acknowledging the importance of the merchant ship building programme, he was quick to point out that they :

> "...started the War with a fairly good supply of ammunition for every class of gun ...[and]...during the three years that have followed , they have been enormously increasing their stocks, and apart from practice ..., have been firing very little anyway...[further]...The reserves now accumulated will be found to be out of all proportion to what would be necessary to sink the German fleet even in the most unfavourable circumstances...[yet]...the Admiralty de-mands [sic] for shell steel are increasing month by month." [26]

On 12 November 1917 Churchill again criticised the Navy's steel allocation and increasing demands. This time, however, he chose as his target the Admiralty's airship programme. He made it clear at a War Priorities Committee meeting (12 November) that in his opinion the programme could not be finished before 1919 and only with the withdrawal of men from aeroplane production. He said that in the opinion of the Ministry of Munitions airships were not worth the necessary material and were of little value as compared to aeroplanes. But Churchill was successful only insofar as he was able to persuade the Committee to reduce the programme and not, as he had hoped, end it altogether. [27]

Six months later, on 2 January 1918 at a meeting of the War Cabinet, the Admiralty's airship programme was once more the target but this time it was the shed building programme. At a time, he said, when a "cut in steel imports could not be resisted", he demanded that the Admiralty's steel allocation should be cut in line with the other services and not, as they had been to this point , protected. He asked, " if the sheds could not be dispensed with, was it not possible for the Admiralty to effect an equivalent diminution of its demands for steel in some other department ?" He went on to argue that the three sheds proposed could not be completed, according to the Admiralty's own estimates, for 15.5, 18.5 and 20.5 (decimals are mine) months respectively. Further, he said that he was advised that these figures were "unduly optimistic". He concluded that " the same kind of steel and skilled labour required for

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[26] Gilbert,*Winston Churchill* (Vol IV, 1917-22, companion), p 113.

[27] CAB 25 / 84.

this work was, in his view, needed for more urgent undertakings" - namely, aircraft, mechanical transport and tanks.[28]

Armour-plate

Armour plate was perhaps the area of most intense rivalry between the Navy and the Ministry (and therefore the MWD). Winston Churchill's determination to gain access to the surplus of plate steel "lying idle" in the Navy's shipyards in early 1918 was matched by the First Lord's, Eric Geddes, determination to hold on to it. [29]

The Armour-plate Department of Wm. Beardmore conducted an exhaustive research and development programme (referred to in chapter one) at their Parkhead Works under the guidance of Lieutenant Symes and T.M. Service. By the end of January 1916 Beardmore had produced bullet-proof nickel-steel plates of 12, 10 and 8 millimetre thickness, and a bomb-proof 6- millimetre high tensile steel plate.[30]

Beardmore was one of three steel manufacturers to be contracted to produce armour-plate for the tank programme in early 1916. The other two were Cammell Laird & Co. and Vickers, both of Sheffield. After the tank went into mass production at the end of 1916 the increased demand for this steel led to the expansion of the above group to include Edgar Allen & Co., Armstrong Whitworth & Co., Thomas Firth & Sons and Robert Hadfield & Co. However Beardmore retained a unique role for itself as the sole producer of track shoes for both the British and Allied machines. It also manufactured light bomb-proof plate intended " to meet the attack of bombs [grenades], either singly or in groups."[31] In May 1918 the Ministry requested that the production base of this metal should be widened.[32] Again this is in keeping with the expansion of the tank programme, reflecting the the growing importance of mechanical warfare.

Beardmore also manufactured some 20, 000 spherical machine gun mountings for the Hotchkiss and Lewis guns used in the tanks. These, like the shoes, of which there were just under one million made, were manufactured from bullet-proof material

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[28] Robin Higham, "The Peripheral Weapon in Wartime" , 239.

[29] At a War Cabinet meeting held on 8 March 1918 to discuss the question of tank production and specifically the new tank programme, Churchill drew attention to the "surplus stock" of 80, 000 tons of plate steel which was "lying idl e" in Navy shipyards which, he suggested, could be "borrowed" by the MWD for tank manufacture (MUN 4 / 2801).

[30] Beardmore News, 26 February 1919, and Hume and Moss, *Beardmore the History of a Scottish Industrial Giant.*, p 131.

[31] From Sir Wm. Beardmore's speech, Beardmore News, 14 May 1919.

[32] As part of this diffusion of Beardmore's know how Colville& Son were contracted to produce bomb proof plate.

which after machining had to be "hardened, erected and finally inspected". Although Beardmore perfected suitable armour plate by early 1916, logistical difficulties meant that the first trial machines were armed with boiler-plate only. [33]

It is ironic that the Beardmore works were only able to carry experimentation on armour-plate because of a sudden and quite dramatic drop in the Navy's demand for armour-plate in 1916 (from 14, 993 tons in 1915 to just 7, 712 in 1916 - before picking up again in 1917). [34]

Engines

Competition for production capacity and for scarce metals inevitably led to compromise in design and, therefore, effectiveness. This was particularly the case with tank engines. The engine designers' search for the ideal tank engine, one capable of delivering both reliability and performance, was hampered by serious shortages of certain materials, particularly aluminium. Because of its light weight and strength aluminium was almost exclusively reserved for manufacture of aero-engines. Designers were able to obtain small quantities, which in the 105 hp engine enabled the fitting of aluminium pistons leading to a considerable improvement in power over the original Daimler engine. However, these rationed supplies remained very sparse.

The use of high-tensile steel was not permitted in tank engine construction even though engine designers were charged with the task not only of producing engines which did not emit clouds of thick black exhaust smoke (the result of a lack of precision in piston component parts allowing oil into the cylinders), which would give their presence away to enemy artillery, but also of ensuring reliability and performance, both of which demanded precision engineering and quality materials .[35] Tennyson d'Eyncourt later wrote :

> " The selection of the engine, transmission and control gears for the Mk I-IV tanks was considerably influenced by the necessity of having as far as possible to use existing units and material that was already in production. It was in consequence of this that the 105 h.p. Daimler tractor was adopted; this combination gave the nearest approach in design to the tank requirements as then understood." [36]

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[33] Sir Wm. Beardmore's speech, ibid.

[34] Hume and Moss, *History of a Scottish Industrial Giant*, p 130.

[35] H. Ricardo, *The Internal Combustion Engine*, Vol II, p 334

[36] Sir E. d'Eyncourt, "Account of the British Tanks Used in the War, in Engineering, 1919, p 336.

In the light of difficulties experienced in developing some of the new engine designs on-going research into new models was complemented by continued development of existing engines. On 25 June 1917, at the ninth meeting of the"New" Tank Committee, Admiral Moore was asked to approach the MWSD design section with a view to modifying an aero-engine for the proposed Medium 'D' tank which could not take the 300 hp, but which needed a more powerful engine than the 225 hp.[37] The result was the Siddley Puma 240 hp engine which claimed to be able to produce a top speed of 20 mph. An experimental model of the Medium 'A', which was originally fitted with two Taylor 45 hp engines, was fitted with two Rolls Royce engines giving a much improved top speed of some 30 mph as opposed to the 8-9 mph of the Taylors. However, this experiment, which owed a great deal to Lieut-Colonel Philip Johnson of the Experimental Section , Tank Corps in France, was not followed up before the Armistice. The later medium marks retained their original engines : 'B' and 'C' were fitted with Ricardo engines of 100 and 150 hp respectively.

It is clear that, despite the enormous difficulties with labour and machine tools, a great deal of time and effort was expended in creating new engines for a continually evolving series of machines.

Armament

At a discussion on armament for tanks, on 23 January 1918, it was pointed out by George Layton, Director of DMRS, that the 6-pdr situation was secure, but that steel for this could only be obtained at the expense of the 2-pdr programme.[38] As a result the 2-pdr was effectively cancelled in March. The fact, as has been said, that it performed badly in trials also contributed to this decision.

However, it was clear that whilst the 2-pdr had been shelved the need for a new anti-tank tank gun persisted. General Bingham, Military Advisor and Director-General of Munitions Design, pointed out on 5 September 1918 at the fourth meeting of the Tank Board , that he "understood" that 2-pdr (40m/m) guns, originally made as anti-aircraft guns and mounted on armoured cars in France in 1915 and 1916, were in fact still being made. Moreover, since" it is practically impossible to get a new article now, and if the existing 6-pdr is not sufficient, we should try and adopt a gun which is in supply." [39]

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[37] WO.158 / 859.

[38] Ibid.

[39] Ibid.

Bingham's comments came in answer to an investigation by members of the Board into the possibility of acquiring a " quick-firing, high muzzle velocity "Pom-Pom" 6-pdr gun of .40 Calibre" (as Seely had warned Stewart in July). Such a gun would necessitate a long barrel, much longer than the existing 6-pdr, (similar in fact to the .40 calibre, 6-pdr gun mounted on the original Mk I), and the members were told that since the Navy enjoyed priority in long barrelled guns it would almost certainly not be sanctioned. [40]

The Admiralty again made its presence felt when, at the same meeting, a decision had to be made regarding the inner and outer shields for the 6-pdr guns fitted to the male Medium 'C' tanks. J. B. Maclean reported that a decision would have to be made as to whether these shields would be 9 or 12 m/m thick . He said "the thicker shields [which used more steel] could only be obtained at present at the expense of 6-pdr guns." [41]

At the "Discussion on Armament for Tanks", on 23 January, the War Office demanded 17, 678 machine guns for tanks. This figure was expanded by a further 8, 250 for the Inter-Allied programme, making a total of 27, 000, equal to an output of 2, 500 per month, possibly rising to 3, 000 in 1919. Responding to this Lieut-Colonel S.C. Halse, Deputy Controller of Small Arms and Machine Gun Supply, reported that there was a stock of some 4, 000 guns without allowances for spares, and an output of approximately 9, 200 for the first six months was possible. This would give 22,400 of the required 27, 000. The deficiency would, suggested Layton, probably be made up through "salvage, failure to live up to programme, etc." [42]

Steel for mechanical warfare

It is clear that the MWD experienced some difficulty in obtaining engines, production capacity and in developing units of sufficient power and reliability. This was due largely to the intensity of competition , but also in part to the tank's telescoped time scale of development. The availability of armament for the tanks (both guns and machine guns) was hampered by competition from the Navy for both the basic raw material from which to manufacture them, and, in the case of the long barrelled guns

[40] The importance of the long-barrelled guns to the Navy and the priority that it exercised over these guns was amply demonstrated by the fact that the first items to be salvaged from the first tank battle casualties on the Somme in 1916 were the guns - they were salvaged specifically to arm merchant shipping against German 'U' boat attack.

[41] WO 158 / 861.

[42] WO 158 / 867.

for the male tanks, for the finished product too. Compromises had to be made in terms of design and efficiency for both engines and guns. However, these difficulties should be seen in context. For a newly created body (MWD) and an equally new (one might say revolutionary) machine of, at best, only modest capability, the tank did surprisingly well in gaining the level of support that it did. It should not be forgotten that at a time of very scarce resources, and when claims on those resources were being made by established and essential weapons and logistical systems of proven worth, the tank's development was never seriously hampered by neglect. This is highlighted by the the fact that the MWD's steel orders were always met in full.

The estimates for steel requirements for the first half of 1917 were discussed in late 1916. Based on demands from the MWD it was decided to allocate 25, 000 tons for the first six months' tank production.[43] It was, however, recognised that if the Mk IV programme went ahead, as it did in early 1917, this figure would have to be doubled. In December 1917 it was decided that allocations for 1918 would be increased to 8, 000 tons [44] per month. This figure was increased still further in January, when the MWD was allocated 3,480 tons per week .[45]

Material Requirements Per 100 Tanks (in tons) [46]

	Heavy tanks	Medium Tanks.
Armour plate	1,100	550
Steel	1,930	1,161
Steel alloy	100	75
Cast iron	170	80
Copper	22	13
Yellow metal	38	35
Aluminium	5	4

For the first six months of 1918 the MWD was allocated 3, 480 tons per week. However, it took up only 61 per cent [47] of its steel allocation, and it was only in the

[43] *M of M.*, Vol VII, Pt.II, Ch.I, p.21.

[44] Ibid. p 22, and Admiral Moore's estimated requirements for MWD supplied to W.M. Page of DMRS (14 December 1917) in MUN 4 / 2801.

[45] First class status was reflected in a massive increase in steel allocation from 2, 000 to 3,480 tons per week. These figures are taken from M.S. Birkett, Statistical Officer for the National Federation of Iron and Steel Manufacturers, "The Iron and Steel Trades During the War", in The Journal of the Royal Statistical Society , May 1920, p 362.

[46] *M of M.*, Vol XII, Pt III, Ch IV, pp 58.

[47] Calculations based on figures from Birkett, " The Iron and Steel Trades During the War", pp 361-5.

final month of June that dispatches came near to matching allocation when 3, 312 tons were dispatched. For the second half of the year the weekly allocation was reduced to 1, 916 tons. However, weekly dispatches rose to 2, 547 tons,[48] representing an increase of some 424 tons per week on average over the first six months.

A little simple arithmetic, off-setting the surplus of steel accumulated in the first six months of 1918 with the deficit running in the latter six months , demonstrates, in theory at least, that 900 tons of steel per week over the whole year that had been allocated for tank production which was not used by the MWD.[49] These figures reveal that there was no shortage of steel for tank manufacture. The MWD was able to draw on supplies of steel over and above their allocation for the last six months of 1918. In fact if we look at the steel requirements for both heavy and light tanks we can see that on average there was sufficient steel left over at the end of each month of 1918 to build two extra heavy tanks per month or, alternatively, three light tanks.

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[48] *M of M.*, Vol VII, Appendix VI, Ch.III, p 158.

[49] Figures reached by deducting the figure dispatched (424 tons per week) above the 1,916 tons per week for the second half of 1918 from the average weekly surplus not dispatched during the first six months of the year (1, 357 - 424 = 933 tons per week) on average allocated to, but not taken up by the MWD.

Section Two

Obstacles to Employment

A considerable number of obstacles had to be surmounted before the tank could be effectively employed in battle. The tank was almost totally reliant on the railways for movement about the Western Front, with the effect that the rail network was periodically subject to considerable dislocation in order to meet the special demands made by tank transport. To carry tanks by train required specialised rail wagons. These had to be designed and produced in large numbers at a time when vital manufacturing capacity, skilled labour and materials were in short supply. Moreover, when at last the tank was able to operate under its own power, its performance was found to be poor, and its mechanical reliability suspect. Any of these weaknesses could arguably have ended the tank's future, and might easily have justified the curtailing of its expansion. Yet there is no evidence of this. On the contrary, despite only limited success in 1916 and 1917 its research and development programme continued to expand with the support of Haig and GHQ. Moreover, support for the creation of two salvage companies within a short time of the tank's early debut highlighted continued enthusiasm for the tank . Even the so-called "battle of the spares" was a contest over which should have priority, spares or complete machines, and not whether the programme should survive at all. By late 1917 early 1918 this had been largely settled. And finally, at a time when the supply of skilled manpower was critical the Heavy Section / Branch / Tank Corps was able to expand from four companies in late 1916 to 54 in late 1917 (a proposal to increase this to 102 was passed in July 1918 but was not implemented before the Armistice).

Despite obstacles which might have ended, or at least severely curtailed the development of other weapons, the tank continued to elicit enthusiastic support at the very highest levels.

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Transportation

A discussion of the difficulties involved in the movement of tanks from their place of manufacture to France and, once on the continent, about the battlefields is important if we are to appreciate the enormous logistical obstacles to their successful employment . But it is also important for another reason. Namely it highlights the considerable lengths to which the War Office, the Army and the Ministry of Munitions went to ensure that tanks actually got to the front. Tanks were not easy to move, and the fact that considerable efforts had to be made to accommodate them and their particular needs, especially at a time when all available rail movement was utilised to its maximum capacity just keeping the BEF supplied, goes some way to suggest just how much across-the-board support the tank received. The construction of special rail wagons ("Rectank") in particular, and in general the building of special ramps to facilitate entraining and detraining of machines, together with the laying of extra lines to the front, all occupied valuable time, manpower, and materials at a time of national shortage.

The movement of tanks by rail

General Elles pointed out in March 1918 that "...without trucks to move them by rail [tanks] are next to useless... ."[1] The problems associated with the transport of tanks were, therefore, chiefly those associated with rail movement.

The first machines destined for France arrived at Bernersfield Farm, Elvedon in late June 1916. The farm was located near a small wayside station called Barnham on the line between Thetford and Bury St. Edmunds. The public had been denied access to the area since the middle of the month. The train arrived at night and the machines were unloaded and driven across country under cover of dark in order to avoid prying eyes. The Great Eastern Railway, which was responsible for transporting the machines to Elvedon, was soon involved in the construction of a side line between the station and

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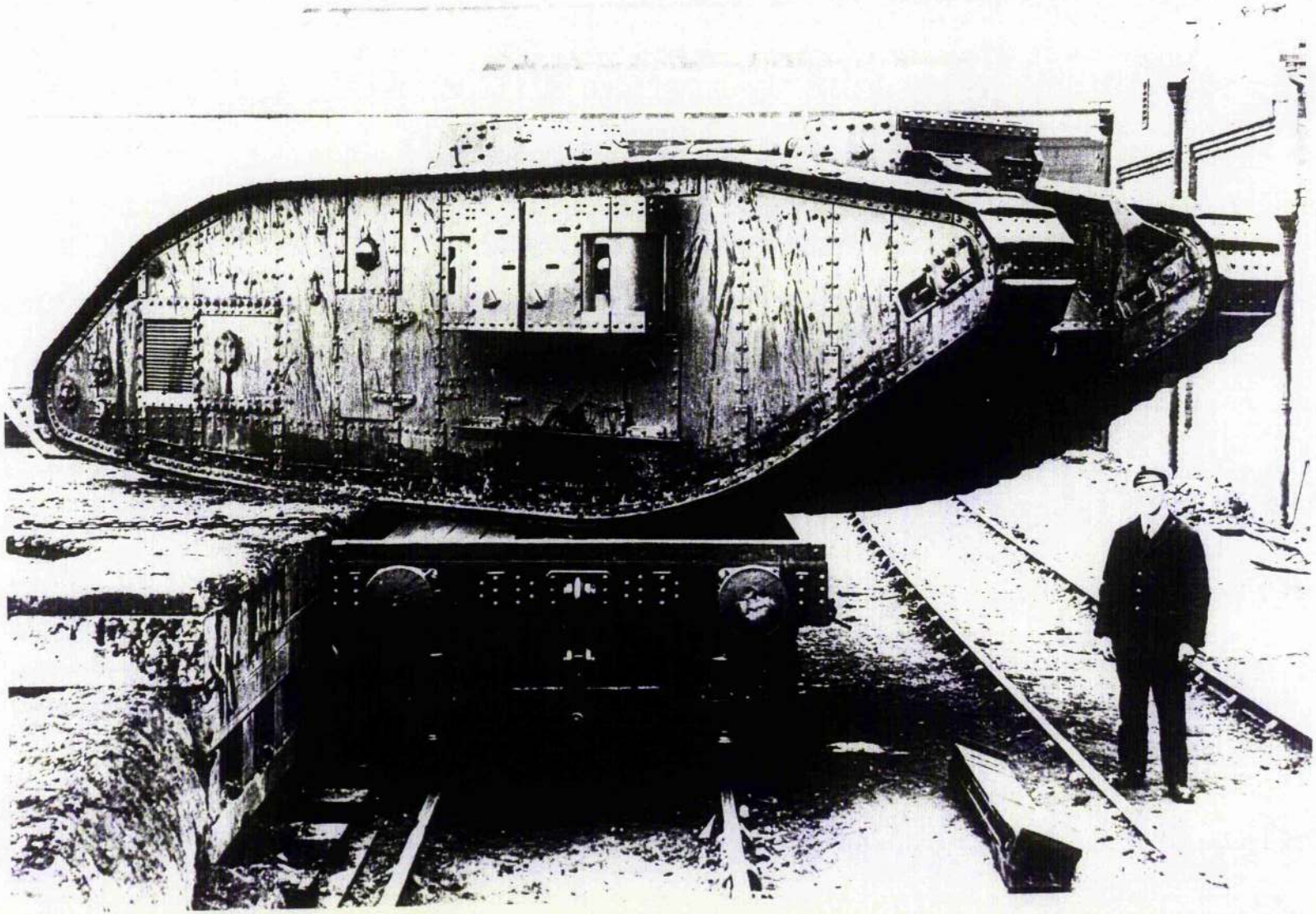
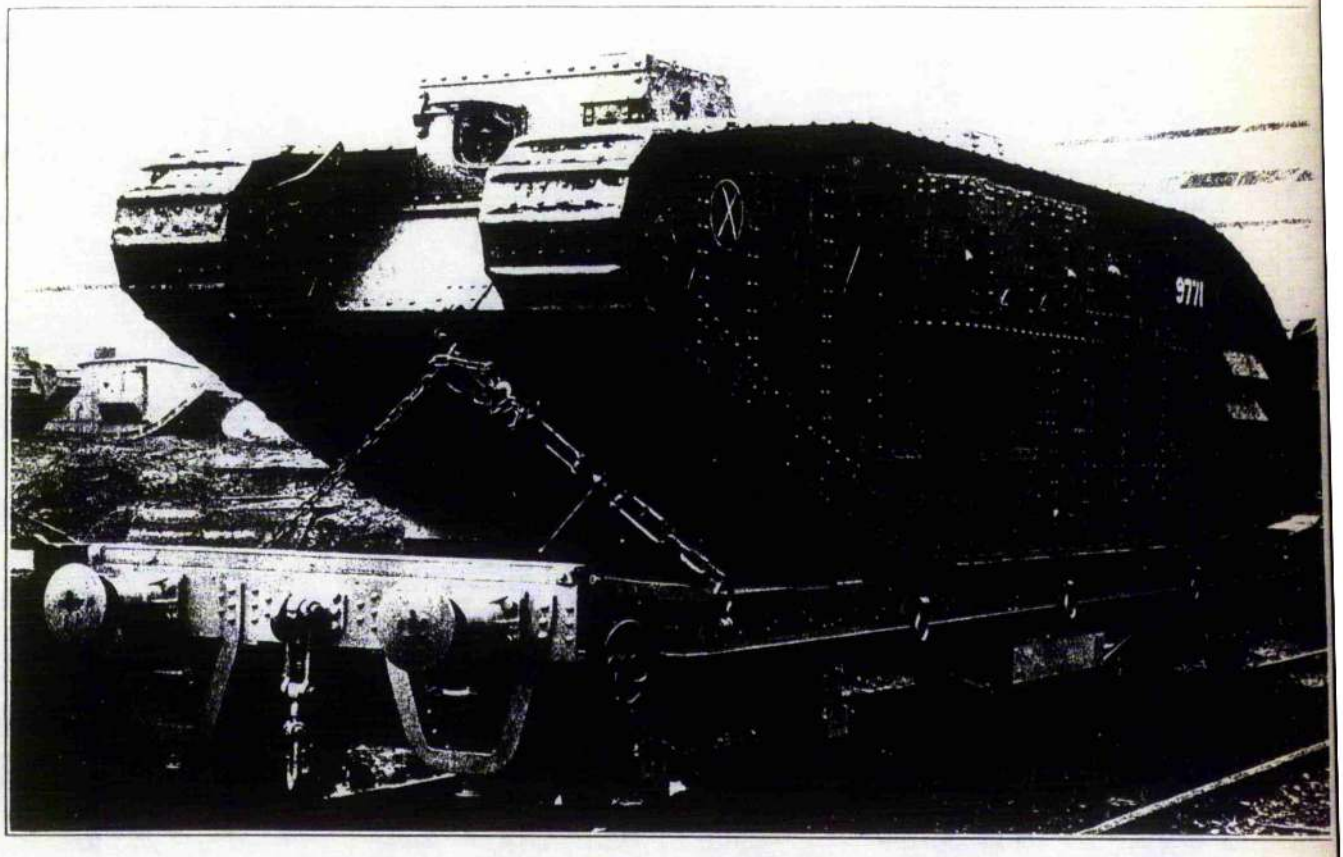
[1] WO 158 / 865, Elles's paper on the use of tanks (19 March 1918).

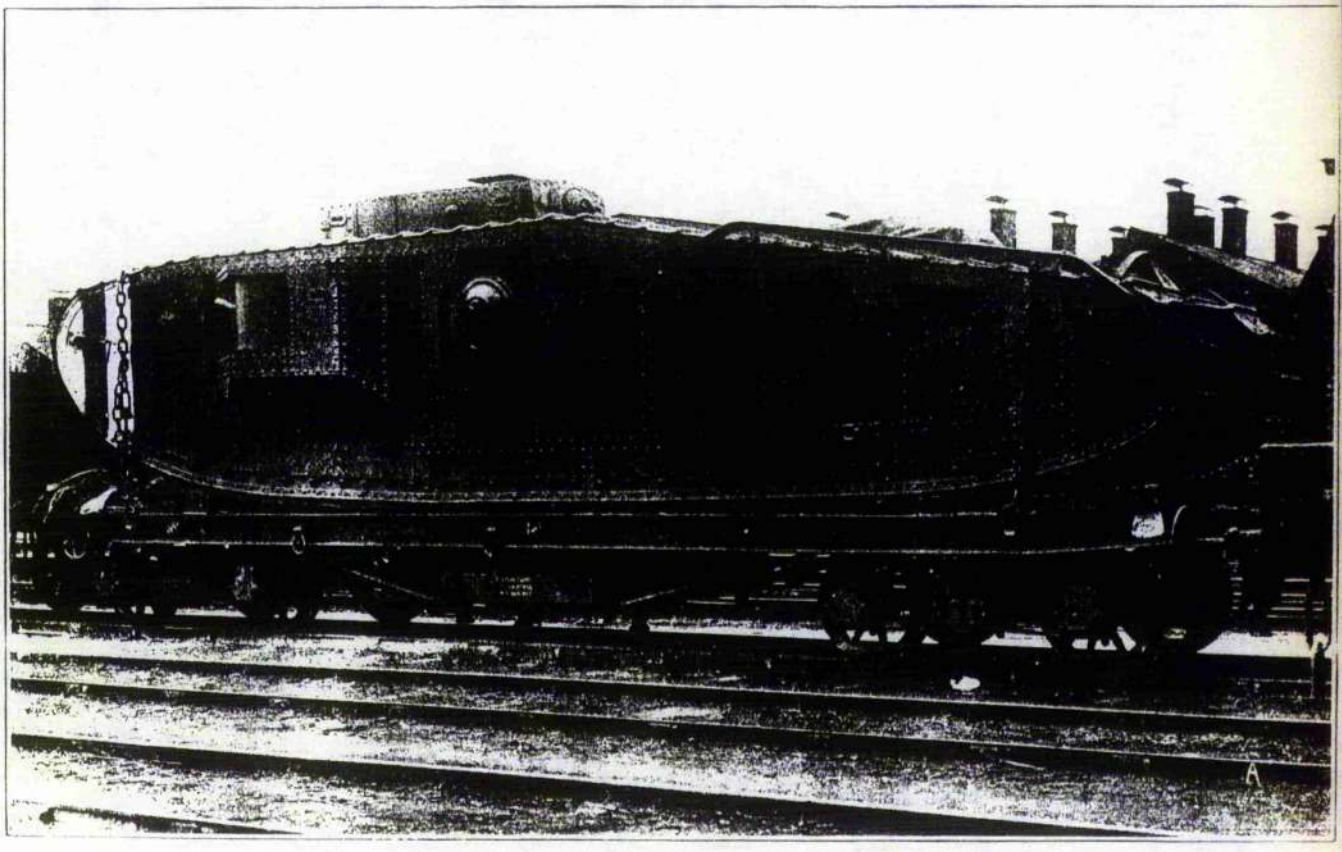
A Mk V tank being loaded on a rail wagon at the Metropolitan Works, Birmingham in late 1917 or early 1918. The naval officer is almost certainly a member of the MWD's transport section which initially comprised former members of the disbanded RNAS Squad 20.



The tank in the bottom picture is a Mk VIII. Given that only one test model was built and tested during the war, this picture was almost certainly taken in Glasgow, perhaps near the NBL Works where the Mk VIII was erected.



Tank Loaded for Transportation. Front View.

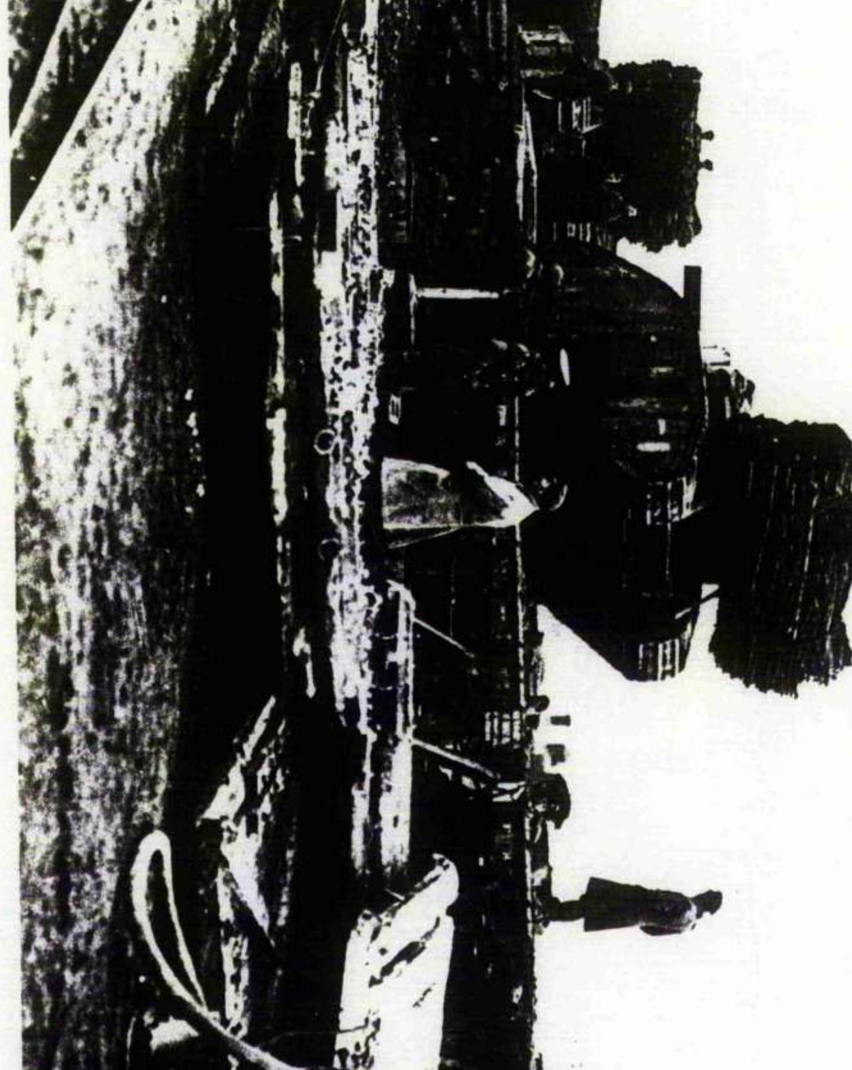


Tank in Travelling Position.

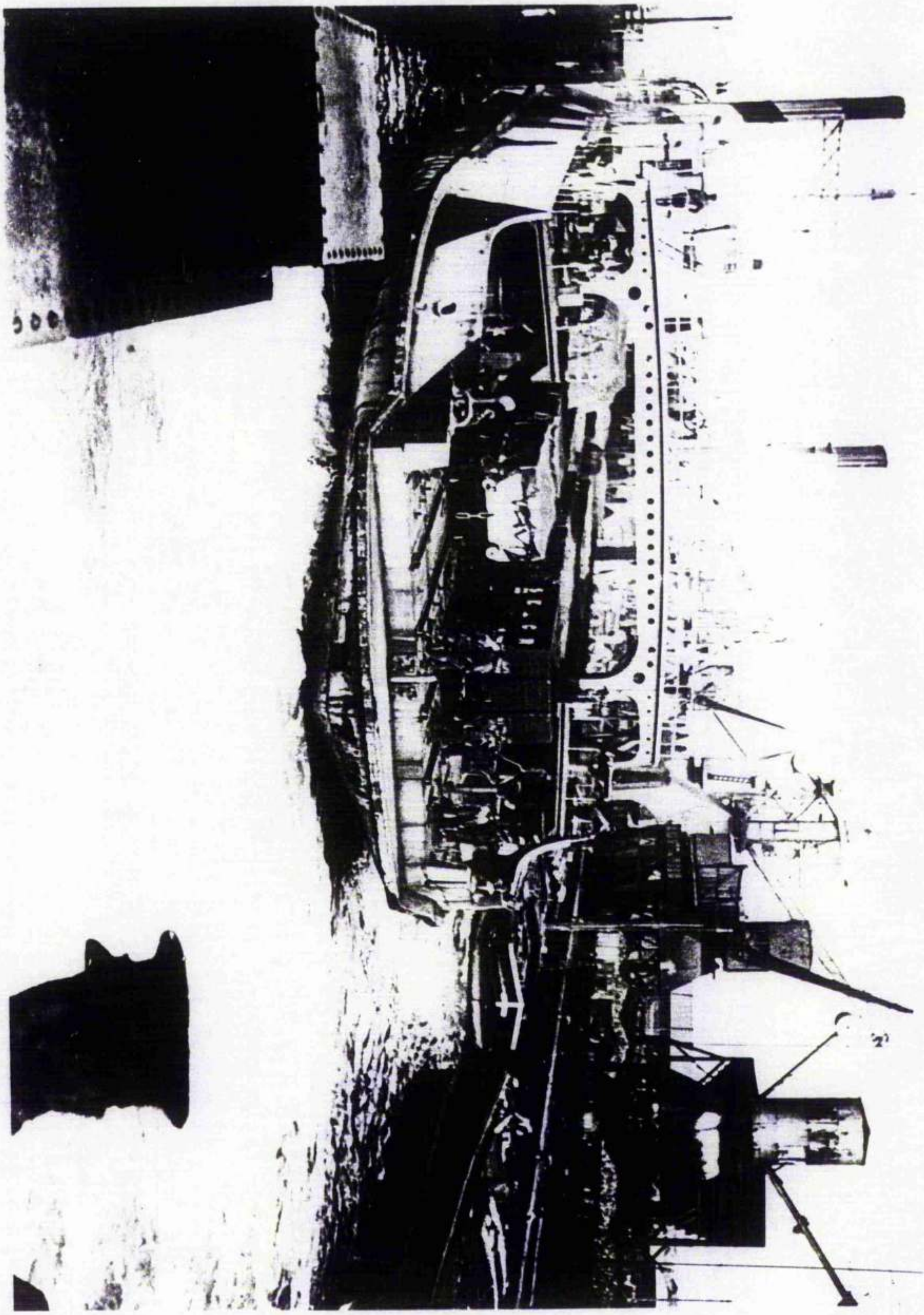
Mk V tanks being loaded by means of an end ramp for transport to the front - near La Vicogne in April 1918. It is worth pointing out that all the tanks are facing the same direction for detraining at their destination.

WAD

Once again tanks being loaded ready for transport to the front . This time they are Mk IVs being prepared for the battle of Cambrai. The loading ramp is constructed from railway sleepers. Also noteworthy is the fact that each machine is carrying its own fascine to enable the tanks to cross wide trench systems.



The roll-on-roll-off train ferry which was first introduced February 1918. The idea of a channel ferry was first discussed in 1916, but did not receive the go-ahead until late 1917. A tank (covered by a tarpaulin) can be seen on the port side, under the gantry.



the camp. By mid-August, after trials at Elvedon, the machines were entrained at Barnwell, once again at night, for embarkation to Avonmouth from where they were shipped to Le Havre. Once in France they were entrained for their final journey to a point some fifteen miles behind the lines where they made ready for the attack on 15 September. [2]

Subsequent shipments of tanks were to follow much the same route. In early 1917 testing grounds were opened at the main centres for production.[3] They were established at Oldbury and Saltly, for the Metropolitan Works, at Scotstoun for the Coventry Ordnance Works, Wm. Beardmore, and later North British Locomotive, and in Lincoln for Fosters. From here they were sent by rail directly to the south coast, or to the training camp at Wool, Dorset. The usual port of embarkation was Portsmouth which had a sufficiently powerful crane to lift the tanks from their railway wagons on to the waiting ships.[4] The same rationale applied in the choice of Le Havre as the entry port into France.[5] It possessed a 60-ton crane capable of off-loading the tanks onto the waiting railway wagons for their trip to the Central Stores at Erin,[6] and later Teneur.

The first tanks (Mks I - III) were fitted with larger sponsons than the later Mk IV, and unlike the Mk IV, they did not swing inboard to facilitate easy transport. On these models each sponson, weighing some 35 cwt (including the gun), had to be unbolted and transported separately. The sponsons were loaded and unloaded five times on a typical journey from the manufacturers to France, involving a considerable amount of manual labour.[7]

The manoeuvring of tanks and sponsons required a degree of specialised, technical knowledge and was initially given to that body of men which had from the first been involved with the tanks and their predecessors, the armoured cars. These men were taken from Squadron 20, RNAS . They formed the Transport Section of the

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[2] *History of the Tank Corps Technical Office and Workshops*, p 1. The Tank Museum.

[3] Stern, *Logbook*, p 90.

[4] See chapter one. The London & North Western Railway was responsible for the transport of the machines from the Metropolitan testing ground at Oldbury and Saltly from the station at Spon Lane. The London & North East Railway performed the same function from Fosters of Lincoln. Presumably, as the war progressed and centres of production expanded, the testing ground in Glasgow linked up with these railways.

[5] Le Havre was also the closest main port to Amiens which had been designated the centre of British rail operations in France. Tanks weighed between 15 and 35 tons , depending on the type and model.

[6] The sites for the Tank Corps Central Workshops and Stores.

[7] Stern, *Logbook*, p 90.

MWSD within whose remit the transport of tanks lay until late 1917, when the Tank Corps, in theory at least, took control of both transport and testing.[8]

The severe constraints placed on the movement of tanks by the necessity of having to move them via centres where sufficiently powerful cranes were located was further complicated by the fact that tanks had only a very slow and uncertain reverse gear.[9] This effectively restricted the tanks to detraining in one direction only. It was not unknown for tank trains to arrive at their detraining station only to find that the wagons were pointing the wrong way. As a result the routes taken by tank trains had to be very carefully worked out in advance in order that tanks arrived at their detraining points facing the ramp. The fact that for reasons of secrecy they were nearly always transported at night further complicated what was already a very tricky procedure.

All of this made the movement of tanks a very time-consuming exercise. 'There was little heavy lifting gear outside the main ports. Side and end-loading platforms were hardly known on pre-war French railways. These" took time to construct, were easily seen from the air, and confined the movement of tanks to fixed points."[10] Also, their construction in sectors close to the front was an immediate signal that tanks were likely to be deployed in that area. "It was found to take 20 men ten hours to build a 1 in 7 ramp of sleepers."[11] Particular care had to be exercised by the locomotive drivers when aligning their trains as the slightest error on their part could result in a collision between their 600 ton trains and the relatively fragile tank ramps. The loading and

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[8] There is some confusion over exactly who was responsible for both testing and transport in the second half of 1917. The testing of tanks at the testing grounds near the manufacturers was nominally given to the Heavy Branch (Tank Corps) by the Tank Committee in May 1917, but this was not to be implemented until later in the year. But it is unclear when this actually took place. See chapter one for more on this.

Responsibility for transport seems to have followed much the same course. The *History of the Ministry of Munitions* and Albert Stern's *Logbook* both suggest that the Transport Section was made up of men from the RNAS, Squad.20. However, the *History of the Tank Corps Technical Office and Workshops*., suggests that it was the men of 711 Coy ASC , MT who were responsible for the transport of the early machines. Perhaps this reflects the "mixed parentage" of the Heavy Branch. The weight of evidence suggests that the men of Squad. 20 played the more significant role. The Transport Section was responsible for the movement of tanks from the testing grounds to Heavy Branch (Tank Corps) HQ in France until well into 1917. The RT& D of Central Stores assumed responsibility for newly arrived tanks at Le Havre from January 1918. But such was the tension that existed between the War Office and the MWSD - they were not officially talking to one another for much of the second half of 1917 - that it is unclear when this transfer of responsibility took place, and how effective it was when it did.

[9] The heavy tanks had a reverse gear of about 0.9 m.p.h. A combination of no visibility to the driver's rear, an extremely noisy environment making an outside observer's instructions very difficult if not impossible to understand, and a lack of sensitivity in small adjustments to direction all rendered the detraining of tanks from their wagons in reverse gear practically impossible, certainly without courting disaster. David Fletcher, librarian at the Tank Museum and an authority on tanks, particularly of this period, has driven the Museum's First World War tanks and this judgement is based on his experience.

[10] A.M. Henniker, *Official History of the War Transport on the Western Front, 1914-18*, p 312.

[11] Ibid, p 311.

unloading of tanks via the end of the wagons often resulted in considerable damage to the wagons.

Major E.W. Hick's, Royal Engineers,report "Movement of Tanks" (26 November 1917) on the transport of over 480 tanks in preparation for the Battle of Cambrai (20 November 1917) emphasises many of the logistical difficulties involved in moving large numbers of tanks around the battlefields of France:

"On the 5th September 1917, I was asked...to advise on the technical question of handling a large number of Tanks secretly and quickly for an attack which was under consideration.

The first proposal was to send forward 200 Tanks in one night. These would all have to be forwarded, received and detrained in the hours of darkness before midnight.

I found it was possible to erect the usual type of ramp for end entraining at the following stations which were the stated sector of the front :

RUYAULCOURT	2	roads
YTRES	2	"
SOREL	2	"
HEUDICOURT	1	"

It is necessary to have a straight approach, and in 5 of the 7 sidings only half a train length (of 12 tanks) could be dealt with at a time. I considered this not sufficient accommodation for so large a number of Tanks in a few hours. I therefore proposed side-off loading at two sites (BERTINCOURT and NEW HEUDICOURT, near EPEHY Avoiding Line).

I went to Erin on the 18th October and found from the "Tank" Corps standpoint, side detraining was possible, and arrangements proceeded on this basis. It was later found that the number of Tanks to be employed would exceed 200 : that they could not be sent forward in one night : that side detraining was not admissible. It was therefore decided to convert BERTINCOURT and NEW HEUDICOURT into end detraining ramps built across the main line.

Tanks were concentrated at PLATEAU, at which station 5 ramps were built in addition to one which was already there. 75% [sic] of the number were detrained at PLATEAU and later entrained for the forward stations. The remaining 25% went through without detraining at PLATEAU.

It was necessary for the Tanks to arrive at the detraining point facing the ramp so that they should not have to walk off backwards. This was arranged by each forward detraining point having its own entraining point at PLATEAU. To allow for contingencies and also for the 25% which came through without detraining at PLATEAU, a chord line was introduced at MARICOURT Junction. This line was used nightly during the move. Cross-over roads were inserted at YTRES and OLD HEUDICOURT for dealing with the traffic.

Tanks arrived at PLATEAU in trains of 15 tanks. Difficulty was anticipated in shunting in these heavy trains of about 700 tons gross against a ramp weighing about 20 tons. We experimented with hitting one with a loco, and found the ramp would stand a considerable blow without serious distortion. In practice however we found it impossible to ensure the train being in place at the end quite without a shock. The momentum of 700 tons even if hardly travelling was enough to damage the ramp sufficiently to put it out of action. One was so destroyed after 55 Tanks had been detrained, and yet all witnesses were unanimous in saying it was not a rough shunt which had done the damage."

The author then went on to describe(referring to a diagram which is sadly missing) the considerable effort involved in re-designing and strengthening the ramps made necessary by the effect described above.

"Owing to the secrecy of the move it was laid down as a first essential that the ramps at the forward stations were not to be stated before 48 hours before the move commenced. Also owing to the secrecy it was impossible to instruct gangs or even warn anybody of the work in prospect until very shortly before the building had to start.

Very careful forethought was necessary therefore in (1) Designing the ramps (2) Working out (a) the bill of quantities (b) the list of tools required (c) number of men required (d) length of time necessary (3) Preparing all special parts beforehand and distributing these and all tools the day before construction began. 10% excess material was sent to each ramp and in addition a stock was kept at a central point in case of damage to any ramp.

In actual result the quickest time for building a ramp was 6 hours with 15 men, This was for actual building, the preparation of the track and levelling of foundations having been done the previous day. The average time was about 10 hours with 20 men.

The total number of Tanks forwarded to date is 486. They were sent in 9 trains (of 12 Tanks) on each of 4 nights, and the balance later.

For the first time, each tank had to carry a large fascine on its back , which weighed 30 cwt. and was 4' 6" in diameter. It was necessary to put this in the travelling position before leaving PLATEAU.

When I was at Erin making experiments and learning what I could about Tanks, I had a fascine loaded on to the back of a Tank on a truck . I measured this and found it was 15' 6" above rail level. This I was assured was the travelling position, but when the first night's trains went forward from PLATEAU , many telephone wires were carried away, and on measurements being taken, it was found that there was considerable variation in sizes, and the highest were over 18' from rail level, which up to now has been the standard height for wires crossing the railway." [12]

One of the most critical problems associated with the transport of tanks was the availability of suitable wagons. The need for specialised wagons had not gone unnoticed by the Director-General of Transport, who had foreseen the problem in December 1916.[13] At this time he had asked the Great Western Railway Company for 50 wagons capable of carrying 25 tons. Meanwhile, existing wagons had to be pressed into service. The Nord Railway [14] had a type of flat truck capable of carrying 20 tons, but when loaded it could not travel on the Etat system, which served the Havre area, owing to the load being too high. However, the Etat system had at its disposal 50 wagons designed to carry 25 tons each. Because no alternative could be found it was these wagons which were used in the build-up to the Cambrai offensive, in November 1917. The 28 ton Mk IV machines which featured so prominently at Cambrai were a considerable burden to wagons designed to carry a maximum load of 25 tons. It was no surprise that, of the 43 wagons of this type used, 28 were later found to be so badly damaged as to be unserviceable.[15]

The French possessed wagons designed to carry rails, but owing to the tremendous pressure to lay new lines, and maintain the existing system, they could not be spared. British wagons designed for the same purpose could carry 48 tons, but the bodies of the wagons overhung the bogies, which often resulted in damage to the wagons when tanks were loaded and unloaded from the end. Like their French

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[12] Fuller papers, B / C / 1. See the map of the rail network in chapter 11 for the location of the rail stations mentioned in this report.

[13] A.M. Henniker,*Transport on the Western Front, 1914-18*, p 307.

[14] The Nord Railway covered that area of France within which the British sector fell.

[15] A.M. Henniker, *Transport on the Western Front* , p 306.

equivalents, they were also in great demand and scattered throughout northern France and Belgium. When in November 60 were required for the build up to Cambrai, only 24 could be gathered on time. [16]

By June 1917 the Great Western Railway had delivered the 50, 25 ton wagons ordered in December 1916 [17], with a further 26 to follow later in the year. These later wagons were fitted with screw-jacks which enabled the weight of the loading tank to be evenly dispersed over both bogies rather than being borne by just the one bogie as it had been with the earlier design. In April 1918 orders were placed for wagons capable of carrying 35 tons. This was later increased to 38 tons.[18] These specialised wagons were called "Rectanks" (Railway Executive Committee's Tank Trucks). By the end of the war there were nearly 400 of these in use in France.[19] Attempts were also made to remove the tell-tale construction of off-loading ramps from the front. The manufacture of "tank ramp wagons" was intended to combine the wagon with its own built in ramp which could be lowered in a relatively short time. As an experiment six of these were built in France out of old wagons. They proved so successful that a further 21purpose-built wagons were ordered from England. One of these wagons was eventually included in every tank train. [20]

The movement of tanks from England to France was to remain a protracted and labour-intensive process until the first Channel ferry [21] came into service in February

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[16] Ibid, p 307.

[17] Ibid.

[18] Ibid. See also Don Rowland, *British Railway Wagons*, p 125, and Peter Tatlow, *L.N.E.R Wagons* , p 100.

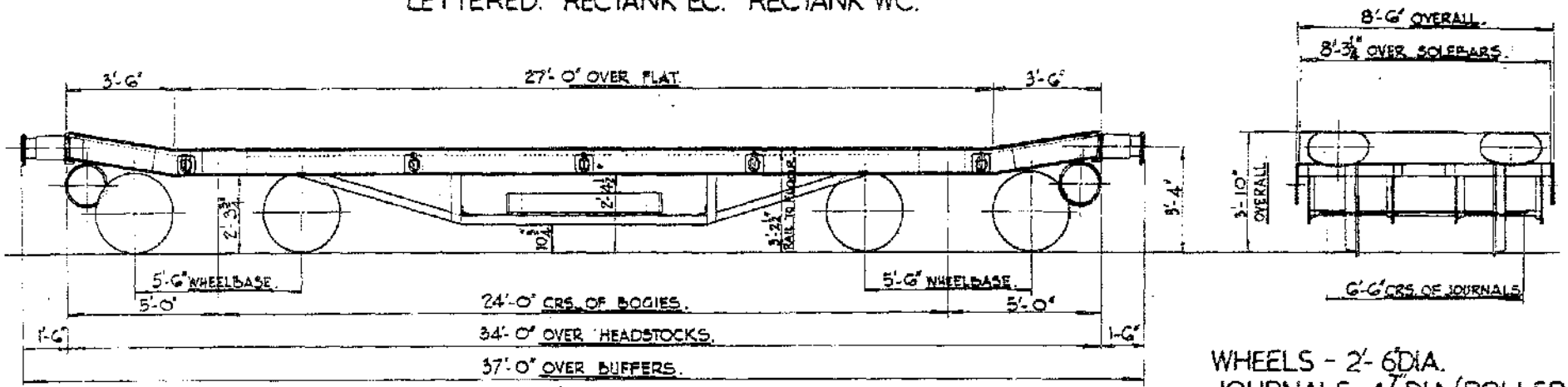
[19] A.M. Henniker, *Transport on the Western Front*, p 312. The exact number of Rectank wagons built in Britain during the war was 905. This figure can be broken down : the Great Western Railway Co., Swindon, built 78 38-ton wagons in three lots in early 1918 (Don Rowland,*British Rail Wagons*, p 125); Midland Railways, Derby Works, built 40 35-ton wagons in April 1918 (R.J Essery, *Midland Wagons*, p 168); and the Leeds Forge Co., built 787 wagons during late 1917 and 1918 (The Railway Gazette, 21 September 1920, p 20). Of the 905 some 240 were presumably built for the United States government to transport their tanks about France. Evidence for this can be found in a series of letters written during February 1918 between the Director of Railway Materials, E.W. Allen, and Colonel Wright, Controller of Iron and Steel Production [MUN 4 / 2801], concerning this order and the avialability of some 3, 600 tons of steel necessary to build them. The production capacity was available as Mr Allen wrote (23 February 1918), "The wagons they [the United States] require are to be exactly similar to those now being built by the Leeds Forge Co., for the Conveyance of the British Fighting Tanks." It is not at all clear that this order was finally sanctioned, but the fact that such a large number of wagons was built would support this. Further, it is not inconceivable that a certain number of these specialised wagons, perhaps a number approximate to the United States order, were also built for the French Army to facilitate the movement of their heavy tanks (British tanks, since the French models were of a light or medium design). One might therefore, support the the *Official History's* figure of some 400 in use by the BEF.

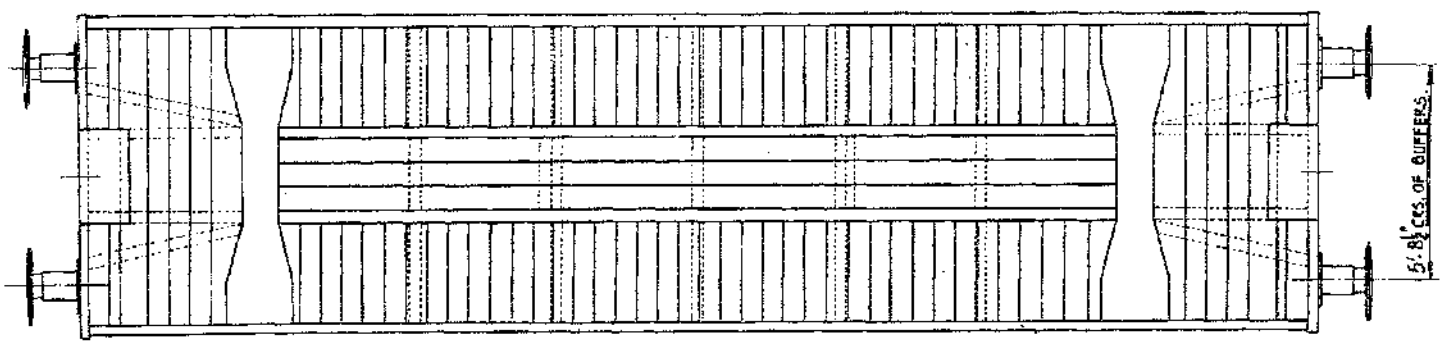
[20] A.M. Henniker, *Transport on the Western Front, 1914-18*, p 312.

[21] *History of Tank Corps Technical Office and Workshops*, The Tank Museum, Ch. II, p 21.

38TON RECTANK WAGON.

LETTERED. RECTANK EC. RECTANK WC.

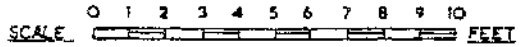




WHEELS - 2'-6" DIA.
JOURNALS - 4⅛" DIA. (ROLLER BEARING)
BUFFERS - SELF CONTAINED.
BUFFER HEADS - 24" x 14" OVAL.
COUPLINGS - INSTANTER.

TELE. CODE. - RECTANK EC. RECTANK WC.
BRAKE - STD. SLACK ADJUSTER (SCREW.)
THROUGH VACUUM PIPE.
MINIMUM CURVE. - 70 FT.
TARE. - 15 TONS. 3 CWTS.

FLOOR AREA (EXCLUDING RAMP ENDS) - 223 SQ. FT.
FLOOR - WOOD.
BODY - STEEL.
BODY BOLSTER - CAST STEEL.
BOGIE - CAST STEEL.



1918. This roll-on-roll off train ferry enabled the tanks to be transported directly from the testing grounds in England to the tankodromes in France without having to be unloaded from their Rectank wagons. The first tanks to be shipped by the ferry arrived in France on 27 February. The trip from Birmingham to Teneur took just 48 hours. Captain T.E. Wender, officer in charge of the Receiving, Testing and Despatching Section of Central Stores (RT & D), commented in May that tanks were arriving from England by ferry in unprecedented numbers. Whereas it had been previously unusual for 20 machines to arrive in a day, he recalled that on one occasion 49 had arrived, completely swamping the reception staff. [22]

Tanks under their own power

Once the tanks left their rail wagons they still trailed behind them a long umbilical connection from the nearest standard gauge railhead. The tank was entirely dependent on vast quantities of fuel, oil, grease, spare parts, ammunition and a host of other items indispensable to the tank's progress, all of which at some stage of their journey from stores to the forward tank depots would be moved by rail and road. The logistical problems posed in attempting to keep tanks in the forefront of the military advance were enormous.

After the tanks had been transported by rail to within a relatively short distance of their starting point for the next day's battle (invariably by night to maintain secrecy), a new set of problems emerged to do with the difficulties of moving tanks under their own power. Transport problems were discussed at the first meeting of the "New" Tank Committee on 26 November 1918 :

> " If sent by road [that is under its own power a tank] must not be too heavy to cross the bridges it will meet with, or special arrangements for crossing streams, rivers etc., must be made for it. If sent long distances by road the wear and tear on certain parts may be very heavy before it arrives in the fighting area." [23]

Wet and boggy conditions highlighted the tank's poor off-road performance which often confined them to the roads on their way to the front . This was an entirely unsatisfactory situation given that these roads were always very congested with vital motor transport. The nature of the tracks and the weight of the machines contributed to the serious damage and congestion of the road network. Ironically for a machine so

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[22] Ibid, Ch III, p 9.

[23] WO 158 / 859. This is a point will be raised again in more detail in the discussion on tactical employment during the last 100 days.

reliant on rail transport for fast and efficient movement about the country, the tank could unintentionally do a great deal of damage to the rail lines themselves. Further, the lines themselves could at times prove an obstacle to tank movement. Special ramps, or at the very least make-shift arrangements involving railway sleepers, had to be used to ensure that not only did the tanks' tracks not damage the rail lines as they crossed them, but also that the tracks themselves were not damaged by the manoeuvre. Further compounding the difficulty of moving tanks around under their own power, their passage to the front lines had to be cloaked in darkness as had been the case with the tanks' earlier trip by rail, but now it required the added assistance of the RFC / RAF to over-fly the tank manoeuvres providing a sound barrage to mask the noise of the tank engines. All of this in order to preserve secrecy of movement.

Until March 1918 the limited employment of the tank and the static nature of the war meant that, although these problems could not be ignored, they were manageable. But, once the German spring offensive and the Allied counter-offensive of July reintroduced mobility to the battlefield, they became critical. The tank's poor off-road performance together with its inability to cross even relatively small rivers without the aid of engineers and wooden cribs, soon found the tank flagging behind the British advance once the Hindenburg Line had been broken. The tank could not even make use of most road bridges which, in theory, offered a means of crossing the numerous water hazards which faced the British advance in late September and October, since most were not capable of carrying the weight of a heavy tank . Moreover, to have relied on road bridges to assist in the forward movement of tanks would have led to the dangerous bunching of tanks at key strategic points rendering them vulnerable to German artillery or sabotage attacks.

In conclusion. The introduction of the Channel ferry not only meant that tanks could be delivered in record time and numbers, but also that other stores and vital materials could also reach France with the same efficiency. However, a general shortage of locomotives and rolling stock for the BEF in Belgium and France (not until the final three months of the war would Britain approached self-sufficiency in these), and in particular a lack of specialised wagons prevented this efficiency being reflected in the distribution of tanks and their stores about the battlefields of France. By the early summer large numbers of Rectank wagons were being manufactured, thus providing the solution to one problem. But by this time having the locomotives and rolling stock counted for little when German saboteurs were destroying and mining vital rail and road links in the wake of their rapidly retreating forces after the failure of their spring offensive. [24] The problem by the late summer of 1918 had therefore shifted

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[24] A.M. Henniker, *Transport on the Western Front*, p. XV. The German spring offensive set back the expansion of the British railways in France when some 300 locomotives and petrol tractors (used for

from being one of a shortage of rolling stock with which to transport tanks to one of a shortage of rail lines to operate them on. At the same time the performance of the new Mk V tank, which made its debut on the battlefields of France in the summer of 1918, and which represented a technological improvement on the Mk IV, still suffered from suspect reliability and limited cross-country capability. Therefore, like its predecessor, the Mk V was still confined to operations in the immediate locality of standard gauge railheads. On 31 October 1918, General Furse made a statement to the Tank Board which again focused on the tank's dependence on rail transport : "Tanks [are] an urgent necessity, yet they are useless unless there are sufficient locomotives to transport them." [25] This will be discussed in greater detail the chapter 11.

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pulling on the narrow gauge lines) had to be stripped of vital parts and abandoned to the German forces. Also some 2, 000 wagons had to be burnt rather than let them fall into the hands of the enemy.

[25] WO 158 / 867. Tank Board meeting (31 October 1918)

[6]

*The **Imperfect** Machine*

The tank had evolved from an agricultural tractor to the most sophisticated and technologically advanced weapon of war (outside of the battleship aeroplane) in less than three years. However, its mechanical novelty was not matched by reliability on the battlefield. It was, therefore, the mechanical frailty of the tank which was to prove the most significant factor in determining the tank's role on the battlefield, confining it the a subordinate, peripheral role of an infantry support weapon.

Early development

The story of the development of the tank has been told time and again. This thesis will, therefore, touch on it only briefly in an attempt to convey some of the enthusiasm and support that the tank project recieved, and also to stress again the pace of technical development which inevitably led not only to problems in the drawing offices and erection workshops in England, but also on the battlefields of France.

In his memorandum of 28 December 1914 Lieut-Colonel Maurice Hankey,[1] Secretary to the Committee of Imperial defence (CID), posed the rhetorical question : "Can modern science do nothing more ?" What concerned him was the growing impasse to open warfare presented by the maze of trenches and other fortifications which had been springing up on the western front. He suggested a possible solution to the problem, involving engines, bullet-proof armour and heavy rollers for crushing barbed wire. When the First Lord of the Admiralty, Winston Churchill, read this memorandum he was inspired, on 5 January 1915 to write to the Prime Minister H.H. Asquith, to state confidently that :

> " It would be quite easy in a short time to fit up a number of steam tractors with small armoured shelters, in which men and machine guns could be placed, which would be bullet-proof...The caterpillar system would allow trenches to be crossed quite easily and the weight of the machine would destroy all wire entanglements . Forty or fifty of these machines [would be enough]..the cost would be small. If the experiment did not answer what

[1] *M of M*, Vol XII, Pt III, Appendix 1, p 80.

harm would be done ?" [2]

The Navy had been actively involved in the development and employment of the tank's immediate predecessor, the armoured car. The Armoured Car Section of the Royal Naval Air Service (RNAS) had been established by Churchill on 1 September 1914 to recover navy pilots forced to make an emergency landing in the Dunkirk area. Armoured cars developed by Commodore Murrey F. Sueter and Squadron-Commander (later Major) T.G. Hetherington, were armed with a revolving turret, machine guns and overhead armour protection. There was also a heavy version which was armed with a 3-pdr gun. These cars , whilst obviously very different from the tanks of late 1916, were part of the evolutionary process, and experimental work done on armour-plate for construction on these cars at Wm. Beardmore, Glasgow, was to prove invaluable for tank production.[3]

But the Navy was not alone in spotting the potential of mechanical warfare. The Army also had its team of enthusiasts. Major E.D. Swinton, Colonel M.P.A. Hankey, who was Swinton's immediate superior at the CID, and Captain Tulloch, a ballistics expert formerly of the Chilworth Powder Co, completed the trio which shared the idea of creating a "land cruiser." [4]

In January 1915 the trio approached Maj-General Scott-Moncrieff, Director of Fortifications and Works, as the person most likely to be receptive to "their" idea. Tulloch's idea for a bullet-proof, motor-driven, personnel-carrying and armed vehicle pre-dated the war by several years. After its debut in September 1916, once the secrecy which shrouded the infant machine was lifted, various "inventors" emerged from the woodwork to claim the invention as their own. But in reality it was an idea whose time

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[2] Gilbert, *Churchill : A Life* , p 293. It is ironic, perhaps, that here Churchill felt that "forty or fifty" machines would be sufficient to prove the new weapon's worth, yet some eighteen months later he was one of the most vociferous critics of the early employment of the first tanks - 49 tanks in all - in September 1916, when as one of many critics he suggested that the tank's debut should be delayed until greater numbers were available.

[3] Armoured Car bodies were produced at Wm. Beardmore, Ltd., Armour-Plate Department, Parkhead, under the supervision of department manager T.M. Service and with the assistance of Lieutenant K. Symes, representing first the Royal Naval Air Service, and later the MWSD (a post he held until October, 1917). The department conducted exhaustive tests on steel of varying thickness and type using the German Mauser rifle bullet, and even a captured German machine gun supplied by Colonel E.D. Swinton. Lieutenant Symes is reported to have fired his rifle from a position " just round the corner...".

Incidentally, it is worth mentioning, in regard to the rapid evolutionary change in design which was to prove such a problem for tank production continuity, that Service experienced similar problems with the tank's forerunner. "So rapidly", he wrote in the *Beardmore News,* 26 February 1919, "were opinions changing in these early days that the [armoured] cars were obsolete as soon as finished and the design improved as experience was rapidly gained."

[4] Ibid, p 10.

Punch. Nov.

THE GREAT UNKNOWN.

JOHN (to unknown inventor): "Tanks."

had come. [5] The Army team envisaged their machine moving on "caterpillar" tracks. Swinton had in mind the tracks used by the Holt Caterpillar Tractors, of the United States, for his machine.[6] Swinton submitted his memorandum entitled: "The Necessity for Machine Gun Destroyers",[7] to Sir John French, Commander-in-Chief of the BEF who, on 22 June subsequently forwarded it to the War Office. In his memorandum, Swinton suggested detailed specifications for his machine. Although the idea of an early armoured vehicle had been discussed and early experiments had been conducted, there were no fixed specifications for the first tank. At this time no one knew exactly what the War Office wanted.

Swinton's specifications called for a machine weighing some 16 tons when fully manned and equipped. It was to be armed with a "2-pdr quick-firing Maxim and 6 Madsen rifles."[8] It was to be capable of achieving a speed of 4 mph over flat ground and crossing a ditch four feet wide (anything wider should be passable by the machine first climbing in and then climbing out). The armour-plate should be capable of

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[5] The original idea for a "Tank" like vehicle was not confined to the British Isles. In 1911 Gunther Burstyn, an Austrian inventor, offered his designs to both the Austrian and German governments who both rejected it. In 1912 the British Army rejected Australian Lancelot de Mole's ideas for a tracked armoured fighting vehicle (David Fletcher, *Landships British Tanks in the First World War*, p 3, and Chamberlain and Ellis, *British and German Tanks of WW I* , p 21). After the tank's debut, questions were raised in the British press and in the House of Commons as to who was responsible for the design and promotion of the new weapon. Claim and counter claim involving Churchill, Lloyd George, Commodor Murry Sueter, RNAS Armoured Car Division, and Colonel Swinton amongst others, failed fully to resolve the issue. In November 1919 the Royal Commission on Awards to Inventors finally awarded £15,000 each to Mr. Tritton and Major Wilson. Other influential figures received lesser amounts. Yet the matter was not resolved to everyone's satisfaction. A Scottish sugar planter named R.F. Macfie, who was awarded £500 by the Commission, claimed that this sum did not reflect his contribution to the early development of the tank. Returning from the West Indies to join the RNAS, he recalled how he had whilst in the Caribbean seen Holt tractors at work on the plantations and that his idea and subsequent model based on this experience had in late 1914 provided the inspiration for experimentation with the creeping grip tracks by the Landship Committee. (The Macfie Papers, Glasgow University Archives). Clearly, the idea was very much in the air !

[6] It is ironic, although perhaps sadly not out of keeping with the Britain's record of failure in bridging the gap between invention and commercial production, that patent fees had to be paid to the Holt Manufacturing, Co., U.S.A, for what was, originally, a British invention.

Various attempts had been made throughout the 19th century to devise a workable track system in Britain, but with no success. As ever war proved the motive spur to over come the difficulties. In 1903 the War Office offered a prize of £1000 for a tractor which could haul a 25-ton load for a distance of 40 miles without stopping to take on extra water or fuel. The prize was won by R. Hornsby and Son, of Grantham. David Roberts, Hornsby's Chief Engineer, had visions of mechanising the whole of the Army's artillery. In 1906 he fitted his own design of track to the prize winning tractor. The new machine, christened the "Caterpillar", encouraged Roberts to experiment further. He fitted wooden wheels and tracks to a Mercedes car which reached a speed of 25 mph on Skegness beach - a record for a tracked vehicle which was not broken until after W.W. II. Yet, the Army showed little interest, seeing little future for the track system. Hornsby's sold it to the Holt Manufacturing Co., of the U.S.A. in 1912 for the sum of £4, 000. For the full story see the " Lincoln Tank Papers ".

[7] *M of M.*, Vol.XII, Pt III, Ch 1, p 19.

[8] An automatic rifle of Danish origin.

resisting the German steel-cored armour piercing and reversed rifle bullets. [9] There was also the suggestion that the machine should pivot in the middle if the weight proved too heavy for one set of tracks. These specifications formed the general basis for discussion when the Joint Military and Navy Committee met on 30 June 1915. At this meeting it was decided by Scott-Moncrieff and d'Eyncourt that experiments should be conducted to produce a machine based on a revised set of specifications. The machine had to be able to go backward as well as forward, preferably at the same speed:

> "... it must be able to bridge 5' gaps without falling into them , anything wider it should be able to climb out of; it should carry petrol and water to last at least twenty miles ; it must be able to climb parapets 5' high and 5' thick; and have a weight not exceeding the strain on bridges created by 14 tons on an axle with a pair of wheels." [10]

Having decided on a basic design format, research and development programmes into so called "Big Wheeled" and Crompton's "Pedrail" machines were abandoned in an effort to focus resources.[11]

The research and development programme continued at Foster & Co., Lincoln who received the contract on 24 July to build the first machines (up to 12 in total). Inspired by the creative imaginations of William Tritton, chief designer, and Major Wilson, the works quickly produced a range of prototypes. The "No.1 Lincoln Machine" (also known as the "Tritton Machine") entered early trials in September 1915, closely followed by "Little Willie" which began trials in December. But the most successful design, and the one which introduced the now famous lozenge shape, was

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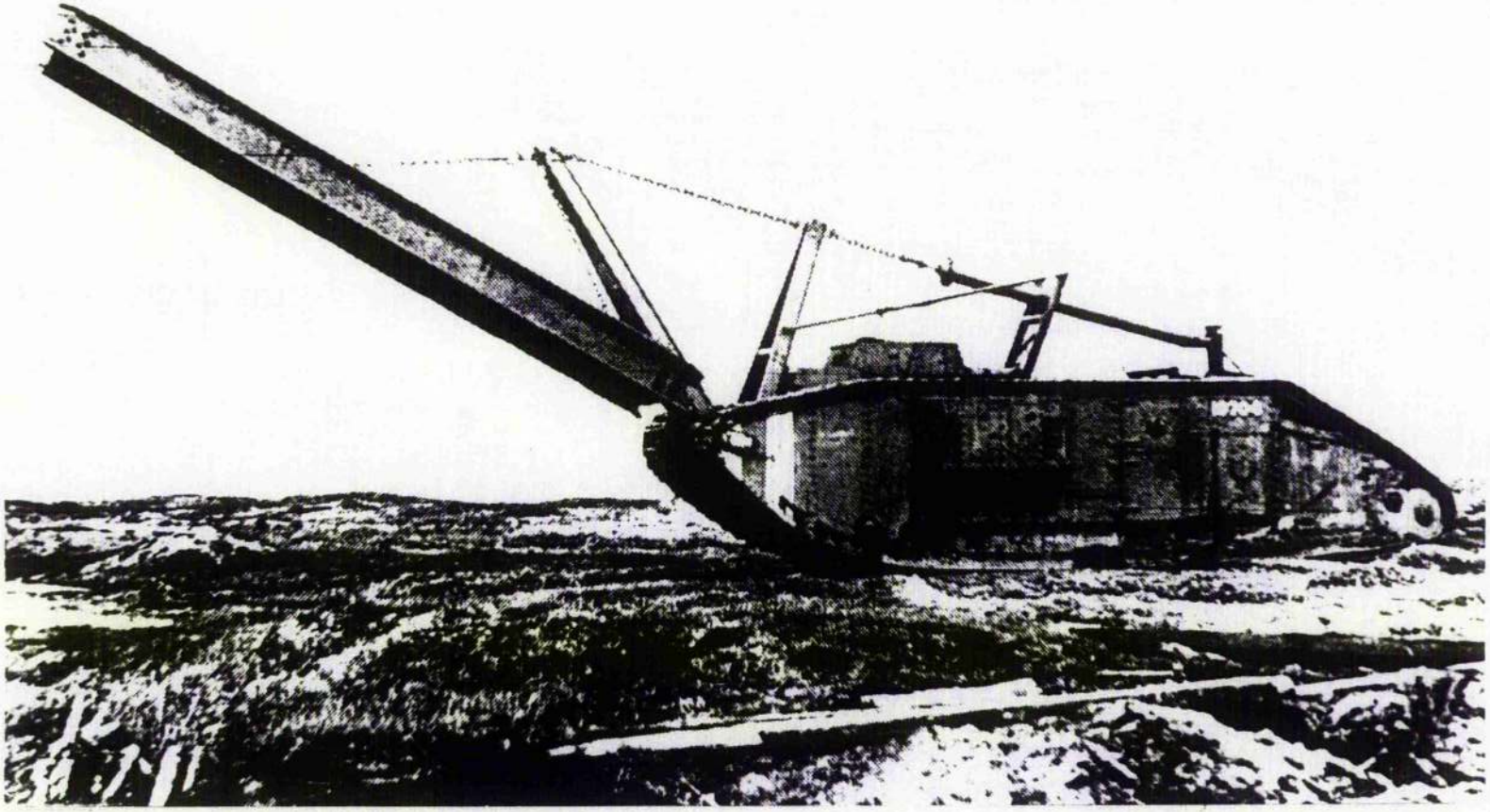
[9] Experiments to produce armour-plate capable of resisting the German steel-cored armour piercing and reversed bullets were being conducted at Wm. Beardmore's Armour-Plate Department, Parkhead, under manager T.M. Service, and Lieutenant K. Symes, MWSD. Writing in the *Beardmore News* , 26 February 1919, Service said "...the Germans about this time [were]....using their Mauser bullet in the reverse way ... this gave the bullet much greater penetrative power, so that the 7m/m plate which would stop the bullet fired pointed nose foremost was easily penetrated, and it took 10 m/m to stop the bullet fired the reverse way".

He continued, "It was strong evidence of German preparation for the war that all Mauser bullets were so constructed that they could be removed by hand and replaced in the reverse way in a few minutes." This does, of course, ask the question as to why the Germans felt they would need such ammunition before the war - aircraft perhaps ?

Finally, regarding the steel-cored bullets "...the armour piercing bullet , originated by the French and produced later by the Germans, ...[the] feature of these bullets was a central core of special hardened steel alloy which did not break up on impact, but could pass through a steel palte with very little damage to itself and still with a fairly high velocity. This new bullet necessitated much heavier plates and later Tanks were fitted with 16 m/m (more than 5/8") thick."

[10] *M of M*, Vol XII, Pt III, Ch 1, p 19.

[11] Big-Wheeled (so-called because they literally had big wheels of 15 feet in diameter) were constructed by Fosters of Lincoln. They were essentially giant agricultural tractors with armour plate. Pedrail machines were self-propelled tracked trailers fitted with armour plated shields. Six of the former and twelve of the latter were ordered in February 1915.



Another variation : a bridge-laying tank, 1918.

begun when the previous two machines were still in their early stages (such was the pace at which the tank project was developing - a pace which was never to slow) and was called variously "Mother", "Big Willie" or the "Centipede." It first ran at the Fosters works in December 1915 and officially went for trails at Hatfield Park on 26 January 1916. The success of these trials, as we have discussed above, led to the war Office placing its first big order for 100 machines. The tank had entered the first phase of mass production.

There was a sense of tremendous energy and enthusiasm surrounding the tank's development and production programmes, and the considerable achievements of those involved. Yet for all this the tank, even in late 1918, was still lumbering and unreliable ; in need of constant attention and coaxing by mechanical attendants to keep it in action. Inevitably the never ending changes in design - the result of on-going research and development, which only goes to highlight the support that the tank enjoyed in both civilian and military circles - had a negative effect on the continuity of production, with neither the Tank Corps in France, nor the MWD in England being in possession of permanently fixed drawings for any one tank. Inevitably, this had a knock-on effect in terms of continuity of orders from the War Office. Which tank model were they to order in large numbers ? To place such an order would be to commit the Army to a machine, which given the rapid pace of technological change, was likely to be rendered inferior if not obsolete by the next model to come off the drawing-boards of the research and development personnel. But not to order one machine in large enough numbers to enable the MWD secure manufacturing capacity risked the future of a large scale tank programme. Inevitably, therefore, a "Catch 22" situation quickly developed.

Into action

The first machines went into action in September 1916 with large steering / balancing wheels attached to the rear of the tank. Some carried anti-grenade frames on their roofs constructed of wood and chicken-wire. Neither of these innovations survived the passing of the first Mk I model. Yet, to the casual observer successive models of heavy tank would seem to have remained remarkably unchanged, reflecting the not inconsiderable efforts on the part of both the MWD and the War Office to achieve continuity of production where ever possible. Increasing the length of the Mk V* and Mk V** by some six feet is an obvious example of the effort to find compromise solutions to immediate battlefield obstacles. The only real exceptions to this rule were the Mk VI, which did not progress beyond the stage of a wooden prototype (largely because its design, featuring a centrally mounted gun, was too radical a departure from the existing line of models and would, therefore, have posed

enormous continuity problems in the production workshops and drawing offices) and the ill-fated Mk VIII tank of 1918. However, in order to improve both reliability and performance, it was necessary constantly to improve many small, but vital, internal component parts - hence the absence of fixed drawings. The tank - both heavy and medium machines - of late 1918 represented a phenomenal leap forward in the technology of warfare, and was constantly improving. But to reiterate, it was still a ponderous and essentially unreliable weapon whose capabilities fell considerably short of those supposedly possessed by the"mythical" machine beloved of the so called "pioneers" of tank warfare.

The personal account of Major E.R. Parsons's experiences in the 8th and later 10th Tank Battalions and in the advanced workshops reveals some of the obstacles which had to be overcome on an almost routine, daily basis in order to keep tanks in the field :

" About October [1917] we entrained for the Ypres area, detraining at Onderdom later at night. Here the Coy. Engineers and their field sections had a very hard 48 hours fitting on unditching gear which had been taken off old tanks. Some sprockets had to be changed and there was other such work to be done. The field section and a few of the crews had to work all night under very bad conditions as to rationing, accommodation, etc. A few men who could use a cold set and a sledge would have been invaluable as also would a few rough drilling machines.

We had a long trek to Vormezeele. One tank being burnt out and two badly ditched before getting there. While we were stationed here tanks were sent up beyond Ypres doing towing work, breaking differs [differential gearing ?], getting hopelessly ditched and upsetting traffic on the wooden [?] roads, etc.

After three or four weeks of this we eventually got back to Monteneiscourt for preparation for the Cambrai battle. We fitted new sprockets to nearly all the tanks [also] unditching rails, got fascines on board and practised with the infantry for the fortnight and then went up to Dessart Wood...where the Tanks were got into [sic] as near a state of perfection as the field sections could make them. Not a thing was forgotten or carelessly done and my field worked with a will and a spirit they had never shown before.

A very trying treck [sic] on the night before the battle brought the Tanks to their jumping off place behind our front line. Right up to the last minute all my fitters were going round the tanks looking to the last details, examining spare brake boxes, testing fan belts, looking for loose nuts, etc.

During the Battle my field section again showed its worth for inspite of instructions they followed up the tanks, actually helping some of them out of ditches. I found them all ready and waiting at the rallying point. This is when the presence of the field sections was felt for many of the tanks and crews came back in very poor condition and during the next day or two several new extension shafts, clutches, Auto-Vacs, etc., were put in and some of the tanks were sent into action 2 or 3 times.

The Batt. tecked [sic] back to Fins and again the field section functioned at high pressure for about 20% of the tanks were reported fit for action, yet in less than three hours notice all save one were sent forward again when the Enemy broke through. Crews could not have done this work , did not know how to, nor had they time...After Cambrai we went back to work at Bray, where great trouble was experienced with freezing radiator pumps, tracks, engines, etc."

"6 hours after the action [April 1918 but not named] only about 3 [of 8] of the tanks could return to Batt. H.Q. All the others were either ditched or had broken gear box (one) or broken sprockets (one). With a party of men and 2/Lieuts. Jones and Stuart I got four of them back to a place of comparative safety and would have eventually got the other back on 1st May [but] I was returned to the 8th Batt. who were about to draw Mark V's. After the "panics" on the part of H.Q. re bull-pinion shafts and couplings, we entrained at Erin for the Amiens Area. Detraining at Poulainville we only had one trouble - a clutch - this was eventually found to be clutch pedal and R.H. epicyclic level fouling. Trecking up to Querrieu Wood one engine had a burnt crank-case and the obtaining and putting in of a new engine took us more than a week. After a 24 hours rest at Q.Wood Coys. set off to other positions round about Blangy Tronville. One gear box needed a new cross shaft and bushes before starting. I

believe that after this new gear boxes repairs were carried out by M.S. Sgt. and crews under the Coy. Engineers. It was quite successful, but slow.

When the tanks eventually arrived at their locations Coy. Engineers proceeded to get them properly fit...Eventually we attacked Hamel on July 4th...This was a very good action from our point of view. The Engineers had taken great pains with the tanks both before and during the approach march and each tank was seen to its starting off point and inspected. All tanks got into action and all but 3 came out the same morning. These had mechanical trouble but were got back within 48 hours. The Batt. reformed in its old position round Blangy Tronville where the tanks were repaired and got fit again.

At the end of August about 16 fit tanks all remaining to H.Batt. entrained at Villers-Brettonneux for Boishux au Mont. From here I went on leave and returned to 8th Batt. at Tincourt Wood when they moved in two days time to a stop half way between Roisel [and] Hargicourt. The following morning we attacked through Hargicourt to Bellicourt. One tank ran all its big ends and another burst its engine, 2 ditched and were burnt out, one hit and burnt and 4 or 5 badly hit. The remainder returned to Hargicourt next day.

A composite Coy of 6 was lent to 16th Batt. of these 6 only one got into action owing to the very bad state of the ground to be passed over and also to the fact that the Batt. did not take any of our engineers with them to look after our own 6 tanks."[12]

Major R.P. Butler recounted similar experiences of *ad hoc* mechanical arrangements in order to over come persistent failings in the fuel and cooling systems. In some cases these failures occurred as a result of damage in action, in others their failure directly contributed to the tank being abandoned in the field. He described one example where "...a couple of 4-gallon oil drums connected in series to the water jackets of the [engine's] cylinders through a semi-rotary pump." This pump had to be worked by hand'...and the tank would usually go a quarter to half a mile before the water boiled away. Then we had to stop and fill it up again from a shell-hole." It was he said "rather crude, but when one's average speed was about one mile an hour an occasional stop for a few minutes made very little difference."

Problems were also experienced with the petrol feed system. The first tanks had been fitted with a pressure feed system, but the precarious angles that the tanks frequently had to negotiate often left the engine starved of fuel. According to Butler the replacement system called the "autovac" was supposed to be :

> "...more fool-proof. But in practice it gave infinitely more trouble. Sometimes we drove tanks for hours by 'spoon-feeding', i.e., a man sat by the carburettor with a can of petrol and kept pouring it into the float-chamber to keep it full."[13]

There were, of course, other mechanical ailments which affected the performance of the tank. One of the most common was the failure of the sprocket wheel, but this will be discussed in some detail below in relation to the availability of spare parts.

The tank's problems were not confined to internal mechanical matters. Even when operating efficiently the tank left a great deal to be desired. Its poor top speed

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[12] Major E.R. Parsons, "Experiences in the Tank Corps, 1916-18," Tank Museum, pp 7-8 & 10-11.

[13] Major R.P. Butler, "Reminiscences of Salvage Work," The Tank Corps Journal, June, 1932, pp 59-60.

and very high fuel consumption which, on average, were between 1-2 mph, and between 2 - 12 gallons per mile , depending on conditions, severely limited its role. The "Official" figures suggest that the top speeds of the Mk IV, V and Medium 'A' were : 3.7, 4.6 and 8.3 mph respectively, but in reality, as Butler suggests, they were often very much less. "Official" fuel consumption figures must also be taken with a pinch of salt. For the two heavy tanks they are approximately 2 gallons per mile (gpm), and for the Medium 'A' they work out at approximately 1.5 miles per gallon (mpg). But again practical conditions often resulted in very much higher figures.[14] The transcript of an interview with Captain D.M.F. Sheryer, former commander of the 6th Battalion (when it was equipped with Mk IVs and later with Medium 'A's) reveals that 12 gpm was not unusual.[15]

The tank was created to resolve the log-jam of static warfare; its trench spanning ability was therefore crucial to its success. But at times unusually wide and deep lines of enemy fortification found it wanting. And, of course, experience soon taught the German forces that the excavation of especially wide trenches could thwart tank attacks. These were countered in the short term by the use of fascines [16] which filled the trenches allowing the tanks to drive over them. Tanks also found it difficult to operate where the terrain was wet and boggy, and where trenches, shell-craters and boggy conditions combined, as they often did, the tanks frequently became ditched. The records of tank operations are littered with references to having "ditched" in action with the result that the crew had to abandon their tank and make for the safety of their own lines. Stranded in such vulnerable positions, these tanks often became the targets for concentrated German artillery which could, as we shall discuss below, render a tank completely unsalvable. To overcome these weaknesses a variety of measures were implemented. Over the medium term the answer was to increase the length of the tanks and therefore improve their trench-spanning ability.[17] But this did not take place until early 1918 because of the pressure to maintain continuity of production. In the short term a partial answer was found by the addition of what became known as "unditching beams." Butler described the process by which they came into being :

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[14] The "official" figures are available from a wide range of sources including : "Military Characteristics, 1916-19 : Tanks." Issued by the Inspection department of the Royal Arsenal, 1925. Also, "Tanks : Description and Construction Details," Tank Museum; Chamberlain & Ellis, *British and German Tanks of WorldWar 1*, p 75. and Sir E. d'Eyncourt," Account of the British Tanks Used in the War", Engineering, 1919, p 337.

[15] Captain D.M.F. Sheryer, "War Experiences", the Tank Museum.

[16] The construction of these fascines by Chinese labour is described in chapter 3.

[17] The "Tadpole Tail" was just such an attempt to increase the length of the Mk IV tank without severely disrupting production. It was unsuccessful and was superseded by the "stretched" version of the Mk V, the V* and V**.

"The first unditching gear made its appearance at Arras in April 1917. It consisted of two short beams which could be attached, one to each track. The tracks being free to work independently , the tank could keep these beams on throughout an action. As can be imagined, the running of the tank, particularly on hard ground, was not improved by them, for progress was a series of crashes. There was a crash as the tank rode over each beam, another as the beam was drawn forward past the ' cab', and another as it fell down in front of the 'nose'. The early tanks were clumsy at best, but with the ' torpedo unditching gear' they reached the limit. At the same time, it was better to ride bumpily than to be ditched, and this unditching gear was undoubtedly better than none. We found that for extricating a ditched tank the effectiveness of this gear was vastly increased by putting a sleeper through the chains by which the beams were attached to the tracks, and this idea occurred to others also, and resulted in the standard unditching beam which was first used in the Mark IV tank at the third battle of Ypres on July 31st, 1917." [18]

Continued research & development

A brief discussion of some of the ideas which emerged over this period, particularly the new innovations which would have gone into production had the war continued into 1919, further demonstrates the support and enthusiasm that the whole tank project excited.

When the Advanced Workshops were created in late 1917 and early 1918 one of the five units (No.3)was designated an experimental unit. Under the command of Lieut-Colonel Philip Johnson it concerned itself with the search for practical solutions to the immediate technical problems being encountered by the tank. It also undertook a wide range of developmental work which led to the emergence of some of the most novel and useful machines of the war.[19]

It is worth noting here that although the civil and military bodies supported the development of the tank they were not always agreed on how best to achieve it. In theory at least the testing of new machines and their transport were transferred to the Tank Corps in late 1917, but when, or even whether, it was possible to draw a clear demarcation line between production and user in this area is very difficult to say. Although testing and transport were supposed to have been transferred, design (which also included experimentation) remained very firmly in the hands of the MWD. However, the creation of Johnson's "rival" body in France, with its "interference" in matters of design, was as much a result of the strained relations

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[18] Major R.P. Butler, "Reminiscences of Salvage Work", p 43.

[19] Major S.G. Brockbank, "History of the Central Workshops", Ch VIII, pp 1-5.

between MWD and France, as it was an enthusiastic response to the needs of the further development of the tank.

The extent to which relations between the MWD and the Tank Corps remained difficult over the issues of design and experimentation even as late as November 1918, can be seen in Lieutenant Shaw's letter to Maclean (2 November 1918) :

> " It has never been fully appreciated how serious and far reaching the results of carrying out experimental work in France.
>
> It is inevitable amongst large numbers of Engineers possessing both practical and theoretical knowledge that a great many suggestions for the improvement of tanks should arise. Provided these suggestions are sifted out by the Technical heads in France and those of value forwarded to the MWD there is no harm, but if any of these suggestions are immediately acted and Central Workshops or Advanced Workshops put on to carrying them out [sic] on actual machines, the result to my mind is serious. Suppose the suggestion is of no value then valuable manpower and material has been wasted, but suppose the suggestion is of value it at once becomes widely known and a feeling of dissatisfaction with the existing machine is spread broadcast . The suggestion, for the purpose of experiment, may have been carried out in a rough and ready manner and prove quite satisfactory for a short trial and the assumption made, that if properly designed and carried out in a serious manner the result would be equally satisfactory under actual working conditions, which may prove a fallacy. Further the suggestion may be of a nature which is not applicable to machines in production and in consequence a delay of six or eight months may occur before it can be applied. Meanwhile the feeling that this Department is not ready to accept the results of investigations in France is engendered and the foundations laid for the statement so frequently heard that the MWD is not prepared to adopt any suggestions put forward by the Tank Corps, France.
>
> The desire to put to immediate test such suggestions as would seem big improvements is quite natural but for reasons already given these should not be carried out in France. arrangements which are made for carrying out this work at the MWD Experimental Ground [Dollis Hill] or suitable Contractors Works should provide for the close co-operation of those putting forward the suggestion." [20]

Johnson's unit worked on projects as mundane, though important, as solid flange rollers for the tank tracks and sledges to tow field guns to the more imaginative mounting of 3-inch and 6-inch trench mortars either directly on to existing tanks or on to tail extensions known as "tadpole tails." Perhaps the project for which Johnson is best remembered is the last British tank design of the war, the Medium ' D' tank. With its 240 hp Siddeley Puma aero-engine it was intended to have top speed of over 20 mph, and would have filled the role of the "pursuit tank" envisaged in Fuller's " Plan 1919." It made use of Johnson's earlier development in track design, the "Snake" tracks. Their creation stemmed from his interest in improving the Mk V's speed and ride quality. Consisting of a "sprung wire rope with flexible track shoes", they enabled the tracks to self-adjust, compensating for irregularities in the ground. When fitted to a

[20] MUN 4 / 5201.

Mk V test model, they improved its top speed to 12 mph. The Medium ' D' was also intended to have an amphibious capability (eliminating the problems of having to rely on engineers to build special bridges or to modify existing railway bridges in order that tanks could cross rivers and canals), the "Snake" tracks acting as a means of propulsion through the water. But the Medium ' D' machine was plagued by engineering difficulties, especially with the sprung suspension (typical of the fate many of the technical innovations for tanks). Begun in mid-1918, the Medium' D' tank never progressed beyond the experimental stage. Eventually, the design was abandoned on economic grounds in the early 1920s. [21]

Given the rapid technological evolution that took place between 1915-18 it would have been nothing short of miraculous had an "ideal" machine been produced in such a short time from such humble beginnings. The fact that the designers and producers were able to achieve what they did has to be seen as a positive achievement and a testament to their ingenuity and hard work as well as to the support of both civil and military bodies. But the dictates of time, the economies of war and the need to maintain continuity of production militated against the further development of a great many of their ideas.

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[21] Chamberlain & Ellis, *British and German Tanks of World War 1* , pp 46 & 51.

[7]

Salvage

The mechanical vulnerability of the tanks and the shortage of spares left many machines stranded in the field. Clearly, if the greatest number of tanks were to be available to GHQ in a "fit to fight" condition then the salvage of whole or part machines from the battlefield was of pressing urgency. But this operation was not without its problems. The skilled labour shortage was felt in the salvage companies as it was in the workshops. So too was a deficiency in specialist tools with which to carry out the removal of complete or part machines from the battlefield, machines which were much heavier and far more complex than anything that Army salvage teams had ever been called upon to deal with in the past. Moreover, the fact that the tank had been introduced so quickly, and with necessary secrecy, meant that salvage crews had not been organised in time for the tank's debut in September 1916. Yet the speed with which all of this changed once more bears witness to the support that tank matters received.

In peace time the Army Ordnance Corps (AOC) was responsible for the Army's salvage work.[1] Since a high percentage of this salvage was ordnance-related this was quite natural. However, a critical shortage of materials felt in the early stages of the war soon led to the creation of a number of specialist salvage units on the Western Front. Originally the maintenance of mechanical transport (MT) in France was to be shared between the AOC and the Army Service Corps (ASC).[2] But the "hoarding of scarce spare parts by front line ASC units" led to them being given responsibility for the great majority of this work.[3] The recovery of broken down or disabled MT also quickly became part of the ASC 's remit. But, despite the fact that a number of the first tank maintenance engineers and drivers were transferred from the ASC to the Heavy Section, it was a former Royal Engineer who was to organise the first tank salvage unit.

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[1] Maj-General A. Forbes, *A History of the Army Ordnance Services* , p 51.

[2] Brian S. Baxter, *Breakdown. A History of Recovery Vehicles in the British Army* , p 4.

[3] Ibid.

Salvage of vital components from stranded or disabled machines was recognised as crucially important even before the first machines went to France. However, the first concerted effort to retrieve components, in this case the 6-pdr guns from stranded male Mk Is on the Somme, was something of an amateurish (in the best sense of the word) affair, as Captain R.P. Butler, a Canadian engineer, recalled· Between 25 September and 15 November 1916 some 70 tanks had been used in action. Butler observed that whilst some of those abandoned were burnt out or badly mangled by artillery the majority were relatively intact, and of those no less than 58 were salvable. In many instances the tanks had been abandoned due to comparatively simple mechanical problems. 'There had", he said," been so little time for training that it had been necessary to take personnel with some slight experience of one part of the functions of the tank crews and to let them keep to that." As a result " all technical work, including driving in action, was done by 711 (MT) Company, ASC, while the crews, except for the one ASC driver...were machine gunners, some of whom had been taught by naval ratings to shoot the 6-pdrs...and who were not supposed to drive or touch the engine." [4]

By mid-November the tanks which had returned from action were in need of a major overhaul. This work was the responsibility of 'D' Company 's workshop personnel. However, Butler observed, " ... this Company had its hands more than full without attempting to salve even the easiest of the derelict tanks." He pointed out that the " technical experts said that the tanks left out could not be salved...but the authorities insisted that at least the 6-pdr guns must be brought in... ." Since there was no one else to lead the salvage party Butler, along with another officer and 18 other ranks, set out with their two 15-ton lorries and one "Napier" van from Blangy on 22 December to tour the battlefield. In all 32 guns were salved, the last being shipped out on 25 January 1917.

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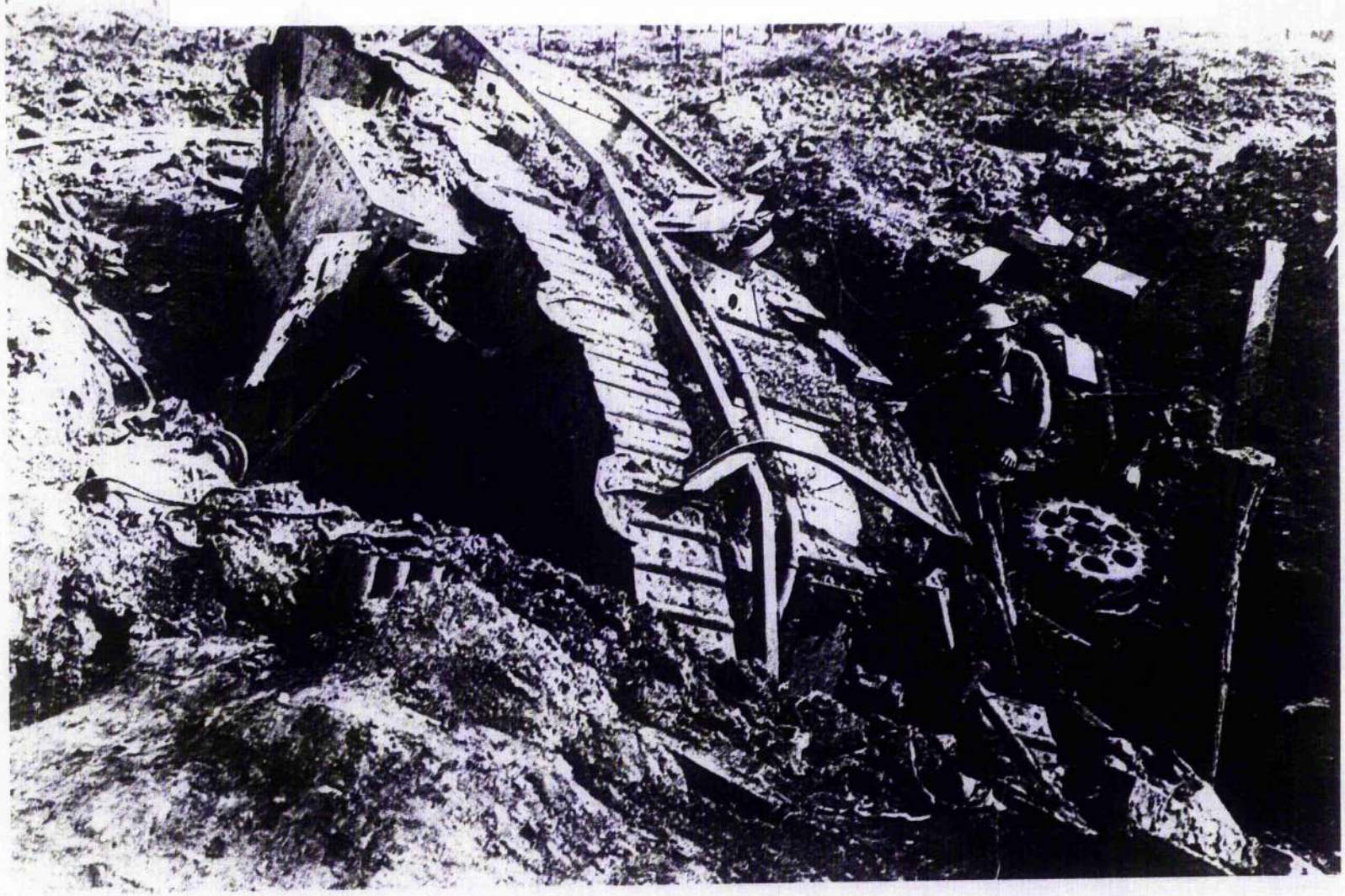
[4] Captain R.P. Butler, " Reminiscences of Salvage Work ", p 40. The majority of the men from the A.S.C (M.T) who were already working with the tanks were transferred to the Heavy Section in November and December of 1916 and together with men and officers transferred from various infantry regiments, provided the additional (additional that is to men already recruited from the Heavy Machine Gun Corps and other volunteers recruited earlier in the year) personnel necessary. Initially all but the most elementary of maintenance tasks in the field were performed by personnel of the 711 .A.S.C. (M.T). However, such a sharp division of labours where even driving was at this stage in hands of the A.S.C. was gradually dissolved as crews by necessity became more proficient in all aspects of tank operation and maintenance. This policy called" maintenance by substitution" was introduced after the brigading (that is the further expansion of the workshops from battalion to brigade level) of the workshops at the end of 1917 as part of the delegation of maintenance work to the tank crews. Each battalion retained from its workshop an engineer officer, and each company a M.S.S.(a sergeant qualified in motor engineering), but in a supervisory capacity only. This signalled a clear distinction between tank maintenance (which could include *ad hoc* repair) and tank repair proper. In this way skilled men were detached from the battalions and went either to strengthen Central Workshops or to man Brigade, later Advanced (after Cambrai demonstrated the need for greater mobility) Workshops.

Some were beyond salvage! Note the sprocket wheel which can be clearly seen on the right of the picture.



"In many cases", wrote Butler, " the guns [9 feet long and weighing 9 cwt] had to be man-handled for considerable distances, sometimes for miles... ." [5] Hand sledges were improvised from old sheet-iron or duck-boards, and where possible mules and wagons were borrowed. It is worth noting that these very same problems also faced the advanced workshops which were often faced with hauling large spare parts over very difficult terrain. Both units, salvage and repair, often operated at night and frequently under enemy fire.

The shortage of specialist tools and equipment (or the fact that they had yet to be devised) with which to carry out salvage or repair operations handicapped the efficiency of the units. But they were often able to overcome these deficiencies by *ad hoc* means. Butler wrote of one such example. He described how the salvage company had been ordered to conduct a series of experiments to determine the effect of hand-grenades on armour-plate. Quite by chance the experiments revealed that these relatively small explosive charges allowed badly mangled or twisted steel plate and fittings to be bent or reshaped, so greatly aiding the efficiency of the salvage units. He recalled the salvage of one particular tank in 1917, which is noteworthy, not only because of the use of grenades in the operation , but also because it highlights the enormous lengths that the salvage crews sometimes had to go to salve machines :

> " This tank (it was number 711) was in the front line...it was useless to attempt to bend the plate with a sledge-hammer or a jack, but a few hand-grenades judiciously applied at the correct distance did the trick. It was a long business as the track and other parts had to be removed while the bombing was being done, also all work had to be carried out in the dark, and even so the party often attracted a heavy bombardment. After a week's work No. 711 was able to move to a more sheltered spot, and eventually onto a rail head under her own power." [6]

But the salvage crews were not always so lucky. Sometimes, after working on a tank for several days, it was hit by enemy artillery and wrecked beyond repair.

The end of April witnessed the expansion of this unit to a four-section company. In July the Second Tank Salvage Company was created under Major Radclyffe, the nucleus of its men coming from the First Company. By late 1917 the work of the salvage units had become very wide ranging. Apart from their immediate duties of salvaging tanks, they were called upon to remove trees, tractors and any

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[5] Captain R.P. Butler, "Reminiscences of Salvage Work", p 41.

[6] Captain R.P. Butler, ibid, pp 42-43. Also it is worth pointing out that a year later (November 1918) the Advanced Workshops and the Salvage Companies were merged to form Field Tank Battalions in a move intended to further increase the efficiency of returning tanks to the battalions in a "fit to fight" state.

general debris hindering the Army's movement; these tasks included assisting the artillery in moving bogged guns.[7]

A balance sheet covering the period beginning January 1917 to the end of March 1918 debited the salvage company with capital and working costs including rations, petrol, oil, etc., and credited it with the estimated value of the material salvaged. It may be pointed out here that this value was decidedly under-estimated in some cases - for example 38, 000 track plates (shoes) valued at £1 each when they were 30 /- from Glasgow. Despite this a saving of £286, 526 was proved. During the critical phase of the Third Ypres these companies were able to salvage approximately £1, 000 of Tank Corps material per man per week.

The first Mk V battle casualties came in for repair after action at Hamel in July 1918. Major S.G.Brockbank, who commanded the Central Workshops and Stores from June 1916, pointed out that it was foundthat these machines were susceptible to catching fire when hit, " for causes unknown", and consequently suffered a great deal of fire damage. This was the cause of considerable trouble to both the salvage and the workshops units because :

> "...in the first place, a great deal of difficulty was found in getting these machines to railheads and at the workshops they arrived a charred mass of iron. This increased the man-hours to repair them by 50 percent."

After Amiens Brockbank complained of "receiving trainloads of Tanks in a similar condition." [8]

According to Brockbank the period July - end September 1918 saw the works pressed to turn out as many fighting machines as was possible. Included in this work load was the conversion of a number of Mk IVs which were in demand as tenders and

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[7] Captain R.P. Butler,ibid, p 1. He described an occasion when 1, 000 "good" track plates were urgently required. Since they could not be obtained from England [why, he does not say] Tank Corps H.Q sent his unit to salvage them. They were able to provide all the plates asked for within a few days earning great praise from H.Q. However, he says that, although he did not admit it at the time, the bulk of the plates came from a discarded dump of new plates which they came across quite by chance on the battlefield. As he says, he did not want to report this to H.Q because someone, somewhere would already have reported them lost, probably destroyed, and he did not "want to make trouble" for that person.

[8] Major S.G. Brockbank, "History of the Central Workshops" , Ch 2 , p 2. During December 1916, after the reorganisation of the company workshops, it was decided to expand the Heavy Repair Workshop and Stores. After consultation with the French authorities who wanted it in the neighbourhood of St. Pol at Ramecourt, the site for the workshops was eventually settled at one hundred yards west of Erin. Construction began early in the new year but was severely hampered by bad weather, and a shortage of both building materials and labour. By January 14 the establishment of Central Workshops, as they were now known, had increased by some 236 men to 13 officers and 630 other ranks.

By September 1917 the Central Workshops had received from salvage, repaired and made ready for re-issue 227 machines, together with some 940 new machines from England (of this figure 745 were Mk IV). In line with the further reorganisation of the workshops which led to the creation of the Advanced Workshops, Central's establishment was increased by 25 officers and 1029 other ranks by early 1918. Many of these coming from the "brigading" of the workshops.

supply vehicles. This was a period which saw large numbers of Mk Vs and V* arrive with instructions to produce "composite" tanks. This involved the creation of "uni-sex" machines out of tanks which had left the manufactures' workshops as male and female tanks in Britain only weeks, if not days, before. The "composite" machines were fitted with only one 6-pdr gun and supporting machine guns (another example of the confused state of tank development and production and the search for continuity).[9]

In late October Elles stated that on August 8 there had been 630 fighting tanks "on charge" to the battalions. Between this date and October 20 830 tank casualties had occurred, "of which over 300 have been repaired and re-issued" and a further 300 had been salvaged (33-35 tanks per week being salvaged, repaired and returned to action)[10] . Moreover, he stated that over this period of 74 days (during which the tanks fought for 32 days) 1, 890 tanks were in action.[11] Clearly many tanks made more than one appearance on the battlefield and indeed in the repair workshop. There is a record of one tank being knocked-out by artillery, salvaged, repaired in the Central Workshops, and re-issued three times in five weeks during September and October 1918.[12] Yes, the tanks were durable in the sense that of the 830 "casualties to tanks from all cases " reported by Elles in his "summary"(29 September 1918), he anticipated that only "about 50 will have to be abandoned". Durable, yes, but even the latest models were inherently unreliable. The more effectively the salvage and repair shops returned the tanks to a "fit to fight" state, the more quickly they fell victim again. It surely cannot be argued that the tank lacked support.

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[9] Ibid, Ch 4, p 2.

[10] Colonel Searle's report to the Tank Board (24 October 1918), MUN 4 / 6400.

[11] General H. Elles, "Summary of Tank Operations", the Tank Museum. "On charge" meant the total number of tanks allocated to the battalions, but not necessarilly, indeed probably very rarely, if ever, were they all in a "fit to fight" state.

[12] Major S.G. Brockbank, "History of the Central Workshops", Ch 4, p 2.

[8]

"The Battle of the Spares"

As was discussed in chapter one the struggle for the control of the tank programme in all its aspects was often bitter and acrimonious (especially up to late 1917), but it was a struggle for control and not survival. Both sides, producer and user, were above all anxious to ensure the survival of the tank programme. The"Battle of the Spares" represents the essence of that struggle. A reliable supply of serviceable spares was crucial if the constant struggle to keep machines in the field was not to be lost. In 1917 it was calculated that a Mk IV tank travelling an average of 3 miles per day for 14 days needed 20 tons of spare parts ; for a month it required 50 tons.[1] But the importance of maintaining continuity of production of finished machines, thereby enabling the MWD to retain its contractors in the face of competition from rival Ministry production departments, did not permit a major increase in the supply of spares. Despite mechanical warfare's favourable position in regard to its claim on materials and manpower, it faced the persistent dilemma of having to find a balance between the supply of spare parts and the erection of complete machines.

The spares problem first reared its head in August 1916. Albert Stern wrote to Edwin Montagu, Minister of Munitions, on 3 August,[2] setting forth his view of the spare parts situation. He stated that the original order for 150 tanks had stressed that they were to be delivered"with necessary spares". However, he said that he was "under the impression that these [the tanks] would not be used until the order had been completed". "Therefore", he continued " the spares would not, in the ordinary way, be available until the 150 machines were completed." Of course, we know that delays in production were to put the spares programme behind schedule. In fact the production of spares was never to catch up, and spares for both the Mk IV, and later the Mk V and its variants, were always behind schedule.

By February 1917 the spares situation in France was in such a dire state that Haig himself sent Major Uzielli, Heavy Branch, to England to investigate. In connection with this visit and GHQ's obvious disquiet over the issue Dr Addison,

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[1] Refer to Colonel F. Searle's quote, p 119.

[2] Stern, *Logbook*, p 87, and MUN 4 / 2809.

Montagu's successor as Minister of Munitions, wrote to the War Office on 28 February.In this letter he claimed that the Ministry was on schedule with delivery of the spares requested by France. However, he was at pains to point out that a shortfall in spares had arisen due to " the expenditure on spares at the Front [being] very considerably in excess of the agreed programme." He went on to state that in January of that year General Elles had ordered "considerable" quantities of sprockets, "steering wheels" and track components. He also cited as a further example of what he regarded as excessive ordering by France, an order , again from Elles, for 7, 270 track shoes for the first two months of the year. The Ministry had, stated Addison, already supplied 6, 000 in the previous five months. The number of spares laid down by the agreed schedule was 2,400 per machine. He concluded :

> "I am therefore to suggest that for the consideration of the Army Council that the Heavy Branch in France should be requested to make every effort to reduce unnecessary wear and tear." [3]

In reply to the War Office letter of 21 February, informing the Ministry of Munitions of Uzielli's impending visit, Stern wrote to the DMRS pointing out that"the provision of spares has been arranged with the Heavy Branch, France, at a figure per 3 months". Further, he stated that taking into consideration the " difficulties of prophesying anything in the way of production in these times ", he could see no reason why the supply of spare parts could not be kept to "the ratio agreed". He then launched into a criticism of Heavy Branch, France, for not keeping to their agreed programme, suggesting that they were " not capable of cutting their coat according to their cloth." And that "having laid down a certain ratio of spares, their expenditure on spares must not exceed that ratio, or they will always be in difficulties." Stern, referring to a telegram received on 17 January in which Elles requested a series of spare parts to be urgently delivered, stated that the output of :

> "...these particular articles necessitates starting from the Foundry, practically all steel castings, and it is impossible to obtain these under 8 to 9 weeks. It is essential that the War Office should inform us whether this is an exceptional demand or whether this is the ratio they will require on the 1, 000 machines, because if it is ...it is quite impossible to provide even an infinitesimal quantity of these replacements."

He went on to state that the provision of spares at that rate would mean a total end to the production of tanks. Stern continued " far from the spares being unsatisfactory from this end, the position demands an inquiry in France into this extravagance." He concluded his letter by suggesting :

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[3] MUN 4 / 2801.

> "The Heavy Branch, France, are under the impression that the Tank's life is unlimited . The Branch of the Ministry who have designed and constructed the first and every other Tank know that its life is extremely limited, and were only asked to design the tank for a 50 mile life.
>
> Every effort is being made to extend this life, but the Army Authorities should also make great efforts to limit unnecessary or even necessary wear and tear." [4]

Where Stern derived his " 50 mile" life span from is as yet a mystery. Stern saw the tank as a "projectile" [5] - used once and then discarded. He suggested that it was the military that regarded the tank's life as being "indefinite". No further evidence has emerged suggesting that the War Office laid down specific instructions that the tanks were to last for any given time, especially one as short as this. On 20 February 1917 General J.H. Davidson, DMO, GHQ, together with members of the Heavy Branch met Stern in his office to discuss the necessary improvements to the Mk III for the 1, 000 tank order recently placed by the War Office. The improved tank (i.e. the Mk IV) was, the general said, to have new spuds to improve track traction, new track rollers to increase track efficiency ; it was also to be equipped with the Lewis instead of the Hotchkiss machine gun ; its sponsons were to be permanently fitted on the machine at its arrival at the front, and not arrive separately as was then the case ; and its gun shields were to be increased to 12 mm thickness. Other improvements were later carried out to improve still further the safety and performance of the Mk IV. However, the point to stress here is that, at a meeting of senior representatives of the tank programme in early 1917, both user and producer discussed everything it seems but the life-span of the tank. Why go to all this trouble for a machine which was to be a "projectile", used once and then discarded ? [6]

Admittedly several months after the debate began, Stern may have received some encouragement in his view that numbers of completed tanks were more important than spares when on a visit to the front in April. He claimed that Haig told him "to hurry up [tank production and produce] as many as I could - not to wait to perfect them but to keep sending out imperfect ones as long as they come out in large quantities." [7] Haig's enthusiasm is evident and particularly noteworthy given that critics of his

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[4] Ibid.

[5] *M of M*, Vol.XII, Pt.III, Ch.III, p 34, and Stern papers, 1 / C / 3.

[6] Stern papers, 1 / C / 3.

[7] Ibid. There is no mention of this in Haig's own diary. This is somewhat at odds with d'Eyncourt's experience a few months later in August, when having written to Haig regarding suitable ground for tank action, he was urged by Haig to make improvements to the then Mk IV as quickly as was possible (see Chapter 10).

attitude to the tanks cite this period as being the darkest of the "dark days" in terms of Army support for the tank. However, this aside, there does appear to be an element of confusion here between producer and user as to exactly what the priority should be. Stern may even have read in Haig's statement tacit support for his view that the tanks were disposable.

Sir John Keane in an interview with Basil Liddell Hart on 9 November 1947 recalled how his main impression of the state of communications between the various bodies involved during his time at War Office Tank Directorate was one of being at "cross purposes" with the Ministry of Munitions. "Stern", he said, "wanted to increase the numbers of tanks and was not interested in the question of spare parts - for which the people in France were clamouring." [8] "Cross" communications and a stubborn determination on Stern's part that he knew best seem to have been at the root of the problem.

Perhaps it was suggested that a minimum of 50 miles should be expected for the first tanks before a major service or rebuild. This would be much more in line with contemporary thinking since it was recognised by those with practical experience of operating tanks, particularly in the light of the experiences of late 1916, that the life of any one set of components was very limited. For the Mk I machines it was believed to be something in the order of only 20 miles.[9]

Given that spares were in such short supply, the importance of salvaging whole or part machines (i.e. components) from tanks which had broken down through mechanical failure, become ditched, or had fallen victim to enemy artillery, should have been given high priority. However, there seems to have been very little in the way of an organised response to this problem. And when salvage units were first established it was done at the initiative of the individuals involved rather than the active instigation of GHQ. Does this say something about GHQ's and the War Office's view of the early tank, i.e. that they were disposable ?

The answer to this question must be in the negative, for two reasons. The first is that GHQ was clearly in a hurry to introduce the tanks to the battlefield. Salvage had been recognised as being of vital importance (for all areas, not only tanks) even before the tanks were sent out to France. But inevitably haste meant that this was not immediately translated into material support. The second reason can be found in the rapid growth of the salvage units during late 1916 and early 1917, which suggests, at the very least, the passive support of GHQ, without which they could not have been established. The shortage of technical personnel from which to form salvage companies

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[8] Liddell Hart papers, L.H. 9 / 28 / 59-62.

[9] Captain R.P. Butler, "Reminisences of Salvage Work", p 40.

was acute, but they were found, and the companies were formed. In common with almost every one else who came to work with the tanks Canadian Royal Engineer, Captain R.P. Butler, by his own admission, knew very little about tanks when he first began his salvage work. However, within the first few months of 1917, inspired by Butler's enthusiasm, the initial *ad hoc* arrangements of the first salvage team rapidly expanded into organised sections and then into two companies tackling the salvage of whole machines, and not just parts. The immediate absence of an organised salvage team on the Somme in September 1916 simply reflected the fast moving and chaotic nature of tank development, and not an impression that the early tanks were disposable. As the early months of 1917 unfolded, the expansion of the salvage companies clearly signalled that GHQ and the War Office took the view that the tank's life was to be extended for as long as possible.

Furthermore, by late February the new Mk IV tank was entering production. This tank, although an improvement on the previous three marks, still employed a great many of the same component parts. There is no mention by Stern that production of spare parts for this new mark has been increased. So was he still working on the assumption that the Mk IV had a life span of 50 miles ? This almost defies belief.

Stern's letter to Montagu, referred to above, uses the term "necessary" to describe the quantity of spare parts to be provided with the delivery of 150 tanks. Yet, it is unclear as to exactly what the "necessary" quantity was. If we accept that Stern saw the tank as a disposable item, and that spares need only be provided for training tanks, then clearly the number of spares he would have deemed necessary would have differed significantly from the War Office who expected an "indefinite" life span. This would seem to be the case, given the fact that in Stern's own words, the "Army Authorities" were making "every effort [to] extend this life." They, it would seem, were expecting a supply of parts for every machine and not just those employed in the tank training schools.

The letter to Montagu was written before the order for 1, 000 machines was finally confirmed in October, so perhaps we might overlook the ambiguity in the term "necessary." However, the order for 1, 000 tanks clearly came with an agreed schedule of spares to be delivered. Heavy Branch were, in Stern's view, obviously exceeding this schedule, demonstrating not only the unpredictability of war, particularly when using a new and relatively untried weapon, but also a degree of insensitivity and poor organisation on the part of the Tank Corps / GHQ France. But it also suggests that Stern was being somewhat disingenuous when he stated that the "first and every other Tank[s]...life is extremely limited", given that a schedule of spare parts to rebuild each tank (what other reason could they have been ordered for ?) had been in existence for several months.

The main problem seems to have been one of interpretation, symptomatic of the poor state of communications between producer and user. Vague and unhelpful terms such as "necessary", and later in 1918 "adequate," when discussing the supply of spares, were misleading. Yet one also has a sneaking suspicion that Stern was revelling in the opportunity offered to continue his personal battle with the War Office for control of the tank .

Elles's concern over the spares issue was aroused by a long letter from Lieut-Colonel Frank Searle written on 24 March 1917. Searle had been transferred to the then Heavy Branch as a technical advisor (on Stern's recommendation). His letter to Elles expressed in very critical terms the potentially disastrous state of spares supply. He wrote :

"At our first meeting...you will no doubt recall my first warning, which was to the effect that unless your store were forthcoming, you would have failure. So far as Tanks are concerned, this Summer's Offensive is going to see one of the worst failures and scandals of the war unless [those] spares are forthcoming...In December last year I personally handed in my estimate of what would be required for 300 machines for three months. Two and a half months later I am asked to make another estimate which has been done.

In both cases the estimate was made out in conjunction with and with the assistance of all those officers who, for the past four months , have been gaining experience in the maintenance of Tanks.

In spite of my estimate having been made in December last, of spares required, we have only been able to maintain an average of 25 Tanks in service out of 125 Tanks in France; 60 of this number were certainly left on the Somme [see chapter 7], but many of these could have been brought in had spares been available.

I do not wish to convey the idea that no spares have been sent to France - the quantity sent has been collossal [sic], and I feel sure the Ministry of Munitions will bear me out on this point - but huge quantities are of no use, we must have sufficient of the sorts required.

As you know 60 Mark I and II machines have just been put into fighting condition, which condition embodies all the mechanical improvements embodied in the Mark IV, in spite of which, if they were to be run an average of three miles a day for 14 days, they would require approximately 20 tons of spares, and if run for the same distance per day for a month, approximately 50 tons would be required to put them into serviceable condition.

If, as is proposed, one thousand of similar machines are to be operated, it is easy to calculate the astounding quantities of spares which will be necessary to maintain them.

I now understand from you that the Ministry of Munitions state that the quantities required cannot be provided.

Under these circumstances, and considering the urgency of the needs of the Country in other engineering directions, I feel it would be a crime to manufacture and send to this country, machines which there is no possibility of maintaining.

With modifications in design, the quantity of spares necessary could be halved; of this I am positive, and the other Engineering Officers of this Unit are of the same opinion, but I understand that the Ministry do not agree."[10]

The following month, on 13 April, Searle again expressed, in a letter to Dr Addison, his dissatisfaction with the spares programme, and in particular with the performance of Stern. At issue this time was the availability of a particular spare part affecting the function of the tank's gear system. In an earlier letter Stern had told Searle that supplies of the "13-tooth sliding gear pinions" could not be produced from new in

[10] WO 158 / 838.

under eight weeks. Searle had replied that he personally knew that the Daimler Co. could supply the necessary parts in "14 days", a statement that Stern had apparently "ridiculed." In his letter to Addison, Searle enclosed proof that Daimler could now (mid-April) apparently deliver "IN SEVEN DAYS FROM THE DATE THE ORDER WAS PLACED [sic]." Searle went on to outline the problems in France that were, he said, the result of Stern's actions :

> "The training in France has been seriously hung up for the want of these particular pinions, and that our order was telegraphed to the M.W.S.D. on 17-1-17, I feel sure you will quite understand my attitude... ." [11]

One year later, with the arrival in France of the Mk V, the situation had not significantly altered for the better as Elles was at pains to point out. On 29 March 1918 he wrote to Capper to inform him that he was sending Colonel Searle to investigate the problem :

> "... so that we may know in particular what our present difficulties are[and] know exactly where we stand as regards maintenance."

He then went on to question the MWD's interpretation of the"Schedule of Spares" for the Mk V. There was a problem with this too. According to Elles it was not what had been asked for "in spite of an agreement in principle many months old and quite uncontested". Spares were" not [sic] coming in advance or with the machines." He urged Capper to :

> "...impress upon the MWSD that spares are of little use unless they come early in anticipation of needs [we are] now in the same position [with] the Mk V as [we were] with the Mk IV." [12]

The following month (April 26) Elles again expressed his continued disquiet to Capper. The MWSD were still not living up to their promise to send a proportion of spares before or with each consignment of machines. He pointed out that if matters continued as they were the Tank Corps would be in the "position of having urged the importation of the Mk V machines [but not be able] to keep them running." [13]

On 25 July the War Office sent a memo to the Ministry of Munitions drawing its attention to the serious delay arising in the delivery of spare parts for the Mk V and

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[11] Stern papers, 1 / C / 3.

[12] WO 158 / 838.

[13] WO 158 / 816.

V*. It stated that the percentage of items delivered against the schedule rose rapidly, first reaching 62 per cent on 25 June. However, since that date the past twelve months had seen an improvement of only 12 per cent . This meant that only 74 per cent of the required spares had been delivered. A memo from the Ministry to the War Office stated that " no effort was being spared to secure the immediate delivery of the balance". It then went on to urge the Tank Corps to "give notification in regard to any special requirements affecting delivery". On 10 August the War Office informed the Ministry that the percentage of spares delivered referred to in their recent communication dealt chiefly with hull and transmission spares, and that there had been "no improvement in some 267 other categories of items." [14]

At the sixth meeting of the Tank Board (15 September 1918) it was stated by J.A. Corcoran, Secretary of the Ministry of Munitions, that " the Army Council emphasise most strongly that a demand for Tanks should be interpreted as to mean Tanks and an adequate supply of upkeep spares, and that no delivery is complete unless accompanied by these spares." [15]

At the eleventh meeting of the Board (24 October) Lieut-Colonel F. Searle stated that between 33-35 tanks were being repaired every week, but that they were in need of ever more spares. He pleaded, "give us spares even at the cost of production". However, J.B. Seely (President of the Board) pointed out the necessity of fulfilling the existing programme and emphasised the requirements of the 1919 campaign. This view was supported by Fuller who drew attention to the necessity of maintaining production in order that the training schools should have a constant supply of machines ensuring that both machines and crews would be available for 1919.[16]

The same subject was raised once again at the thirteenth meeting (7 November) when General Furse advocated the suspension of tank production in favour of spares. He reported that he was aware of 331 machines in France awaiting spares which could be repaired at a rate of " 30 per week." However, J.B.Maclean was able to reassure the Board that, apart from magneto spares, which he hoped to be able to get from the Air Ministry, he could" supply France immediately with all parts".[17]

The Tank Corps was clearly exasperated by what it perceived as the obstructive and overly bureaucratic administration in England. However, it would be unfair to lay

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[14] MUN 4 / 2801.

[15] MUN 4 / 5180.

[16] MUN 4 / 6400.

[17] WO 158 / 816.

the blame for the spares problem solely at the door of the MWD. The system of accounting for stocks of spares in France was not what it might have been.

Major Brockbank, commanding the Central Workshops and Stores in France, described the arrangements for keeping track of newly arrived machines and spares in late 1916 and early 1917 as " lamentable". Brockbank soon introduced a system of "Tally Cards", against which all stock was checked. This meant that at all times a sufficient stock of components for a maximum of three months and a minimum of half this period were in stock at any one time. At least in theory.

> "This allowed England 6 weeks to deliver spares. Theoretically we should never be out of stock."

But a persistent shortage of clerical staff in Britain and France often resulted in despatches of tanks and components arriving from England without the proper paperwork, or, if correct, being incorrectly catalogued upon their arrival in France. Given this state of affairs one can understand some of the frustration felt on both sides of the channel.[18]

A second line of manufacture

The debate over the possible suspension of tank production in favour of spares, touched upon above, is also reflected in Brockbank's history. He described how in 1918 it was increasingly the case that time was lost in the "Repair Section" due to tanks having to be "put aside" when only half repaired for want of spare parts.[19] Salvage crews were working round the clock and extra men were despatched form Central Workshops to assist in stripping parts from abandoned machines in the field to complete tanks in the shops. Owing to this shortage the Central Workshops were asked in late 1918 to manufacture all the parts they could themselves in France. This had a very negative effect on the output of the workshops in terms of tanks repaired and ready for action since skilled men were now being employed on what was in reality a second line of tank manufacture.

But this situation was not confined to 1918. Shortages of vital machine tools, which persisted on both sides of the Channel throughout the war, were also felt in the early days of the tank's arrival in France. Without the assistance of the RFC during the winter of 1916-17, armour plate could not have been cut and machine gun mountings for the Lewis gun could not have been fabricated. Supplies of both cutting equipment

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[18] Major S.G. Brockbank, "History of the Central Workshops" , Ch 2, p 2.

[19] Major S.G. Brockbank, ibid, Ch 2, p.27.

and gun mountings were not at the time forthcoming from England. During the same period a local agricultural machine repair shop in Blangy-sur-Ternoise had to be enlisted. Work carried out here included the completion of some 70 sets of "fittings" to make the tanks more "battleworthy". [20] These included locking devices on all doors and revolver port holes. It also included the conversion of ammunition racks from the belt fed Vickers / Hotchkiss machine guns to the Lewis gun.[21] These might seem relatively insignificant jobs, but it should be understood that, for example, the locking devices on the revolver port holes consisted of 25 parts per set. In all some 1, 500 were made, all of which had to be forged and drilled and then fitted. Not only were the means to fabricate components found locally, but also, in many cases, the materials too. When the RFC could not help with cutting gear, private cars had to be pressed into action to range as far as Paris in search of oxygen supplies.[22] Many tools were specially developed by fitters and other maintenance staff to cope with unforeseen difficulties. However, in other cases there were just not enough of the basics to go around. As late as September 1918, Major E.R.Parsons, No. 1 Field Tank Company, described a situation in preparation for what became the battle of Amiens, in which there was only one new " ratchet and drill and one set of taps " in the area suitable for the job of fitting new " bearing cup stands" on the Mk V machines. These vital tools apparently belonged to a "Major Dick", Royal Engineers, and "consequently engineers were running round the country on motor bikes after them. Everyone wanted them at once." [23]

The problems continued to mount throughout the winter and spring of 1917. New track rollers were not available from England at this time so old ones had to be filled with cast iron to reinforce them. Similarly the supply of "13 tooth transmission pinions" was deficient, so once again they were left to their own devices. Where, one may ask, was Stern's spares supply that he thought so "satisfactory" at this time ? It is worth pointing out that these tanks, the objects of such irregular repair and refitting, were amongst those employed during the battle of Arras. During the first week of 1917, 62 tanks were "fitted up" by Central Workshops. The situation did not improve as the summer developed. The principal output of the Central Workshops between April and September was not, as one might have expected, tanks ready for battle, but spare parts which could not be obtained from England. Or, if they could be obtained, then they frequently required re-working due to faulty workmanship or even design. One such

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[20] Major S.G. Brockbank, ibid, pp 4-6.

[21] And presumably back again given that the adoption of the Lewis gun was so short lived.

[22] Major S.G. Brockbank, "History of the Central Workshops, Ch 2, p 7.

[23] Major E.R. Parsons, "Personal Experiences, 1916-18", p 12.

task was the reduction in the width of the sprocket wheels, owing to the"cold rolling" of the tracks. There was apparently only one lathe available for this work which was fully employed, "day and night", for many months. Sprockets were key components and a source of much trouble throughout the war. [24]

Sprockets

General Elles first highlighted the problems with sprockets as early as 1916.[25] On 11 July 1918, Maj-General H.A. Lawrence, CGS, in a letter to the Secretary, War Office, was still pointing out the deficiencies in design and quality of this vital component. Lawrence highlighted not only the problems with sprockets, but also with the related pinions and hubs. Writing in conjunction with the arrival of the new Mk V tank in France, he complained that tanks had been plagued with :

> "... similar and related troubles with the above parts [from] as early as 1916 , despite...being under discussion since Tanks were first used in France, nothing has been done to finally remedy this potentially disastrous situation."

But he conceded that the initial problems with the sprockets (part of the final chain drive mechanism), had been remedied after some considerable work by their manufacture in manganese steel. "A substance...which if properly mounted will last from 300 to 500 miles, according to the weather... ." Yet, Lawrence continued :

> "... from the dates on the drawings it appears that the designs for these new sprockets were completed in October 1917...[the]...drawings ...were not received in France until April, 1918."

Clearly, this reveals, once again, the difficulties that the overloaded MWD design section were experiencing with problems of constant redesign work, and the general communication log-jam between England and France. It also highlights the source of much of the frustration which existed between the MWD and the Tank Corps.

The forging of sprockets and pinions in manganese steel successfully resolved the initial difficulties presented by the undue wear and frequent breakages of the early sprockets. However, the difficulties now seemed to have progressed to the wheel hubs themselves. Again Lawrence felt it necessary to comment :

> " ...upon trial of the new Tanks [MkV] it was found that the hubs upon which

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[24] Major E.R. Parsons, Ibid, p14.

[25] Elles commented on the excessive wear on sprockets in the Mk I tanks in a letter to Brig-General Sir J.E. Edmonds (4 September 1934) regarding the Official *History* (CAB 45 / 200).

> the final sprockets were mounted were very liable to break after the minimum distance of 50 miles."

He went on to say that, although in some cases the machines went on to run for as long as 350 miles without trouble from these parts , "it was impossible to forecast the life of the machinery". [26] Finally he drew attention to the fact that at the time of writing (July 1918) there were some 400 MkV and Mk V* tanks in France and that an additional 600 were due to be constructed in England and that :

> "The largely increased life of the machine due to the introduction of the manganese steel sprocket wheel is practically negated by the weakness of the hub in the machines already in France and presumably in those due to arrive from England...
>
> This defect which [sic] due to either faulty design or faulty execution of design , seriously affects the fighting value of this type of Tank , and not only creates uncertainty as to the performance [of the tank] but also entails a large amount of manual labour in carrying out repairs necessitated by the breaking of the hubs."

Lawrence urged that immediate steps be taken to remedy the situation, and called for the imposition of more stringent trials in England prior to shipment. [27]

Writing on behalf of the DMRS, W. Ridler (19 July 1918) mentioned to Admiral Moore on 19 July 1918, that "other correspondence" on this subject (besides that from Lawrence) had been circulating through various departments. Ridler asked the Admiral for the earliest possible rectification of the"weakness" of the hubs in the Mk V and Mk V*, whether by " design or manufacture", in order that future tanks would not be "liable to fail in this respect". Admiral Moore's response was to ask Lieutenant Shaw, MWD, design section , on 7 July to compile a report on the subject. [28]

Shaw's report, a full two and half pages worth, was sent to the Admiral on 23 July. In it Shaw explains that the manganese steel sprockets were not unique to the Mk V (as was suggested by Lawrence), and as such they had not been subjected to stringent testing and examination by the authorities in England before being sent to France. He told Moore that manganese sprockets had been fitted to the Mk IV machines from 20

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[26] Not only did wear and breakages occur, but also faulty machining too. H. Knothe, General Capper's Assistant Director, states, in a letter to Admiral Moore (7 January 1918), the "France is having trouble in assembling Road Chain Sprocket Wheel Centre [sic] owing to the bolt referred to being too large in diameter". He went on to ask "...whether in future these Bolts could not be substituted by bolts machined all over, as this would save France very considerable work in the Field owing to the fact that they have to dress down the bolts and endeavour to file out the holes in the Manganese Sprocket Wheels." (MUN 4 / 2801).

[27] MUN 4 / 2801.

[28] The life of machinery is discussed further in the section on tactics.

November 1917 onwards, that an alternative track wheel sprocket had been fitted to the Mk V from 29 April, and that this differed only in that it had six instead of three bolt holes connecting it to the hub. In support of the design section, Shaw then cited a letter between the MWD and the Secretary of the Tank Committee (General Capper, Tank Corps, 20 July 1917) in which it was said that the design section, in answer to the Tank Committee's question regarding the approximate mileage of the manganese sprockets on the Mk IV, replied that little data was to be had, and that what did exist was drawn from tests on only one machine. They (the design section)" would be glad if France could be urged to supply this information at the earliest possible opportunity".[29] Shaw then cited a minute, dated 26 September 1917, informing the Tank Committee of the results of the MWD 's tests which suggested that their one test machine had returned figures of 372 .75 miles in 156.5 hours. Shaw argued that as a result of these minutes " no defects or recommendations for alteration in design were put forward by France".

Shaw said that in the opinion of the MWD technical officers, manganese driving wheels were proving troublesome because of the " insufficient bearing surface between the manganese wheels and the cast iron hubs". He reiterated his earlier point that no complaints had been received from France regarding the hubs or wheels on the Mk IV, so none was anticipated for the Mk V. However, he then revealed that subsequent inspection of a large batch of salvaged manganese wheels had revealed "very considerable" wear. He concluded:

> "It is reasonable to conclude that a certain amount of trouble due to this was experienced. Had this information been promptly reported, alterations in design could have been made to obviate the difficulty." [30]

By Shaw's own admission, manganese sprockets had been fitted to the Mk IV from November 1917 onwards. Are we to believe that, given the considerable amount of salvaged material that was returned to England from France, the MWD had, some six months later, and at the prompting of the DMRS and GHQ, only just noticed this "very considerable" wear ? [31]

In conclusion. The very fact that a "battle" was fought reflects the strength of feeling at all levels. There was no room here for indifference or apathy. But it was a "battle" for the control and not the survival of the tank programme. Each side felt that it

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[29] MUN 4 / 2801.

[30] Ibid. Brockbank stated that a "fortnightly" visit of a "junk train" was arranged from early 1917 to remove steel scrap for shipment back to England.

[31] It seems ironic that the MWD were expecting Tank Corps, France to do their testing / inspection work for them given that this was one of the areas of responsibility so jealously guarded for so long by the MWD.

knew best what was needed. There did emerge, however, a growing sense of co-operation in 1918, as each side, producer and user, was able, via the Tank Board, to put its case. Having said this, the supply of spares was to remain one of the most contentious areas to the end of the war. Finally, the Tank Corps may seem to have been particularly neglected when it came to vital tools, but it must be remembered that certain specialist tools, machine-tools in particular, were in short supply throughout industry during the war. Further, the tank's chief rivals in this area, the RFC / RAF and Mechanical Transport, were older bodies with workshop establishments that reflected this. What was remarkable was that at a time of growing national hardship the Heavy Branch / Tank Corps was able to establish itself as comprehensively as it did, given the fact that the tank was still a relatively modest performer on the battlefield, even in late 1918.

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The Fighting Arm

In line with design and production the arrangements concerning the organisation and function of the fighting arm were in a continual state of flux. The ensuing confusion which inevitably surrounded constant reorganisation undoubtedly compromised efficiency, although the overwhelming impression seems to have been one of change for the better. The constraints of a finite manpower reserve, the conditions under which the fighting crews had to operate, and limited time for joint training between infantry and tanks, can only have had a negative effect on the tank's contribution to the battlefield. However, despite this, the fact that the Heavy Branch / Tank Corps was not only able to survive, but to expand at such a time, and under such conditions, reflected the continued support that the Tank Corps in particular, and the whole tank programme in general received.

Changes in organisation

Technically speaking one should not refer to the Tank Corps until 28 June 1917,[1] when this body officially came into being. Prior to this it was known as the Heavy Section Machine Gun Corps (MGC), and later the Heavy Branch (MGC). During August 1916 the Heavy Section was organised into four companies : A, B, C and D, and each company was divided into four sections. Companies were allocated twenty five tanks: six tanks per section with one spare per company. Within the sections tanks were equally divided between female and male machines, with further sub-divisions within each section of three male / female pairings.

Section crews consisted of six officers and 43 other ranks : one officer and six other ranks per tank. A quartermaster's establishment of one officer and four other ranks together with a workshop of three officers and fifty other ranks was provided for every two companies. [2]

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[1] "A Short History of Tanks in the Great War", a series of articles issued with "Weekly Tank Notes by SD7, War Office", published in The Tank Corps Journal, 1919, ChV, p 73.

[2] Ibid, p 73.

On 8 October 1916 Lieut-Colonel Hugh Elles was provisionally appointed Colonel Commanding the Heavy Section.The headquarters of the Section consisted of one hut in the middle of Beauquesne village square. However, this soon proved to be unsatisfactory and a new HQ was established at Bermicourt (a small village just north of the Hesdin-St. Pol road). Tank Corps HQ was to remain here for the duration of the war, expanding rapidly from three Nissen huts to a site occupying many acres.

At the end of the first week in October the provisional establishment for the head quarters was confirmed. The suggestion that the Heavy Section become a corps with an administrative HQ in England and a fighting HQ in France was first aired in October, along with a proposal that the four existing companies in France should be expanded to nine (the additional five being newly raised in England) and that they should be up-graded from companies to battalions. While the creation of a corps was not sanctioned until June 1917 the other measures were given immediate approval. On October 20, Brig-General F. Gore-Anley was appointed administrative commander of the Tank Training Centre, Bovington Camp, Wool, replacing Lieut-Colonel Swinton.

The re-organisation created three brigades, each of three battalions. Each battalion consisted of three companies. Each company consisted of four fighting sections together with a HQ section. A fighting section was equipped with five tanks, while a HQ section had eight. The battalion's full strength was therefore 72 machines. These changes were approved on 18 November. The new year saw 'C' and 'D' battalions forming 1st Brigade (30 January 1917), and 'A' and 'B' battalions combining to form 2nd Brigade (15 February 1917). On 27 April the 3rd Brigade HQ was established in anticipation of the arrival of 'E' and 'F' Battalions from Wool. Yet, no sooner had these changes been implemented than a further reorganisation was suggested. [3]

The size of each battalion was to be reduced from 72 tanks to 60, with each company having 20 (four sections of five) as opposed to 25 machines. However, experience soon suggested that each section could not handle more than four machines.Therefore, the number of tanks in each battalion was reduced to 48, 36 of which were intended for fighting with the remaining 12 kept for training purposes.

In March 1917 General Gore-Anley was appointed administrative commander of Heavy Branch with his HQ in London (17, Cockspur Street). In May he was

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[3] Ibid, p 73. Colonel H.J. Elles was appointed Commander, Captain T.J. Uzielli was Quartermaster General, Captain F.E. Hotblack the Intelligence Officer, the head quarters staff also included as Staff Captain Captain M.J. Tapper, and Brigade Major, Captain G.Q. Martel.

'A' Batt was stationed at : Huniers, Eclumeux, Bermicourt.
'B' " " : Sautricourt, Pierremont, St. Martin Eglise.
'C' " " : Erin, Tilly - Chapelle.
"D' " " : Blangy.

succeeded by General John Capper. In recognition of the ever-widening gulf between the producer and user of tanks there was at this time a move, signalled by Capper's appointment, to foster closer links between the War Office and the Ministry of Munitions, and the closer integration of the Tank Corps within the Army . In addition to his role as Director-General of Tanks in England Capper also became head of the War Office Tank Directorate, answerable to the DCIGS, the main body through which the MWD and the Heavy Brigade, France were to liaise.[4] That same month saw the promotion of Colonel Elles to Brig-General, commanding Heavy Branch, France.

When Elles wrote to Anley on 23 April 1917 regarding the reorganisation of the Brigade his comments were prompted by the experiences gained that month at the Battle of Arras. He wrote that the "Battle has proved conclusively that we want a more complete organisation in Brigades, and perhaps also in higher formations for fighting purposes." He went on to outline how he was "organising BrigadeSignal Sections with a few borrowed men and some borrowed material", and that there was also an urgent need for separate "Supply Services" in preference to the situation at the time which involved the "getting forward of supplies by borrowed GS Wagons or by Infantry working parties", which was at best "cumbrous, uneconomical and uncertain".[5] As a result the conversion of obsolescent machines for this purpose was begun, with the effect that by November 98 of the 476 tanks employed at the Battle of Cambrai were either supply or support tanks. [6]

The lessons of Arras were also reflected in the decision to expand the number of battalions from nine to eighteen,half of which were to be equipped with medium tanks, the other half with heavy machines.[7] This expansion was finally authorised on 28 June. On the same day the Heavy Branch became the Tank Corps. However, it was not until 27 November that the proposals to expand the Corps received official approval. The delay was largely attributed to the shortage of manpower. When the expansion scheme was revived in October it was suggested that a great economy of manpower could be achieved by the abolition of the battalion workshops in favour of Mobile Brigade Workshops (created as a result of the "brigading" of the battalion workshops) working

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[4] Although Capper described the Directorate (10 June 1918) as "something of an anomaly in the War Office", it continued in existence until the summer of 1918 when, together with the 'New" Advisory Tank Committee, it was wound up and replaced by the Tank Board. Various letters, memos, etc., mentioning this recurrent theme of reorganisation and closer integration within the Army can be found in WO 158 / 806 and 814. The former contains detailed discussions of proposed organisation of the Tank Corps along the lines of the RFC.

[5] WO 158 / 814.

[6] General Sir Michael Carver, "False Dawn at Cambrai", Tank Corps Journal ,(n.d), p 2436.

[7] "A Short History of Tanks in the Great War", p 73.

in conjunction with an expanded Central Workshop at Erin. Future tank crews were to be trained to assume greater responsibility for the general care and maintenance of their machines. Elles said:

> "At first a large variety of excellent arguments were advanced to show why it [brigading] would fail. Nevertheless, it not only succeeded [in] making a very large saving...in artificer personnel, without which successive expansions [of the Tank Corps] would have been impossible." [8]

In the spring of 1918 the German offensive deprived the battalions of the necessary manpower to carry out the planned expansion . Instead it was decided to downgrade two of the three remaining battalions being raised in England to cadre status and to convert the third to an armoured car battalion. Resumption of the offensive in July led to the cadre units achieving full battalion status. That same month the proposed expansion of the Corps to 34 battalions, which had first been discussed in January but had been shelved because of the German offensive, was considered. But the expansion of the Corps was to take time. It was not until September 1918 that the expansion programme first proposed in October 1917 was complete. [9]

Reserve crews

Between 8 August and the Armistice the number of fighting tanks "in service" remained constant (630 and 641 respectively).[10] In August there were 7, 700 fighting crew members (both officers and men of whom Elles said 500 were inexperienced - but this was always the case and simply reflected the constant upheaval of replacements and expansion), which meant that there was a 76 per cent reserve of fighting crews in early August falling off to 66 per cent by the end of the month.[11] Of

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[8] General H. Elles, "Notes on Tank Development During the War", Tank Corps Journal, March, 1922.

[9] "A Short History of Tanks in the Great War", p 74.

[10] Statistics taken from General H. Elles, " Summary of Tank Operations", and" Organisation of Branches and Services, November 1918-January 1920", in WO 158 / 849.

[11] This is a particularly interesting point in the light of criticism by many historians of GHQ's failure to manage the available tank resources, especially in the provision of tank crew reserves, during the final 100 days. The 76% reserve of fighting crews has been obtained in the following way.

There were 630 fighting tanks "on charge" (that is issued to, but not necessarily "fit to fight") at the beginning of the August campaign. Of those 72 were Medium 'A' machines (Whippets). Therefore, 630 - 72 = 548 heavy machines. There were 8 crew members in a heavy tank = 4,384 heavy tank crew members. Since there were only 3 crew members to a Whippet there were only 216 crew members. If we add the heavy to the light to give the front line strength we find that there were 4, 600 fighting crew members. If we subtract this figure from the total number of fighting crew members = 7, 700 - 4, 600 = 3, 100 reserve crew members. The 72 Whippets constituted 13% of the fighting tank force. 13% of the reserve crew members = 403 -:- 3 = 134 Whippet crews (90%) in reserve. Which

the 7,700 crew members 3, 188 became casualties during the period 8 August - 20 October .[12] This represents a casualty rate of some 41 per cent at a time when manpower was in very short supply. Yet even during the period of the most intense tank activity of the war the Tank Corps was never seriously undermanned in regard to tank crews. There was always a reserve capacity of never less than 60 per cent for the heavy tanks, the most important of the machines. The operational difficulty was not numbers but sustainability, with many of the casualties caused by exhaustion rather than shell, shrapnel or bullet wounds. All but exceptional crew members found it difficult if not impossible to operate effectively for long periods in deafening noise, breathing noxious fumes in extremely high temperatures. Generally speaking crews could not function efficiently for more than a few hours of continuous action, while reserves were quite literally exhausted within a matter of days. However a day's rest usually saw the great majority of crew members fully recovered.[13]

The Inter-Allied Tank Committee proposed in July 1918 that in 1919 the number of battalions expand still further from 18 to 34.[14] On 9 September Churchill wrote to Lloyd George Churchill described the state of the Tank Corps and outlined the plans for its expansion :

> "Up to present there have only been about 18, 000 men in the Tank Corps, and they have only had 600-700 Tanks to use in action. It is universally accepted out here [he was writing from Chateau Verchoeq] that they have been a definite factor in changing the fortune of the field...It has now been settled to raise the Tanks [sic] to 55, 000 men. This is only about half of what we shall need for the Tanks I shall actually have ready for the summer 1919. Although my out-puts are only about half what I expected, Elles tells me ' that the tanks they have will see out the Tank men this year '." [15]

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means that 3, 100 - 403 = 2, 697 -:- 8 = 337 heavy crews (62%). This gives the total number of reserve as 337 + 134 = 471 (76%) reserve crews at the beginning of August. If we examine the figures for the end of August which was by far the most active month of the last 100 days [this period saw 1, 184 tanks engaged over 14 days] we can see that these percentages hold true in the case of the heavy tanks : 230 heavy tanks "on charge" and 344 tank crews = 67% reserve capacity. The Whippels reserve capacity had been reduced but only to 64% (39 machines and 61 crews). This gives us a 66% reserve crew strength at the end of August. Statistical information used in these calculations was taken from General H. Elles, "Summary of Tank Operations" (29 October 1918), "Weekly Tank State" (30 August 1918), and"Tank Note" (31 August 1918) in [MUN 4 / 600 and Official History, Vol IV, p 384].

[12] General H. Elles, "Summary of Tank Operations".

[13] A report on "The Medical Aspect of Tanks", by Major L.R. Broster, Tank Corps (30 October 1918) offers a detailed discussion of the conditions inside the tanks and their medical effect on the crew. MUN 6 / 400.

[14] "The Organisation of Branches and Services, November 1918-January 1920".

[15] Gilbert,*Winston S. Churchill* (Vol IV, 11917-22, companion), pp 389-90. Churchill is once again demonstrating a characteristic interest in the running of other peoples's departments since the function and organisation of the Tank Corps did not come within the remit of the Minister of Munitions ! Having said that his letter is still a useful source of information regarding the general trend if not the specific detail of the growing importance of technology on the battlefield and in particular tanks, and also in

He concluded his letter with the statement that he felt that there " ought to be 100, 000 men in the Tank Corps by 1919".

Combined training

The impact that the tank could make on the battlefield, particularly in relation to mass tank and infantry co-operation, was limited by poor tank to tank and tank to infantry communication, and by the restricted opportunities offered for combined training with the infantry.

Throughout the war communication was a major stumbling block to the efficient use of the tank in battle. An 8th Battalion report for theTank Corps HQ, January 1919, stated that methods of signalling which aspired to anything more sophisticated than the most basic proved unworkable. In the case of signal communications between tanks and infantry this meant a rifle or pick shown from the back of a tank. The noise and darkness made signalling within the machines extremely trying and unreliable with the introduction of the "speaking tube" a notable failure. Communications between section and company commanders were successful only if kept to the elementary level of runners. Pigeons, often advocated as reliable means of communication between HQ and the tanks, were in reality, the report says, too slow. The use of "Tank Discs" and"Semaphore" as a means of inter-tank communication was, says the report, "quite useless". The report does not mention the use of early wireless sets. Whether one is to deduce from this that 8th Battalion did not experiment with them or that they were a total failure in the opinion of the report's writers is unknown. [16] However, what is known, and this reflects the spirit of enthusiasm and sense of eagerness , not only in the Tank Corps itself, but at GHQ as well, is that document SS. 167, Signal Organisation for Heavy Branch Machine Gun Corps , issued by GHQ down to Brigade level by the General Staff in June 1917, placed special emphasis on the importance of improving communication between tanks , HQ and GHQ. It was

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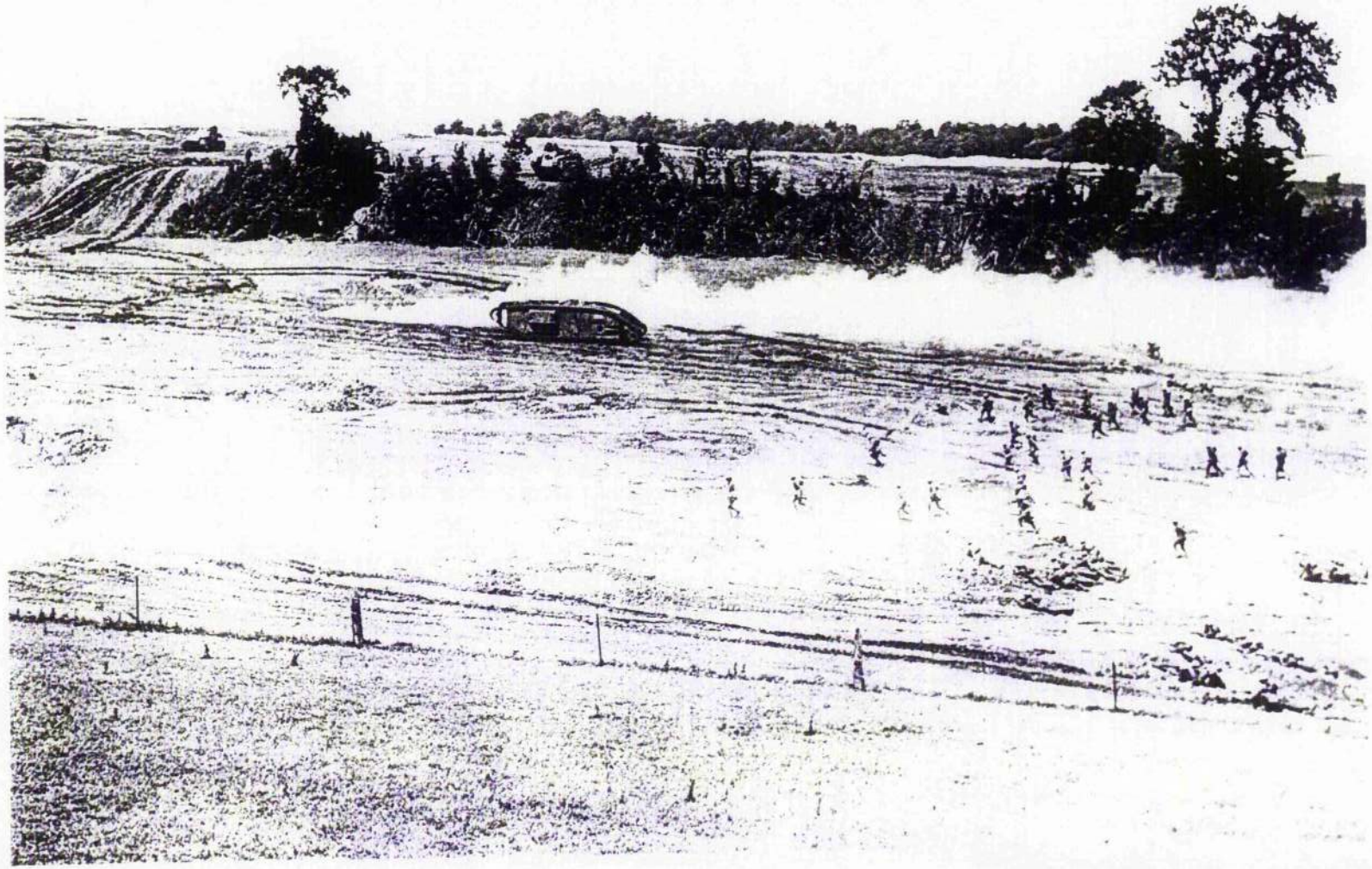
regard to the employment of tanks in the last hundred days. He is not suggesting that all the tanks available at this time should be committed to a mass tank battle, but like everyone else at the time he was anticipating further tank actions in 1919.

[16] 8th Battalion History, Tank Museum. In *The Guinness Book of Tank Facts & Feats,* Kenneth Mackesy stated that two wireless sets per company were delivered in July 1916, but they were soon returned to Woolwich Arsenal when it was thought that they might interfere with "existing installations. Tank wireless trails began again in May 1917...In July, six stations were available in tanks for the Ypres operations." However, these proved to be unsuccessful. "At Cambrai", said Mackesy," one wireless tank per battalion was used." A practical wireless system which permitted use while the tank was on the move was not available until the 1930's.



Combined infantry / tank training, northern France, 1918

hoped the latter would be met by the "Signal Service" system (shown in fig. 1) whilst communications between the tanks and Tank Corps HQ were to rely on slow but reliable carrier pigeons enhanced by the use of "Wireless" (fig 2). Paragraph three reads :

> "Experiments are now being carried out with Wireless in the Signal Tanks, and have so far given most promising results. The intention is to employ Wireless between the Signal Tanks at rallying points and fixed Wireless Stations erected at any suitable HQ such as an Infantry Brigade...The Signal Tanks have aerials permanently shipped on them , and are at present working on 850 metre wave length , but one or more additional wave lengths will be allotted later...It is expected that Signal Tanks will be able to accept messages, from Infantry and other units, for transmission to the rear by Wireless."

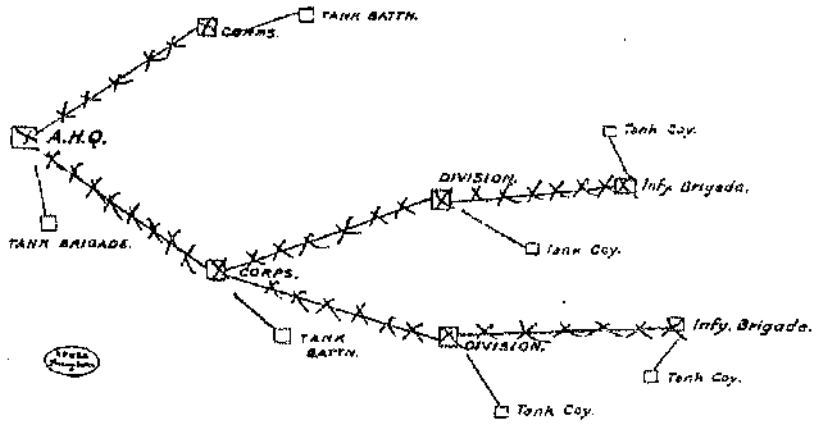
Deficiences in Tank Corps communications had to off-set by a hightened awareness of the requirements of other tanks and the infantry when acting in close co-operation. This could only be achieved by instructional pamphlets and practice. The first of a series of instructional pamphlets on combined training was issued by GHQ in May 1917. Entitled, Notes on the use of Tanks and on the general principles of their employment as an adjunct to the Infantry attack, (SS. 164), it states that :

> "The tasks and role of the tanks should be worked out by the commanders ...in co-ordination with the artillery programme, and each tank should be supported by mopping up parties and sufficient infantry to consolidate and hold the objectives when gained."

It is implicit in this passage that co-operation between infantry and tanks was to be practised. However, one must reiterate, that the performance of the machines militated against too much emphasis being placed on extended joint training for, as the pamphlet pointed out, tanks could not be relied upon to reach their objectives.

By March 1918 the emphasis had shifted. The infantry were still the dominant arm, but the tank now occupied an enhanced role, one which was in keeping with the improved performance of the new machines. Infantry and Tank Co-operation and Training (SS. 204), states that :

> " It is...necessary for the Infantry and the Tank Corps to obtain a full knowledge of each other's powers and limitations...The Tank crews must understand that the advance of the infantry is limited by their physical endurance and the enemy's fire, and the Infantry must equally realise that the advance of the Tanks is chiefly limited by the condition of the ground...There is little time on the battlefield to work out methods of co-operation ; these must have been thought out and assimilated before hand, and the more carefully this has been done the closer will be the co-operation...Not only must there be a common doctrine and a full understanding of each other's difficulties , but Tank and Infantry commanders must get to know each other,

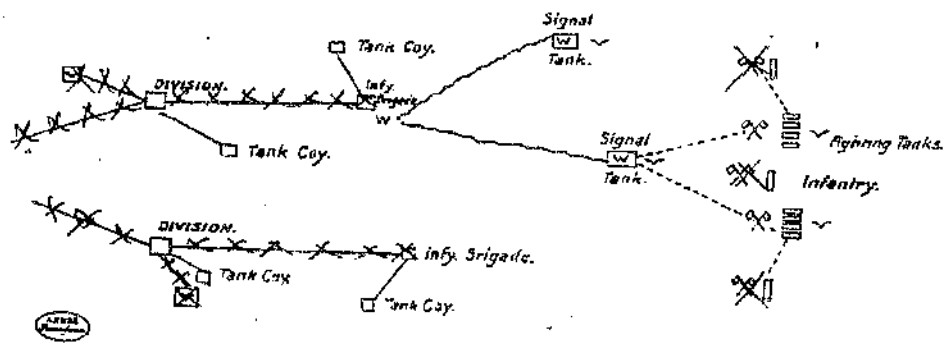


TANK COMMUNICATIONS.

FIG. I.—PERMANENT OR SEMI-PERMANENT TELEPHONE COMMUNICATIONS.

BLACK—General Signal Service System. Marked with x x x

RED—Special Circuits for Tanks.



TANK COMMUNICATIONS.

FIG. II.—MOBILE COMMUNICATIONS.

NOTE.—The Tank Section Commander may be with the fighting Tanks during action.

BLACK—General Signal Service System. Marked with x x x

RED—Special Circuits for Tanks.

APPENDIX B.

NOTES ON COMBINED TRAINING BETWEEN INFANTRY AND TANKS.

1. It is essential for successful co-operation between infantry and tanks that the infantry tactics laid down in S.S. 143, and the tactics for tanks laid down in this pamphlet, should be practised.

2. Before the training begins the infantry brigade commander and the tank brigade commander should carefully work out the various exercises, and the former should attend a demonstration carried out by the tanks with tank personnel representing the infantry. He will then be in a position to criticize effectively the work of his own men and of the tanks during the actual training.

3. In order to ensure that the training throughout a brigade may be uniform, it is advisable that a company of infantry should be specially trained for demonstration work. The duty of this company will be to carry out a demonstration of the various exercises in the presence of the remainder of the infantry of the brigade before the training begins. An infantry officer who understands the movements of tanks should be made responsible for the training and should carry out all practice demonstrations.

4. The general procedure in carrying out the exercises should be as follows:—

(1) Each exercise should be carefully explained to the men on the ground. The men must be told exactly what the tanks will do and how they can assist the infantry.

(2) A demonstration of the exercises should be carried out by the infantry demonstration company in the presence of the other companies.

(3) The remainder of the companies should carry out the exercises.

(4) The infantry and tank brigade commanders should criticize the manner in which the exercises have been carried out.

5. The exercises should be simple and should consist of three or four kinds of attack, *e.g.*:—

(*a*) An attack without a barrage on a strong point or locality.

(*b*) An attack under a barrage.

(*c*) An attack without a barrage as the continuation of an attack under a barrage.

(*d*) A counter-attack without a barrage.

A good way of combining every kind of attack is to start the exercise with a barrage. It should be pointed out to the men that this represents the initial phase in an attack. Once this phase has been completed, the men should go back to the starting point and carry out the exercise again without a barrage. It should be pointed out to them that this represents the phase of the attack which follows after the zone of the protective artillery barrage has been passed.

6. It is important that before any exercise takes place the infantry should be fully acquainted with the few simple signals now laid down, green and white flag, red and yellow flag, etc. Not only should the men understand what the green and white signal is meant to convey, but also the tactical situation under which it will usually be employed. In an attack it may frequently occur that hostile machine guns will open at ranges which may inflict considerable casualties on the infantry. In such circumstances the infantry should take cover while the tanks deal with the machine guns. Directly these have been dealt with, the tanks should hoist the green and white flag to shew that it is time for the infantry to move forward. If the machine guns are far distant from the infantry, the infantry will have to push forward scouts so as not to lose touch with their tanks.

reconnoitre the ground together and so plan success... ."

Paragraph V, " Training for an Infantry and Tank Attack Against Trenches", places particular emphasis on joint training. The exercises for the attack "...may be carried out with or without Tanks. If no Tanks are available , a man carrying a flag should be used as a substitute." Behind either the tank or the flag troops were expected to practise "Forming up behind tanks, advancing to the attack, passing through the wire and clearing trenches". The first exercise "should be carried out as a drill parade both by day and by night". The second "is not a parade, but a fighting movement...section commanders may have to use their initiative to meet unexpected difficulties". The infantry was instructed to advance behind the tanks by "bounds, making use of ground as far as possible for fire effect and cover", and not at a "steady even pace" as behind a creeping barrage. The message within SS.204, emphasised by the inclusion in the pamphlet of ten diagrams depicting the various attack formations for combined forces, was clear : co-operation between the infantry and the tanks was vital and should be practised at every opportunity.

Tanks and their Employment in Co-operation with Other Arms (SS.214), issued by GHQ in August 1918, superseded SS.164 and SS.204. The pamphlet's detailed notes on combined training between infantry and tanks can be seen opposite. GHQ was emphasising the importance of combined training, but how much time was there for tank and infantry officers to train for combined attacks ?

The time and opportunity for combined training prior to Flers was negligible. Limited numbers, late arrival of machines at the front and the need to maintain secrecy all militated against training[17]. This, of course, is not to suggest that GHQ did not appreciate the importance of combined training. GHQ's "Preliminary Notes" on the use of tanks, issued in mid-August stressed the vital importance of such training. In what appears to have been a covering letter to these "Notes" General L.E. Kiggell, Chief of the General Staff, made it clear that he understood the limitations of the tank and the importance of combined training :

> " The objectives of the 'Tanks' must be clearly stated and as simple as possible, as it is difficult for the "tanks" to manoeuvre...It will be necessary to specifically train the divisions who may be earmarked to work with the 'tanks'." [18]

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[17] CAB 45 / 200.

[18] Haig diary, 15 August 1916, Vol.10.

And although the opportunity for such training was not widespread it did take place. Haig commented on one such exercise which he witnessed first-hand :

> "I was present at a demonstration in the use of "Tanks". A Battn. of Infantry and 5 Tanks operated together. The Tanks crossed ditches and parapets representing the several lines of defensive position with the greatest of ease, and one entered a wood, which was made to represent a 'strong point' and easily 'walked over' fair sized trees of 6-inches in diameter! " [19]

At a 4th Army conference held on 1 September, at which representatives of all arms, including tanks, artillery and the RFC were present, Rawlinson made his views on the matter plain :

> "Corps Commanders should get hold of their front line Divisional Commanders as soon as possible and discuss with them both the plan and the uses to be made of the"tanks". If they are to be of value infantry must have confidence in them. The divisions, therefore, which were to go forward with the "tanks" must be trained with them, and "tanks" will be brought up into their areas as soon as possible so that practice may be possible." [20]

Clearly the importance of combined training was understood. However, suspect reliability and limited numbers relegated the tank to a supporting role, calling for only limited co-operation between infantry and tanks and therefore limited training. Consequently the period between the end of 1916 and the summer of 1918 was largely one of tank development. Whether time or conditions would have permitted more extensive training in the hustle and bustle of war had the tanks been more useful in terms of performance, or whether the period late 1916 to early 1918 was necessary for tanks crews to gain sufficient experience in the use of tanks in battle are moot points. Hugh Elles was to comment after the war that it took in the end two years to build up the necessary level of expertise and gain battle experience in tank warfare before something like Amiens could be attempted, knowledge that could not be imparted to the novice crew by way of a pamphlet or indeed on the training ground.

Just how far things had to improve is evident from a" Confidential" Tank Corps report written on 27 November by Captain F.E. Hotblack and addressed to J.F.C. Fuller (on the operations at Bourlon Wood, 26 November 1917). He made the following recommendations necessary to improve infantry tank co-operation :

> "(1) Whenever possible Infantry units should send guides to conduct Tank Officers to their Headquarters; the finding of Infantry Brigade and Battalion

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[19] Haig diary, 26 August 1916, Vol. 10.

[20] Rawlinson diary, RAWL 1 / 6.

Headquarters in a little-known area by night, involves a great waste of time and energy.

(2) Physical fitness of Company Commanders is of great importance. A large number of Company Commanders are unable to walk the very large distance necessary for them to carry out this type of operation.

(3) Attack formation. In many cases Tanks attacking a village are obliged to enter it in file; they frequently approach in file and do not deploy at all. This is undoubtedly wrong, it gives little opportunity for the Infantry to follow closely or adequate protection.

(4) It is essential that while the leading Tank makes straight for the entrance of the village, the remaining two or three Tanks of the section should deploy to assist the Infantry on the outskirts of the village, then swinging and entering the village themselves.

The greatest difficulty in attacking strongly held villages is undoubtedly to get the Infantry as far as the outskirts; after that Tanks should have little difficulty in forcing a covered advance for the Infantry stage by stage.

The attitude of some Tank and Section Commanders is still that is merely their duty to get to certain objectives in a village or somewhere, "do their bit", and return home having taken during the proceedings no interest whatever in the movements of the Infantry, and blaming the latter for failing to have attained the same objectives." [21]

Certainly, the Battle of Hamel in July 1918 did mark a significant shift in emphasis toward greater combined arms operations, and consequently in the level of training given to the tanks and infantry. The new Mk.V's offered much greater scope for such operations, and it was the Australians in particular, under John Monash, who led the next stage in the evolution of tank tactics :

> "Set-piece manoeuvre excercises on the scale of a battalion were designed and rehearsed over and over again; red flags marked enemy machine-gun posts; real wire entanglements were laid out to show how easily the tanks could mow them down ; real trenches were dug for the tanks to leap and straddle and search with fire; real rifle-grenades were fired by the infantry to indicate to the tanks the enemy strong points...in these practices the artillery barrage was, as usual, represented by a line of men carying flags ... The tanks kept open house...the infantry were taken over the field for a"joy ride," and allowed to clamber all over the monsters, inside and out, and even to help drive them and put them through their paces. Platoon and Company leaders met dozens of tank officers face to face and they argued each other to a standstill upon every aspect that arose... ." [22]

During the battle Monash had the command of the tanks temporarily placed under the infantry in order to improve co-operation and trust. The success of the battle led GHQ to publish an account of it for the "guidance of commanders generally". Numbered SS. 218, Operations by Australian Corps Against Hamel , Bois de Hamel, and Bois de Vaire, it was published in July 1918.

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[21] Fuller papers, B / C / 1.

[22] Quoted from *The Australian Victories in France in 1918,* itself quoted in, C.E.W.Bean,*Official History of Australia in the War of 1914-18,* Vol IV, pp 267-8.

The experience gained at Hamel was invaluable and was studied carefully for the Battle of Amiens. The training given before Hamel was continued in preparation for the next offensive. Training infantry and tanks to co-operate was :

> "...carried out before batches of training troops by demonstration of the 5th Aust. Div. together with tanks of the 5th Bde. The exercises included an advance under a creeping barrage, an attack on a strong-point, and an attack on a farm. The demonstration company carried out the practice first, with other troops watching. These then carried it out themselves with the tanks." [23]

Clearly, at least one third of the 4th Army at Amiens (Australian Corps) was familiar, in as far as conditions allowed, with their role in relation to the tanks. Further, one can suggest that, if one element of the 4th Army was trained, then, bearing in mind that GHQ had not only printed the lessons of Hamel, but had, in March and August 1918, printed similar training instructions and tactics (as cited above), it is inconceivable that the British III Corps and the Canadian Corps did not instruct their infantry along the same lines. Therefore, whilst prior to Flers the effort given over to the combined training of infantry and tanks was very limited, this was not the case in 1918. GHQ had given careful consideration to the employment of the tank and had published pamphlets and training manuals to this effect. Time and materials were made available whenever possible for actual combined training of tanks and infantry. Yet, it was still a far from perfect set-up as Elles made clear in a letter to Ivor Maxse, Inspector-General of Training, on 14 November . In this letter Elles refers to Maxse's wish (expressed in a previous letter to Elles) for there to be a "trained body of demonstrators thoroughly practised to bring out the main lessons". According to Elles :

> "... except in the case of the Australian Corps and one or two isolated instances, we have never been able to get a semi-permanent body of infantry, nor have we been able to arrange demonstrations to be run for a considerable period, say one month by a senior officer of Infantry. These things combined with the great haste with which we have been suffering the last six months, havebeen, I think, the main causes for the failure in training"[24]

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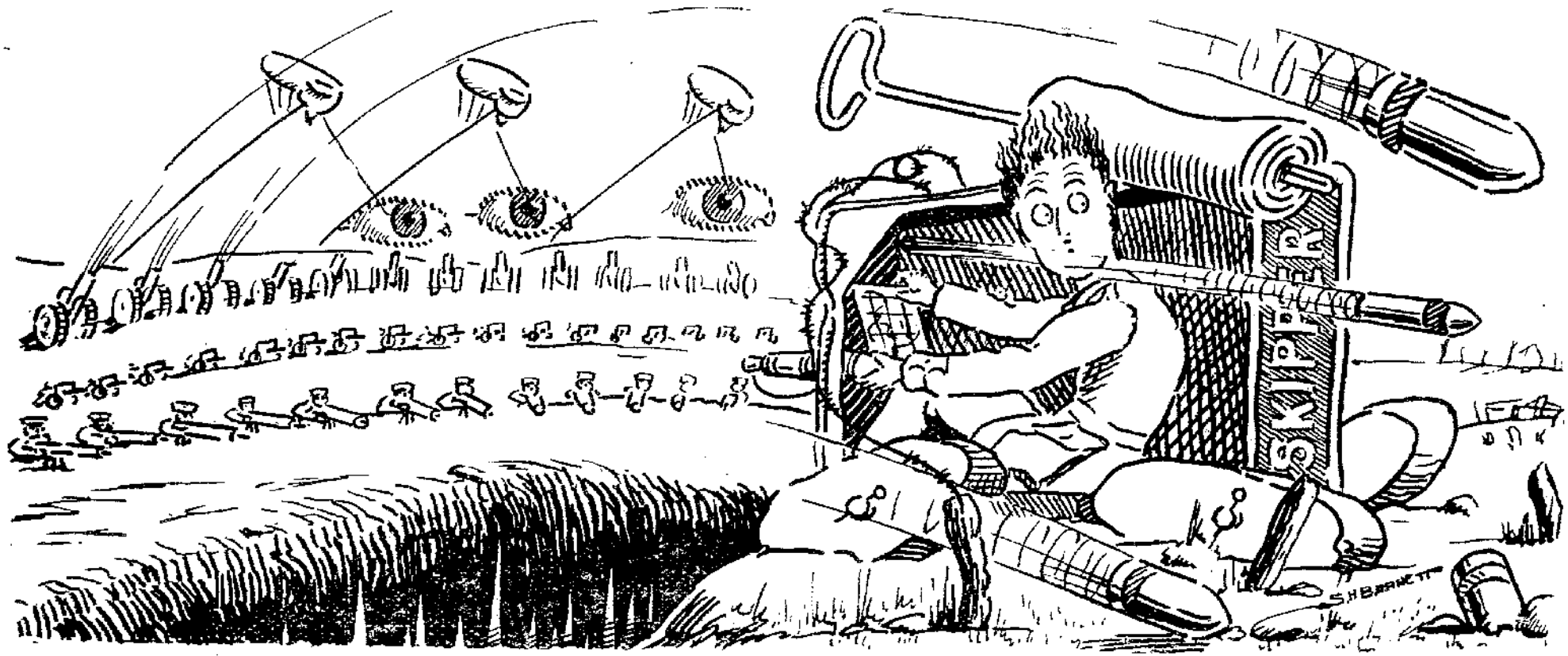
[23] Ibid, p 496.

[24] Maxse papers, file 58.

Section Three

Employment

The search for a coherent doctrine of tactical employment was never to be "solidified". But this does not mean that this was neglected. There is ample evidence to suggest that from mid-1916 onward Haig and GHQ went to some considerable lengths to formulate a doctrine, and that the debate was very much alive even as late as November 1918. Further, the "failure" to commit significant numbers of tanks to battle in the closing months of the war did not signify a lack of enthusiasm for tanks as some have argued, but rather it was a decision that reflected above all a pragmatic appreciation of the tank's capabilities at this time.



"WIND UP"

What it feels like to go "over" for the first time in a Tank

[10]

The Search for a Tactical Doctrine of Employment

The preceding two sections of this thesis have sought to demonstrate the vital support to the tank's development offered by the Army and its upper echelons. This final section will further argue that this support extended to the employment of the tank on the field. But before discussing the search for a tactical doctrine, it is worth briefly examining the attitudes of Haig and GHQ to the tank. It has been suggested that although Haig and his senior commanders readily accepted the tank, they were unable to make the mental adjustment necessary to exploit fully the tank's potential. As a result the tank never delivered its true "war-winning" capability during the war.

Haig and GHQ : *attitudes to the tank*

It is an interesting point that even Colonel Philip Johnson's "Snake" tracks (as discussed in chapter six), which were quite striking visually, were not the most outrageous of design modifications suggested for the tank. This must surely go to the suggestion of fitting scythes to the new Medium 'C' tank as discussed by members of the Tank Board in September 1918.[1] Together with search lights, this addition to the tank's armament would, it was hoped, spread even greater terror among the enemy troops. The idea had apparently been discussed earlier in the year and obviously a decision had been delayed until this time. However, it is not known what decision was eventually made beyond referring it to the Inventions Committee. The idea of transforming what was at the time the most sophisticated piece of military technology into a Boudiccan (ironically Boudicca was supposed to have died at Thetford, the first tank training camp) chariot is, strangely, not out of keeping with the whole explosion of technological ideas at the time. As technologically complex as this new weapon was, it was still the product of a programme of rapidly accelerated engineering development led by the demands of war ; however, the mental frames of reference of the men who

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[1] WO 158 / 867.

produced them, and more importantly of those who used them, were still largely those of the previous century. The tank came with its share of cultural baggage in the early years of its inception. It originally bore the name "Landship" denoting the naval influence in its origins. The picture of "fleets" of these"Landships" sweeping all before them on the battlefields of France was not wholly fanciful in 1915. Even as late as 1918 tank "visionary" J.F.C. Fuller employed similar naval terminolgy in his "Plan 1919". The revolution in technological ideas, out of which the tank was born, not only outstripped the tank's ability to perform consistently in action, but posed serious questions of those who were to determine the nature of this employment. The most important of those questions was whether Haig and the GHQ would be able to devise a tactical doctrine of employment which reflected the strengths of the tank and not the preconceived notions of how a war ought to be fought.

On 19 May 1918 Lieut-Colonel C.N. Buzzard, General Staff, submitted his report, "Tanks and Mechanical Warfare", to the Supreme War Council. In it he argued :

> " that the introduction of any new arm to our Army or Navy invariably produces, at first, violently antagonistic schools of thought. On the one side there are the optimistic enthusiasts, the pioneers, on the other the ultra conservatives, who regard innovations with considerable suspicion, which is usually accentuated by certain failures which invariably attend the inauguration of a new arm...If anyone wishes to test the limitations of human psychology...let him put the following propositions to any Horse Artillery Officer of his acquaintance. Supposing a reliable tractor were provided, capable of hauling a field gun at 8 miles an hour over ordinary ground, capable of crossing any obstacle that can be crossed by a team of horses, only requiring two men to look after it (and these protected by armour plates) and capable of coping with mud to the same extent as can a horse, would you be prepared to adopt such a machine and scrap all your draught horses ?" [2]

"It is obvious", he argued," that, granted the possibility of such a machine, there should only be one answer..., but it is exceedingly doubtful whether even a highly intelligent and practical officer of a mounted branch would give an affirmative answer. The fact is:

> that the average human mind has well defined limitations, and it is hopeless as a rule, to expect an unprejudiced opinion of a new invention from anyone who has spent half or two thirds of his lifetime in carrying out his duties with considerable success without feeling the want of such an invention."

But Buzzard was wrong to be so pessimistic about his fellow officers. In a paper written by Major Stephen Foot, General Staff,[3] on 9 February 1918 entitled "

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[2] Supreme War Council minutes, CAB 25 / 12.

[3] Whilst Foot's paper is signed "Stephen Foot, Major, G S " Paul Harris, *Men Ideas and Tanks*, p 165, states that Foot was transferred to the War Office's Tank Directorate under General J Capper in January 1918.

Petrol Versus Muscle" , the exact same situation regarding the substitution of mechanical power for horses power was discussed. Foot drew attention to the critical question of "manpower and shipping" and the extent to which the "available supply" was being utilised to its " best advantage".

Under a sub-heading , "Food for Horses In France", he stated that there were not less than 400, 000 horses and mules in France requiring 80, 000 tons of fodder per month. Since "the main work of these horses is that of transport", he asked " are we getting the best value out of our tonnage by employing it for bringing food to develop the muscles of a horse ?" "I suggest", he answered," that a very great saving could be effected by the substitution of petrol... ." He argued:

> "...the main reason why motor transport has not up to now entirely supplanted horse transport is that vehicles at the front are still required to go over country racks, bad roads, etc., which are accessible to the horse but not to the ordinary motor vehicles. The development of the tank, however, has produced a [vehicle able to] move in to any place where a horse can go, and through many places which are quite impassable for a horse-drawn vehicle, e.g., shelled ground, small trenches, barbed wire, etc.[4]

He went on to cite as an example of the savings possible, "Petrol versus Muscle for a Field Artillery Brigade." Such a brigade he argued relied "entirely on horse flesh for movement of guns and ammunition." A brigade :

"...exclusive of the Brigade Ammunition Column, has 723 horses and mules, of which about 560 are used entirely for transport work and its supervision. These 560 animals require approximately 5

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[4] Foot was arguing a case for the creation of a mechanised army with the Medium 'A' tank providing the mechanical component. But although in this first section of his report he was suggesting using tanks as tractors with the added capability of doubling as mobile light artillery when the occasion demanded, he later went on to argue the case for replacing the cavalry with tanks, i.e. the adoption of mechnanical warfare itself. Under a sub-heading, "Petrol Versus Muscle in a Cavalry Division", he advocated the replacement of the cavalry's chargers with tanks. While he acknowledged that "questions of tactical value" were involved in such a move, he confines himself to a discussion on potential manpower savings :

"A Company of 20 tanks may be considered the equal in fighting value of a Cavalry Regiment....Replacing horses by tanks...we would have the following results :-

(1) 9 Tank Companies (180 tanks) in place of 9 Cavalry Regiments.

(2) Approximately 1,890 officers and men in place of 4, 674; or, after making provision for the manufacture of the tanks, repair shops, etc., 2, 610 in place of 4, 674. This is exclusive of the Cavalry Supply Column, Field Ambulances, etc., on which a further large saving would be effected.

(3) A decrease in weight of fodder to be transported of more than 1, 000 tons per month after allowing sufficient petrol to move ten miles daily."

The Medium 'A' was not to make its first appearance in action until March 1918. But it was at Amiens in August that it was most successful. Here Rawlinson had been persuaded to employ it in conjunction with the cavalry. The experiment was not a great success. The performance and requirements of machines and horses were entirely different. However, it did at least point the way to future post-war operations.

tons of food per day. I suggest that the work of hauling guns and ammunition could be done quite as efficiently by 24 tanks. This number allows 6 tanks per battery, 3 of them for ammunition and the other 3 for moving the guns (1 tank hauling 2 guns). The tanks pulling the guns would also carry ammunition and be used for this purpose when not required to move guns.

This allowance of 6 tanks to a battery should be ample to allow for breakdowns, and still perform as much work as can ever be done by a battery of horses.

The horses require 5 tons or fodder per day and 5 tons of petrol should take this light type of tank a distance of 1, 200 miles, or take the whole of 24 tanks a distance of 50 miles each.

A small weight of oil and grease would also be required, but this is compensated for by the saving effected as against corn and hay, by the fact that petrol can be moved in bulk by tank ships and tank railway wagons.

Of course an Artillery Brigade in never called upon to move such distances as that, and here we come upon the most striking feature of the problem. THE HORSES GO ON EATING THEIR 5 TONS PER DAY WHETHER THEY ARE WORKING OR STANDING IDLE."

Turning to the question of savings in manpower. The artillery brigade would require 320 men to "look after" the 560 horses mentioned above. "A liberal allowance for the 24 tanks," he wrote, " would be 72 men." He than argued that since a :

"...large sized fighting tank [a heavy tank] requires for its construction about 3, 000 men-days, or say 10 men working for a year .... the small tank, about one-sixth of its weight and about one-fifth of the cost, would require the equivalent of not more than 3 men's work for a year, though if the tanks are constructed in large quantities this would undoubtedly be reduced to 2 men.

Taking the higher figure, however, and putting the life of the tank at a year we require only a further 72 men in the manufacturies to keep the Brigade equipped with tanks. On the basis of our present experience with tanks, an allowance of repair workshops at the rate of 1 man per tank is a liberal estimate, so that with a good margin of safety one can reckon a saving of more than 150 men per Brigade.

Even putting the life of a tank as low as 6 months we should still have a saving of about 90 men, while if the tanks are being manufactured in large quantities this saving would be increased to about 130. On the other side no mention has been made of the man power absorbed by Remount depots, Mobile Veterinary Sections, etc."

Foot concluded his paper with the recommendation that "the substitution of machines for horses is now possible in a large number of cases. A large economy would be effected in tonnage and man power by this substitution." [5]

Major Foot's paper is a little sanguine on matters concerning the logistical arrangements for tanks in general, although it must be said that his "light tanks" (i.e. Medium 'A') required less attention , and used less (in terms of weight at least) of spare parts than the heavy tanks. The problem with using light tanks is that they were very much more expensive to produce than caterpillar tractors which could do the same job.

Was Foot's paper just another example of the frustrated outpourings of the lone enthusiast of mechanical warfare ? Or did it reflect the thinking of the upper echelons of the Army ? A shortage of horses at the front in early 1918 was responsible for giving added impetus to the search to find a mechanised alternative to the vast numbers of horses employed in general logistical work (bearing in mind that the Army had employed tractors to move guns since 1914). By mid-1918 the War Office had placed

[5] Liddell Hart papers, L.H. 9 / 28 / 59.

orders with the Ministry's Agricultural Machinery Branch for large numbers of caterpillar tractors. Buzzard's pessimism would seem not to have entirely reflected the mood amongst even the "traditionalists" given that War Office plans for 1919 centred around a force of 20 American, 20 French and 20 British divisions all equipped with tractors for towing artillery instead of horses !

Much more recently, however, Tim Travers has taken-up Buzzard's line of reasoning. Travers has applied Thomas Khun's work on paradigms to attempt to explain the"cautious" acceptance of new technology on the battlefield :

> "Thomas Khun's work on paradigms suggests that learning and problem solving will continue to take place within a paradigm of set ideas until a problem cannot be solved , at which time some (younger) individuals will switch to a new set of ideas. But until that moment, every effort is made to solve problems within the framework of the original paradigm or set of ideas." [6]

But was this ever the case ? Was the employment of this new and potentially "war-winning" weaponry being hobbled by its subordination to the demands of the traditional arms ? Travers has suggested that the tank's potential was never fully exploited during the First World War because of the inflexible nature of British doctrine. There was a "tendency ", argues Travers, " to slot the piece of new technology into understood and "traditional" roles." This was particularly the case with the tank which, he maintained, was allocated a role"that reflected its own logic ; in other words, accepting the tank , but not really thinking through the capability of the new weapon." [7] Arguably this might have applied to the employment of machine guns, mortars and the consequent development of the all-arms infantry sections, though some have recently begun to question this,[8] but one seriously doubts whether it applies to the tank. The "problem" which Travers argues prevented the full realisation of the tank's potential was not mental, but mechanical.

Buzzard was wrong. As Foot's paper, and the actions of the War Office by mid-1918 suggest, mechanisation was not an alien concept to the British Army. As a small professional force, the Army had always been receptive to new technology as a means of off-setting numerical inferiority. Replacing the cavalry with tanks as Foot suggested was , however, a different matter. But the experience at Amiens proved at least that Army minds were not entirely closed to the matter. The key factor at Amiens was the mechanical reliability and performance of the Medium 'A' tanks which operated with

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[6] Tim Travers, *The Killing Ground*, p xix.

[7] Tim Travers, ibid, p 75.

[8] Paddy Griffith, *Battle Tactics of the Western Front* , chapters: 6, 7, and 8 in particular.

the cavalry. Their mechanical vulnerability meant that Travers's "problem", which would have been encountered head-on had the Medium 'A' tanks been all that their designers had hoped for (i.e. the replacement of the cavalry with tanks), did not realistically arise in 1918. Nor would it have in 1919, despite the pace of technological development. And even if it had there is sufficient evidence to suggest that Haig and GHQ were perfectly capable of, and in fact actually did envisage, employing the tank (in both its heavy and medium formats) in a role more demanding that of an infantry support weapon.

The search for a tactical doctrine

From the first the tank was devised with a very clear tactical role in mind, namely breaking the stalemate. Its role was to be that of a machine-gun destroyer, capable of crossing hitherto impenetrable barbed wire, freeing the infantry or cavalry to exploit the newly restored mobility. What the tank was expected to achieve was therefore clear. Exactly how it was to go about achieving this in co-operation with the other arms was not so clear, as Haig's comments (which concluded an enthusiastic report of a demonstration of combined training between infantry and tanks on 26 August 1916) show,"...we require to clear our ideas as to the tactical handling of these machines." [9] This was to remain the case to the end of the war. However, it cannot be stressed strongly enough that this failure to produce a coherent tactical doctrine of employment was not the result of lack of imagination at GHQ, or the result of any resistance to the introduction of the tank, but was instead the inevitable consequence of the quite extraordinary pace of technical and administrative change in all matters concerned with the tank.

The first codification of the parameters of the new weapon's tactical employment came in February 1916 when Colonel Swinton produced his paper "Notes on the Employment of Tanks". This was to form the basis of all future doctrine. Much of the common sense thinking in these notes, for example on the importance of infantry / artillery / tank co-operation, found its way into "Preliminary Notes on the Tactical Employment of Tanks (Provisional)" issued by the General Staff in mid-August of the same year. Over the years many have criticised GHQ for ignoring the tactical requirements of the tank. This document provides, in nine full paragraphs, a quite detailed outline of the tactical employment of tanks. One may argue that the very existence of this document is sufficient proof, regardless of the extent to which

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[9] Haig diary, Vol 10.

subsequent military action adhered to these guidelines, to refute the suggestion that GHQ was tactically barren when it came to the employment of the new weapon.

" The object of the tank is to help the infantry forward, and especially to deal with the enemy machine guns " (Note 1) :

> "There are also several purposes for which individual tanks may be useful; for taking up stores, for hauling guns over trenches, for clearing up behind the leading lines of infantry, for destroying obstacles, and possibly for reconnaissance. The closer the country, the more useful the individual tank is likely to prove."

Note.1 further suggests just how realistic an appreciation of the tank's performance GHQ had :

> "The original conception of the employment of these machines was the advance of large numbers in line at 100 yds to 150 yds interval, closely followed by the infantry. This implies an approach march and deployment under cover, a surprise start, accurate keeping of alignment and direction, and on a suitable objective, such as parallel lines of trenches in open country; these conditions combined with the extent and regularity of the target offered to the enemy's artillery, render this a difficult operation."

Note 2 continues in the same cautious and thoughtful vein :

> "A tank cannot, except at great risk, cross a heavy barrage of H.E. or gas shells, and it cannot lie out in the open under shell fire. Its safety lies in surprise, in rapid movement, and in getting to close quarters...also it must have infantry with it. These considerations limit its employment, unless we are prepared to risk the loss of all the tanks by pushing them as far forward as they can go, if possible right through the enemy's gun positions."

This , as Note 3 points out, "entails...risk , and also requires that a large number of tanks should be available. As probably only small numbers will be available in the first instance, and as it may be required to use them as they arrive, it is necessary to consider how they can be employed under these conditions." Succeeding notes outline what GHQ believed to be the prime objective of the tanks.

"What is wanted...is a means of applying extra weight" against obstacles which impede infantry advances such as " villages, woods, strong points and hidden machine gun positions." But, as Note 4 points out, " No bombardment seems to succeed in obliterating these places so completely as to prevent the re-appearance of machine guns there as soon as the artillery lifts." "The weight" to overcome these strongpoints" cannot be applied by throwing in more infantry , as there is a limit to the density of infantry that can be used. The tank is designed to afford a solution to this difficulty...An allotted number of tanks should be told off to deal with each of these points of defence.

They should be closely supported by bodies of infantry told off for the purpose, who will advance under cover of the tanks, clear up behind them, and eventually consolidate the locality when taken."

There are, therefore, suggested Note 8, " 4 ways in which tanks may be employed :-

(a) The advance in line in large numbers.
(b) The attack in groups, or pairs against selected objectives.
(c) Employment singly, or in pairs, for special purposes.
(d) Employment as mobile light artillery."

The last method of employment, that of mobile light artillery, envisaged the use of the Male tank's 6-pdr " in close support of the infantry during the final stages of a successful advance, until such time as field artillery can be brought up."

Further evidence of GHQ's tactical appreciation and flexibility of thinking may be derived from the paths or lanes which the artillery were instructed to create to facilitate the safe passage of the tanks to their objectives.

The creeping barrage was a tactical innovation designed to overcome the problems encountered when infantry advanced on enemy trenches. Until the adoption of the creeping barrage it was standard practice to subject enemy emplacements to artillery bombardment for hours , sometimes days, lifting it only when the attack by Allied forces was to commence. However, the step-by-step, progressive character of the battle possessed two undesirable side effects. First, the end of the bombardment signalled a warning to the enemy of an imminent attack. Second, it gave sufficient time for enemy troops to emerge form their trench fortifications (which in most cases were heavily protected and proof against all but a direct hit) and man their machine guns in time to wreak terrible casualties on the advancing infantry. The creeping barrage was intended to overcome these effects. The artillery, after the prolonged preliminary bombardment, would then lay down a protective barrage ahead and keeping pace with their own advancing infantry. This tactic had seen only very limited use prior to the Somme, and was to be by no means universally applied in every sector during that battle. But sufficient training had been received by this date (along with an adequate supply of ammunition) to suggest that a reliable creeping barrage could be laid down, with some confidence that the infantry who were attacking under its cover would not too often fall victim to its shelling. Clearly, if the tanks, as suggested above in "Preliminary Notes", were to set off with the intention of arriving at their objectives, i.e. strong points, barbed wire entanglements, machine gun nests and artillery positions, some five minutes before the infantry, to ease the latter's path , then they would run the risk of not only attracting a hostile bombardment but falling foul of their own barrage.

Hence, the decision to leave lanes or paths in the barrage down which the tanks, attacking in twos or threes would advance.[10]

What follows is a brief excerpt from a record of the conference held at 4th Army General Staff HQ, on 1 September 1916 at which representatives of all arms, including the tanks and the RFC, who were to be involved in the operations of 15 September were present :

> "R.A. XV Corps brought up the question of the difficulties of the artillery if the "tanks" are to go forward in advance of the infantry.
>
> The Army Commander suggested that the "tanks" should go forward with the shrapnel barrage, that they should be concentrated in groups on trench junctions and strong points, and that the shrapnel barrage should be put on between the groups of "tanks."

"Instructions For The Employment Of Tanks" was issued by 4th Army HQ on 11 September. Under "General notes" point (c) states that :

> "Every tank going into action should be provided with a map showing its track clearly marked, and the objectives of the infantry with time table. " (See 47th (London) Division Operation Order No.101 and map)

Paragraph 10 of the" Instructions" states that: " If tanks get behind time table or get out of action , infantry must on no account wait for them." The intention to leave paths or lanes in barrages through which the tanks could pass to their objectives in no way, as paragraph 10 points out, overrode the importance or the supremacy of the infantry. As suggested in "Preliminary Tactics", GHQ was well aware that the tank was a weapon of uncertain mechanical reliability and as such was subordinate to the infantry. When, however, the time came to commit the tanks to battle things, predictably, did not always go entirely according to plan.[11]

Potentially there was one major drawback to the creation of these lanes. Research carried out on the battle around High Wood on 15 September by R.M. "Monty" Rossiter suggests (an argument which has also attracted the interest of Professors Wilson and Prior), that the creation of 100-yard wide lanes to accommodate the tanks in a small area like High Wood (three tanks were used to attack High Wood) meant, in effect, that three hundred yards of the Wood were immune from artillery bombardment. British infantry would, therefore, have attempted to advance upon

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[10] Frank Mitchell, *Tank Warfare*, p 28; Appendix A, CAB 45 / 200; and J.F.C Fuller ," A Short History of Tanks in the Great War", The Tank Corps Journal, Vol 1, 1919, p 5.

[11] Rawlinson diary, RWLN, 1 /6.

Appendix 40

79

Copy No. 1

47th (LONDON) DIVISION OPERATION ORDER No. 101.

Ref. Maps LONGUEVAL & LE SARS 1/10,000. 14th September 1916.

1. With reference to para 5 of 47th Div. Operation Order No. 99, four Tanks are available for the use of the 47th Division.

2. Table A issued with 47th Division Operation Order No. 99 is cancelled and the attached Time Table shows the moves of the Tanks allotted to the 47th Division.

3. The attached Map "B" shows the routes to be followed by the Tanks, two Tanks will follow Route A and one Tank each routes D and E.

4. In accordance with para 5 of "Instructions for the employment of Tanks" issued with 47th Div. Operation Order No. 99, the Divisional Artillery will arrange to leave gaps 100 yards wide in the barrage for the passage of the Tanks.
Similarly the Medium Trench Mortars and Stokes Mortars will leave gaps for the passage of the Tanks.

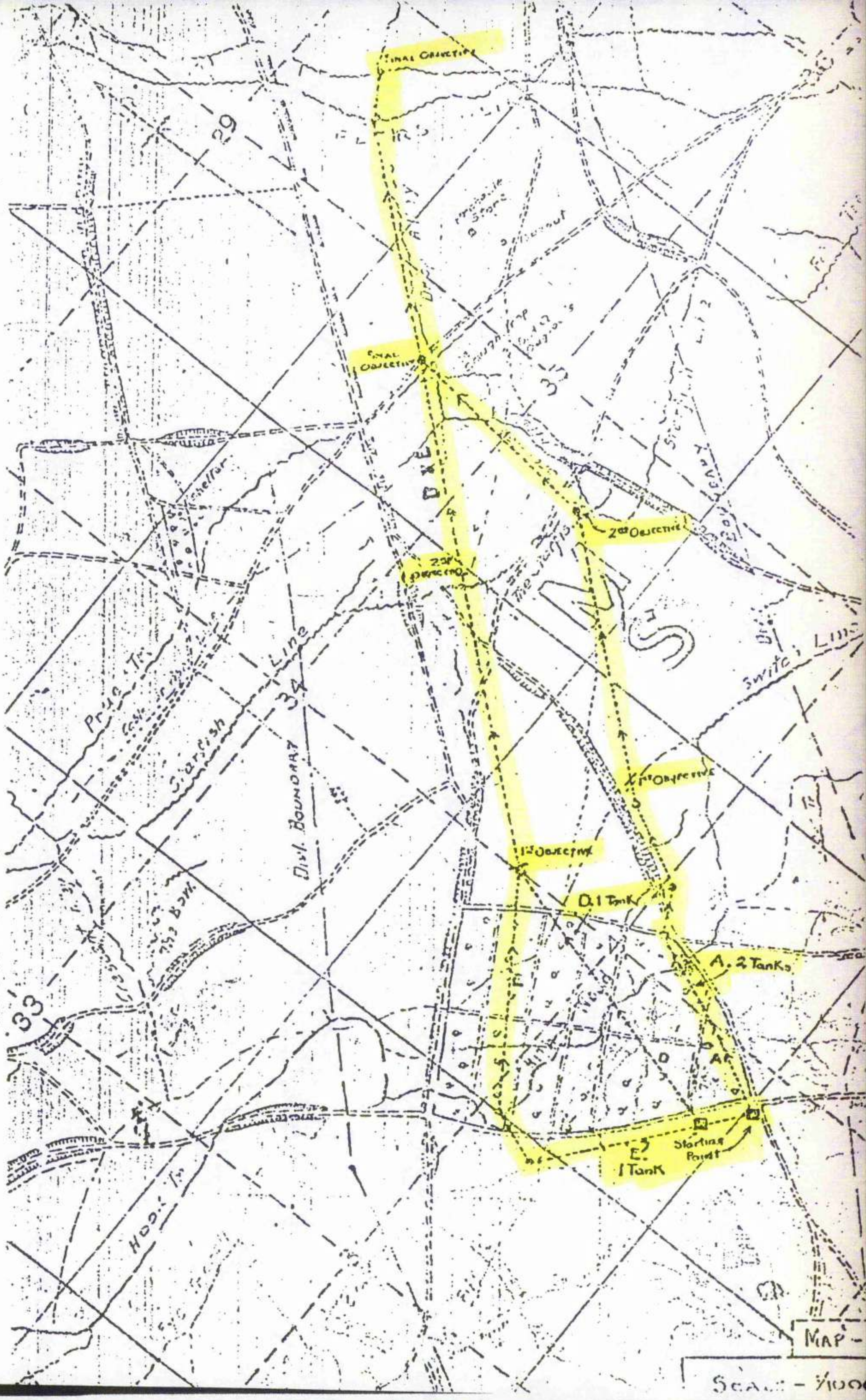
5. If a Tank for any reason drops behind the infantry the nearest troops will detail a small party to accompany the Tank to remove wounded from its path, and similar parties will be detailed in case a tank returns to its starting point.

6. It is of the greatest importance that no Tanks should fall into the hands of the enemy.

H. Hearnshaw Capt
for Lt. Colonel,
General Staff,
47th (London) Division.

Issued at 11 a.m.

Copy No. 1 Op. Order File.
2 War Diary.
3 General Staff.
4 A.A. & Q.M.G.
5 47th Div. Arty.
6 47th Div. Engrs.
7 47th Sigs.
8 140th Inf. Bde.
9 141st Inf. Bde.
10 142nd Inf. Bde.
11 4th Bn. R. W. F.
12 47th Div. Train.
13 47th Meds.
14 A. P. M.
15) IIIrd Corps.
16)
17 50th Division.
18 New Zealand Division.
19 23rd Division.
20 No. 4 Section, D Coy., Heavy Section M.G.C.
21 IIIrd Corps Arty.


Final Objective
Final Objective
2nd Objective
2nd Objective
1st Objective
1st Objective
D.1 Tank
A. 2 Tanks
E. 1 Tank
Starting Point
Divl. Boundary
Starfish Line
Switch Line
29
33
34
35
Map
Scale

enemy machine gunners, "surprised only at having been unmolested."[12] What is implied in this argument, and is explicitly stated in the Wilson and Prior work,[13] is that unnecessary casualties were caused to the attacking infantry by the tactical alterations made to the artillery bombardment. One can counter this argument by stating, firstly, that there is no evidence to suggest that greater casualties were suffered in this area. Secondly, on that very same day the capture of Flers was made possible by the intervention of a tank at the cost of fewer casualties, one could argue, than might have been the case if the tank had not been employed.

A great deal of debate was given over to the decision as to the best time to launch the tanks into battle, that is at the same time as the infantry, before it, or after it, and the length of any interval. It was finally decided that the tanks should begin in sufficient time to reach their first objective five minutes before the infantry and hope that their appearance did not bring down a hostile bombardment on the following troops. Each tank commander was provided by divisional staff with maps on which the course to be taken was marked, along with the compass bearings and aerial photographs (repeated in "Tactical Instructions," issued on 11 September by 4th Army HQ).[14]

Owing to the limited number of tanks, the restricted preparation time available and the difficult terrain which the tanks were expected to cross, only the second and third methods of employment advocated in the "Preliminary Notes" were possible on 15 September.

> "The actual terrain which had to be faced by the tank commanders was very different from that which Swinton and his designers had in their minds as a battlefield. They undoubtedly visualised something in the nature of the Battle of Loos, smooth ground intersected at intervals by shell-holes large or small which could be circumvented. If my memory does not fail me the number of shells fired at the Battle of Loos during three weeks was something in the nature of three-quarters of a million, whereas the number of shells fired in the first week of the Battle of the Somme and the first week only was something in the nature of two million...the result was that at the end of a dozen weeks the Somme ground was when dry rather like aerated soft sand and when wet a quagmire, conditions which simply appalled the tank officers to whom I showed them." [15]

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[12] Dissertation on "High Wood", 1987, The Tank Museum.

[13] Prior and Wilson., "Dawn of the Tank", R.U.S.I. Journal, Autumn 1991, p 63. Also *Command on the Western Front*, p 234.

[14] CAB 45 / 200.

[15] An extract from a letter that General H. Elles sent to Brig-General J.E. Edmonds regarding an entry in the *Official History*, CAB 45 / 200.

The reality : Flers.

The offensive was launched at dawn on the15th[16] with the 49 available tanks going into action between Combles ravine and Martinpuich (see map of the Somme campaign).

> "Instead of massed employment, the tanks were divided and the orders contemplated their use in sub-sections of two or three against specified strong points and singly for special purposes. C and D companies were sent up ; of the total of 49 tanks available, three sections of each company worked on the right and right centre with the XIV. and XV. Corps (17 tanks each); one section of eight tanks of D company was attached to the III. Corps in the centre and the remaining sector of seven tanks of C company was put under the Reserve Army on the left."[17]

General Rawlinson remarked in his diary for that day that he was well pleased with the overall performance of the tanks :

> "The Tanks appear to have been a great success. Many broke down... only about 25 to 30 out of the 50 at the departure of the 4th Army succeeded in crossing the line. The moral effect on the Boche was great. Prisoners say they thought the end of the world had come. I fear one and possibly two have fallen into the enemy's hands. The one that went through Flers with a cheering crowd of British soldiers behind it enabled us to take the village. The tanks at Martinpuich also did very good work."[18]

Of the 49 machines which began operations nine managed to arrive at their predetermined points ahead of the infantry; three fell behind the advancing infantry but eventually caught up; whilst nine never caught up with the front line of advancing infantry but nevertheless did valuable work clearing up enemy strong points. Ten were hit by shell-fire and eighteen were rendered inoperative through mechanical breakdown before action.

The experience of the "paths or lanes" demonstrated that actual practice differed considerably from planning. First-hand accounts give little encouragement to the view that the detailed preparations by GHQ bore fruit in battle. The only tank to achieve any notable feat on that first day was tank D9 ('D' Company) which assisted in the capture

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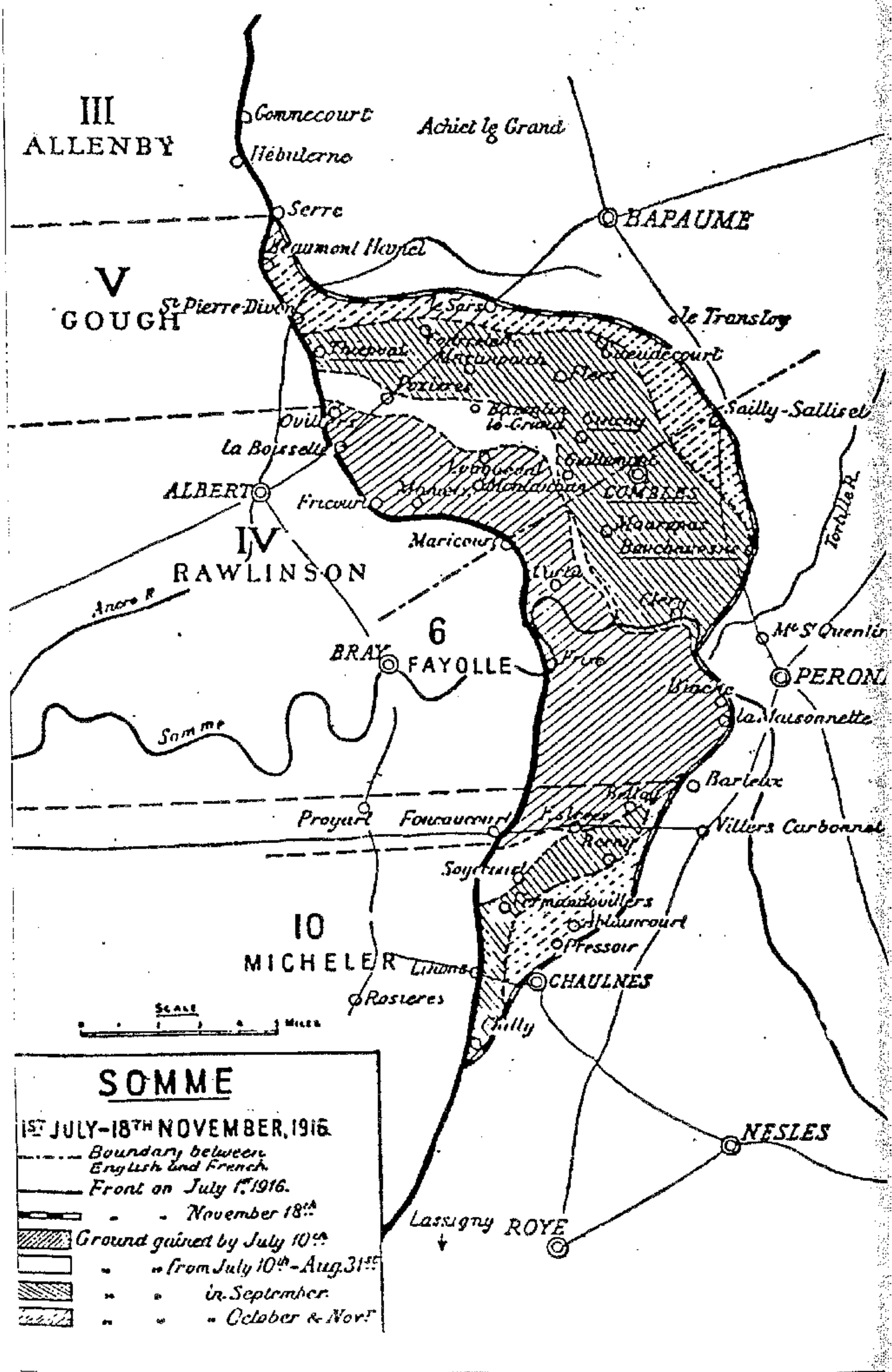
[16] Rawlinson said 4.20 am, diary 1 / 11.

[17] Appendix A , CAB 45 / 200.

[18] Rawlinson diary 1 / 11. Also d'Eyncourt said that only 23 of the 49 tanks "went forward successfully." "Report of Tactical Employment", War Office, 4 March 1917. MUN 4 / 2791.


III
ALLENBY
V
GOUGH
IV
RAWLINSON
6
FAYOLLE
10
MICHELER
Gommecourt
Hébuterne
Achiet le Grand
Serre
BAPAUME
Beaumont Hamel
St Pierre-Divion
Le Sars
le Transloy
Thiepval
Gueudecourt
Pozieres
Sailly-Saillisel
Bazentin le-Grand
Ovillers
La Boisselle
ALBERT
Fricourt
Maricourt
COMBLES
Bouchavesnes
Ancre R
Tortille R.
Mt St Quentin
BRAY
PERONNE
Biaches
la Maisonnette
Somme
Barleux
Proyart
Foucaucourt
Villers Carbonnel
Soyecourt
Ablaincourt
Pressoir
CHAULNES
Rosieres
Chilly
NESLES
Lassigny
ROYE
SCALE
MILES
SOMME
1ST JULY–18TH NOVEMBER, 1916.
Boundary between English and French.
Front on July 1st 1916.
November 18th
Ground gained by July 10th
from July 10th–Aug. 31st
in September
October & Novr

of Flers village before being knocked out by enemy artillery. In his first hand account 2/Lieut. Vic Huffam,[19] commander of D9, commented that the barrage "...was a wonderful experience, a barrage of terrific intensity, the rising ground in front seemed to disappear." Unfortunately D9, with its companion D14, was ditched at the time and Huffam could only marvel at the barrage from his spectator's vantage," the roof of our tank" (D9 was able to carry out its attack on Flers only after being extricated from its ditch by Chinese labourers). This was not exactly the level of co-ordination between artillery and tank that had been hoped for. Gunner Reiffer gives a similarly discouraging account of the battle. The tank commander received a message by runner that the infantry had been held up and that as a result "we were in our own barrage and had orders to retire".[20] Clearly, in this instance the tanks were not going to arrive at their objectives five minutes before the infantry. Further, it poses the question where were the lanes ?

Obviously theory and practice were two different things. David Fletcher argues, "many of the tanks aimed at specific objectives like the Quadrilateral did not move there in a straight line, and I cannot see how they could make lanes that were not straight." Nevertheless, the existence of the lanes indicates the not inconsiderable lengths to which 4th Army HQ went to accommodate the tanks. The fact that the experiment was not successful does not detract from that. Tank commanders experienced such difficulty in navigating a course that their tanks must inevitably have strayed out of designated lanes and fallen victim to the Royal Artillery, or been hit whilst in their designated lanes as a result of inaccuracy and/or confusion on the part of the Royal Artillery. Moreover, taking into consideration the fact that the tank commanders also had to contend with shell cratering, irregular trench patterns, primitive steering and poor visibility, one can only concur with David Fletcher's view :

> "It would be more reasonable under the circumstances, to consider it a miracle that they achieved anything at all ..[given that it was the] first tentative use of a new and untried weapon in a war which was, itself, a novel experience for everyone in the military." [21]

Given the prevailing conditions vis-a-vis training, mechanical infancy, limited numbers, and condition of the ground, the tanks did as well as could reasonably have been expected.

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[19] As a member of the 18th Australian Light Horse (West Australia) this former engineer volunteered for the HBMGC in May 1916, the Tank Museum.

[20] Gunner Reiffer was a member of tank D 14 (eventually ditched) which accompanied tank D 9.

[21] David Fletcher, Librarian, The Tank Museum. Extract from personal correspondence.

The search continued :1917

"Notes on the use of Tanks and on the General Principles of their Employment as an Adjunct to the Infantry Attack " (SS.164) issued by General Staff to Regiments, Batteries and Battalions in May 1917, urged all " Commanders and subordinate leaders of all arms to realise the limitations and capabilities of tanks, and to know the general principles of their employment... ". Whilst the tank had secured its place and improvements were being made all the time to its reliability and efficiency, it was still very much considered as ancillary to the other arms. "...Owing to accidents of ground or mechanical trouble, it is not safe to rely on all the tanks reaching their objectives." From this it was deduced that it was prudent to employ not less than one section of tanks (three or four) to any one objective. Clearly, the notion that tanks could be employed individually, as was suggested in 1916, had been revised in the light of subsequent events. So too, was the operation of creating paths or lanes in the barrage for the tanks." It should seldom be necessary to employ tanks at the commencement of an offensive... As the appearance of tanks will immediately bring down a hostile artillery barrage ... Normally tanks should wait concealed at first, and go out later." The view held in 1916, that the best method of employment was the massed attack, is still repeated in 1917, " The best moral effect is obtained, where conditions are suitable from the employment of large numbers of tanks."

However, such employment was out of the question owing to the performance of the tank. Clearly, it was appreciated that the development of the tank still had some way to go. It would seem that the General Staff was more cautious about the tank's ability than the Commander-in-Chief. Still, SS.164's eight pages suggest, as "Preliminary Notes" did before it, that GHQwas still sensitive to the tactical potential of the tank. They were right, as technical reports suggest, to be conservative in their estimation of the tank at this time.

The Mk IV tank first saw action at Messines in June 1917.[22] It enjoyed improved armour plate over its predecessor, the Mk III, which had increased its ability to withstand the German armour-piercing rifle round. Further, the old steering wheels had been abandoned and an external petrol tank had been fitted for greater safety. Yet, these technical advances aside, the Mk IV differed very little from the Mk I, as used on the Somme. "It was the same old slow -moving and slow-manoeuvring tank, with four-

[22] Whilst it is generally accepted that the Mk IV made its debut at Messines, Elles seemed to suggest in his letters to General Anley (see chapter 2) in April and May 1917, that the Mk IV took part in the Battle of Arras. In those letters he wrote that the experience gained at the Battle of Arras rendered the Mk IV unsuitable. However, perhaps Elles, mindful of the fact that the Mk IV, although an improvement over the Mk III, still had much in common with the pervious marks, felt that a more significant improvemnet was needed immediately !

man control."[23] These were "dark days" for the tank, relegated to the role of following up the infantry and "mopping up" points of resistance. This was certainly not the combined role with the tank leading the infantry into battle as earlier envisaged . Did the tank suffer from a crisis of confidence at GHQ ? Was it only the dogged determination of the tank's supporters that led to the "dawn" at Cambrai in November ? No, GHQ's summing up of the tank's potential was realistic but not dismissive, as later pamphlets were to reveal. The continuing research and development programme, which was receiving the full support of Haig and GHQ, was soon to produce the Mk V, the first really effective heavy tank. Haig's support for the tank after Flers and before Cambrai can be gauged from the his comments on 5 June 1917 when he wrote :

> " I am of the opinion that events have proved the utility of Tanks, both as a means of overcoming hostile resistance...and of reducing casualties in the attacking troops...and consider that sufficient experience has now been gained to warrant the adoption of Tanks as a recognised addition to the existing means of conducting offensive operations." [24]

Further evidence of the support that the tank received from Haig, GHQ and from Rawlinson in 1917 can be seen in the preparations for an extraordinary assault and landing on the Belgium coast at three points between Middlekerke and Ostend by three Pontoon craft carrying troops, motorised transport, artillery and tanks (one for each landing).[25] In fact it would seem, from an entry in Haig's diary made on 18 September 1916, that Haig was instrumental in suggesting the use of tanks in this operation. Just three days after what he termed the "successes obtained by the Tanks" at Flers, he suggested to Admiral Bacon (whose idea it had been since late 1915 to carry out a joint Navy / Army landing on the Belgian coast) that :

> "...he should carry out experiments with special flat bottomed boats for running ashore and landing a line of Tanks on the beach with the object of breaking through the wire and capturing the enemy's defences Such an operation would be carried out in cooperation with troops... ." [26]

Each pontoon, some 550 feet long (see diagram) was to be pushed to its place of landing by two Monitors "lashed together for the purpose" with the bow of the

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[23] "History of the 6th Tank Battalion", The Tank Museum.

[24] MUN 4 / 2801.

[25] Full details of the tank's role in this operation are to be found in the Tank Museum Archives. An account of this operation is given by A.J. Peacock in Gun Fire, Vol.13 (The jounal of the Western Front Association). Also in Admiral Sir R. Bacon, *The Dover Patrol , 1915-17*, chapter 9.

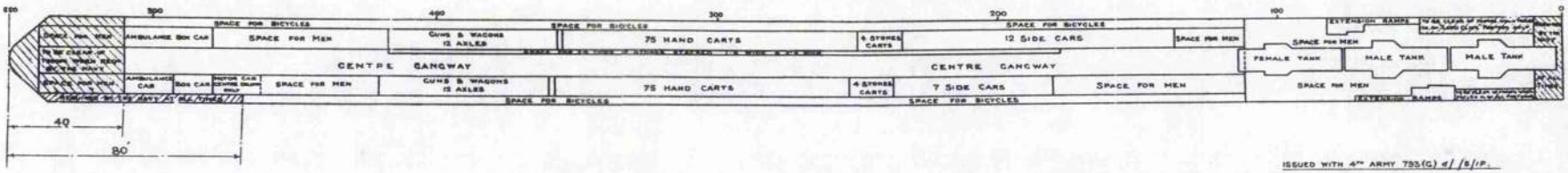
[26] Haig diary, Vol 11.

Fig. 1

N.B. MEN WILL BE ACCOMMODATED IN CENTRE GANGWAY BUT GANGWAY OF 4FT CLEAR WILL BE LEFT.

SCALE OF FEET.

DIAGRAM C.



ISSUED WITH 4TH ARMY 733(G) d/8/1P.

Just one of several technical innovations intended to enable the tanks of the proposed Ostend landing to climb the sea-wall.

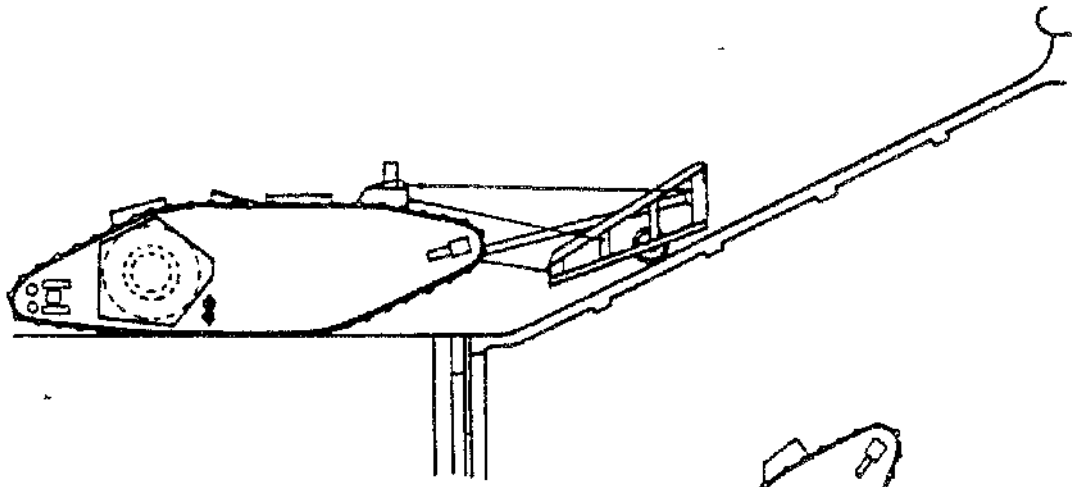


Fig.2

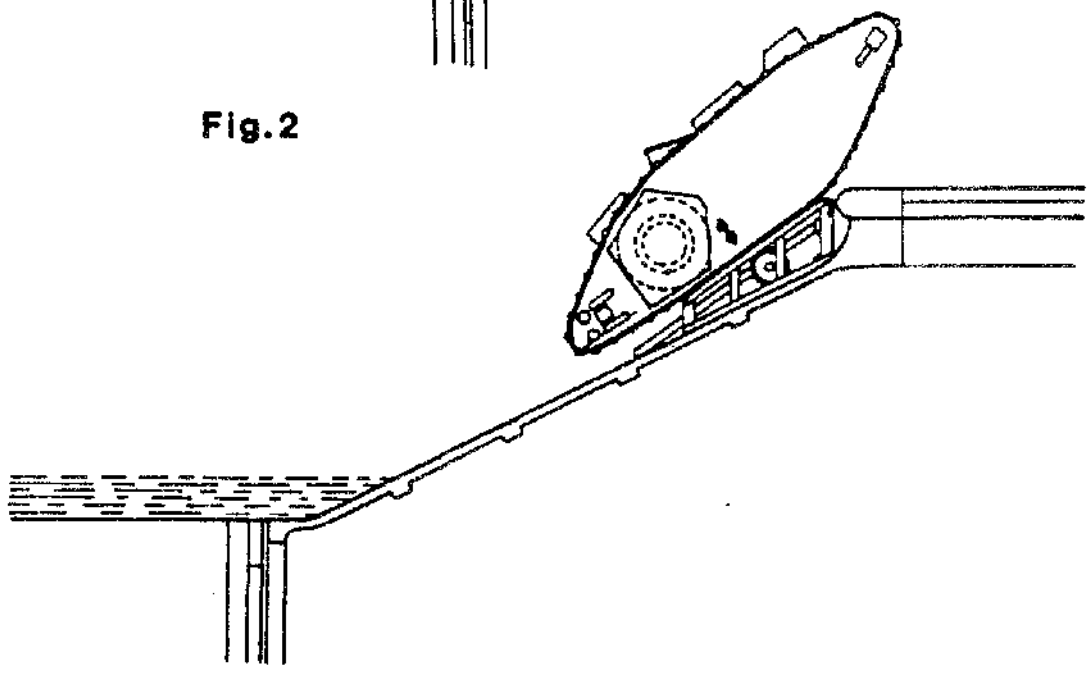


Fig.3

pontoon constructed so as to fit between the bows of the Monitors. [27] The pontoons were effectively large landing craft containing what amounted to an armoured spear-head unit comprising: three Mk IV tanks (two male, one female), motorised transport (including 3-ton lorries, ambulances and motorbike and sidecar combinations), artillery and troops (the bulk of which were to be transported in the Monitors themselves). This audacious plan, which was intended to take the German defences completely by surprise, was to have taken place once the Ypres operations had succeeded in driving the enemy eastward beyond Roulers.

The landings were expected to have to overcome daunting obstacles, both man-made and natural. These included a beach landing itself, with all the problems associated with the corrosive and clogging effect of salt and sand, barbed wire, machines guns and artillery all of which were in place defending the Belgian coast, and, once the beach area itself had been consolidated and the landing force moved in-land, countless dykes and canals. But by far the most serious and immediate obstacle that would have faced the landing forces was the 15-20 feet high concrete (bricks and cement) sea wall. It was intended that the first stage of the operation was not to exceed 4 minutes. That is four minutes in which to land the two male tanks , for them to negotiate the sea wall and to neutralise all enemy resistance. It was found after repeated trials that all the wheeled vehicles, including artillery, could be landed and deposited over the sea wall in under half an hour. Extra time was necessary for the unloading of spares and other supplies by sledge. Yet the whole landing had to be successfully completed in a little over half an hour owing to the fact that the pontoons and Monitors would have had to have pulled away from the beach as the tide receded.

The practical difficulties and mechanical complexities were daunting. The tanks had to have sufficient grip to enable them to negotiate not only the steep gradients of the sea wall , but also the special ramp intended to surmount the over-hanging lip. To resolve this difficulty a special type of " claw spud" was fitted to the tank tracks. Developed from armour plate, each "claw spud" was fitted with a set of sharp teeth to allow it to bite into the concrete. But perhaps the most demanding problem to be encountered was the movement of the wheeled vehicles over the sea wall. To negotiate this difficult manoeuvre a "see-saw" arrangement had to be devised (see diagram) which allowed the female tank to winch the vehicles and guns up the ramp. The apparatus, weighing three-quarters of a ton, had to be man-handled into place by 20 men. Without this device none of the wheeled vehicles could have negotiated the wall.

All of the preparations for the landing were competed by June / July 1917. Training had been carried out under conditions which, as far as possible, resembled those which were expected on the landing sites. Practice continued up until August

[27] The description here is taken from A.J. Peacock's account.

when the scheme was eventually abandoned. Despite the fact that the landings never took place (through no fault of the tank) the plan more than adequately demonstrates the support that the tank had in the period which many critics of the handling of the tank have repeatedly pointed to as the period in which the tank programme nearly died. Here were Rawlinson, the 4th Army HQ, Haig and GHQ (without whose support the planning could not have taken place) proposing a quite novel and futuristic use of the tank. Were these really such "dark days" ?

On 22 August 1917 a letter from Sir E.Tennyson d'Eyncourt called Haig's attention to the necessity of ensuring that tanks were used only on "suitable ground". Haig's reply on 28 August, was polite, but to the point - France knew best ! :

> "The conditions favourable for the use of tanks are fully realised here and it is also realised that the present design of tank cannot show its full value under the difficult conditions in which tanks here have been called upon to operate."
>
> It would, of course, be preferable if the tanks could be employed on suitable ground such as you describe. As I am sure you fully realise the choice of front on which to make an attack must be made with regard to many considerations, tactical, strategical, political, and so forth. In making this choice the tank - at any rate in its present state of development - can only be regarded as a minor factor. It is still in its infancy regards design. It is of uncertain reliability.
>
> Looking to the future, and seeing what they have already accomplished, I feel convinced that the course to pursue is undoubtedly to put every effort into improving design and reliability, in order to ensure that tanks may give the best results in the theatre in which we are forced by circumstance to operate at present." [28]

Haig's view of the tank is undoubtedly supportive, but it is also pragmatic. Plans for its employment and the extent to which it could be a decisive factor in the planning of an offensive had to be based on what the tank could be reliably expected to deliver and not on what some members of the Tank Corps (certainly those ex-members writing in the inter-war years) would like to have done.

The Battle of Cambrai began on 20 November 1917. Despite the initial success in breaking through the Hindenburg Line and penetrating some five miles, these gains were not consolidated and were eventually lost to German counter-attack. The battle is often seen as a turning point in the tactical employment of the tank . Here, Haig's and GHQ's critics argue, is proof of what the tank could have achieved, and here is evidence of Haig's and GHQ's failure to reinforce this success. There are many reasons for the failure of the offensive. The initial break-through by the tanks was not adequately supported by the infantry, whilst the cavalry, given their first chance to exploit a breakthrough, was ineffectual. Criticisms for the failure have been levelled at

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[28] Fuller papers, B / C / 1.

the inadequate number of tanks kept in reserve, the lack of reserves of infantry, the limited opportunity for combined training, and the fact that the cavalry were too far back to link up to the breakthrough. With regard to the tanks, our main area of interest, there were 476 in total supplied by the Tank Corps. Of those 324 were available for specific tasks, i.e. fighting, and the remainder were used in the supply and signal areas. [29] The criticism that more machines should have been kept in reserve to follow up the first wave of attack does not bear close examination. First, all the tanks that were available from a delivery of 824 machines made on 27 October were brought up for the battle. The remainder were apparently unfit or the crews not sufficiently trained. Even had the numbers of machines and crews been greater , the logistical problems (the constant supply of spare parts, the availability of rail transport and reserve crews) involved in assembling such a force for battle were formidable. One of the most important reasons for the failure of the Cambrai offensive, certainly one which would have rapidly ended the tank's direct involvement in a continued offensive even had the other arms been able to offer greater support, was the mechanical unreliability of the Mk IV. Major Parsons's first-hand account of action at Cambrai [30] outlinedin detail the extraordinary lenghts to which he and his workshop crew had to go in order to make the machines under his charge ready for action. Preparations included the replacement of the chain drive sprockets on nearly all machines. A constant tinkering, with amongst other things, fan-belts, brake units and the ever present loose nuts. And once the tanks went into action, his account reveals how his workshop crew actually disobeyed orders and followed the tanks into battle providing running maintenance as the action continued around them.

Here was the real weak-link at Cambrai (as it would have been in any of the other operations planned for 1917 and early 1918). The tanks required constant attention and a vast quantity of spares in order to keep them running. Ideas, some of them quite far-reaching, as the planned Ostend landing highlighted, were not the limiting factor nor, indeed, was the support given to research and development, so vital to the creation of new and more reliable machines. The overriding problem was one of mechanical reliability.

December 1917 was to witness the launch of two new tanks, the Mk V and the Whippet. 1917 had seen their development, 1918 would see them in battle at Hamel and most notably at Amiens.

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[29] General Sir Michael Carver, "False Dawn at Cambrai ", The Tank Corps Journal, (n.d.), p 2436.

[30] See chapter 6, p 100.

The plans for 1919

At a War Office conference on "Tank Policy", held on 28 September 1917 Lieut-General R. Butler (representing Haig) explained the C-in-C's view on tank tactics :

> "...where [there] were so many considerations governing the employment of Tanks that it was neither possible nor desirable to state under what given circumstances Tanks would be employed next year...Tanks would be required as an adjunct to an infantry attack...but provision should be made, so far as possible, for suitable Tanks for exploitation of success and possibly for a Tank battle." [31]

Here we have the "possibility" of a "Tank Battle", i.e. a massed tank attack, being considered by GHQ even before the "dawn" of Cambrai.

During February / March, 1918 General J. Capper submitted a very lengthy and detailed report to the Supreme War Council on tank operations for 1919. In it he made a strong case for the large scale (involving some 8, 300 tanks in total) tank battle involving heavy, medium and light machines. As well as the expected detail on the time of day and terrain, and on objectives, he stressed the necessity of combined arms training. Of particular significance were the calculations contained in his report as to just how long it would take to build these machines and when, therefore, they could be expected to be ready for action. [32]

On 19 March Elles presented his own paper, "The Future of Tank Operations and Production Requirements ", to the War Office. Obviously the very close working relationship between Capper and Elles would have meant that they would have been privy to each other's thoughts but this is not simply a submission by Elles of Capper's report or indeed vice versa. Elles goes in to much greater depth on the logistical requirements for moving his force of 4, 000 tanks (remember Capper proposed a force of over 8, 000). They would require some 1, 500 tank wagons over a period of eight days to move his tank army by rail. Like Capper's, his report is long on the benefits to be obtained by the mass use of tanks. [33]

Lieut-Colonel C.N. Buzzard's report to the Supreme War Council, "Tanks and Mechanical Warfare" (14 May 1918), contains a short section entitled "A Tank Offensive in 1919". While it does not advocate an actual plan as such, it does

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[31] WO 158 / 819.

[32] CAB 25 / 121.

[33] WO 158 / 865.

encourage the establishment of combined training programmes and the firm adoption by the British Army of the light tanks to complement heavy and medium machines as the French had done and the Americans were proposing to do for the 1919 campaign. He further suggests that what he termed "tinkering with design" should end and the large-scale production of the best existing machines should begin at once. [34]

In July the CIGS, General Henry Wilson,produced a memo on large-scale tank operations for the following year. In it he stated that:

> " The brain and stomach of the enemy must be struck concurrently with, or in advance of, the blow at his body. This can only be done by having at our disposal a large number of rapid (Medium) Tanks capable of travelling long distances...The main attacking infantry supported by Heavy Tanks and Mortars in Tanks, Light Tanks, and Low Flying Aeroplanes will take place at or before daylight under cover of Artillery fire, smoke and all usual appliances. Infantry will be on foot, but many machine gunners will be carried up to their objectives in Long Heavy Tanks...As the main advance takes place the medium Tanks, assisted if necessary by Heavy Tanks laying Bridges, will proceed as one to their distant destinations, groups being told off to attack enemy Divisional, Corps and Army Headquarters destroying all telegraph and wireless communications... ." [35]

Not quite the mechanised force of Fuller et al's " Plan 1919", but not that far removed either. "Plan 1919" (its official title was "The Tactics of the Attack as affected by the Speed and Circuit of the Medium D Tank") envisaged the use of a tank force of about 5, 000 machines consisting of Light, Medium and Heavy types. In terms of the size of its proposed tank force at least, it was in line with "plans" proposed by Capper, Elles or Wilson. A lightening attack by fast Medium tanks and aircraft against the enemy's command HQ, severing the spinal cord between brain and body, would be followed up by the main attacking force comprising Heavy tanks, infantry and artillery. Once the enemy forces had been broken a third element of the attacking force, consisting of cavalry, light tanks and lorry-born infantry, would then harry and pursue the enemy preventing his consolidation and possible counter-attack until such time as the enemy forces capitulated.

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[34] CAB 25 / 121. Britain never seriously considered undertaking the manufacture of a "Light" tank. The prototype American Ford tank did undergo trials in Britain in 1918. If Britain had decided upon the use of large numbers of Light tanks it is probable that the French model would have been used as they in turn used Britain's Heavy machines. Despite the fact that the United States and France made use of British tanks, the BEF did not avail itself of the opportunity to employ French light machines. Stubborn independence on the part of the British perhaps ?

[35] WO 158 / 842.

How original was this plan when compared to those outlined above, particularly Wilson's ? [36] Fuller's plan is predicated on the assumption that a fast and reliable Medium tank would be available, and in great numbers. The fact of the matter is that the Medium 'C' tank, which did not possess the performance characteristics of the proposed Medium 'D' machine, was still plagued by technical difficulties even in November 1918. It had a top speed of only 8 mph compared to the estimated 20 mph for the Medium 'D', and only 48 were completed by the Armistice. The Medium 'D' project which had been underway since mid-1918, was, by November, still essentially in the prototype stage, and had encountered numerous problems especially with the design of its suspension system and its high performance engine. There was no fast, reliable Medium tank available to GHQ during 1918. Moreover, given the technical difficulties facing the Medium 'D' project, a tank capable of fulfilling Fuller's requirements would not have been available even had the war continued into 1919. The other enormous obstacle which does not seem to have been addressed, unlike Elles's plan, was the immense logistical difficulties inherent in moving large bodies of tanks about a very mobile theatre of war. Tanks of First World War vintage could not operate effectively, certainly in mass formation, in such a theatre, as will be discussed in the following chapter.

The myth surrounding the originality [37] and viability of Fuller's "Plan 1919" owes much the prevailing anti-Haig / GHQ propaganda of the inter-war years and beyond. Fuller's undoubted gift for writing, the friendship and support of Captain Sir Basil Liddell Hart (another influential character in regard to the formation and development of mechanical warfare doctrine whose work has until very recently been uncritically accepted), combined with a need for a national scape-goat for the losses incurred on the Western Front, have assisted the perpetuation of this myth. "Plans" for 1919 were not the sole prerogative of the "young bloods" at Tank Corps HQ. The fact that there were so many "plans" for future massed tank operations in conjunction with other arms in 1919, indicates that ideas for such an operation were "in the air" and reflected a shift in emphasis in regard to a greater role for all the new technologies.

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[36] J.P. Harris, *Men, Ideas and Tanks*, p 171, suggests that Fuller's memorandum had reached Wilson's desk by this time and that it may well have influenced Wilson's own ideas. But, as Harris admits, it is not at all clear what route Fuller's memorandum took through "official channels", and therefore, who actually got to see it.

[37] J.P. Harris, *Men , Ideas and Tanks* , has discussed this same issue in considerable detail, pp 166-172

Practical interpretation : 1918

Sir Henry Rawlinson was to demonstrate his enthusiasm for a more significant role for the tanks in the coming battle of Hamel. Yet, however keen Rawlinson was to engage the tanks, there were others, in this case General Monash, Australian Corps Commander, and General Arthur Currie, Canadian Corps Commander, who did not entirely share his enthusiasm. It is worth pointing out that it was Monash in particular but also the Canadians who have often been cited as the innovators of many of the new tank tactics which emerged in late 1918. There is a great deal of truth in this. Once the "colonials" found that the tank's performance had been considerably improved - past experience had found the tanks wanting and they were understandably reluctant to place much faith in them [38] - they were quick to embrace them. But Rawlinson was to experience some difficulty in overcoming this initial resistance. On 28 June Rawlinson noted as much in his diary, " I went this morning to the 4th Aust' Div practice with the Tanks ...still not got the idea" he commented ; however, he was optimistic, " The Tanks must keep within 100 yards of the leading line...and all will then be well." On 30 June he recorded in his diary :

> "I attended another demonstration with the tanks at [illegible] which went very well and at which [the Canadians and Australians] was [sic] also present . I think we have now got the Australians to understand and appreciate the Tanks. Monash held [illegible] conference of 4 hours & 20 minutes this afternoon at which every detail was discussed and settled." [39]

Brig-General A. Courage, Commander 5th Tank Brigade, was responsible for briefing Monash for the offensive on the 4 July.[40] Originally conceived by the Tank Corps as a tank-dominated operation , it was envisaged that the approach of the tanks was to be masked by the use of aircraft, that tanks should lead the advance without the cover of a creeping barrage, and that the tanks were to be divided into three attacking echelons which would "leap frog" one another. The Australian Corps Commander was enthusiastic about the plan ; however, his Chief of Staff, Brig-General Blamey, drew

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[38] It may be argued that this was a good reason for not having introdced the tank in late 1916 when, compared to the MkV, it was still a very "imperfect" machine. The psychological impact of experiencing at first-hand or hearing of the vulnerability of the first machines may have persuaded those who would otherwise have been enthusiastic supports to adopt a more cautious attitude. However, the arguments for the introduction of the tank in late 1916 are too strong to be overturned by this consideration. If the Mk I tank had not been introduced when it was, it is extremely unlikely that the Mk V would have been available in mid-1918.

[39] Rawlinson, diary 1/11.

[40] C.E.W. Bean, *Official History of Australia in the War of 1914-18*, Vol IV, pp 242-249.

up a list of criticisms against such a heavy reliance on tanks. The Australian experience at Bullecourt 1917,when they suffered severe casualties due to the failure of many of the tanks to keep up with the advancing infantry (due mostly to mechanical breakdown), had prejudiced many against the tanks.[41] The Australians were determined that Courage's tactic of abandoning the creeping barrage should be dropped and that the whole emphasis of the operation should be shifted from tank predominance to one where, once more, the tanks played a supporting role to the infantry and artillery.

The entry in his diary for 4 July reflects Rawlinson's success in pushing the acceptance of the tank, or at least in overcoming some of the major Australian and Canadian reservations: "The tanks did very well all rolled up on time and out of the 60 [illegible] we only had 5 casualties." 4 July had seen the debut of the Mk V tank which , in close support of the Australian Corps, took the village of Hamel and Vaire Wood, positions which would prove important in the coming battle of Amiens. Initially confined to mopping-up points of resistance in the heat of battle, the tanks were able to demonstrate their much improved performance, passing the infantry and rendering valuable service (the performance of the new Mk V's was something of a revelation to the Australians whose only previous experience of tanks had been the ponderous Mk II's and III's). The tank was gaining new supporters. The Australians and the Mk V's were to combine again at Amiens.

Perhaps it is worth mentioning here, if it is not already clear, the reasons for concentrating on the 4th Army. This army was allocated the majority of the available tanks, reflecting their greater familiarity with the new arm stemming back to its introduction on the Somme, and more importantly the successes of the summer of 1918. Quite simply the corps which made up the 4th Army, particularly the Australians, had more experience with tank / infantry / artillery co-operation than any other Corps. This is another point to be made in favour of GHQ's "responsible" and thoughtful attitude toward tank employment, i.e. that the tanks were consistently allocated to those units who were able to make best use of them. Paddy Griffith [42] makes more of this point in relation to general infantry tactics, when he argues that certain units of the BEF were used time and again in preference to others because they had proved themselves efficient at getting the job done.

The purpose of the attack was to reduce, if not eliminate, the existing German threat to Amiens, a key rail centre. The opportunity also presented itself to follow up the damage inflicted on the Germans in the Champagne offensive of May 1918 [43] and to shorten the Allied front. The conditions, as Rawlinson pointed out :

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[41] Ibid, p 254.

[42] Paddy Griffith, *Battle Tactics of the Western Front* , pp 82-3.

[43] The Allied forces had inflicted heavy casualties stemming the German offensive.

> " were extremely favourable to the carrying out of a successful offensive. The weakness of the enemy's defences [they were believed to be poorly constructed, and] Trenches captured on the 4th July were bad and there was little wire." [44]

Moreover, it was noted that there was an absence of any "considerable reserves behind the hostile divisions holding the front". The enemy's morale was, he suggested" poor on this front." Conversely, the morale in the British and Commonwealth camp, after the successes in the previous three months, was high. The "good artillery" and the "excellence" of the observation posts available were also cited. Moreover, "...covered lines of approach render a surprise attack comparatively easy." Rawlinson's proposal stressed the importance of the role of the tank and the significant contribution expected from it in the coming battle. Of particular importance to the tanks was the" open nature of the country, which renders it particularly favourable for an operation with tanks. This is accentuated by the absence of shell craters and the dry weather of the past few months."

The importance of the tanks in the coming battle is supported by Rawlinson's statement :

> "As in the case of the attack on July 4th, it is proposed to employ as many fighting tanks as possible, so as to save casualties to the infantry , and also to make full use of the supply tanks that may be available, so as to reduce infantry carrying parties. Whippets will be required for exploiting success." [45]

It is clear that the improved performance of the tanks relative to the early machines and the degree of technical innovation in tank design had led by 1918 to a more versatile machine and consequently (though the critics would deny this) to more versatile thinking and employment.

It was estimated in the "Proposals" that 196 tanks or 6 battalions [46] would be necessary for the offensive. The figure was calculated on the basis that one Mk V or Mk V * would be required for each 100 yards of each objective. In addition this number would be further increased by two battalions of Whippets for exploiting

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[44] Rawlinson's," Proposal for an Offensive on the 4th Army Front, 17th July, 1918", diary 1 /11.

[45] Ibid, para.10.

[46] This was the initial number proposed by Rawlinson, but this figure was later substantially increased to 415 fighting tanks. Wilson and Prior attribute this to Fuller's persuasion, *Command on theWestern Front*, p 307.

success. The operation on 4 July had further highlighted the importance of the use of the tanks in a supply capacity and it was noted that "two tanks per infantry brigade practically did away with all carrying parties." It was expected that supply tanks would only be necessary for those divisions going to the furthest objective (there being two objectives), necessitating a " total of 30 supply tanks, and a few spares if such are available".

The attack on the first objective was to be launched (as on 4 July) without a preliminary artillery barrage but under the cover of a creeping barrage with tanks and infantry following close behind. Those attacking the second objective were to " leapfrog" through the leading divisions and were to be supported by "mobile field artillery and trench mortars, which will go forward with them." Here was a repeat of the tactics successfully employed at Hamel, and it seems, shades of the tactics of infiltration and all-arms support practised by the German in their spring offensive. The use of the tanks in the capacity of mobile field artillery (as was envisaged in 1916) was also planned. In the event of the proposed targets in" the old Amiens defence line" being too strongly held to be taken , then "the infantry will continue to consolidate the RED line...covered during their consolidation by the tanks."

It was noted by Rawlinson that the Tank, Cavalry, and Corps commanders would have to give the proposals careful consideration and that they would be required to co-operate with one another fully. "It is", he said:

> "essential that the Canadian Corps, Cavalry Corps and Tank Corps Commanders should be placed in communication with me at the earliest possible date, and that later, Divisional commanders and others concerned should be made available to study the problem in detail before the troops come down."

However, Rawlinson's entry for 5 August reveals that he was still encountering some resistance to the tank. His entry states he took exception to the absence of tanks with the Canadian 2nd and 3rd Divisions "to start with at zero hour...told Currie to correct this.[47] " The entry for 7 August, the eve of the battle, reads :

> "There is nothing to show that the Boche knows what is coming [illegible] We shall have 8 excellent Div and 300 tanks against him in perfect tank country with 3 Div [sic]of Cavy [sic] ready to [illegible] any hole that is made. I have great hopes that we may win a big success."

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[47] The allotment of tanks to armies was the responsibility of GHQ since they regarded tanks " for the purposes of administration, as GHQ troops, [to] to be allotted in Brigades to Armies for certain operations", (SS.164, para 9).

The armoured cars show the way ?

In "Plan 1919" J.F.C. Fuller advocated the use of the Whippets in conjunction with lorry-borne infantry in a sweep across German rear areas. However, his argument, if it ever reached 4th Army HQ, fell on deaf ears. They were determined to use the Whippets in support of the cavalry. Who was right ?

Fuller, it is said, was particularly pleased with the performance of the 17th Armoured Car Company, Tank Battalion, on the first day of the battle of Amiens.[48] Sixteen cars had been made available to the Australian Corps. An experiment on the eve of the battle had shown that, if towed by tanks over the rough ground until the well maintained transport roads behind German lines were reached, then these cars could cause considerable damage "to the enemy's personnel, organisation, transport etc." The cars were split into three groups, two of six with the four remaining cars to "carry out a special long distance reconnaissance under instructions from Corps H'qrs". The six cars of 'B' Company, once behind German lines, left the "Main Road" and turned toward Framerville. 'A' Company turned toward Proyart and on to Chuignolles. It was the exploits of 'B' Company which , it is said, particularly pleased Fuller. For they were able to surprise a "number of Officers and personnel and destroyed transport, limbers etc., quite upsetting the enemy's organisation there."

> "The outstanding feature of the operation is, that by working Armoured Cars with Tanks, they need not be confined to roads, nor are they stopped by obstacles. Armoured cars can be towed so that the wheels follow the Tank tracks over almost any ground or obstacles.
>
> From the experience of recent battles, particularly Cambrai and that of August 8th last, it will appear that a successful tank attack will usually penetrate in the zone of intact roads on which the enemy's transport is working, and as soon as this is attained, an opportunity for the use of Armoured Cars is presented which, if it is timed at the right moment, can do enormous amount of damage to the enemy's rear organisation and reserves." [49]

Could not something along these lines, Fuller asked, have been done with the Whippets ? In actual fact something along these lines was attempted.

"The Armoured Cars are to work on the roads and co-operate with Whippet

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[48] Brian Perrett, " Fuller's criticism of the employment of the Whippet tanks at Amiens", The Tank Museum.

[49] A report on the operation of the 17th Armoured Car battalion, August 8, by Lieut-Colonel E.J. Carter (C.O), the Tank Museum.

> Tanks operating on the intervening ground. The whole force to act as a mobile force to exploit success... owing to the difficulty in crossing "No man's land", it was decided to concentrate effort on one place to get Cars on to sound roads in the enemy's lines, and let the Cars detailed for the purpose gain contact with the 6th Battalion [Whippets]." [50]

This particular venture was, says Carter, severely disrupted by dense fog which completely prevented the co-operation between Whippets and Cars. Of the twelve cars which started the attack, only five returned. Of the losses one was due to receiving a direct hit from an artillery shell. The remaining losses were all "Mechanical Breakdowns". Once more mechanical failure was the decisive factor. In his report on the operations of 8 August Carter states that :

> "The operations of the Armoured Cars were limited by the unsuitability of the chassis on which the Cars are mounted. No less than 7 out of the 16 were at various times out of action from mechanical trouble which would not have occurred with a suitable chassis. Initiative and scope were considerably restricted because the chassis could not be relied upon in doubtful positions .
>
> Had the Cars been reliable they could easily have gone as far as the River at Peronne...As it was, so many cars were temporarily out of action from mechanical trouble and the rest so unreliable that they had to be withdrawn behind the lines at dusk."

The History of 6th Tank Battalion has many accounts of Whippets ditching or falling victim to German artillery. Seven tanks under the command of Captain J.A. Renwick were placed at the disposal of 6th Cavalry Brigade who were held up by a machine gun on the road to Parvillers. Of the six tanks, one was hit by a shell causing track damage whilst moving up the road. The remaining machines all eventually became ditched in an old trench system, three of them afterwards receiving direct hits from enemy artillery fire. The History of the Battalion comments that :

> "As a result of the Amiens battles, it was found that the present Whippet was not suitable to operate with mounted troops. One of two things invariably occurred; either the cavalry wanted to move forward at a gallop, in which case they out distanced the Whippets, or the Whippets were able to move forward and the cavalry were prevented by machine-gun fire or barrage."

Here then, is the answer to Fuller's question. Why not more efforts like Frammerville ? Mechanical unreliability rather than any evident lack of tactical imagination on the part of GHQ is the reply.

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[50] Lieut-Colonel Carter, this time "in the field", 27 August.

Lessons learnt

Concern over the need for a tactical doctrine for the tanks amongst the upper echelons of the Army was reflected not only in the above"plans", but also in the publication of instructional pamphlets which continued in to late 1918. The lessons learnt at Hamel had been published in SS. 218 [51] Operations by Australian Corps Against Hamel, Bois de Hamel, and Bois de Vaire, issued in July. This was superseded by SS. 214 : Tanks And Their Employment In Co-operation With The Other Arms, issued by the General Staff, August 1918, states :

> " As the speed of tanks is developed and their machinery perfected, it is possible that their tactical employment and that their role may become more independent...[however at this time] It is unwise to place too much reliance upon mechanical contrivances. The machinery of tanks has been much improved and engine trouble will become less and less frequent, but the presence of unexpected obstacles and the effects of the enemy's artillery fire may, at any time, deprive the infantry of their support and co-operation...[so for the present]...the role of tanks is to act in close co-operation with the infantry both in attack and defence."

SS. 214 goes into some detail on the performance of the two chief tanks of the battle: the Mk V and the Medium 'A' (Whippet). The former, it says, enjoys "considerably greater" mobility due, in part to its improved top speed, but also to its improved steering"...in daylight [it] can travel 1, 300 yards across undulating country in the same time that the Mk IV could only travel 700 yards". The Mk V* being slightly less mobile than the Mk V, though possessing greater trench-spanning capability, could, it was suggested, be employed in the carrying of stores and the ferrying of wounded, as well as in its primary role of trench clearing. The Whippet (having a three-man crew and a top speed of between 8-9 mph compared to the 2-4 mph of the Mk V) would be " especially useful in open warfare". Yet the employment, of both the Mk V's and Whippets " in active operations [was] still somewhat limited owing to the following reasons :

(a) The physical endurance of the crews cannot be counted upon after 12 hours in action.[52]

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[51] It may seem strange that SS..218 was published before SS..214, but this was apparently the case. Peter Scott's "Numerical Checklist, Part V", of Stationery Services documents clearly indicates this, The Great War, Vol II, No 3, p 107.

[52] "12 hours" would seem to be only an "official" estimate. Obviously it depended on the freshness of the crews and the weather which could affect the already very high temperatures in the tanks. One of the surviving battlesheets for the tanks involved at Amiens is that belonging to tank 9199 (H.41) of the 8th Battalion, 5th Brigade. A male MkV, it was commanded by Lieutenant Harold Whittenbury, and was

(b) Tanks cannot cross swamps, streams or deep sunken roads , nor can they make their way through thick woods.

(c) The field of view from tanks is somewhat restricted. Objectives should, therefore, be easily recognisable and the routes to them straight forward.

(d) Tanks cannot be depended upon to go over country which has been heavily shelled, but their capabilities in this respect are being constantly improved."

To add to the poor visibility cited above one should also add the equally poor state of communications. Eyewitness accounts recall the confusion that the dense mist and smoke shells caused in the ranks of the British tanks which resulted in numerous collisions. If the tanks had been assembled in greater depth - greater than the one machine approximately every 100 yards, as a massed attack would have necessitated - not only would the chaos have been much greater but it would have offered the German artillery a tempting target once it had found its bearings. SS. 214 suggests that one day their time would come to act with greater independence, but until such time their role was to ease the path of the infantry.

Dissemination

GHQ was responsible for producing instructional pamphlets such as SS. 214. But having produced them they had to ensure that they reached the bodies or individuals for whom they had been printed. GHQ's success in achieving this will be discussed briefly below. However, GHQ could do only so much . Clearly it could only be hoped that the recipients of this literature would not only read it , but also have the time, resources and initiative to act upon it in both training exercises and in actual combat.

The Base Stationery Office landed in Le Havre with the BEF in August 1914. It had a strength of just three officers and seven other ranks. Its duties were to supply stationery to the Expeditionary Forces and to issue censor stamps, but, most importantly from the point of view of this discussion, it was responsible for the printing and distribution of both ordinary and secret publications. It was the printing and distribution of manuals, regulations, orders and instructions that occupied the greater part of the Depot's time, accounting for an increase in staff and branches, which was to see its strength swell to 62 officers and 860 other ranks by 1918.

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deployed to assist the 4th Australian Infantry Division. H.41 dealt with several machine gun nests before returning to camp at midday. "...the crew all suffering from exhaustion after four hours of continuous action having covered 8 miles and fired 105 rounds of 6-pdr ammunition".

At first the Depot (which later became the Army Printing and Stationery Services, AP & SS) was equipped with only hand presses which were inadequate for the weight of material demanded by the Army, " Work of any size had to be put out to local contract or sent to the War Office. The former was impossible in the case of secret or confidential documents and always inconvenient, and the latter led to delay." The first AP & SS press in France was opened in Le Havre in July 1915 and a second in Boulogne in January 1916. The installation of these presses meant that the important printing of manuals and pamphlets could be carried out in France.

The printing of manuals and pamphlets was undergoing improvement. When it came to distribution, however, it seems that during the first two years of the war AP & SS relied on units "indenting for their requirements". The system worked well enough for everyday stationery items " but was wholly unreliable when it came to manuals and instructions". Peter Scott cites the pamphlet "Prevention of frostbite for chilled feet" as an example (later CDS. 312). On its arrival in Le Havre in February 1915 the depot received " indents for only 103 copies" even though the Army Commanders had been informed. Needless to say the system could not operate efficiently under such conditions. The answer was a " systematic and automatic distribution scheme that would ensure that all such publications would reach the hands of every officer, NCO and man who needed the information they contained." This system came to be known as the Central Distribution Section (CDS) and later the Publications Department. A system through which :

> " the vast majority of printed orders and information circulars and pamphlets [were issued] without trouble to the branches or departments originating them , directly to formations and units concerned...[this system]...was applicable alike to secret documents of which only a few hundred copies exist and to instructional leaflets issued by the million." [53]

Clearly, the mechanism was in place by mid-to-late 1916 not only to print but to distribute pamphlets and manuals " without trouble" to those for whom they were written. Peter Scott again :

> "Such evidence as survives seems to indicate that the AP&SS system was both quick and efficient...supplies of manuals were sent in bulk to formation headquarters.They were accompanied by a receipt (returned to the AP &SS) and a separately printed scale of distribution that indicated the numbers to be issued to each subordinate unit." [54]

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[53] Peter Scott, " Printed in France", The Great War, Vol 1, No 2, p 46.

[54] Personal correspondence with Peter Scott, 27 June 1992.

Such literature was received by tank commanders in preparation for the tank's debut at Flers in 1916 :

> "Before leaving the position of assembly, the Divisional operation orders which concerned each tank or group of tanks were discussed with the Tank Commanders to each of whom was given (1) a memorandum of directions recalling the points which previous training had been designed to teach (11) detailed orders giving objectives, strong points, particulars of route and compass bearing... ." [55]

One can be reasonably confident that point (1) refers to either "Preliminary Notes on the Tactical Employment of Tanks (Provisional) "or a document very similar in content. If so, then tank commanders did receive tactical instruction, and were privy to the tactical thinking of GHQ. But of course, whether they read them, or, if they did, whether they fully understood them (given that as the war progressd tanks were increasingly commanded by senior NCOs or inexperienced junior officers) is another matter. A clear and accurate understanding of what GHQ intended was not always conveyed in its instructional literature owing to GHQ's tendency to put too much into each document and to couch the instructions in Staff College terminology.

If we assume that the information concerning the efficiency of the CDS is accurate, we can then make the assumption that because pamphlets SS.164 and SS. 214 (1917 and 1918 respectively) were printed by the AP & SS they reached the individuals for whom they were written. Both documents were issued down to "Regiments, Batteries and Battalions", and SS.164 bears the warning: " Not to be taken into action or into front line trench". It might be a cynical point but not too many high ranking officers frequented the front line trenches, so the pamphlet and therefore the message must have been aimed at middle and junior officers. Training note " Tank and Infantry Operations Without Methodical Artillery Preparation ", was issued to No. 25 Company "I" Battalion, Tank Corps prior to the battle of Cambrai. A copy of this document (fully one inch thick) was presented to the Tank Museum by a retired Major of the above Company. Whether this was his rank in 1917 or whether he was of lower rank it does not matter, save that if he was of lower rank in 1917 then it further reinforces the point being made: that is that he was given a copy of this training / instructional manual, which must have been printed by AP & SS, as a relatively low or middle-ranking officer. The distribution system must have worked in this case and therefore one suspects, but of course cannot prove, that it did so in the case of many others. It is unlikely that by mid-late 1916, after nearly two years of operation in

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[55] "Appendix A", CAB 45 / 200.

France, the distribution system was so inefficient as to be unable to distribute tactical literature to the appropriate personnel.

"Not solidified on the subject"

All matters relating to tanks were in a permanent state of flux; tactical doctrine was no exception. Writing on 28 May Maj-General Guy Dawnay (General Staff, GHQ) again expresses this state of flux in regard to tactics when he wrote to Lieut-General Sackville-West, British Section of the Supreme War Council, saying that in his opinion the views amongst the General Staff had "not solidified on the subject. He wrote :

> " We have not enough data on which to base a body of tactical doctrine as regards the use of Tanks at present. We have to rely very much on the Cambrai battle and on very incomplete and not wholly reliable accounts of minor instances of the use of Tanks subsequently, such as the occasion on which the Germans employed them at Villiers-Bretonneux [24 April, 1918]. I have one of my people especially working on the subject, and no doubt we shall get a little clearer on the matter as time goes on." [56]

Submitting his report, "The Tank Problem", to the Supreme War Council on 22 May 1918 Lieut-Colonel Olivant (General Staff - was this Dawnay's "man" ?) stated that the :

> "means of breaking [the stalemate rested on] our supremacy in aircraft and tanks...[we are]...at present approaching the problem of tanks in a muddled manner and from a wrong point of view. Attempts are being made to decide questions of organisation and even manufacture before the principles of tactical employment have been laid down. The consequence is delay, discussions which revolve in a vicious circle, unsuitable organisation and disappointing results in battle." [57]

This, of course, was one of the weakness and, at the same time, one of the strengths of the whole tank programme. The free-thinking and unconventional nature of the first administrative structures in both Britain and France, i.e. the Landship Committee / TS Committee / Heavy Section, was essential to the rapid promotion of the new weapon. However, the long-term effect of this is evident here in 1918. The usual structural arrangements concerning administration and employment normally associated with the Army's procurement of a new weapon were by-passed in order to

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[56] CAB 25 / 12.

[57] Ibid.

get the best machine available to the battlefields of France as quickly as was possible. What Olivant and the Army needed at this time was a period of consolidation. However, this opportunity was never to present itself - the pace of change (technical and administrative) and the mobility of the last 100 days militated against "logical procedure".

Olivant suggested that a committee of tank, infantry and artillery officers should meet for a "week's work" to decide on a re-structuring of tank matters. The result would include the "abolition" of the Tank Corps structure, together with its status as a "separate" body - a command apart from the rest of the Army. Three days earlier Maj-General Noel Birch, Royal Artillery, received instructions from Haig, who had just observed Tank Corps gunnery practice, to "supervise" their artillery practice and experiments. Birch saw his instructions as an indication of the General Staff's intention to bring the Tank Corps under its wing in the near future. [58] General Tim Harington, DCIGS, had written to Sackville-West on 30 May presaging this organisational change:

> "I am absolutely certain that we must get tanks brought inside the Army and their policy controlled by the General Staff. There are too many people playing with this subject." [59]

But as has already stated above, Capper made known what he believed to be Haig's views on the matter, that is that the Tank Corps would not be represented on the General Staff until "knowledge of the tanks was more widespread". By " knowledge" Haig was clearly indicating the need to resolve any confusion surrounding the employment of the tank, so that a common understanding and outlook on tank affairs prevailed at GHQ, before the Tank Corps was represented on the General Staff. This, of course, did not suggest a lack of support for the tank, only a body of differing opinions as to how best to promote the tank. Writing to Sackville-West at the British Section of the Supreme War Council, Versailles on 6 May 1918, Maj-General J.H. Davidson, Director of Military Operations, GHQ, reported that :

> "We find ourselves in some considerable difficulty at Versailles as to your views on the construction and employment of tanks...for some unknown reason anyone to do with tanks seems to be seized with the spirit of opposition to everybody else who has to do with tanks. The result is it is quite impossible to get any sort of collective view on the subject." [60]

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[58] WO 158 / 832.

[59] CAB 25 / 12.

[60] Ibid.

The exclusion of the Tank Corps from direct representation on the General Staff was one of the more persistent criticisms levelled at GHQ during and particularly after the war. Tactical control was to remain in the hands of the infantry. Lieut-Col C.N. Buzzard, General Staff, summed up the argument for integration and General Staff representation in May :

> "There is a tendency on the part of tank enthusiasts to aim at obtaining for Tanks an organisation similar to that of the Royal Air Force, that is, to look upon the arm as something apart from others...It seems absolutely necessary that the Tank Corps should be represented on the General Staff as is the Artillery but the creation of an organisation on what may be termed "Brahmin" lines is open to the gravest objections. As it is, one hears of complaints by the Artillery that Tanks have wandered about cutting all telephone communications. From other officers their carcasses are 'littering up the battle front' and that they have been sent up in driblets to a Division to be made use of in defence, probably by abstracted Army or Corps Staff who thought they might be useful and ought to be used...There seems to be very little objection to Heavy Tanks being Army Troops and distributed to Corps, as is the case with Heavy Artillery, with a representative on the Corps Staff." [61]

On 1 September 1918 Lieut-General Lawrence, Chief of the General Staff, wrote that the:

> "...commander to whom tank units are allotted should consult the Tank Corps Officers as to the practicability of employing tanks for any particular operation; these officers have now a wide experience of offensive battles." [62]

Clearly if circumstances did not permit the full integration of the Tank Corps within the Army and a representative on the General Staff then Tank Corps officers were for the first time being acknowledged as equals.

Much of the tactical thinking which found its way into SS. 214 & 164 reflected the practical feedback from Hamel, Amiens and the encouraging performance of the new Mk V's. However, the movement toward closer integration of the Tank Corps within the Army proper and the emergence of a definitive and coherent tactical doctrine for the tank was handicapped by the pace of the war and of technical change.

The reintroduction of mobility in mid-1918 intensified the on-going struggle to maintain the advantage over German anti-tank defences. Buzzard commented on the effectiveness of the German anti-tank measures when on 3 September he wrote :

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[61] Ibid.

[62] WO 158 / 832.

> "It is incontrovertible that the success of recent offences has been principally due to the use of tanks in large quantities ...but German methods of meeting these weapons has now been so much improved, that there is a risk that the advantage we possess in the development of the weapon will be neutralised." [63]

On 1 September, as part of his detailed paper on the employment of tanks (copies of which were sent to all units of the BEF) Lawrence made the observation that recent heavy fighting had seen the Germans employing "artillery dispositions", i.e. what became known as "tank forts" to counter tank attacks. This combined with the unfamiliarity of many division and brigade commanders with the functions and limitations of tanks (despite the SS pamphlets) led to tank losses, which Lawrence argued were "not compensated for by the results attained". He then went on to list some general points in connection with tank employment " which should be impressed on all concerned". These included tanks not being used without properly organised artillery co-operation, namely " smoke screens or H.E. [High Explosive] barrage and counter battery work". He drew attention to the fact that when tanks were allotted for particular tasks, often the time necessary for approach marches and for the establishment of proper liaison between infantry and Tank Corps officers was not taken into account. This had to rectified. The role of the tank as a form of mobile artillery had not been seriously discussed since the initial battle preparations prior to the tank's debut in September 1916. But the pace of tank actions by mid-1918 often denied them the artillery cover they had come to rely on, exposing them to German artillery and increasingly heavy losses. A combination of improved performance and the more fluid engagements, meant that the role of the tank as mobile artillery was was once more considered. On 14 September 1918 Lieut-General Braithwaite, GOC IX Corps, offered a solution to this problem. A certain number of "specially constructed tanks" should be fitted with "Howitzers or long range Mortars". These would be able to move forward with the tanks taking advantage of natural cover and so provide the necessary artillery cover. [64] Rawlinson came to a similar conclusion on 16 September. This involved mounting a 6-pdr gun on a "Whippet" or Medium 'A' tank. Owing to this tank's mobility it would "have no difficulty in following close behind the infantry advance", from where it would be able to deal with anti-tank obstacles. [65]

Another school of thought favoured concealment rather than fire-power. If the Royal Artillery could not provide adequate cover for advancing tanks then clever use of

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[63] Ibid.

[64] Ibid.

[65] CAB 25 / 12.

camouflage ought to deny the German gunners a target, or at least reduce target opportunities to a minimum. Lieut-Colonel Lister, "E" Branch, War Office wrote on 22 September that :

> "They [tanks] are being knocked out by single field guns at short range. Armour piercing bullets are the [next] most serious danger...since we cannot increase the armour adequately [i.e. the relationship between mobility and protection] we must improve concealment." [66],

He went on to list the importance of smoke barrages and camouflage, both as to shape and colour. Tank Corps practice was to carry a large red and white distinguishing plaque to assist recognition both by other tanks and by the infantry so as to improve combined operations, but which had the unwanted effect of rendering them "very conspicuous". It should be noted that camouflage paint techniques had been applied to tanks in mid-1916 under the direction of Soloman J. Soloman , Royal Engineers. But it was considered more trouble than it was worth and the practice was soon abandoned. Research and development into tanks producing their own independent smoke barrages in order to cover their advance had been the subject of on-off investigations also since 1916. These ideas, together with the use of tanks as mobile artillery, received renewed attention in the final months of the war. What was happening in late 1918 was a case of the tank's performance finally catching-up with some of the more far-sighted ideas that had been encouraged by GHQ and implemented by the Heavy Section in mid-1916 before being shelved after the limited performance of the Mk I was fully appreciated.

Finally, Lister recommended the adoption of what he termed "more elastic tank tactics admitting of more cunning use of the ground". On this point he cited the German attack at Villiers-Bretonneux on 24 April 1918 as a good example. The Germans, he said,"employed natural cover and eschewed rigid formational [sic] attacks over crests of hills where they offered targets for enemy artillery".

Regarding more elastic tactics, Tim Harington wrote to Sackville-West on 7 October informing him that "GHQ were in the process of establishing their own Tank Tactical School for all higher forms of tactical instruction". This was to be independent of the Inter-allied school for tank tactics at Fontainbleau which senior British representatives had criticised for being too general and not specifically related to the needs of the tank. [67]

The search for a tactical doctrine for tanks was very much alive. However, vigorous and lengthy debate among the upper echelons of the Army never produced a "solidified" doctrine during the war. As Olivant implied, no one had had the luxury to

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[66] Ibid.

[67] Ibid.

take time out since the tank's introduction to give careful consideration to the manufacture and tactical employment of this new weapon . Constant technical and administrative changes militated against this. But Rawlinson's and Braithwaite's practical solutions to the effectiveness of German anti-tank measures, and the use of smoke and camouflage, not only reflected the direction of research and development, but also highlighted continuing support for the tank programme at the highest level. A greater role, including a place at the General Staff for Tank Corps' officers whose experience by this time of the war was considerable, was recognised. The most obvious point to emerge from this discussion is that once again the limitations imposed on tactical planning were not those of mental "paradigms", but the mechanical ability of the machines themselves.

[11]

The last 100 days

Tim Travers has expressed the view that had tank numbers been more carefully marshalled and not thrown away in "penny packets", the "durability" of the machines and the success of the salvage and repair workshops would have meant that a sufficient number of tanks would have been available for use in a "major tank-artillery-infantry"[1] offensive in late 1918 . Cambrai and Amiens are cited as examples of the type of "tank-artillery-infantry" battles which should and could have been copied and which could perhaps have ended the war sooner thereby saving many Allied lives.[2] This raises several questions. What role did the tanks actually play in the post-Amiens period of the war ? And when and where was the Travers's "tank-artillery-infantry" battle(s) to have taken place, and what logistical difficulties would have had to have been overcome in order to mount it (or them) ?

However, before discussing the Travers battle scenario, the term "mass tank attack" (to use Brig-General J.E. Edmonds's term as cited by Travers) used in connection with a possible major tank deployment during the last months of the war, should be clarified. If, as Travers suggests, Cambrai and Amiens are the models, then a battle involving 400 plus fighting tanks is necessary to qualify for this category of battle. But this makes no allowance for the length of the fighting front and therefore for the density of the tanks, which must surely define mass.

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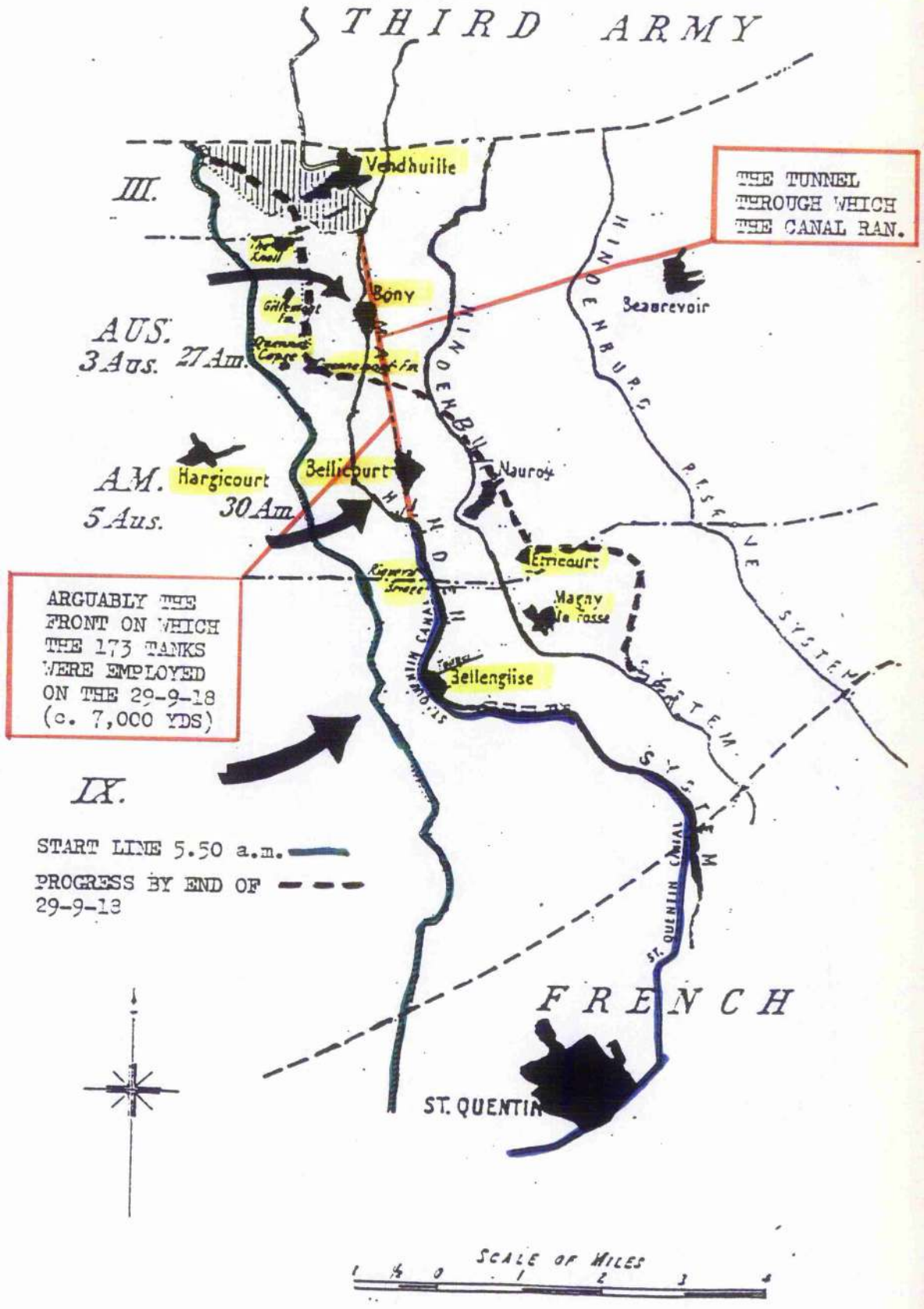
[1] Tim Travers, "Could the Tanks of 1918 Have Been War-Winners for the British Expeditionary Forces ?", Journal of Contemporary History, Vol 27, 1992, p 393.

Maj-General Heinz Guderian, *Achtung Panzer !* , p 126, voices much the same criticism. "All the lessons of 18 July and 8 August seem to have been cast aside", he wrote. "There was", he said, " not a single occasion on which the huge quantities of tanks now available were directed at a common objective, simultaneously and with due co-ordination." He like Travers fails to take into account the enormous logistical problems that will be discussed below ; further, again like Travers, Guderian implies that the most important factor is the number of tanks available. Guderian suggests that there were at least 4 , 500 available to the BEF when, in reality Britain never built more than c. 2, 400 of all types and models. In reality numbers and durability could not compensate for mechanical unreliability.

[2] Tim Travers, ibid, p 403.

THE BATTLE OF THE ST. QUENTIN CANAL.

(29TH SEPTEMBER 1918)



Tank density

	Cambrai	Amiens	St. Quentin.
Front	10, 000 yds	16, 000	7, 000
No. of Infantry Divisons.	5	9	7
No. of Fighting Tanks.	378	415	173
Tanks per Infantry Div.	76	46	25
Territorial Density of Tanks. 1 tank every ....yds	27	39	40

If we consider the table above tank density, defined in terms of tanks per infantry division employed on the first day, declined considerably from Cambrai to Amiens (both of which Travers considers to have been models of tank employment for the late months of 1918) and still further by 29 September when the Fourth Army opened its assault on the Hindenburg Line at St.Quentin. However, if we choose to define a mass employment of tanks not by their relationship to their accompanying infantry but by their territorial density, that is the number of tanks over a given area, then the assault at St.Quentin (see map) was only marginally less massed than Amiens which itself had significantly fewer tanks in terms of territorial density than Cambrai. Yet, in Travers's terms, Amiens was still a model of employment.[3]

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[3] In reality this table represents little more than an exercise in juggling statistics. One does not wish to detract from their value, but they can only ever contribute one side of the story. Moreover, when the statistics themselves are so variable in terms of the length of the frontages and the numbers of tanks used, their value is still further diminished.

The table includes figures supplied by General Sir Michael Carver for Cambrai in *False Dawn* , Tank Corps Journal, General Rawlinson's figures given in his memo of 17 July 1918 for Amiens, and my own calculation for St.Quentin. This calculation is based on information from Elles's "Summary of Tank Operations" of tank actions together with the map provided in the OH (*Military Operations in France and Belgium, 1918*, Vol IV, sketch 26). Elles said that the 4th Army front extended from Bellenglise to Vendhuille, some 14, 000 yds (my measurement). However, Wilson and Prior in *Command on the Western Front* , p 361, suggest that the 4th Army front was only 10, 000 yds and Montgomery, *Story of the Fourth Army* , pp 151-152, states that it was as long as 21, 000 yds.

If we examine the tank allocation, we can see that in the north and central areas tanks were allocated only to the Australian and U.S Corps and not to the III Corps in the Vendhuille area. In the southern sector the IXth Corps also received tanks. But because, as Elles's "Summary" said, these tanks could not cross the canal below Bellicourt, they effectively had to begin the assault at this point. So my argument is that when the attack opened on the 29th all of the 4th Army's tanks were confined to a front between The Knoll and Bellicourt - not more than 7, 000 yds at least until they crossed the canal and then, in theory at least spread out north and south.

Incidentally, if we apply Wilson and Prior's frontage figures for Amiens (they give 19, 000 instead of my 16, 000 - both are taken from the same document) and St.Quentin (their 10, 000 to my 7, 000) we get 46 and 58 yds per tank respectively. From this we may deduce that a difference of 12 (58-

The reality : the Hindenburg Line and beyond

The 4th Army's objective on 29 September was to force the Hindenburg Line between the villages of Bellenglise and Vendhuile.[4] This front covered that stretch of the St Quentin Canal that had been diverted underground between Bellicourt and Vendhuile. This was therefore the obvious place for the tanks to cross the canal given that it was some 35 feet wide, had steep banks and a water level of about 6 feet. An operation in this sector had been the subject of careful study by the Tank Corps since the summer of 1917. Indeed some of the tank crews found themselves fighting on the same ground that they last saw during the battle of Cambrai.[5] This key stretch of the front was therefore very well defended making an attack without a preliminary artillery bombardment inadvisable.

The first objective, the centre trench system east of Bony, was assigned to the American Corps (27th Div.) while the Australian Corps (3rd Div.) was to pass, or "leap-frog" through this gap, and exploit north and south to the east of the canal. To the south the American Corps (30th Div.) and the Australian Corps (5th Div.) were to take Bellicourt and the southern tunnel defences. IX Corps was to clear the east bank of the canal under cover of the southern wing of the American force. III Corps, which was not allocated supporting tanks, had essentially been given a holding role to cover the northern flank of the American forces and provide a link with the 3rd Army. Their front covered that area immediately south of Vendhuile where the canal emerged from underground.

Originally the "jumping-off" line for the commencement of the assault was going to be that line between Knoll-Guillmont Farm and Quennemont Farm, but very stiff resistance encountered by the American 27th Division two days earlier meant that

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46) is enough to suggest that on this calculation St.Quentin's tank territorial density is sufficiently inferior to that enjoyed at Amiens to render the former's application for mass tank battle status invalid. However, if we compare the 46 yds per tank (still using Wilson and Prior's figures) with the table's figure of 27 yds per tank at Cambrai we can see that there is an even greater difference of 19 (46 -27). This would suggest that on this basis Amiens has no more right to be included in this category than St. Quentin!

We must also explain the origin of the figure of 173 tanks for St.Quentin. Elles's "Summary" states that 181 tanks were employed on 29th. All of these save the 11th Battn were allocated to the 4th Army front. The OH (*Military Operations in France and Belgium, 1918*, Vol V, pp 116-117) states that 8 tanks of the 11th, all that could be spared from the 4th Army front, were allocated to Vth Corps [21st and 33rd Divs]. Therefore, 173 (181 - 8) tanks must have been used on the 4th Army front. Wilson and Prior suggest that 162 tanks were used. My 173 does include 17th A.C Battn ; perhaps they deducted these vehicles (number not specified) from the original number.

[4] Tank Corps, "Weekly Note No. 51 : The Battles of Epehy & Cambrai - St.Quentin", p 5.

[5] This in fact applies far more to the 3rd Army and in particular to the 7th Battn (Mk IV) immediately to the north of the 4th Army. But it serves to highlight the fact that both sides had had a good look at one another.

on the morning of the 29th the infantry was still some way short of this point. As a result the creeping barrage which had already been fixed and could not be changed without great confusion ensuing (and without incurring the possibility that those troops who had made progress on 27th would come under "friendly" artillery fire) was well in advance of the infantry. This, combined with determined German resistance, led to the failure of the American (27th Div) advance and to considerable losses.

The American 301st Tank Battalion supporting the American 27th Division met with disaster west of Ronnsoy when it ran into an old British minefield, consisting of rows of buried 2-inch trench mortar bombs each containing 50 lbs of ammonal. These had the effect of tearing the whole bottom out of some of the machines. Ten machines fell victim to the mines and only two succeeded in assisting the infantry.[6]

Further south at Bellicourt the American 30th Division, supported by tanks from the 4th and 5th Brigades, broke through the Hindenburg line. However the mist which had shrouded their initial progress lifted and exposed them to enemy artillery fire from the rear. According to the Tank Corps [7] several tanks which had been allotted later objectives went to their assistance on their own initiative without infantry or artillery support and succeeded in saving " a great many infantry casualties". But tank casualties were also reported to have been high (though no actual figures are given).

On the right of the attack IX Corps were able to cross the canal at their first effort and captured the villages of Etricourt and Magny with 4, 000 prisoners. However, as stated above, the tanks were initially unable to accompany the infantry

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[6] As we have discussed above one of the difficulties when analysing tactics in this period is the far from reliable information. In this particular case the 301st U.S Tank Batt did assist the 27th U.S. Div. However, the OH (*Military Operations in France and Belgium, 1918,* Vol V, p106) states that on the 29th 34 tanks of this battalion were in action, of which 12 received direct hits (artillery) and 7 were ditched (stuck in trenches or soft ground). Others (an unspecified number, but simple arithmetic says 5) hit an old British minefield. At the end of the day only 10 tanks rallied.

Montgomery, *Story of the Fourth Army* , p 163, states that 39 tanks assisted the 27th of which 12 received direct hits. "In one instance", he wrote," 7 approached to within 100 yds of Gillemont Farm, but were put out of action by enemy [artillery ?] as soon as they became visible through the mist. Only one tank succeeded in crossing the Bellicourt tunnel on this divisional front." No mention is made of the minefield!

If we turn to primary sources the picture still remains blurred. Elles's summary of tank actions states very succinctly that " on the American front the attack did not meet with success. Some tanks of the 301st American Tank Battn. were put out of action on a minefield." They at least mention the minefield, if not the numbers.

All of this is to a greater or lesser extent at odds with the source that is quoted in the main body of my text, that is the "Weekly Tank Note No 51."

Wilson and Prior, *Command on the Western Front* , p 370, have resolved the numbers dilemma, to their satisfaction at least, by using the Australian OH (C.E.W Bean ,*Official History, of Australia in the War of 1914-18,* Vol 6). This source furnishes us with yet another combination of the above figures. There were, it says, 34 tanks, 10 of which ran on to the old British minefield (despite it being roped off by the Germans and furnished with a warning sign), 11 fell victim to artillery, and 7 became ditched.

[7] Tank Corps, "Weekly Tank Note No 51", p 7.

and had to cross the canal at Bellicourt before wheeling south to assist the infantry in the capture of Magny. This was the situation at the end of the first day of the battle.

The attack on the Hindenburg line was necessarily a "set piece" attack, in the same way that Cambrai and Amiens had been. Like Amiens the offensive had begun in the early morning (5.50 am) under cover of fog and smoke shells. The density of tanks , as discussed above, was not greatly inferior to that at Amiens. Where comparisons do differ from either Cambrai or Amiens is in the use of a 48-hour [8] artillery bombardment prior to the offensive at St.Quentin : this had not been employed at either of the two former battles. Yet an attack on the most heavily defended line of fortifications on the Western Front, consisting of 6 lines of wire and entrenchment, bunkers, and "tank forts" some 6, 000 yards deep, necessitated a preliminary bombardment. This was not the first time that the Germans had been attacked by tanks in this area. It had happened before during the Cambrai offensive and they had learnt the lesson. The emphasis of the attack had to be on infantry and artillery. Yet, as the re-working of the statistics above has suggested, in terms of territorial density it was not of any less significance as an infantry-artillery-tank action than Amiens.

Statistics aside, no other conclusion can be reached other than this was not tank country. An assault and breakthrough of a line of fortifications as strong as those of the Hindenburg Line was far from an ideal undertaking in which to employ tanks in mass numbers. Consequently, if it was to be contemplated at all, a mass employment of tanks after Amiens would have had to be delayed until after the Hindenburg Line had been broken and "open country" had been reached.

When and where could a massed tank / infantry / artillery attack have taken place ? The conditions as outlined above would certainly have delayed any such operation until the end of the first week in October at the earliest. However, at this stage fighting was still taking place on all areas of the Fourth and Third Army front.[9] Realistically, therefore, the first clear opportunity to organise such an attack would have been at the halt before the Selle between 11 and 16 October. [10]

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[8] This bombardment consisted of gas and high explosive.

[9] The Battle of Cambrai was not concluded until 9 October.

[10] As suggested below the number of days taken to gather the tank forces for the battle of Cambrai and St. Quentin was 5 / 6 days. Therefore, a similar period would have been required for the grouping of our c.400 machines for the Travers battle. The halt before the Selle offered very nearly this period. Yet even on the 11th two brigades (137th (46th Div) and 71st (6th Div)) of IX Corps were engaged in the capture of Riquerval Farm - accomplished with the aid of just one tank. However, a number of "dummy" tanks were used at the beginning of this action as a ruse, a "Chinese" attack, thereby greatly assisting in the success of the day. The use of only one "real" tank is perhaps a measure of the intensity of the fighting that had occurred in the previous weeks and the immediate availabity of tanks "fit to fight". However, the time and effort involved in constructing "dummy" (see photo) tanks were not negligible and the importance of the tank in general terms (even though Travers suggests that a shift to a more "traditional" tactical thinking had taken place) is perhaps reflected in this.

How did the 48 tanks that were employed on October 17 fare in the conditions which faced them at this point ? The "Summary of Tank Actions" between 8 August - 20 October, states of this action that :

> "Very little difficulty was experienced in crossing the R.Selle. Tanks steered to their objectives through a thick fog and in many cases the Infantry lost their direction." [11]

The action is described in the report as having been "moderately" successful. But the river crossing was not without its problems. On the 301st Battalion front the River Selle was in effect only a stream, but one tank managed to become bogged down in mid-stream and had to be abandoned. Nine of the remaining nineteen Mk Vs were lost to enemy artillery. On the XIII Corps front "wooden cribs" [12] were constructed to

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Dummy tanks were referred to as early as the first half of 1916, when the War Office suggested that "canvas structures carried by men" might be useful for training purposes. It seems that their first use on the battlefield, certainly in 1918, took place on 18 September by the 4th Army (Montgomery,*Story of the Fourth Army,* p 125) and again on October 17 (p 210). The OH (*Military Operations in France and Belgium, 1918,* Vol V, p 248) has only one mention of these tanks and that is on October 11. Strangely enough Churchill mentions them in a letter to Scely (4 October 1918) Martin Gilbert,*Winston S. Churchill,* (Vol IV, 1917-22, companion),pp 400-01, in which he wrote " I wish to have a proposal submitted for the construction by February of 1, 000 camouflaged or training tanks." MUN 4 / 5213 also mentions them in connection with Maclean, Wilson and Shaw and a discussion on the same day regarding the possibility of putting a "mock up" of the MkV on one of Sir Percival Perry's tractors. Churchill's tank specifications called for a two-man crew (one driver and one machine gunner). The driver and machine gunner immediately behind him were to be encased in a "strong steel cupola" (bullet proof). These dummy tanks were to be powered by "ordinary lorry engines". The "object" of these machines was to "create alarm and panic among the enemy" and to "divert and distract fire from the real tanks", generally multiplying the numbers of tanks giving the impression that "unlimited numbers were available". Two points are raised here. Did Churchill's dummy tanks represent a evolutionary leap forward from those being constructed and used in France ? I am not entirely sure whether those used in France were powered by an engine or whether they were simply dragged into no mans land under cover of darkness to give the impression in the dawn mist of attacking allied tanks. If this was the case then why did Churchill not acknowledge the existence of the more primitive versions of the dummy tanks and put forward his as improvements ? The second point raised here concerns Churchill's statement that materials used should not clash with those used on the tank programme. That is why he suggested using lorry engines. But surely this was rather short sighted. Mechanical Transport (MT) and mechanical warfare were keen competitors for priority status as has been discussed above. Engine manufacture for either tanks or MT shared the same basic material and personnel requirements - an obvious clash one would have thought !

Travers suggests that there had been a shift in tactical thinking toward a more "traditional" pattern of warfare. One would argue that far from a shift taking place, what had actually occurred was that the tank , despite its rapid technical evolution, was quite literally left behind - the pace of battle had now outstripped the pace of technical change.

[11] General H. Elles, "Summary of Tank Operations from August 8th to October 20th", to CGS, 29 October 1918.

[12] Montgomery describes these "cribs" as " hexagonal wooden frames." They were constructed by the Tank Corps and dropped into the river at a point alongside the road bridge (the tanks were obviously too heavy to use this bridge - again highlighting the difficulty of moving tanks). Careful reconnaissance" had revealed that this was the most favourable spot for the 1st Battalion's 11 MkV's to cross the river (which at this point was 8 feet wide and some 4 feet deep - again highlighting the difficulty of moving tanks. Troops could wade this in a matter of seconds but tanks were stranded!). These cribs were probably similar in function to the fascines carried into action by the leading tanks at Cambrai and intended for use in filling holes and trenches too wide to cross in the ordinary manner.

enable the eleven Mk V* tanks of the1st Tank Battalion to cross the river. Of those, three later broke down, two become bogged and were abandoned, and the remaining machines lost contact with the infantry in the fog. The war diary of the 6th Battalion reports that three tanks were so badly damaged by enemy artillery that they had to be handed over to salvage. How would 400 plus tanks have coped in such conditions ?

Were there enough tanks on October 17 to mount a massed attack ? Before we examine the logistical arrangements we should, of course, attempt to ascertain how many fighting machines were available at this time. Were there 400 plus machines in a "fit to fight" state ? It is known that there were 357 (including 125 Mk Vs) fighting tanks "fit to fight" available to the whole BEF on 15 October.[13] Figures for 11 or 17 October are not available. However, an average of the number of tanks "fit to fight" over the period beginning 30 August - 26 October gives us 280[14] fighting tanks. Despite the success of the salvage and workshop crews and the "durability" of the machines, there would still not have been enough fighting machines available to mount a mass tank action on 17 October. This picture changes, of course, if the findings of the statistical re-think above are accepted and the 280 machines are confined to a narrow front so creasing their "territorial density". The logistical arrangements, without which no mass employment of tanks could take place, must now be considered.

How difficult was it to transport tanks ? When Elles compared the tank actions fought in the period 8 August - 20 October with those fought a year earlier at Cambrai he said that there had been " a very marked improvement as regards mobility and elasticity - Tanks are now operating 30 miles from Railhead [sic] - and in tactical and administrative ability of senior ranks".[15] However, it could be argued that this improvement could not obviate the enormous logistical difficulties created in the wake of the German spring offensive. Further, although Elles goes on to state that " Rail concentrations and assemblies for surprise attack [sic] have gone practically without a hitch", he can only have been referring to the earlier period covered by this "Summary", that is up to and including the breakthrough of the Hindenburg Line.

While the 48 tanks used in the assault on the Selle on 17 October did go into action with the aid of RAF cover to mask the sound of their engines, and were therefore a"surprise", it is unlikely that they were entrained to their jump-off points. No mention of such a movement exists in the war diaries of the 6th Battalion (although previous

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13 Figures provided by Travers, "Could the tanks have been War Winners ?" , p 394. They are confirmed by "Weekly Tank State." MUN 4 / 6400.

14 261 [30-8] + 177 [7-9] + 357 [15-10] + 317 [19-10] + 289 [26-10] = 1398 ÷ 5 = 280.

15 Elles,"Summary of Tank Operations."

references to rail movements had been mentioned as such). It is suggested, therefore, that when they moved forward it was under their own power. The 6th Battalion diaries make no mention of being entrained to its objectives beyond the end of September or early October. The same applies to the 12th and 15th Battalions which were allotted to the 3rd Army immediately to the north of the 4th Army. Even if the tanks used on the Selle had been entrained to their objectives, the movement of such a relatively small number of tanks over a period of five days (11 - 16 October) would hardly have caused a significant problem in terms of transport organisation. On the other hand a mass force of 350-400 tanks would have required a considerable shift in emphasis and priority in regard to the arangements for rail and MT. Finally, Elles's enthusiasm for the growing efficiency of tank movement sits more easily alongside the successes of August and September than it does in relation to the events of mid-October and thereafter. When he actually wrote his summary (29 October 1918) the few tanks that were operating in forward positions were, as we shall discuss below, within a few days to be withdrawn from the field" 30 miles" from their railheads.

The Whippets of 6th Battalion spent the first week of October at rest and being overhauled. Thereafter they were engaged in a cycle of action and maintenance. Several days of action were followed by as many, if not more, days of maintenance and repair, and of handing damaged machines over to salvage and receiving replacements. Not until 3 November is a significant move forward recorded and this took " 71/2 hours - had to cross 2 rivers and no bridges strong enough for Tanks - lost 3 machines in rivers - 9 made it to rendezvous... ." On the 4th they were "ordered to follow the battle and get into position where tanks could go in at dawn" the following day.

The Mk V* machines of the 15th Battalion[16] had a similar experience. An account of one incident clearly depicts the hazards and complications of moving tanks under their own power and the extent to which tanks, even though they were tracked vehicles, were often confined to the roads when the conditions were soft or muddy. This did little for either the fast decomposing roads or for the fast passage of MT carrying supplies to the forward lines. On the night of 26 September 'A' and 'C' companies "trekked" to their jumping-off points in preparation for an advance on the Canal du Nord with the Third Army the following day. The only route was apparently through Havrincourt Wood. This road was very congested with MT traffic and was also under enemy artillery fire. Arrangements had been made with the RAF to provide a sound barrage at mid-night to cover the noise of the tanks. However, this failed to

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[16] The 15th Battalion war diary. The problem with contemporary data for tank movements is that not all of it has survived. Battle sheets where available offer detailed information on the conduct of battle but rarely anything on preparations in the days leading up to action. Battalion war diaries and histories offer a more rounded picture of the life of the battalion including details of movements, but even these are at times incomplete or sketchy on certain periods.

materialise, and the tanks had to wait until the early hours of the morning before they could attempt their journey. When they did finally get under way they soon found their road blocked by a broken down lorry and, while waiting for the obstruction to be cleared, they came under heavy gas and high explosive shelling from enemy guns. Eventually, having escaped serious damage (no significant tank damage, and suffering one fatality only), they arrived at their jumping-off point shortly before zero hour. The movement of tanks, even a small number, was evidently not a simple matter .

The story of the 12 Battalion[17] is a remarkable one, not only for the distance that it trekked, but also for the fact that it was one of only two Mk IV fighting tank units in operation in late 1918. By the end of October the three companies had trekked " an unprecedented" distance averaging some thirty miles since their last action. Some of the tanks had been fighting and trekking since August 16 with only a short period of rest covering in a straight line "over 50 miles". "Including actions and movement some tanks must have travelled nearly 100 miles."

However valiant their efforts the 12th - in common with the 6th and other battalions - could only "follow-up" the infantry advance. A combination of poor top speed, frequent maintenance, and obstacles consigned the tanks to at best "mopping-up" enemy strong points. These obstacles were both man-made and natural including rivers, streams, canals and even railway lines. The latter had to be crossed using special ramps to avoid damaging either the rails or the tank tracks, and proved as significant obstacles to the rapid and unfettered movement of tanks as did the water hazards. During October the 12th Battalion continued to follow the infantry but only "one minor tank action was fought or indeed possible for the country was traversed every few miles by small rivers which no tank could cross without the help of engineers". By the third week of October the enemy was withdrawing steadily. A succession of rivers running north into the Scheldt lay across the British line of pursuit. This " held out a cheerless prospect of endless trekking with very little probability of arriving anywhere in time for action." Orders were received from the Tank Corps HQ to withdraw to an entraining point while 'the trail of dumps and detail which every tank Batt. scattered behind it were cleared and collected".

Captain D.M.F. Sheryer's account of trekking with the 6th Battn (the 6th had previously been a Mk IV battalion before being issued with Whippets) perhaps gives a more accurate picture of the Mk IV's capabilites. In a recorded interview Sheryer recounted that the engine "life" of a Mk IV was a "matter of about 60 miles". Various componants wore out, such as track rollers and sprocket wheels. When tanks could not be transported by rail they had to travel under their own power. But this was costly in

[17] 12th Battalion war diary. The 7th Battn was the only other battalion equippedwith the Mk IV tank in late 1918.

terms of time. Sheryer told of how it had been possible to " see your day's march ahead of you", such was the speed of the tank, which he said had an average speed of 2 mph, "certainly no more". And also trekking caused considerable wear and tear on tank componants. As a consequence a journey of any distance often involved a good deal of major maintenance on the way :

> " We knew roughly how long it was going to take...for instance if we had a trek of 30 miles ...[we knew]...that somebody'd have to change those sprockets on the way because they would start off half worn, or somebody might even want an engine."[18]

Clearly, transporting tanks under their own power was a costly and time-consuming business. The number of tanks used during October (the last complete month of the fighting) was 309 over nine days fighting. This gives an average of 34 tanks per fighting day.[19] If this number of tanks experienced difficulties in moving from front to front in an increasingly mobile theatre, how much more difficult would it have been for hundreds of machines to have negotiated rivers and have been maintained while keeping up with the infantry whose pace was dictated by a retreating enemy ?

In the last few months of the war there was no shortage of specialist wagons or trucks with which to transport tanks. Collecting them together in one area would have taken time, but it could have been done. The most urgent problem facing the transport of tanks by rail was the availability of track to run on.

What was the state of the rail communication on the Fourth Army front on or about October 11 ? The 4th Army had to wait from mid-August to early September before it received a significant number of standard gauge rail links. By this time it was expected to outrun its railheads. The most obvious rail line in the 4th Army sector at this stage of the offensive was the Chaulnes - Peronne line (see rail map). The reconstruction of this line was sanctioned on 10 September. In the meantime the 4th Army had to make use of the Maricourt - Peronne line which had been opened for 4th Army traffic as far as Hem. During the initial stages of reconstruction the Chaulons - Peronne line could carry only 4 - 6 trains per day, the majority of these being for construction personnel and materials. On 12 September the 4th Army also received permission to use the link between Peronne - Moislans which "might" be reconstructed to meet " a battle situation". On 9 September the General Staff declared that as a result of the acute shortage of useful lines (in particular a shortage of rails which necessitated

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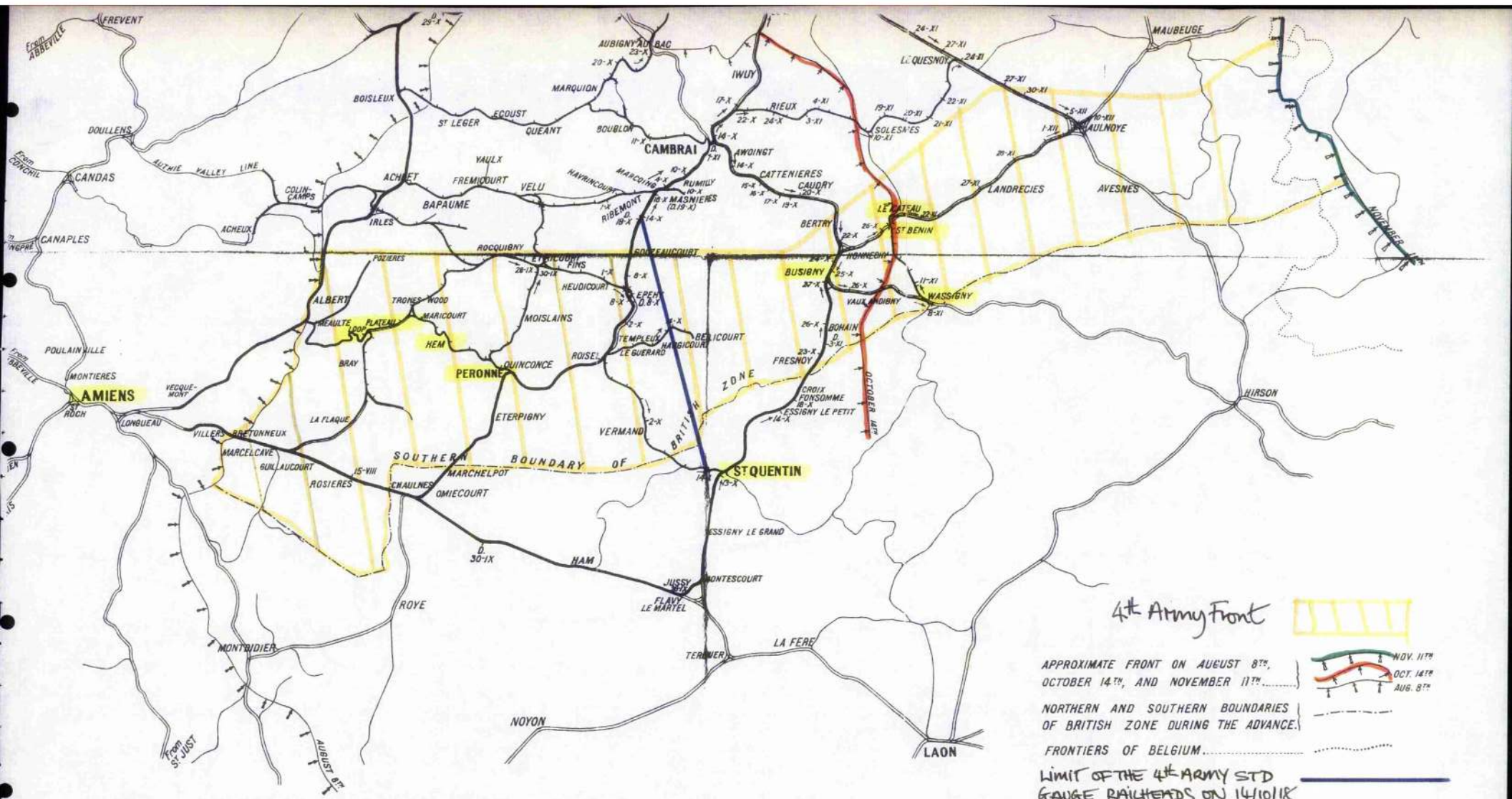
[18] Captain D.M.F. Sheryer, "War Experiences", Tank Museum.

[19] Figures are taken from Elles, "Summary of Tank Operations."



4th Army Front

APPROXIMATE FRONT ON AUGUST 8TH, OCTOBER 14TH, AND NOVEMBER 11TH

NOV. 11TH
OCT. 14TH
AUG. 8TH

NORTHERN AND SOUTHERN BOUNDARIES OF BRITISH ZONE DURING THE ADVANCE.

FRONTIERS OF BELGIUM

LIMIT OF THE 4TH ARMY STD GAUGE RAILHEADS ON 14/10/18

PRE-WAR RAILWAYS WITH ADDITIONS AND ALTERATIONS MADE BY THE ALLIES..... SINGLE ——— DOUBLE ———

LINES RECONSTRUCTED FOR THE ADVANCE..... SINGLE LINES RECONSTRUCTED AS SINGLE..... → 17-X

DOUBLE " " " " SINGLE..... ⟹ 25-X

DOUBLE " " " " DOUBLE..... 20-X / D. 3-XI

ARROWS SHOW THE DIRECTION IN WHICH THE CONSTRUCTION TROOPS WERE WORKING. FIGURES 17-X, D. 3-XI, GIVE THE DATES ON WHICH CONTINUOUS TRACK, SINGLE OR DOUBLE, REACHED THE POINT INDICATED.

0 10 20 30 Miles.

THE GENERAL OUTLINE IS TO SCALE, BUT THE RAILWAYS ARE DIAGRAMATIC.

Map showing the relationship between the standard guage railheads and the rapidly advancing front during the last 100 days.

the taking up of side lines to provide extra rails) all reconstruction work was to be confined to six main feeder lines. In the 1st, 3rd and 4th Army sectors these were the Boulogne - Arras - Douai - Valenciennes - Mons line (Ist Army), and the St.Quentin - Busigny - Le Cateau - Maubeuge - Charleroi line which served both the 3rd and 4th Armies. [20]

The problem of reconstruction was hampered not only by the shortage of rails but also by sabotage of the rail lines by the retreating German forces. The most damaging weapon employed by the German forces, in terms of material damage, time wasted and the psychological impact on the rail staff and troops on rail transport alike, was the delayed action mine. By the end of October some 24 mines had been discovered in 3rd and 4th Army sectors but many more remained undiscovered only to explode days, weeks, even months later.[21] In the first four days of November 13 mines exploded on the St.Quentin - Busigny line alone. The delays caused by these explosions could render lines impassable for several days, or for just a matter of hours only, but in each case the fact that there were so few lines open, and each was so heavily used and so vital to the momentum of the advance, as the Allies strove to keep touch with the fast retreating German forces, meant that even a delay of a few hours could be critical. These difficulties were reflected in the amount of rail traffic operating. During October there was a appreciable reduction in the number of trains to all railheads at the front. The average number of trains per day fell from 160 to 133.[22] This was further reflected in the priority given to certain loads. Clearly ambulance trains, and the movement of artillery, shells, ammunition, rations, troops and railway construction material (to enable the railway construction troops to keep the railheads within reasonable distance of the rapidly advancing front) were all vitally important at this stage of the war.

The French began reconstruction work on the St.Quentin - Le Cateau line at the end of September / early October. On 9 September the General Staff had calculated that the 4th Army would need at least 20 trains per day on this line. However, in order to provide this level of traffic the line would have to be doubled and it was calculated that this would not be possible before 10 November . Only 18 trains per day would be possible between 1 - 10 November and these had to shared equally with the French.[23] It

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[20] A.M. Henniker, *Transportation on the Western Front,* pp 435-7.

[21] Ibid, p 440. Other hazards included intermittent air attack and long range artillery. Also, there were inherent problems resulting from the pace of reconstruction such as subsidence of hastily filled shell or mine craters which resulted in buckled or twisted rails and further de-railed trains.

[22] Ibid, pp 455-6.

[23] Ibid, p 443.

transpired that the 4th Army was able to secure 12 trains per day by the end of October after the construction crews reached St. Benin, just short of Le Cateau on 26 October. The destruction of a viaduct at St. Benin prevented Le Cateau being taken on line until 22 November. At this stage of the offensive the bulk of the rail traffic for the 4th Army was still being dealt with at rail heads some 25 - 30 miles behind the front. On 11 November the only reliable railhead for the 4th Army was some 50 miles behind the front. [24]

Regular standard gauge rail links on the 3rd and 4th Army fronts from the end of September onwards were tenuous and growing worse. Could several hundreds of tanks have been moved by rail, bearing in mind that this would also have required the movement of special wagons and very careful and time-consuming loading and unloading procedures ? If it could have been done, could it have been achieved without severely dislocating the already precarious rail situation ?

How many trains would it have taken to transport the several hundred tanks for the massed attack ?

Cambrai -	476 tanks	5 /6 days	=	36 trains	=	13 tanks per train
Albert -	386 tanks	5 "	=	27 "	=	14 tanks " "[25]

Using the information shown above it is possible to calculate that 28 trains would have been needed, i.e. 380 tanks divided by 13.5 tanks per train. The supply to railheads of petrol, lubricants, spare parts, the removal of salvaged machines from the nearest railheads to the Central Workshops, and the need for replacement machines must be accounted for also. A figure in excess of 30 trains to transport such a tank force to the front line is quite reasonable. Of course this operation would have to be carried out more than once if the tanks were to keep in touch with the infantry. This figure of 380 tanks represents an average of the entire stock of fighting tanks available to the BEF - 280 tanks "fit to fight", together with an average of 100 support machines, i.e tank

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[24] Ibid, p 460.

[25] The OH (*Military Operations in France and Belgium, 1917,* Vol III, pp 27-8) gives the number of trains for the movement of tanks for the Battle of Cambrai at 36 over a period of 13-18 November. The figures for the Battle of Albert (21 August) are supplied by a detailed railway programme : "Table 'A' " issued with "Tank Corps Order No. 26" (WO 158 / 835). Obviously 13.5 tanks per train is a piece of statistical nonsense. There were on average 12 heavy tanks per train. However, the Med 'A' machines took up less space and often travelled two to a train. Hence the strange figure, since Travers's tank force must include its usual quota of medium tanks.

Albert was chosen first because of the detailed nature of the rail movements, and secondly because in terms of size (386 tank of all types including 285 fighting) and indeed time (late summer 1918) it corresponds almost exactly with the force available in mid-October. That is an average of 280 fighting tanks in a "fit to fight" state, plus an average of 100 support tanks.

tenders. The above calculations are based on the assumption that they would all (or nearly all with only very minimal reserves) have been committed to battle at the same time in the manner of Cambrai or Amiens. In each of these battles the lack of significant tank reserves has been cited by GHQ's critics as one of the main reasons why the battles petered out after three or four days. If the full 280 fighting tanks were not all committed in one assault but instead Fuller's suggestion (October 1918), that 100 per cent reserves of men and machines be kept back, was followed, then only 140 tanks would have been available for the initial attack. This hardly constitutes the massed attack of the Travers scenario. In order to maintain the momentum of a successful attack comprising all the available tanks (assuming that it would have been successful and the German forces would have pulled back), the tank force would have had to have been gathered once more at convenient railheads and entrained for the new front which, based on the experience of the action in late October and early November, could have been several tens of miles away. The alternative to entraining this tank force would have been to see them scattered over an increasingly stretched battlefield. The Field Workshop Battalions, ASC (MT) drivers, pack-horse teams and engineers with bridging materials would have attempted to keep them in operation while all the time they fell further behind, as the experiences of the tank battalions cited earlier showed.

What was the condition of the roads ? How much petrol, lubricant, ammunition, and how many tons of spare parts would a force of this size have required ? If this tank force could have been assembled would the MT drivers and their lorries have been able to ferry supplies from the nearest railheads to the tank supply dumps ? The state of the roads along the entire BEF front was rapidly deteriorating, particularly in the areas beyond the railheads. As the front began to outstrip the pace of rail reconstruction the road links between railhead and the front lines grew longer and the traffic denser. MT ran both day and night in order to keep supplies moving. But the constant toil told on the both the vehicles and the roads. ASC workshops could not keep up with the salvage and repair of MT and of broken down lorries. The roads crumbled into muddy tracks riddled with pot-holes. On the 4th Army front the "repair of mine-craters in the roads could not keep pace with the advance". Conditions worsened to such an extent that "shortly before the Armistice horse transport from the ammunition columns was being used to carry the loads forward". [26]

The war diaries of the 15 Battalion state that the three companies trekked to Graincourt on October 1 where they waited for nearly one month. At first it was thought that the tanks would advance with the infantry , but they received orders from the Tank Corps HQ to remain where they were. "One morning", the diary reads," we

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[26] A.M. Henniker, *Transport on the Western Front* , p 461.

The unloading of "Shell 'A' " (2 gallon) tins from a lorry at a tankodrome, France, 20 June 1917.

awoke to find the horse lines had vanished. We had been left stranded - a lone battalion of tanks on a barren and deserted land." Here was one battalion that was having to rely on pack-horse to deliver at least some of its supplies.

When the 12th Battalion was finally withdrawn from the field it left a " trail of dumps and details which every tank battalion scattered behind it". Up to this point at least, it seems that the12th had been one of the few lucky battalions to receive regular supplies of fuel, oil, spares and ammunition. Performance figures for the Mk IV tank reveal that it had a fuel capacity of 75 gallons and a range in top gear of 35 miles. That is a fuel consumption of two gallons per mile. However, as with all official figures, they need to be taken with a pinch of salt. Conditions were rarely ideal and rough ground in low gear with a high revving engine could drastically reduce those performance figures. Captain Sheryer's accounts of his days with the Mk IVs suggests that petrol consumption could be as high as 12 gallons per mile! [27] Petrol was not transported in bowsers as is the case with modern military vehicles, but instead came in in two-gallon Shell 'A' tins (see photo). A a delivery or deliveries of something in the order of a minimum of 50 to 100 tins of petrol per tank for this period must be contemplated. Also considerable quantities of grease , various grades of oil for the engine and gearbox, and a supply of ammunition must be allowed for. Moreover, the importance of a regular supply of spare parts, which were constantly in need (sprocket wheels which needed frequent replacement weighed in the region of 2 cwt - over 100 kgs - each!), should not ne overlooked. The delivery of petrol, grease, etc., for the Amiens battle in August, suggests a reasonably accurate picture of the scale of logistical support a mass tank force required to keep it in the field.

The 4th and 5th tank Brigades each received the following quantities :

Petrol 'A' -	80, 000 gallons
Price's Engine Oil -	4, 000 "
Steam Cylinder, Thick -	10, 000 "
Vacuum 'A' -	8, 000 gallons
Grease -	20, 000 lbs.

This was to be supplemented with a reserve supply of half of the above quantities which was ordered to arrive on the day of the battle. An ammunition stockpile was supplied for the use of the 4th and 5th tank Brigades which consisted of 50, 000 rounds of 6-pdr high explosive, 10, 000 rounds of case shot, and 5, 000, 000 rounds of small arms ammunition.[28] The Amiens battle involved some 530 tanks (including 120

[27] Refer to chapter 6 for the official figures for petrol consumption.

[28] Brig-General J.E. Edmonds, *Military Operations in France and Belgium*, 1918, Vol IV, p 564.

supply) so one can begin to appreciate the extent of the planning and logistical support necessary to keep a mass force of tanks in the field.

To have committed a large body of tanks to a mass tank / infantry / artillery battle in the later stages of the last one-hundred days would have been logistically very demanding. The addition of 30 plus trains, with all of the special preparation concerning loading and unloading and the necessity of specialised wagons, not to mention the supply of spares, replacement machines, fuel and lubricants on an already saturated rail system, would arguably have led to a severe dislocation of the urgent transport of supplies to the more established and vital arms of the infantry and artillery. This dislocation would have been out of all proportion to the effect gained. Further, it is entirely possible that such an operation would have had to have been conducted on more than one occasion in order to enable the tanks to keep pace (in anything approaching a mass formation) with the infantry. Such a movement would have had implications not only for the rail network but also for the already equally over stretched MT, with even more wear on vehicles and roads.

Travers suggests that the use of large numbers of tanks in the later stages of the war could have saved casualties by hastening the German surrender. But it could be argued that the dislocating effect of transporting and supplying these machines would have had a detrimental affect on the supply of vital rations and ammunition to the troops in the front line. Certainly the length of preparations necessary for subsequent mass attacks would have had a tangible effect on the supply situation with the imposition of at least several days' delay, entraining and detraining machines, at their new jumping-off points. Would not this have had some effect on their safety ? If it did not directly endanger their lives, it would have done so indirectly. The infantry and artillery might have been unable to maintain contact with the German retreat, thereby enabling the enemy forces to consolidate their defences at convenient points of their own choosing, so once more being in position to offer the British forces (once they regained contact) another set-piece battle with inevitably high casualties - casualties which would arguably have been much higher than might otherwise have been the case. Further, given that the advancing armies were rapidly losing contact with the enemy anyway, and that plans were being made for a general advance in the spring of 1919, could it not be argued that any interruption in the advance of the British armies at this time might have signalled an end to that year's campaigning - thereby delaying the end of the war until the following year rather than bringing it forward as Travers has suggested ?

Finally, in regard to the plans for a resumption of the offensive in the spring of 1919, it is interesting to note that even Fuller, the advocate of mass mechanised warfare was, on 10 October 1918 at the tenth meeting of the Tank Board, arguing that :

> "The whole of this years fighting had accentuated the necessity for keeping a strong reserve of Tanks in hand to make good loses. A reserve of machines is as essential as a reserve of men, and without it the fighting efficiency of Tank units falls to pieces within 72 hours of their going into action." [29]

At the next meeting of the Tank Board on 24 October Fuller once more intimated that he believed that the war was going to continue into 1919, and that plans for a future tank army had to be made with this in mind. He drew attention to the necessity of maintaining production of tanks for the "Training Centre" at Woolwich.[30] Clearly he was thinking of building up a tank force for 1919, by ensuring both that there would be sufficient trained crews, including the essential reserve crews, and a sufficient number of tanks to enable an adequate reserve of machines to be maintained so that a future tank engagement could be sustained for longer than " 72 hours". When the patron of mechanised warfare was not advocating the employment of all available tanks in a mass infantry / artillery / tank battle at the end of 1918, why was Haig irresponsible for not doing so ?

The employment of tanks was about more than just number crunching. GHQ had faith in the long-term potential of the new arm in relation to mass attacks and mechanised warfare in general, but pragmatism dictated that the tank's role in 1918 was as an infantry support weapon. The fact that the tank also offered the potential for a massed shock effect in major set-piece battles was not ignored. But it was the tank's inherent mechanical unreliability and general poor performance rather than its "durability" which proved to be the crucial factors in determining its employment in late 1918.

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[29] MUN 4 / 6400.

[30] Ibid. Fuller was stating his opinion in the light of Colonel Searle's suggestion that production of tanks in Britain should be turned over to the manufacture of spares for France. The output of Central Workshops in terms of repaired machines and the production of new machines in Britain was very nearly the same at this time but that Central Workshops's output was only limited by a lack of spare parts.

Conclusion : Was the Tank a "Peripheral Weapon" ? [1]

Civil / Army support

Did the tank programme receive the support from both the civil and Army bodies necessary for it to develop and successfully enter mass production ? It is true to say that initially the tank did not gain the "full support" of the Army. The fact that the Army did not follow up the Swinton / Tulloch initiative is proof enough of initial Army indifference. Throughout the war the tank was to have its detractors, the cavalry die-hards who regarded the appearance of the internal combustion engine on the battlefield, in whatever guise, as a retrogressive step. Fortunately, however, despite the best efforts of those who would portray the whole of GHQ in this light, they were few and far between. For the most part new technology, particularly tanks was accepted and even eagerly embraced as a potential war-winner, or at very least as an answer to the problem of restoring mobility to the battlefield in order that more traditional arms might finish the job of winning the war. Initial Army indifference, one suspects, was not so much rooted in some technophobe response to mechanised warfare, but rather in the conviction that the tank would take several years to produce, all the while consuming scarce resources of materials and men. Therefore, the war was likely to be won before it could see action.

Civilian support for the tank was not wholly uncritical either. The Metropolitan Works asked to be released from their contract to produce the first tanks because they had been offered a more lucrative order. This is particularly ironic given that Metros were later to become the largest producer of tanks. During the two years of mass production the MWD was to experience difficulty in placing orders with contractors many of whom preferred the more reliable and profitable contracts from the Admiralty, Air Board and the Railways Materials Board (RMB). This was caused by the often erratic stop-and-go nature of early tank production owing to the frequent changes in models and design. However, by late 1917 the shift toward mechanical warfare had begun and the tank, which was in mass production terms still only a year old, had gained a prominent place. Had the war continued into 1919 it looked set to improve upon even this.

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[1] Robin Higham, *The Peripheral Weapon in Wartime : A Case Study* .

Even within the Ministry inter-departmental rivalry was apparent. On 12 February 1918 Churchill instructed that a memo be sent to " some 160" firms involved in the production of tanks :

> "All work in connection with Tanks is to be accorded P1.certificates. In any case where in the same shop other work is proceeding on a P1. certificate the Tank work is to have the preference. Telegrams are to be dispatched today to all shops making Tanks, or any part of Tanks, giving them this super-priority. These directions are imperative and are immediately to be acted upon by all Departments affected." [2]

This telegram and the "P1." status led to some concern among interested departments at the Ministry. On 27 February L.T.S. Stallybrass, Deputy Controller of the Priority Department of the Ministry, wrote to Dr Hazel, DMRS, expressing his concern that the tank's new-found status would affect the production materials for the R FC and for both the Railways and Mechanical Transport. The letter, innocuous enough in itself, obviously passed back and forth between the two offices several times during the following weeks, since the original letter also contains two hand written notes regarding tank production. The first, dated 2 March, from Dr Hazel to Edgar Jones, Controller of the Priority Department, stated that he felt that " of my own knowledge ...orders for Railway Material placed by the RMB are being interfered with by the Priority 1 given to Tanks."

Jones replied on 4 March stating in no uncertain terms his opposition to the new priority status :

> " Such Carte Blanche Priority as has been given for heavy Tank production had disastrous effects 18 months ago. I got it withdrawn, and it took several months to straighten out the effect of it. Though as yet there is no direct evidence of its effect on guns: it is bound to have an impeding effect." [3]

What the two gentlemen thought when the War Office sanctioned an increase in the MWD's steel quota for the new programme on 8 March is not known. But, by the second meeting of the Tank Board on 31 August 1918 Jones seems to have undergone something of a conversion. He is on record as saying :

> " Tanks are not only so important in themselves, but are so much more behind in production as compared with anticipation than any other engine of war, that the best priority must be given to them." [4]

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[2] MUN 4 / 2801.

[3] Ibid.

[4] WO 158 / 867.

However, he had not entirely abandoned his earlier opposition to the tank. He continued with the qualifying remark that " It may be the case that certain components are not in need of P1 Priority, and in such cases the priority need not be given... ."

We have seen that resistance and apathy toward mechanical warfare existed in every branch, whether in the Army, the Ministry or the civilian contractors. Yet this was to prove to be relatively insignificant. The MWD succeeded in engaging enough manufacturers. Resistance to mechanical warfare from within the Ministry was gradually overcome. This is demonstrated by Edgar Jones' s "conversion" and can also be seen in the rapid assimilation of the MWD within the Ministry, from a semi-independent committee (Tank Supply Committee) in early 1916 to fully integrated member of Churchill's Munitions Council in late 1917.

As we have discussed, a major part of the period 1916-18 was characterised by a struggle for control of the tank programme, and in particular the elements of design, transport and testing, and experimentation. The Army / Tank Corps wanted a greater say in these matters whilst the MWD, and particularly Albert Stern , was adamant that control must lay in the hands of the supplier. This is perhaps best illustrated in the "battle of the spares". The continual stream of letters in 1917 between General H. Elles and General J. Capper, concerning the conduct of both Stern and the department as a whole, clearly demonstrated the deeply felt antagonism between not only the personalities involved but also their departments. However, this struggle for the control of the tank programme, was just that, a competition for control, and not a fight for its survival. Stern and the eclectic mix of civilians and military personnel that made up the Landship Committee were, as we have said, absolutely vital to the early progress of the tank. But once the tank had entered mass production, and certainly by mid-1917, the time had come for a more professional organisation to assume control of the tank's development, and for this to include an input from the users as well as the suppliers. One of the main elements of this competition for control was, of course, Stern's unwillingness to accept a diminution of the MWSD's influence on the tank programme. Dr C. Addison continued the inevitable movement of increasing the department's administrative ties to the Ministry. The duplication of resources in such areas as contract, finance and inspection, particularly given the poor performance of the department's own sections in these affairs, especially inspection, could not be continued for reasons of both efficiency and limited personnel. This movement (which Churchill was to continue with his Munitions Council), together with the handing over of testing and inspection and the"sharing", however unofficially, of experimentation with the Tank Corps, was a considerable blow to Stern's "empire building".

Even during such a period of turmoil, it was recognised by the two sides, civil and Army, that they had to work together for the future of the tank programme. The

Landship Committee itself contained both civilians and Army / Navy personnel. In June 1915 the Joint Naval and Military Committee had been established under the presidency of General Scott-Moncrieff. Late 1916 witnessed early negotiations concerning the creation of a committee to bring together both sides for discussions on tank matters. This was finally to get under way in May 1917 as the War Office Tank Committee. Admittedly plagued by ill-feeling between Stern and the War Office representatives, it did little to ease relations, and failed in July, but it did at least pave the way for its successors. In August the War Office created its Tank Directorate to liaise between the MWD and France. The "New" or "Advisory" Tank Committee first met in November, significantly the same month that saw the departure of Stern from the MWD. For the first time the Tank Corps representatives had seats on the committee. This growing co-operation was finally to manifest itself in the creation of the Tank Board in August 1918.

Support for mass production

The telescoping of the development of a new and relatively complex weapon (relatively speaking tanks were very complex) into little more than two years was not without its problems. Most critically it led to a multiplicity of designs and modifications . It is for this reason that development of the tank was handicapped by an almost total absence of fixed drawings, and a seemingly persistent state of crisis over the supply of spare parts. This state of affairs was further exacerbated by fluctuating orders from the War Office and the continual structural reorganisation of the MWD. All of this was to have a negative effect on continuity of orders and production. But it was as a result of the co-operation between the Ministry and the War Office, the civilians and the soldiers, that a succession of models Mk I - V*, each the evolutionary successor to the other, happened at all, reflecting the extent to which the aims of both continuity and technical development were able to be met. One has only to look at the meteoric rise in orders for tanks which increased from 100 to 6, 940 in a little over two years (February 1916 to May 1918), to see the advance made by mechanical warfare.

The supply of steel, and steel components, was crucial to the production of tanks. Yet, as we have suggested above tanks were never deprived of steel, but instead always enjoyed an operating surplus. For the first six months of 1917 the MWD had been allocated 25, 000 tons of steel, but this doubled within the space of several months. In December it was decided that the department's steel allocation should be further increased to 96, 000 tons for 1918, which was increased again in January to 180, 000 tons, and still further in March to 193, 000 tons.

Also, to meet the demands of tank production measures were found to lessen shortages, whether by returning men from the colours, by dilution or by recruiting Chinese labour in France. Further evidence suggests that the beginning of the shift in emphasis toward mechanical warfare in late 1917 and early 1918 indicated that the future manpower needs of mechnical warfare would receive high priority. In August 1918 the most crucial concern in tank production was not for men or materials but for machine tools. As Maclean reported he had 5, 000 tons of armour plate waiting to be machined but no machines to do it.

Priority

A measure of the growing importance and acceptance of the tank can be gauged by the priority status accorded to it. In November 1916, tanks were accorded first class status for labour and steel by the then Minister of Munitions, Edwin Montagu. This was amended on 11 February 1917 by the War Office in favour of aero-engine production. Haig believed that the production of the Mk IV tank would have been under way by this date, and that all necessary men and steel would have been allocated and recruited for tank production, leaving the field clear for aero-engine production.

Mechanical warfare continued to languish in third or fourth place to the Air Force, Mechanical Transport, Artillery and shells and the Railways for the remainder of the year, only regaining first class priority in February 1918. This status was renewed throughout the spring of 1918, much to the irritation of its rivals.

Lieut-Colonel Burgoyne, Controller of the Priority Department, wrote to Maclean on 7 October 1918 regarding tank priority. Burgoyne was relatively new to his post and it seems that the meeting that he had had with Maclean that afternoon was the first time that the two men had met. There had, it appears, been some misunderstanding between Maclean and Burgoyne's predecessor over the Priority Department's refusal to issue first class priority certificates to MWD contractors for steel and manpower. Burgoyne was able to clarify the situation. He wrote that "at no time when a request has been put forward for increased priority (outside an uncontrollable "blanket", i.e. absolute priority for tanks even when tank requirements were in surplus, thereby impinging on other areas of production . Maclean was the first to admit that such a priorty would have been "disastrous to the whole war output") has our Department refused or questioned it". Burgoyne went on to say that three days earlier he had received from Maj-General Seely, Deputy-Minister, a minute stating that :

> "The production of Tanks is of the highest importance and urgency, and I am prepared to face considerable dislocation of other production

if a real increase of output can be obtained."

Burgoyne and Maclean were to continue to meet on a weekly basis to discuss the priority arrangement necessary for tank production.[5]

On 17 October the Admiralty and the Ministry of Munitions were asked to submit separate lists detailing their own priorities to the Priorities Committee.[6] The Committee in turn, under the guidance of the regional committee chairman, compiled from these two lists one list of priorities. On the Ministry's list poison gas and tanks occupied joint first place - reflecting the on-going debate at the time of the relative merits of the two weapons,[7] both in the field and in terms of economy of production.

The General Staff, in a letter read to the Tank Board [8] on 31 October 1918, stated their priority requirements as 4, 000 tanks by 1 January 1919, and second, 25 locomotives per month during 1919. This letter stated that the Army Council was anxious that as far as was possible both the above programmes should be carried out, but in the event of this not being practicable they wished for the following priorities to be observed : a) spare parts for mechanical transport, b) locomotives c) tanks.

Over the whole two years of its mass production life (before the Armistice) the tank was able to hold its own in competition with its rivals. It achieved first class status on three different occasions : November 1916 to February 1917 ; February 1918 to April 1918 ; and August 1918 to the Armistice. The loss of first class priority between April and August was due to the manpower demands of the Army in response to the German spring offensive. It is not entirely inconceivable that had the spring offensive not happened then mechanical warfare would have retained its first class status for the whole of this period. At other times it secured third or fourth place behind its chief rivals, rail, airforce, mechanical transport . If the tank was not able to command first class priority on a permanent basis, one should not forget that at this stage of its

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[5] MUN 4 / 5210

[6] MUN 5 /115 / 620 / 35.

[7] MUN 4 / 6400. The report was commissioned (16 September 1918) by Sir Graham Greene, Secretary of the Ministry of Munitions, it found in favour of tanks, although it is perhaps worth pointing out that J.F.C. Fuller provided the tank statistics :

Weapon including ammunition.	**Steel in tons**	**Man hours**	**Cost**
6" Howitzer	21	15	11
60-pdr	8	6	5
6" Gun	6	5	4
18-pdr	6	4	5
1 weapon on a tank	1	1	1

[8] WO 158 / 867.

development it was by no means wholly reliable, while the Army (including the Tank Corps) could not operate without the logistical support of rail and mechanical transport.

Finally, it must be said that much of the detailed information relating to tank manufacture in this period is hazy and at times contradictory . This is particularly the case with the most numerous tank, the Mk IV. So many orders seem to have been placed and then cancelled or left open ended. We know how many were built , but it has so far eluded the most persistent historians of the subject as to exactly where they were built. Albert Stern, who did so much to champion the tank's cause, seems at one point to have placed open-ended contracts with any firm which would accept them, so keen was he to see the tank succeed. Many of these contracts were never started, or if started never completed. Wm. Beardmore's order for complete machines is a good example of this. There is no record of the original order for Mk IV tanks ever having specified numbers or of it being officially cancelled. It was simply put on one side while the Admiralty's destroyer contract took precedence.

A tactical doctrine of employment

GHQ provided a source of tactical direction for the employment of tanks. From "Preliminary Notes" to SS. 214, (issued in August 1916 and 1918 respectively) the tank was, it seems, consistently assigned to the position of infantry support weapon. Its role was to help the infantry get forward, to tackle machine gun posts and barbed wire wherever they impeded the progress of the infantry. The tanks were, therefore, a peripheral weapon. However, the question that should be asked is, was this supportive role one which was forced upon the tank, denying its true potential, or was it an accurate reflection of the tank's capability at the time ? Clearly, this thesis supports the latter view.

The tank was never a war-winning weapon. The limitations on the employment of the tanks were far more mechanical than mental. The mental paradigms of the Haig and the General Staff were never stretched to the point where they encountered Travers's - Khun's "problem." The SS documents show sufficient tactical insight, on the part of GHQ, as to how tanks of greater reliability and performance would have been employed, to suggest that there really was not a "paradigm" problem at all. This is further reinforced by the "Plans" for the 1919 campaign.

To the casual reader of First World War history there was only one "Plan" and that this was drawn up by Fuller and the other "pioneers" of tank tactics at the Tank Corps HQ. It would appear that they clearly saw the way forward, and that they were the only ones to appreciate the potential of the new arm which was wasted on the hide-

bound upper echelons of the General Staff. Yet Elles (who was not regarded as being one of the inner circle at the Tank Corps HQ), Capper and Wilson all produced "Plans" of some detail and vision. One therefore begins to question the"unique" insight of the so-called "pioneers." And when others on the General Staff, such as Hetherington, Butler and Buzzard, were also suggesting mass employment and a more prominent role for the tanks in 1919, it still further calls into question the status of those "pioneers". What it does is to place Fuller et al's "Plan" in the wider context of 1918 when, to use Dawnay's phrase once more, opinions on the matter of tank tactical doctrine were "not solidified". There was a great deal of attention being paid to the future role of the tank by all concerned, not just by a few individuals battling against entrenched "traditionalists". It was pragmatism that dictated the tank's role.

The tank was "durable" but it was not reliable. There were 630 " on charge" at the beginning of the August campaign and 641 at the Armistice. In need of constant mechanical maintenance the tank fell victim time after time to simple technical failure in fuel, cooling or transmission systems. The number of machines in a "fit to fight" state varied between a low of 177 on 7 September and 357 on 15 October - these figures represent only a snap-shot which changed day by day. The salvage and workshop units performed a vital role reflected in their expansion in returning tanks to the battlefield. The emphasis is on returning because often the same tank would be abandoned in action, salvaged, repaired by the workshops and returned to action in the following days, only to repeat the same process again and again. But these growing levels of expertise could not counteract the basic mechanical frailty which dogged the early machines. The job of maintenance was made even more difficult by the constant shortage of spare parts - a situation which gave grave cause for concern to the very last days of the war.

Tanks could be returned time and again to action and the same could be said for the crews themselves. Reserve crews were never less then 60 per cent of front-line strength which, as the major set-piece battles demonstrated, enabled the tanks to continue in action for several days on end. But the telling conditions in which they operated were responsible for a large "temporary" component to the casualty figures - in the order of 40 per cent. Neither the tanks nor their crews could operate over a sustained period, certainly not more then two or three days.

The constant state of flux in all matters relating to tank design, production and organisation was reflected in the degree of support from civilian and military bodies for continued research and development, even into things as diverse as tanks for wireless operation, gun carriers, mobile armoured cranes, bridge layers, armoured personnel carriers, supply vehicles, and even mechanised "Boudiccan" chariots. This spirit of technical exploration was not confined to the tanks themselves. As we saw the problems surrounding their transport posed considerable difficulties in getting the

machines close to the front. This resulted in the design and construction of many hundreds of specialised " Rectank" wagons. But again the tank's mechanical vulnerability , or its poor performance, especially over soft and difficult terrain, often let it down on the final approach to the front conducted under its own power. Moreover, this was not helped by the necessity, for secrecy's sake, of having to entrain, detrain and move to its jumping-of points in darkness. This state of constant change saw the structure of the fighting arm itself expanded to fill the greater role GHQ expected of it, but the fact that the structure was never settled for more than a few months at any time must have had a negative affect on its organisational efficiency.

Reserve crews and tank numbers remained remarkably constant throughout the final months of the war , but the tank could not operate alone. Either working in small numbers or in massed formation it was an infantry-support weapon. But without close co-operation between the infantry and the tanks they could achieve little. Time and opportunity, however, were not to permit widespread and intensive co-operation between the three arms (artillery too had to take account of the tank's performance), but there is enough evidence to suggest that where it was possible it was conducted. Also, the fact that the tanks were allocated to those groups who had most experience of their use reflects the extent to which GHQ understood the need for this inter-arm familiarity. Nevertheless, the fact remains that despite the best efforts of those involved to enhance this combined arms understanding, time and conditions were obstacles to efficient co-operation.

After the Hindenburg Line had been broken in October and mobility was restored, it was the enormous logistical difficulties (together with the fact that there were only about 280 fighting tanks "fit to fight" on or about 17 October, the first convenient day for a mass tank-artillery-infantry attack) which militated against their employment in mass formation in the manner of August 1918 - unless, that is, one wants to consider the re-thinking of the statistical data offered for the St.Quentin battle and accept this as a "massed" attack.

Was the tank a peripheral weapon ? The considerable support from both civil and Army bodies strongly suggests that in terms of manufacture, research and development the answer must be no. Yet, in terms of tactical employment, the answer must be yes. Limited by its all too apparent mechanical deficiencies, it could, however aspire to no greater role than that of support weapon - but a valuable one at that. If one takes into account the appreciation of its potential, as demonstrated in the General Staff's instructional manuals and the free thinking apparent from many who were both closely and loosely connected with the tank in 1918, then this peripheral status was destined to be short-lived.

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