THE RELATIONSHIP BETWEEN OCCUPATION AND HEALTH AS SHOWN BY AN INVESTIGATION INTO THE HEALTH OF SEWERMEN IN GLASGOW

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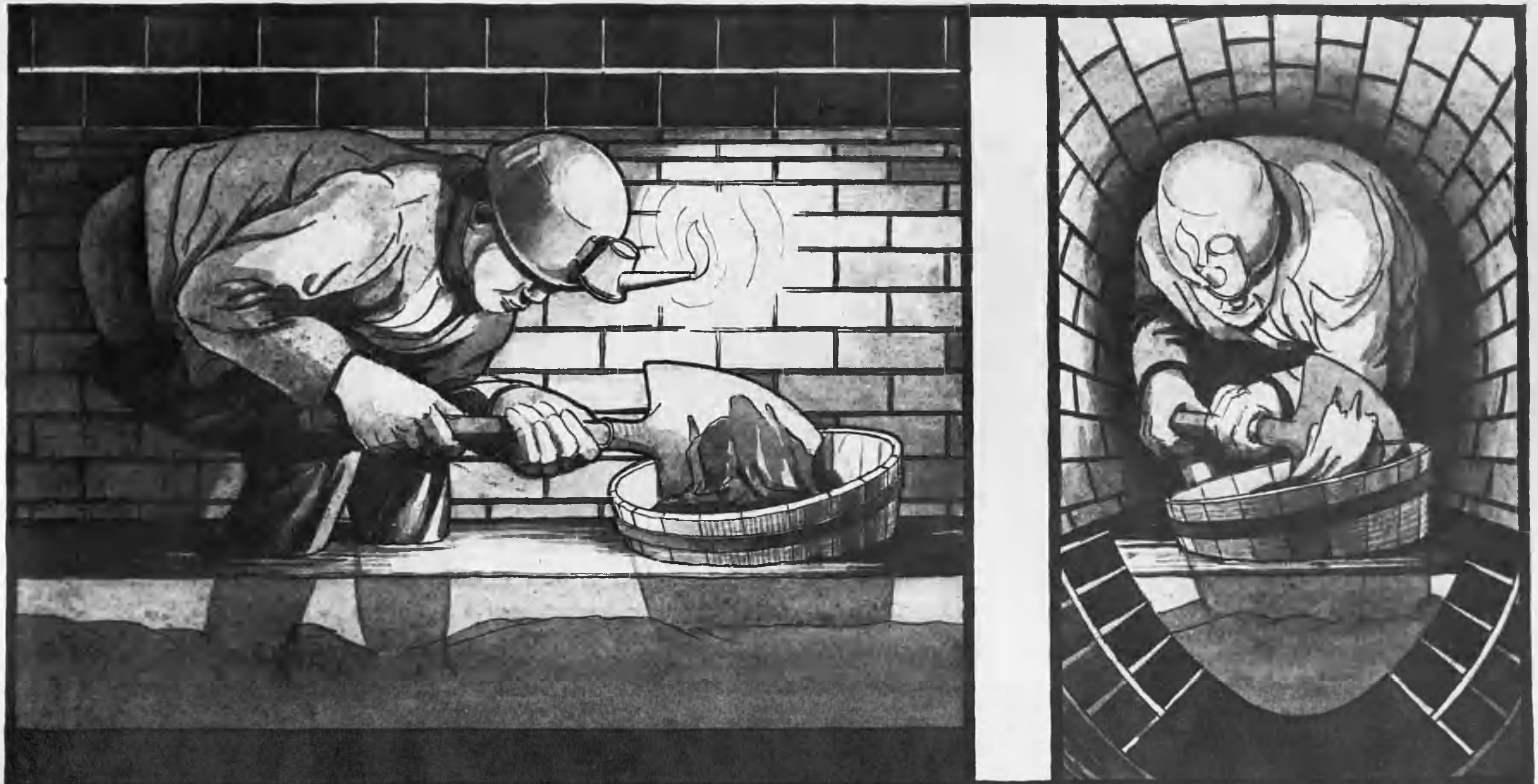
THE SEWERMAN AT WORK

PART I.

THE RELATIONSHIP BETWEEN OCCUPATION AND HEALTH AS SHOWN BY AN INVESTIGATION INTO THE HEALTH OF SEWERMEN IN GLASGOW.

PART I.

Introduction.

"FOCUS ON SEWERMAN"

"SWEPT THROUGH SEWER - Glasgow Man's Ordeal"

"A Glasgow sewerman had the terrifying experience yesterday afternoon of being swept off his feet by a rush of flood water while he was examining a sewer, and washed for 250 yards through the pitch dark tunnel.

"He was Daniel McAllister (48), 165 Gallowgate, an employee of Glasgow Corporation Master of Works Department.

"At 1 p.m. yesterday he was in a manhole inspecting a sewer in Claremont Street at Berkeley Street, when a sudden spate due to heavy rainfall a few minutes previously caused him to lose his footing.

"The torrent of water swept him through a sewage pipe for a distance of about 250 yards until he came within reach of the framework of another manhole, which he managed to grasp and hang on to until help arrived and he was assisted into the street.

"McAllister was much shaken by his experience, and received abrasions to his arms, but refused medical attention."

The Glasgow Daily Record — Wednesday, July 15th, 1931.

The attraction of public interest by reports of unusual occurrences has, in recent years, become highly commercialised in the three main channels of news distribution. Journalists, especially in the weekly press, and their counterparts in cinema and radio organisations, have focussed attention on unusual forms of employment, some of which have been associated with the maintenance of the nation's health. The educational value of the latter is undisputed when truthfully recorded facts form the basis of the title subject. Sales value, however, has become an important factor in publicity, and has created something greater even than poetic licence in the building up of scripts, articles and film shots. Nevertheless, glamorisation of a particular type of work by these means has been invaluable in improving recruitment to the Services during the War, and to the mines in more recent years.

In the past, only fleeting reference has been made to workers in our cities' sewers, reporting merely an incident such as that quoted on the previous page. Some two years ago, however, attention was focussed on the sewers of Vienna by the film, "The Third Man", and it was recorded in the press that an international soccer team had been taken below that city to view the location of "shots" for the film. It would seem that the sewers of Vienna had attained, almost overnight, the fame which has been historically accorded to the catacombs below Paris, so lucidly described in Victor Hugo's "Les Miserables". Even more recently, an illustrated weekly published an article describing the work involved in the maintenance of London's sewers.

During the latter part of 1949, there arose the problem of assessing whether illnesses among sewermen were to be considered as attributable or non-attributable to their conditions of work. A search through the medical literature offered insufficient material on which to base an opinion, and hence it was deemed necessary to investigate the relationship between health and occupation in the sewermen of Glasgow. In order to do this, arrangements were made for me to visit the several types of sewers and view the various operations performed by sewermen. I also had the opportunity to manipulate the tools in each type of work. As well as aiding in the more accurate assessment of the physical energy required for the job, this procedure proved to be of the utmost value in winning the confidence of the sewermen and did much to gain their complete co-operation when the medical examinations were undertaken.

In the course of this special inquiry, it soon became evident that such records of sickness, accidents and deaths among sewermen, as existed in Glasgow, could only be of limited value in the assessment of the health hazards in that occupation. A full clinical examination was thus made on each sewerman, the examinations being carried out on an entirely voluntary basis. The medical interview included the following:-

(1) Medical history.
(2) Social history.
(3) Occupational history.
(4) Full clinical examination.
(5) X-ray examination of chest and lumbar spine.
(6) Blood examination.

Records were kept on case-sheets, a sample of which is shown in the Appendix. In a number of instances, men with defects were referred to hospital out-patient departments for further investigation and treatment. During the period of this inquiry all entrants to the job of sewerman were carefully medically examined before selection for the work, and serial re-examinations were made after entry to this employment.

A control population, for the purposes of comparison, was built up out of men (approximately from the same age and social classes as the sewermen), who attended for medical examination for admission to the Corporation's Sick Pay and Superannuation Schemes. The medical interviews in this group were conducted on exactly the same lines as those performed on the sewermen. Again, consecutive candidates for the Corporation's examination were selected as far as possible, provided that they qualified for inclusion by reason of age and social class. Only candidates examined by me were included in this control group. In a few instances, blood examination was not carried out, due solely to the fact that permission for withdrawal of blood was refused. In all, 92 males are included in the control group (Table No. 23).

Investigations made into the various factors influencing the working environment included examination of temperature, humidity, air movement and lighting in the sewers, and chemical analyses of sewage and sewer gases.

The results of these investigations, recorded in the pages which follow, suggest that working conditions have an adverse effect on the health of sewermen. Recommendations are made, which, if adopted, would tend to reduce that incapacity among Glasgow sewermen which can be attributed to their occupation.

It is a pleasure to place on record my thanks to -

Dr. Stuart Laidlaw, Medical Officer of Health, City of Glasgow, for permission to conduct this investigation from the Health and Welfare Department, Glasgow;

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Chapter I.

THE DEVELOPMENT OF WASTE DISPOSAL METHODS.

A. Historical Review of Early Methods.

There can be little doubt as to the original household methods of disposing of animal waste products in what may be called the normal state of existence, when every family lived apart, surrounded by plenty of ground. Nature provided chemical, bacterial and insect scavengers to dispose of excreta and household refuse. The problem of organised waste disposal, however, appears to have arisen early in the world's history, for the Mosaic record includes sanitary regulations for the proper disposal of the excreta of the camp or household and especially designed to secure the well-being of the community. The ancient Romans had their famous Cloaca Maxima, extensive parts of which have been preserved and still serve their original purpose.

In the Middle Ages, however, when the ruling passions were religion and warfare, every institution concerned with domestic comfort and happiness deteriorated; sanitary regulations, for example, were totally impeded - a folly which was dearly paid for in the frequent and terrible visitations of the Black Death and other fearful diseases. Refuse from the small townships in Britain at that time was dumped in the streets and streams pending removal by farmers for use as fertilisers.

In 1388 the first Act of Parliament dealing with sewage was passed but it applied only to London, even then quite a sizable town. This was the forerunner of a long series of laws which prohibited the indiscriminate dumping of refuse, while failing to offer any satisfactory alternative. During the rebuilding of London after the Great Fire in 1666, a number of covered-in drains were constructed, but permanent underground sewers were not built until the middle of the 19th Century.

B. Conditions in the 16th and 17th Centuries.

That sanitation was bad in Scotland in the 16th Century is revealed in the writings of Dunbar, Weldon and many others. The municipal records of Glasgow and Edinburgh refer to the concern of the authorities over the indiscriminate disposal of refuse in the streets. Nevertheless, attempts to improve the state of cleanliness in these cities appear to have been very intermittent, the greatest efforts being made during epidemics of plague.

C. Separation of Waste into Dry and Wet Refuse.

As early as 1619 there appears to have been a differentiation between dry and liquid waste, for in that year the Town Council of Edinburgh hired a horse and cart at six shillings weekly to remove refuse from the closes. Street cleaning in Glasgow was made the responsibility of the Chief Constable in 1800, the work being carried out by policemen on a part-time basis, until 1815 when a separate cleansing staff was appointed. The City Cleansing Department was not established in its present form until 1868.

D. The Industrial Revolution.

With the development and extension of the factory system towards the end of the 18th and the beginning of the 19th Centuries, townships sprang up rapidly in the new industrial areas, while ports expanded to form trading outlets for Britain's manufactures. Sanitation problems of minor importance in other parts of the country became major items in the densely populated centres.

Gutters in streets and streams quickly became open sewers, and dunghills were often to be found in the centre of towns. Farmers utilised the sewage in streams for enrichment of the soil, either by collection of sludge in pits dug in the water courses or by the damming of the streams so that the sewage overflowed on to the land to form irrigated meadows. This broad irrigation of land was at its worst in the outskirts of Edinburgh.

Glasgow's growth in population (Chart No. 1) was responsible in no small measure for the appallingly insanitary condition of the city recorded by writers in the 19th Century. In 1818, Dr. Robert Graham, Regius Professor of Botany in the University of Glasgow, made the following comments in his "Practical Observations on Continued Fever in Glasgow":-

"Let him (any man) pick his steps among every species of disgusting filth, through a long alley, from four to five feet wide flanked by houses five floors high, with here and there an opening for a pool of water from which there is no drain, and in which all the nuisances of the neighbourhood are deposited in endless succession, to float and putrefy and waste away in noxious gases."

E. The Development of Sewers and Drainage in Glasgow.

The advent of piped water supplies and the perfection of the water closet have promoted the development of water-borne conservancy in cities throughout the world. In Glasgow, sewers were first constructed in 1790 in three, then prominent, streets, and by 1816 common sewers "large enough to admit persons to clean them, extending 4 miles 7 furlongs and 10 poles were formed in the streets"; the recorded size of these sewers being "4 feet 6 inches by 3 feet 6 inches of one brick length" (Map No.1).

Prior to 1804 Glasgow's water supply was scanty, the sources being from 29 public and private wells. Success in achieving satisfactory gravitation supplies was not reached until the opening of firstly the Gorbals Water Works in 1846 and secondly the Loch Katrine Scheme in 1859.

That the installation of sewers and water supplies was slow to spread throughout the city is shown in the following extract from the "Report on the Measures adopted for the Relief of Cholera in Glasgow during the Epidemic of 1848-49" by Dr. Sutherland of the General Board of Health:-

"The cleansing until lately was most inefficient and from structural causes will always, under existing arrangements, be difficult and expensive. There are large square middensteads, some of them actually under the houses and all of them in the immediate vicinity of the windows and doors of human dwellings. These receptacles hold the entire filth and offal of large masses of people and households until the country farmers can be bargained for their removal. There is no drainage in these neighbourhoods, except in a few cases, and from the want of any means of flushing the sewers where they do exist are extended cesspools polluting the air. So little is house drainage used that on one occasion I saw the entire surface of a back yard covered for several inches with green putrid water, although there was a sewer in the close within a few feet. . . . There are no domestic conveniences even in the loftiest tenements where they are most needed, except a kind of wooden sink placed outside some stair window and communicating by a square wooden pipe with the surface of the close or court beneath. Down this contrivance, where it does exist, is poured the entire filth of the household or flat to which it belongs, and the refuse not infrequently takes the same direction till the tube becomes obstructed."

Conditions in the city continued to be bad for a number of years, but, eventually, as the City Improvements Trust cleared away some of the worst insanitary areas and water and sewer services improved, a healthier environment became apparent.

The costs of building the earliest sewers in Glasgow were borne by the Common Good Fund. The Statute Labour Act of 1807, however, authorised the building of streets, sewers and roads and provided for their maintenance by the Town Council. By the Police Act of 1843, proprietors could be compelled to construct private drains snd sewers from their properties to join the common sewer, all connections to the latter being made only with the approval of the City Engineer.

By police legislation, the sewers in the city are classified thus:-

(a) Public Sewers - These serve for the drainage of a public street or road, and are maintained by the Town Council.

(b) Common Sewers - These conduct the drainage of a private street or court into a public sewer. Certain common sewers are maintained by the Town Council.

(c) Private Sewers - These include house drains and sewers for the drainage of lands and heritages into a common or public sewer. The City Engineer can order the cleansing, maintenance or construction of private sewers by the proprietors.

While the growth of sewers was due mainly to the increase in the population of the city, it is noted that the two series of figures (Chart No. 1 and Table No. 1) are not related. The vast increase in the length of sewers in Glasgow since 1900 has resulted from the rehousing programme of the inter-war and post-war years. Whereas, hitherto, one roof and one water closet were shared by several families, rehousing has now reduced the number of families per roof and provided bathrooms for each household in the new housing schemes. In addition, these schemes have been built on spacious lines, necessitating drainage of large areas of streets, roadways and open spaces.

The state of the River Clyde caused grave concern to the citizens of Glasgow for many years, indeed, for many decades. Pollution arose mainly from the sewers which flowed directly into the river. Between 1860 and 1880, many schemes for the cleansing of the Clyde were formulated, but it was not until 1888, when a Bill for the construction of an underground railway through the city was presented in Parliament, that a satisfactory solution was found. The proposed railway, it was argued, would dislocate the entire drainage of a large part of the city, but the Corporation, in their wisdom, saw fit to withdraw their opposition to the Bill on condition that the railway company undertook to meet the whole of the expense of re-arranging the interrupted drainage in such manner as the Corporation deemed fitting.

Thus, a project for the bringing to one point and there purifying the sewage of a large area of the city was made possible, and, in conference with the late Sir Joseph Bazalgette, a new system of sewers was devised whereby the sewage of the central, north-eastern and eastern districts was conveyed to Dalmarnock, at a cost to the promoters of the Bill of £198,947, in addition to a separate charge of £18,319 incurred by them for the construction of sewers in other parts of the city.

This was the first step towards the construction of the present main-drainage system.

F. Glasgow's Main-Drainage and Sewerage System (Map No. 2).

Between 1895 and 1910 three sewage disposal works and a considerable mileage of large intercepting sewers were constructed to serve the 40 square miles of Glasgow and its immediate vicinity. There are three distinct drainage areas:-

(1) Eastern Drainage Area: This comprises the north-eastern portion of the city and part of Lanarkshire. Sewage from these parts is conveyed by main intercepting sewers to the Dalmarnock Works located on the north bank of the Clyde. At the works there is a pumping station to raise

the sewage to the level of the precipitating tanks. In the past few years an additional intercepting sewer has been built to augment that constructed at the end of the last century.

(2) Northern Drainage Area: The works at Dalmuir treat sewage from the north-western area of the city, Partick, Clydebank and part of Dunbartonshire. A pumping station at Partick transfers sewage from the low-level intercepting sewers draining Anderston and Partick areas into a high-level intercepting sewer which gravitates to Dalmuir. Another low-level sewer from Whiteinch and Yoker has its sewage raised by a pumping station at the Dalmuir Works.

(3) Southern Drainage Area: Low-level intercepting sewers from Rutherglen and Cambuslang run through Gorbals to Kinning Park where the pumping station transfers the sewage into a high-level sewer in Pollokshields. Thence the sewage from this area and Cathcart, Pollokshaws and Cardonald gravitates to the disposal works at Shieldhall. The contents of the low-level sewers from Govan and Hillington areas are raised by pumps at the disposal works.

When built, the system was estimated to be capable of disposing of 250 million gallons of sewage per day, allowances having been made for average rainfall and future land development. Special storm overflow sewers running directly to the river were incorporated into the system to prevent flooding during storm.

The intercepting sewers were built as tunnels and vary in construction according to engineering requirements, namely, reinforced concrete, metal and brick. Table No. 2 shows the sizes, gradients and capacity of the main sewers.

Chapter II.

SEWERS AND SEWAGE IN GLASGOW.

A. SEWERS.

(1) Definition.

A sewer may be defined as an underground structure for the removal of liquid waste of domestic and industrial origin. The ideal sewer is self-cleansing and the flow is by gravitation. Despite engineering achievements in the design of sewers, most townships make use of mechanical aids, such as pumping stations, to assist the flow of sewage.

(2) Structural Requirements.

The following recommendations with regard to the construction of sewers have been evolved in the light of engineering experience:-

(a) Material of Construction. Sewers may be made of glazed stoneware, or reinforced concrete, or iron or steel piping treated with Angus Smith solution to prevent corrosion, where the diameter is less than eighteen inches. For sewers of over eighteen inches in diameter, the most suitable materials are reinforced concrete or brick and cement.

(b) Size. No public sewer should be less than nine inches in diameter. This size is sufficiently large to permit of free passage of any solid material which has managed to slip through the S- or P- trap in the four-inch house drain.

(c) Shape. Sewers of less than eighteen inches in diameter should be circular. Where the flow in a sewer tends to be intermittent, the shape should be similar to that of an egg. This tends to prevent the deposition of solids suspended in the sewage.

(d) Gradient or Fall. In sewers of 12 to 25 inches diameter the gradient should be such as to produce a velocity of flow of $2\frac{1}{2}$ feet per second. Where the diameter is over 25 inches, the fall should produce a rate of flow of 2 feet per second. The fall should be equable and all sudden changes in level should be avoided.

(e) Curves. Sewers should run as straight as possible, there being few bends. Where curves have to be made they should have a radius of not less than ten times the cross-sectional diameter of the sewer.

(f) Junctions. House drains entering the sewer should be made to do so at an acute angle so that the contents of the drain are shot into the line of flow of the sewer.

(g) Laying of Sewers. Where the subsoil is such as to render foundations unstable, the sewers should be suitably supported on concrete or other structure.

(h) Access Manholes. These should be constructed at intervals of 80 yards in straight sewers, and at points where there is a change of direction in the sewer.

(3) Domestic and Industrial Connections to Sewers.

The layout of domestic and street drainage is shown diagrammatically in the appendix (Figs. 1 and 2). The plumbing arrangements in factories are essentially similar.

(4) Sewers in Glasgow.

Glasgow sewers vary in shape, size and material of construction. The oldest sewers are built of stonework with a glazed half-tile sole-plate. They range from 2 feet 9 inches to 3 feet 4 inches in height. In many places they are crossed by water and gas mains - a practice which is condemned nowadays. (Fig. 3). These sewers require regular inspection and frequent repairs, mainly on account of their age.

The modern version of the above sewer is one constructed of brick and cement, though the design is essentially the same. Their height, however, may be as great as 4 feet 6 inches.

Reinforced concrete piping in diameters of 9 inches upwards has been employed for many of the sewers constructed in the past twenty years, for example, in housing schemes. Ovoid shapes are to be found in some places but the majority of the pipe sewers are round in section. (Fig. 4) These sewers are usually laid on a foundation of concrete or are supported on concrete platforms.

Steel and reinforced concrete large-diameter piping has been used for sections of sewers where strain is heavy. Fig. 5 illustrates the use of these materials in an inverted siphon sewer passing below a railway tunnel in the east-end of the city.

Fig. 6 shows the elaborate underground structure involved in the junction of a storm water overflow sewer with an outfall sewer. The series of vanes are of reinforced concrete and their object is to divert flood water into the overflow channel which runs alongside the main channel in this underground cavern. By means of the penstock the flow of sewage in the outfall sewer can be controlled, any excess being diverted to the overflow. In this way overloading of the outfall sewer with consequent back flooding in areas drained by branch sewers is avoided. Similar storm chambers are located at strategic parts of the main drainage system.

In some parts of Glasgow sewers are only five or six feet from street level while at other points they are as deep as fifty or sixty feet. Again, the nature of the subsoil dictates the path and construction of many of the sewers. In the vicinity of the river the subsoil is sand or running silt, while in the northern part of the city, boulder clay and rock are to be found near the surface. Another factor which plays a part in the gradient of sewers is the large amount of railway tunnelling within the city boundaries. This factor is also largely responsible for the great amount of repair-work in certain of the sewers.

Thus, many of Glasgow's sewers are not self-cleansing. Inverted siphons are, of necessity, found quite frequently in the system. Where possible, however, they are constructed in duplicate, thereby enabling one to be shut off for cleansing purposes.

The distance between adjacent manholes in Glasgow sewers varies from 20 to 200 yards. In the main, however, access points to the sewers lie 60 to 80 yards apart.

B. SEWAGE.

(1) Definition.

Sewage may be defined as material which flows in sewers. It consists of a mixture of liquids and solids, including discharges from water-closets and urinals, water which has been used for domestic cooking and cleaning, water from baths and wash-bowls, rainwater discharged to the sewers from roofs and streets and waste liquors from industrial processes.

(2) Composition.

The chemical composition of sewage is very complex. No reliable means of chemical analysis is practicable, hence an empirical estimation of certain constituents is usually relied upon for the practical purpose of assessing the efficiency of the sewage disposal works (Table No.3).

In Glasgow, there are a vast number of industrial establishments, many of which are located in the eastern part of the city. It is significant that the Dalmarnock Sewage Works has to deal with a greater quantity of trade waste than the other two disposal units. The amount of suspended solids in the crude sewage at Dalmarnock is materially greater than that found at either Shieldhall or Dalmuir. This factor is of importance to the sewermen for it is in the eastern area that much of their work in silt-removal from the sewers has to be done. Solids in suspension in sewage tend to be precipitated out by certain trade wastes.

Engineering works, despite the fact that many are equipped with salvage pits, contribute oil and grease to the sewers in addition to such materials as "pickling acid", cyanide, suds and many other trade wastes. Garages are a common source of paraffin and oil in sewers. Chemical works, of which there are a number in Glasgow, contribute weak acid, weak alkali, spent carbide (after the manufacture of acetylene) and resins.

In the case of steel works and gas works, ammoniacal liquors containing various coal tar and phenol compounds find their way to the sewers.

Effluents from offensive trades, such as gut-boiling and blood-boiling as well as those from slaughter-houses and fish factories, contain much grease and decaying animal matter. These substances readily solidify out in cool water and may lead to blockage of a sewer.

Tanneries, weaving and dyeing industries and laundries contribute alkali and soaps to the sewers. Paper mills in Glasgow have an effluent which creates a problem due to frothing caused by the alkaline soap content. Alkaline greasy effluents are also discharged from factories engaged in wool-scouring.

(3) Variation in Content.

Depending on the habits of the population or industry served by a sewer, so will its contents vary. In sewers serving residential areas it is found that the flow is less during the period 10 p.m. to 7 a.m. - that is excluding the effects of rainfall. Similarly, a sewer serving industrial premises has variations in its flow and content from hour to hour. In certain processes, spent liquors are discharged during the night, while in others discharge is made at intervals during the day. Thus it is seen that the volume of sewage and its chemical composition can vary from hour to hour. Again, no two sewers drain the same area and hence major differences are likely to be found on investigation of their contents. This is of particular importance to the work of sewermen.

(4) Temperature Variation.

As is to be expected, the temperature of the sewage is liable to wide variations, depending on the temperature of the effluent and its degree of dilution with cold water before entry to the sewer. Temperatures of sewage appear to vary between 35°F. and 100°F.

(5) Control of Admission of Wastes to Sewers.

By various statutes, restrictions are placed on industrial concerns as to what trade effluents may be discharged into sewers. The following two sections from the Glasgow Streets Sewers and Buildings Consolidation Order Confirmation Act of 1937 illustrate this point:-

> Section 81 - The occupier of any land or heritage on which any trade or manufacture is carried on shall before permitting any liquid effluent substance or matter therefrom to flow or pass into any sewer use the best practicable means for preventing the production of noxious effluvia therein.

> Section 82 - The proprietor of any building used for the purposes of trade or gain as a motor garage or motor works or of any petroleum filling station shall provide on every private sewer or drain in or connected with such building or station which may receive the discharge or overflow from the operations of cleaning and washing motor vehicles and supplying petroleum and oil to motor vehicles or otherwise an efficient deep-sealed trap or tank properly ventilated and fitted with accessible surface covers for the interception and removal of oil, grease and petroleum or other volatile substances or liquids.

In a further section the above Act states that -

> "No steam and no hot water or other liquid at a temperature exceeding one hundred and ten degrees Fahrenheit shall be discharged into any sewer except with the written consent of the Master of Works which consent may be granted on such terms and conditions as he may think fit."

These examples show that, from the legal aspect, every endeavour is made to ensure that effluvia likely to lead to danger in, or liable to cause damage to, the sewers are excluded. Where the effluent may not be admitted to the sewers the manufacturer has to make his own arrangements for disposal. Nowadays this is done by the installation of a trade waste disposal plant and in many instances this is combined with a salvage recovery process. In former years, however, the practice was to discharge the trade waste into streams or coups. A chemical manufacturing company in the city at present is maintaining a special private sewer to convey to the river Clyde liquors from trade wastes deposited by their predecessors over a century ago. The waste product is calcium hydrosulphide from the Leblanc process of manufacturing washing-soda (sodium chloride to sodium sulphite to sodium carbonate to soda crystals). The deposit was made on an area where there are natural springs. Sulphuretted hydrogen is given off from the resultant solution in the spring water, and, as it was considered that damage to public sewers would result from contact with this material, the Corporation insisted that the company should construct and maintain their own private sewer. Considerable corrosion of that sewer can be seen as the result of years of exposure. The public sewers do, however, take overflow storm water from this waste ground, consequently hydrogen sulphide is often present in the sewer at this point.

While manufacturers are only too ready to co-operate with the Master of Works, it will be realised that the labourer whose duty it is to maintain and clean out traps and pits within the factory premises is often unfamiliar with the reasons for excluding the particular material from the sewer. His job is to clean out the tank and so he follows the custom practised at home, namely, "pour the dirt down the drain". It is for this reason that from time to time special problems arise for the employees of the Sewage Section, and as the source of the troublesome material is not known at the time, a certain amount of risk may be involved during inspection of the particular sewer.

Bell and Paton in their Book on "Glasgow: Its Municipal Organisation and Administration" state -

> "A sewer is the most recklessly selfish contrivance sanctioned by civilisation, and civilised society has to pay a heavy price for its use. . . . The soil pipe is the most convenient and most reckless structural appliance in the economy of a household. The householder gets rid of his or her troublesome and offensive matter, it is outside his walls immediately it is produced, and therewith he thinks the matter is at an end. It is not so, for his sins assuredly find him out. The sin of the individual is punished on the community, and the gigantic evils which are the inevitable outcome of this immense indispensable selfish convenience are among the most perplexing problems of modern city life."

These statements were written in 1896. They referred to the state of the river Clyde and its tributaries during the construction of Glasgow's main drainage scheme. Much of the statement still applies, not so much to the inconvenience and danger to the public as a whole, but to those men whose daily job leads them into the maze of sewers below the streets of Glasgow.

Chapter III.

THE SEWERMAN AND HIS JOB.

A. Necessity for Sewermen.

> "When our ancestors began to pour their innocent trickles of household and street drainage into the wimpling Molendinar, they did not foresee the time when that romantic burn would become a stream of noisesome and pestilential liquid which we are glad to have covered over and hidden from our sight."

In writing these words a historian of Glasgow gives the reason for the introduction of public sewers towards the end of the 18th Century. In their earliest form, he shows that the construction of sewers merely consisted in the covering over of existing gutters and streams. From these there developed the public and common sewers built of stone and of such size "as to permit the entry of a man for the purpose of cleaning them". In those early days, blockages of the sewers were common, and the only method of correcting the fault was for a man to crawl along from the outfall and restore the flow. As sewers became longer, this method of clearance became more and more dangerous, and, latterly, it became the custom to resort to surface excavation of the sewer in the area of the blockage. The sewer was opened, the blockage removed and the stonework and overlying earth replaced. At that time, the cleaning of sewers was carried out by private contractors, probably because the majority of the sewers were privately owned. It is of interest to note that, even after sewers were constructed and maintained at the expense of the Town Council, private contractors undertook the actual work. A family business was early associated with sewer maintenance, and, indeed, in Glasgow, one family carried on this work for three generations. This would appear to demonstrate the early acknowledgement of the specialised nature of the work of sewer maintenance.

This maintenance work grew rapidly as the city expanded. The attention of engineers was soon directed to the problem of gaining access to the sewers to clear blockages. Several improvements were introduced, together with the adoption of the combined system of water-borne conservancy made possible by the extension of piped water supplies in the city. Manholes were built at intervals to permit of entry to the sewers as well as to provide ventilation of the sewers, and thereby reduce the reflux of dangerous effluvia into houses through faulty connections. Despite efforts made by engineers to develop self-cleansing sewers in an attempt to reduce the heavy cost of maintenance, this ideal has not been achieved, and so a number of men in each of our cities are employed solely for the purpose of maintaining the sewers in an efficient state.

B. Number of Sewermen in Glasgow.

Fifty-two men are employed, whole-time, in Glasgow for the maintenance of the sewers and the main drainage system. This number does not include employees at the three sewage disposal units nor those at the four pumping stations.

Of these fifty-two, ten are engaged in the regular patrol of the main drainage system, i.e., the main intercepting sewers. Their principal work is the oiling and control of storm valves in these large-diameter sewers and little of their time is spent underground. If any major structural maintenance work is required in the main drainage system, it is usually carried out through private contractors.

The remaining forty-two men are normally engaged in the proper work of sewermen and operate as two night-shift squads of five and four men respectively, and on day-shift as nine three-men and one six-men squads. The squad of six men on day-shift is held at the unit headquarters and is equipped as an emergency mobile team. Five squads normally operate on the north side of the river, while four squads work on the south side, but it should be noted that this division is arbitrary, each squad being considered as available in emergency for operations in any part of the city. In the main, however, each squad has an area of the city in which most of its work is carried out. Thus, it is found that some men are engaged in suburbs which are almost entirely residential, while the others (the majority) maintain the sewers in the highly industrialised areas.

The supervision of these men is performed by one chief inspector and two foremen; men of long experience in the sewers who have proved themselves to be efficient leaders in dangerous situations.

C. Social State (Table No. 4).

The sewermen may be considered as belonging to social classes IV or V, as defined by the Registrar-General. With regard to the work, some writers might place them in the lowest class of unskilled labour, but having personally observed them at work in many emergencies, one considers that their job demands a degree of courage and skill well above that of the average labourer and worthy of the higher grading.

(a) Size of Family. All the men are married and in only three instances are they childless. The average size of family is three to four children, and this factor appears to have an important bearing on the recruitment of men to this type of work

(b) Housing. The home conditions of the majority of the sewermen are poor, largely because of the small size of their houses and the lack of proper washing facilities. Twenty-three of them live in houses of two-apartments or less, while twenty-seven of their houses lack bathrooms. Those fortunate enough to have been rehoused by the Corporation have set up comfortable homes, the furnishings of which compare favourably with those of higher income groups. Moreover, this group demonstrates that, given proper facilities, sewermen can and do pay attention to personal cleanliness.

(c) Weekly Income. In fifteen families, the sewerman is the only wage-earner, while, in the others, at least one child is bringing in a pay. The gross weekly wage of the sewerman is £6:10s., night-shift workers earning an additional 11s. weekly. The nett weekly income of the sewerman ranges from £5:14s. to £6:13s.

Because of family responsibilities, the average sewerman's spending habits are modest, his only extravagances being an occasional bet on a horse, 10 to 15 cigarettes daily, and a few pints of beer at the weekend.

(d) Dietaries. In food habits, the sewerman closely resembles the miner, the main meal being taken after the working shift. Breakfast is light, though porridge is a feature in most of their homes. Cheese or meat sandwiches are consumed during the two meal breaks in the working shift. At weekends, normal well-balanced meals are taken with the family. An analysis of the weekly dietary of these men revealed that, although satisfactory in protein and fat, in many instances there is a lack of raw fruit and vegetables.

(e) Working Clothing. Apart from the special items of clothing supplied to each man, the sewerman's working clothes are subjected to hard wear and tear, especially when working in small sewers. Frequent soiling calls for regular washing which shortens the life of garments and necessitates frequent replacement of shirts, trousers, socks and underwear.

D. Recruitment of Sewermen in Glasgow (Table No. 5).

As in the past, the major incentive to recruitment to the job of sewermen is the £1:5s. increase in the weekly wage over that of the ordinary labourer in the Highways Department, from which group the recruits are drawn. Applications readily come from those men with young families.

The selection of men whose standard of work has been watched by the Inspector and his two foremen ensures that only reliable workers are employed in the sewers. The high standard of judgment and intuition of the selectors is reflected in the relatively low labour turnover found among the Glasgow sewermen. This is further borne out by study of the occupation histories of the sewermen at present employed, where it is found that these men collectively have had few periods of unemployment during the years of trade depression between the Wars. They sought out work and gained appointments when competition was at its greatest. This spirit of being prepared to tackle anything is still to the fore among these employees, and it is worthy of note that the latest recruits have maintained this standard.

The average age of entry to work in the sewers is 37.7 years, while the length of service of the present labour force ranges from a few months to 28 years. Table No. 6 shows the distribution according to length of service. It is seen that fully 80% of the sewermen have over five years' service and 44% have been over ten years in this employment.

E. Description of the Work of Sewermen in Glasgow.

The work of the sewermen readily falls into two main classes, namely:-

(a) Routine cleaning and inspection of sewers; and

(b) Breakdown or emergency work.

(a) Routine Cleaning and Inspection of Sewers.

The method of carrying out this job varies according to the size of the sewer, but three main procedures are followed:-

(1) Small Sewers. This procedure is employed in pipe sewers having a diameter between 9 ins. and 25 ins. Adjacent manholes are opened and one sewermen enters each. From the bottom of one an extending rod is passed to the other through the sewer. Having reached the other manhole the rod is pulled through and is used to draw a rope along this section of the sewer. Once the rope is in position a hose-pipe connected to a nearby hydrant is attached and with a good jet of water the sewermen commence to wash through this section of the sewer in the direction of its flow. By means of a to and fro pulling on the rope the hose and its jet of water are gradually worked along the sewer from one manhole to the other. In this way silt lying on the bottom of the sewer is washed down to the manhole. As the silt accumulates it is shovelled into a bucket and drawn to the street level by means of a hand-operated winch. There the silt is collected to await removal by a lorry from the Cleansing Department. Great care is necessary in this flushing method to avoid forcing the silt along the sewer too quickly as this may lead to a blockage.

(2) Medium-Sized Sewers. In sewers having diameters between two and four feet, inspection and cleaning have usually to be

done while the sewage is flowing. This applies to the majority of the sewers. The team of three men operate from one manhole, two men being underground while one man is at the top of the manway. One sewerman operates at the 'face', i.e., the point from which the silt is being removed. Using a short-handled, round-edged shovel he fills a wooden pail with sludge. The pail is then placed on top of the shovel and by means of the latter is dragged along the sewer to the second sewerman. The load is then drawn to the bottom of the manhole where the pail is hooked on to a rope and raised to street level by the third man who is operating the winch. The bucket is emptied on to the street and lowered for another load. It is usual for three buckets to be used so that the loader is kept supplied.

Wooden buckets are preferred to metal since they stand up to greater wear and tear and are more easily slid along the floor of the sewer. In the above procedure the trafficking is done over the part of the sewer which has already been cleared of silt. It will readily be appreciated that the men underground are working in a crouched position and that space may be further limited by 12 to 18 inches or more of water in the sewer. The depth of the silt is usually about a foot, though frequently it is twice that depth. After filling the bucket and having drawn it to the point where it is transferred to his mate, the sewerman has to climb over the bucket and proceed back to the 'face' with an empty bucket. In the return trip the bucket is half floated, half pushed, as the sewerman uses it to maintain his balance. The foot-work involved in traversing the sewer is often tricky as there is insufficient space to take proper steps. One foot is kept in front and after a step has been taken with it the other foot is brought up close behind. As the silt is removed, the walls, roof and floor are examined by touch and visually where possible. Any cracks found in the cement-work are repaired by the sewermen in their progress through the sewer. Each day the men in the team change duties. In this way each man has one day in three on the surface.

(3) Large-diameter Sewers. The procedure in the larger sewers, measuring four feet and upwards in height, is similar to that described in paragraph (2) above, except that there is a greater depth of water. In some instances it is possible to lower a penstock distal to the point of operations and so deflect the bulk of the sewage over a storm water overflow. In this way the water level in the field of operations can be reduced. In the largest of the intercepting sewers of the main drainage system the inspection is made on a raft.

(b) Breakdown or Emergency Work.

Here again the method of approach depends on the size of the sewer, but before describing this type of work it is necessary to mention the causes of breakdowns. These are -

(i) Blockage. This is more common in the smaller sewers, i.e., the pipe sewers, though it does occur from time to time in brick sewers. In the latter, this fault occurs at a low point in the sewer, for example, in a dip below railway lines.

(ii) Fall-in of the roof or walls of a stone or brick sewer: This emergency occurs in various parts of the city from time to time. Subsidence is common in those parts under which old mine workings are to be found, and rupture of a water-main or sewer is liable to occur.

(iii) Falling out of the sole of a sewer: In this case the bottom of the sewer falls out as a result of the washing away of underlying soil by a leak either from the sewer itself or from a nearby water-main. The original fracture of the sewer may have been caused by the vibration produced by nearby heavy traffic.

In dealing with these emergencies the following approaches are made:-

(1) Small or Pipe Sewers. Having decided in which section of the sewer the breakdown has occurred, the team of sewermen then attempt to clear the blockage by passing rods along the sewer. By fixing spikes on to the ends of the rods it may be possible to pierce a way through the obstruction. Once that is achieved, a knotted chain is dragged through from one manhole to the next and the free flow of sewage restored. If these measures are unsuccessful, then the distance between the stoppage and the manhole is estimated and the corresponding spot on street level plotted. The street is dug up and the

sewer exposed. A section of the piping is carefully removed, the blockage cleared and a new section of piping cemented into position.

(2) Stone and Brick Sewers. Blockages occur here too and in some instances it is possible for a sewerman to clear the blockage manually from within the sewer. This is an exceedingly dangerous procedure despite attempts to dam the sewage further back along the same sewer. In some instances, however, because of a dip in the sewer the workman cannot proceed along the sewer to the blockage because of the depth of water. Where it is possible to divert the flow of sewage, of course, the dip is pumped dry and sewermen clean out the sewer in the usual way. In one notorious section in the south-side of the city, trouble arises from the outpouring of tar products from a gas works. When discharged the tar is liquid, but, on cooling in the sewer and on admixture with gravel from the streets and sewage, becomes more viscid and gradually solidifies. One such sample, stored in a jar, solidified within two weeks at room temperature. The sewer into which this tar is dumped dips below some railway lines and as so many blockages have occurred at this point a knotted chain has been left in position between manholes on either side of the dip. Every few days, sewermen pull the chain to and fro to prevent the sewer from being blocked by solidification of the tarry mixture.

In the case of a fall-in of the roof or walls of the sewer a preliminary survey of the breakdown is made, and if the fault is found to be extensive then the sewer is exposed from ground level in the region of the fall-in and the necessary repairs carried out. This work is usually undertaken by a private public works contractor. Where, however, it appears possible to carry out repairs from within the sewer this is carried out by the sewermen. The roof and walls are shored-up on either side of the fall-in, the debris removed and brickwork cemented into position. This sounds a simple enough matter but it must be pointed out that once props have been placed in position very little room is left in which to work. Furthermore, it must be remembered that bricks, cement and other materials have to be carried along the sewers from the nearest manhole in pails held or dragged in such a way as to defy the anatomical laws of correct working posture. In this type of work, not only is there great danger but also, because of limitation of space, the body has often to work at great mechanical disadvantage thereby causing excessive expenditure of energy. For this reason, several teams of sewermen may be employed and a human chain supply line formed from the manhole base to the scene of operations.

A dangerous feature of certain sewers is the liability of the sole or floor to fall out. In one intercepting sewer, located in the east-end of the city, this type of breakdown occurs quite frequently. The sewer runs alongside a railway tunnel and vibration due to the passage of trains causes a crack to appear in the sole. Water escapes and in so doing washes away the running sand below the sewer. A section of the floor is left unsupported, falls out, and the process becomes a vicious circle causing rapid extension of the damage. When the break-down is being located the examining sewerman has to proceed warily along the sewer till he reaches the edge of the break in the sole. One false step at this juncture may lead to a tragedy in which the workman is submerged in a quicksand of sewage and mud. Victor Hugo classifies such a defect in a sewer as a "fontis", and in Les Miserables vividly describes the experience of Jean Valjean when negotiating the "slough of mud in a cavern of night".

In an emergency such as this all available sewermen are rushed to the spot and the defect is repaired by pouring in concrete, which will set under water, until new foundations have been made on which to reconstruct the sewer floor with glazed tiles. In some instances it is possible to keep the site of the re-building work dry by constructing a piped bridge over the defective area. This is only possible where the flow is relatively small. The same procedure of bridging the defective part of the sewer is used in this particular sewer for tracing suspected leakages from the sewer. It frequently happens that railway examiners report leakage of water through the wall of the adjacent tunnel. It is not always easy to decide whether the water is from a water-main or a sewer and so a fluorescein test is carried out on the adjacent section of the sewer. A shallow dam of clay is made in the sewer, and from this dam a five-inch pipe is run to a similar dam farther down the sewer. In this way a section of the sewer floor is dried out for examination, the sewage being conveyed through the pipe-bridge. A solution of fluorescein is then poured into the dried section and left there for several hours. At the end of that time the wall and roof of the railway tunnel are examined for the presence of the fluorescein. The test is repeated along adjacent sections of the sewer until the leak is traced. Under the same conditions of bridging, the crack in the sole of the sewer is repaired. It will be seen that free movement of the sewermen on this job is further restricted by the dams, piping and wooden supports.

(3) Low-Level Intercepting Sewers. A major break-down in this system occurs mainly as a result of a defect in the pumping machinery. At each of the pumping stations there is always a spare pump which is available should a mechanical fault develop in one of the other two pumps. In a recent break-down on the south-side of the river, however, pumping had to be stopped altogether. Several thousand tons of tar found their way into the sewer from a coking plant at a steel-works. This tar gummed up the valves in the pumps and put all three machines in this station out of action. Penstocks were lowered into position and the sewage from this system of sewers diverted

into the river by way of the storm water overflows. The tar was removed from the pump-wells, the valves dismantled and cleaned in a degreaser, while several squads of sewermen cleared the tar from the lower sections of the sewer. The operations took several months, tar lying in the sewer to the depth of two feet. This tar had solidified on mixing with the sludge in the sewer and its removal latterly almost required the assistance of a pneumatic drill. Further reference to this particular experience of the sewermen occurs in the section on dermatitis.

F. Hours of Work and the Working Day.

The sewermen work a 44-hour week spread over five days. The starting hour is 7.15 a.m. and on four days of the week work finishes at 4.15 p.m. On Fridays, finishing time is at 3.15 p.m. One hour is allowed for meals (that is, half-hour at each break). When working in brick or stone sewers (that is, when working inside the sewers), their working day is reduced by one hour. On night-shift, work starts at 10 p.m. and finishes at 7 a.m.

The above figures refer to the normal working day, but when a breakdown has occurred the sewermen, working in relays, may be employed for longer periods.

The day starts with the team collecting its two-wheeled barrow containing tools and equipment, which has been stored over-night in a convenient yard. The next hour is spent in reaching the site of operations and laying out the equipment. This entails the erection of a steel-framed portable canvas shelter at the roadside, the kindling of a fire in the brazier, the removal of the manhole cover with pinch-bars, the filling and trimming of oil cap-lamps, the setting-up of a water tap to a fire hydrant, the collection of pails of water, the marking-off of the utilised section of the roadway with barriers and red flags and red lamps, the donning of overalls and thigh-boots, and the erection of the winch. (See photograph.)

The two sewermen due to work underground on this particular day descend the manhole and enter the sewer. An inspection is made of the section to be cleaned, movement being made with the assistance of a short stick laid across the sole of the sewer on which the weight is balanced. As an alternative to the short stick, the wooden bucket is used to maintain balance during working operations. (See photograph.)

Once the rough inspection has been made and the sewermen are satisfied that ventilation is sufficient - as judged by the brightness of the flame in the cap lamp and by the ease with which breathing is possible - buckets and shovels are lowered via the winch by the sewerman on street level, and operations commence along the lines indicated above.

After a two-hour spell underground, those two men dry their hands on a piece of rag-waste carried in their pockets and climb up the iron rungs set at intervals of 18 inches up the sides of the manholes. (See photograph.) The hands are dried before the ascent to ensure that a firm grip is maintained during the climb. After a break of twenty minutes they descend into the sewer and work again for another hour. At about a quarter to twelve the morning meal break of half-an-hour is taken. The two underground workers return to the surface, wash their hands and forearms in a bucket of warm water, heated on the brazier by the third man, rinse in clean water and then rinse in a solution of carbolic disinfectant. The meal of sandwiches is then partaken of, the sandwiches often being held by the sewermen in the wrapping paper so that the food is untouched by their hands. Cans of tea prepared by the surface-man complete the meal. It should be mentioned here that towels and soap are provided by the Department to each sewerman, as is the solution of disinfectant. A special two-monthly ration of six ounces of tea and a half-pound of sugar is bought by each man through the Highways Department (in addition to the ordinary civilian entitlement of these rationed commodities).

The afternoon programme follows the same routine as that outlined above, viz., two hours below, 20 minutes on top, one hour below, a meal break of half-an-hour, and one hour to clear up and park the barrow.

G. <u>Equipment and Tools</u>.

These comprise the following:-

One two-wheeled barrow.	Hydrant connections
One portable collapsible hut	Supply of rag waste
One winch	Disinfectant
Two pinch-bars	Can of oil (illumination)
Ropes	Thigh boots
Pails (wooden and metal)	Overalls
One brazier	Towels
Supply of coal and coke	Spare lamps
Shovels	Water cock key.
Sweeping brush	

In break-downs more elaborate equipment may be required, including electric and pressure oil lamps, piping, clay, timber, etc. In the case of men engaged in the flushing of pipe sewers then hose-piping is included.

Chapter IV.

THE WORKING ENVIRONMENT.

The working environment of sewermen is perhaps best illustrated in a description of a routine inspection of a brick sewer.

On removal of the manhole cover the examiner is conscious of that sickly sweet odour peculiar to so-called "sewer gas", but detection of this smell is quickly lost, either due to its anaesthetising effect on the nasal mucosa or by its replacement by other more penetrating odours. In some sewers the smell is more of tarry compounds, in others paraffin, while in still others the offensive odour of decaying vegetable or animal matter. The nose, however, quickly adjusts itself to most of these.

In the descent down the manhole, daylight fades rapidly and this adds to the difficulties in negotiating the rungs spaced at three-feet intervals on one of the walls. Once the sewer is entered, a lonely world of inky darkness and deathly silence envelopes the explorer, vision being limited to a few indistinct feet by the spluttering yellow flame of the oil-burning cap-lamp. A stooping posture is enforced by the low roof of the tunnel, while the rate of progress is rendered tardy by the glutinous adhesion to each boot of silt to a depth of some 8 to 12 inches on the floor. On the surface of the water, only a matter of 12 to 16 inches from the face, human faeces and other debris float by. The hands and forearms quickly become contaminated with slime and sewage from the hand-foot crawling mechanism by which progress is made along this three-feet brick sewer. The going is hard, the back aches, and the knees are cramped, but no relaxation is possible until the next manhole is reached. There the investigator can stand upright and temporarily relax after his efforts. The final stress is the climb back to the street level, and once there, and then only, can be enjoy deep breaths of fresh air. The shirt feels moist and the atmosphere cold on the surface as compared with that underground. While it is possible that the dampness in the shirt may have been due to drips of water which have fallen from the roof of the sewer, most of it is due to perspiration. How much more sweat must be lost by the sewer-men engaged in shovelling the silt from the floor of the sewer and dragging the bucket to the bottom of the manhole?

In some sections of sewers frank soaking of the upper garments occurs where junctions with branch sewers have to be negotiated in the course of the days' work. These branches enter into the larger sewers high up on the lateral walls and if sewage is flowing from the former it cascades into the main in such a way that it is impossible to proceed along the larger sewer without the clothing being soaked.

In the case of workers engaged in the flushing of pipe sewers, wetting of the clothing frequently arises at the lower end of the section, when the hose-pipe is pulled to that region.

Again the powerful jet from the hose tends to force a stream of cold air along the section of the pipe and the man at the lower end has to work in this cooler atmosphere. The pipe flushers, however, though still working in a restricted space, have greater opportunity to change their posture than those working in the brick sewers.

On the average, each sewerman spends 24 hours weekly carrying out heavy arduous work in this environment. The mere description of the place of work, disgusting and revolting as it may seem, fails, however, to convey the true nature of the working conditions. Accordingly, it was felt that an effort should be made to define in more accurate terms the conditions under which sewers are cleaned in Glasgow.

In a preliminary inspection of the various types of sewers it readily became apparent that certain physical and chemical forces might have a bearing on the influence of working conditions on the health of this group of workmen. Temperature, humidity, air movement, composition of the atmosphere, the chemical composition of sewage and methods of illumination in the sewers were examined at points where active work was proceeding.

A. Temperature and Air Movement.

The results of surveys in eight sewers are given in Table No. 7.

The investigations were carried out on sewers Nos. 1 to 6 between April and December. The figures quoted for sewers Nos. 7 and 8 were obtained at night during the summer months. All of these sewers were of the brick type and their vertical diameter varied from three to four feet six inches. They were located in various parts of the city and were selected because men were engaged either in cleaning out the silt or carrying out repairs. It is considered that they represent typical examples of the temperature conditions under which sewermen have to work. Trade effluents of one kind or another were noted to be present in each.

One regular finding, noticeable even without a thermometer, was that in winter months the atmosphere of the sewers was warmer than the surface air. In summer months some sewers appeared to be cooler than the surface atmosphere, but in others these two temperatures approximated to each other. In sewer No. 2, for instance, an appreciable air movement was noticeable when the above reading was taken. It should be mentioned, however, that the atmospheric conditions on the surface were gusty on that particular day.

The readings in Table No. 8 were taken at 15-minute intervals during a morning in the month of April. The sewer, as well as draining a domestic area is joined by several branches from various factories. One branch comes from a tannery, while another comes from a nearby gas works. Hot watery effluent from these factories flowed past frequently during the period of two hours under review. These outflows in no small way account for the variation, not only of temperature and humidity, but also in air movement. An appreciable rise in the sewage level was noted as these effluents went by. This rise and fall in the level of the contents of a sewer aids ventilation as does the rate of flow in the particular sewer.

The effective temperature is an index of warmth of an environment. As an index it takes into account temperature, humidity and rate of movement of the air, and refers all of these to standard conditions of still air saturated with water vapour, in which an equivalent sensation of warmth was experienced by the subjects in a long series of tests. In calculating the effective temperature, use was made of the "normal scale" which applies to persons wearing light clothing. The effective temperature does not take into account radiation and so a corrected effective temperature is used in the estimation of the index of warmth of an environment. The radiation factor is measured by means of the globe thermometer. In the investigation under review, it was found that, because of the rapid variations in the environmental temperature and air movement, the globe thermometer readings seemed to approximate to those of the dry bulb, there being a time lag in the case of the former. Accordingly, it was decided to use only the effective temperature, and make no correction for radiation since this factor appeared to be negligible.

Again, the scale used was designed for use where light clothing was worn, and, hence, as sewermen wear rubber waders which prevent free evaporation of perspiration from a large part of the body surface, a correction for this must be allowed for in the interpretation of the final result. Bedford (1948) considers that an effective temperature of 57 to 63 degrees Fahrenheit is a comfortable level for indoor environments where very light sedentary work is being done. For heavier work, he recommends 55 to 60 as a suitable range. In the case of sewermen, it was found that, generally, the effective temperature of their working environment lay within this range, though, in several instances, figures above this level occurred. When allowance is made for the special clothing worn by the sewermen, however, it is evident that the effective temperature of many of the sewers is above the suggested levels for an environment in which heavy manual work is to be carried out.

Sewer No. 2 is given as an example of the rapid variations which can take place in the working environment of sewermen. Changes of more than 20 degrees in temperature have been found to occur during a relatively short period of time. In the example given, the temperature varied over a range of 18 degrees in a matter of only two hours.

B. <u>Chemical Analysis of Atmosphere in Sewers</u> (Table No. 9).

Sampling of the atmosphere in various sewers was made by the water-air replacement method. A large glass bottle of known volume was filled with water and emptied in the particular sewer at a point distant from the open manhole so that a sample of the air breathed by the worker was obtained. The bottle was quickly stoppered and sealed and transported forthwith to the analyst's laboratory where the analysis was carried out immediately. Samples for the estimation of carbon dioxide and carbon monoxide were taken in this way. In the case of aromatic hydrocarbons and benzene analyses, the method of sampling was essentially similar except that special foil-covered cork stoppers were used in place of the usual rubber stoppers and an iron siphon was employed to reduce the possibility of washing out any of the hydrocarbons in the process of filling the bottles with sewer atmosphere.

In the analysis of hydrogen sulphide, a known quantity of air was aspirated directly from the sewer through lead iodide indicator paper and a colorimetric comparison used to determine the content of the contaminant. Table No. 9 gives the results of analyses of atmosphere in sewers.

The five samples in Sewer No. 1 were taken at different times at intervals of one week in parts of the sewer where the men were working. Three manhole covers were open and had been open for several hours on each occasion before the samples were taken. A feature of this sewer was the distance between manholes in one section, "the long draw" as it was referred to by the sewermen. This section had a distance of over 200 yards with no manhole.

Sewer No. 5 samples were taken in sections known as a dead-end branch in which silt readily accumulates. These two dead ends in the same street lead into different sewers. They are really the beginning of sewers, house drains meeting at these points and forming the common sewers.

Sewers No.2 and 3 convey trade effluents from two different gas works in addition to domestic and other commercial drainage. Immediately the manhole covers are raised in these sewers a pungent tarry odour is evident and condensation of tarry compounds drip from the walls of the manholes. A cloud of vapour can be seen hanging over the sewage as it flows on its way to join the main intercepting sewer. The sewage liquor has a brownish colour and an oily film floats on the surface.

This oily film was noticed in many of the sewers which one visited. Frank oil on the surface of the sewage was found frequently to reach the sewers from drains serving garages, while in several instances the odour of petrol and paraffin in sizable quantity could be detected. The presence of commercial petrol was confirmed at one stage of the investigation through the isolation of the diagnostic dye by the analyst.

The pungent fumes of chlorine in one instance and ammonia in another were recognised in two sewers in the south-side of the City during the investigation. In another sewer, one arrived only a few minutes after the three sewermen had been driven out by the appearance of a pungent fume in the sewer. From the odour, it seemed that the fume might be acrolein. A sample of a frothy scum, which had appeared on the surface of the sewage, was taken as it seemed to emanate the pungent odour. On analysis, however, none of the following was found - benzene, toluene, xylene, petrol, halogenated hydrocarbons, formalin, formic acid, acetic acid, ammonia. The scum was established as being composed of mineral oil of the lubricating type.

In another sewer on the south side of the river, two men were overcome by pungent fumes and had to be rescued from the sewer. Analysis of the vapour in the sewer showed it to be free chlorine. Investigation revealed that a bleaching preparation containing chlorine had been used in a flour mill which drained into this sewer. Floor washings and the residue of the material after the bleaching process had been washed into the drains. On entering the sewer the effluent had interacted with weak acid from a chemical works to produce the chlorine gas. A qualitative analysis confirmed the presence of chlorine in the fumes.

Qualitative analysis of the atmosphere in a sewer in the north of the city proved the presence of hydrogen sulphide. Men working in this sewer had complained of irritation of the eyes and two had actually developed conjunctivitis.

C. Ventilation in Sewers.

When originally built, sewers were well ventilated by means of gratings fitted over the manways. From time to time, however, complaints were received from residents in certain areas of the city concerning the emission of foul odours from manholes. It was found that a satisfactory way of removing these nuisances was to fill in the interstices of the gratings with concrete. As reports of such nuisances became more and more frequent, this practice of sealing off manhole covers became general so that nowadays most, if not all, manholes are so sealed over that ventilation from these sources is almost negligible. Small branch sewers and house drains still retain ventilation through Buchan traps and ventilating shafts, but the contributions of fresh air made by these have little influence on the larger sewers. Storm water overflows and the entrance of open streams into the sewers provide such ventilation as now exists.

Before work commences in a section of a sewer, the manhole covers at either end of the section are opened. Where obvious fumes are present, additional manhole covers are opened. There is no doubt that this practice does reduce the concentration of foul air in the section of the sewer, but it must be stressed that in many instances the results cannot be considered adequate. This method frequently works in reverse where there is a distal air inlet, such as a storm water overflow. Depending on the strength and direction of the wind, air may be forced into the sewer through this outlet, along the sewer and out through the open manholes. Fumes in the sewer are thus driven along to the section in which the men are working. Not only are the underground workers exposed to them, but also the sewerman operating the winch at the top of the manhole. On occasions, when the wind is suitable and the fumes in a sewer are known to be dangerous, windsails are erected over the manhole to drive in a fresh air supply. In other sections a mechanical fan is used to drive in the air supply.

In dead-end sections no special aids are used for improving ventilation. If air conditions are bad, the sewermen reduce the length of their spells underground.

Atmospheric conditions other than winds have a natural influence in the ventilation of sewers. Heavy rain, by increasing the level and rate of flow, helps to drive out bad air and fumes from the sewers. These effects are temporary, however, and have little effect on improving the atmospheric conditions under which sewermen work.

Map No. 3 shows sewers where the atmosphere is known to be dangerous.

D. <u>Illumination in Sewers</u>.

The lighting of the working areas in the sewers is achieved by old-fashioned oil lamps worn on the caps of the sewermen. Their design is shown in Figure No. 7.

Sperm oil is the normal fuel in these lamps, but, during the recent war, mineral oil substitutes had to be employed. In the past year, sperm oil has again been available. The lamps are used with about half-an-inch of wick protruding and the continuous burning of the flame depends on the frequent agitation of the lamp. Even with efficient trimming of the wick, the lamp burns with the production of some smoke. The amount of smoke varies according to the oil used and is least with sperm oil. In addition to the smoke there is also produced the smell of burning oil. With some oils the odour is quite pungent.

The sewermen, like the older miners, attach great importance to the use of an oil lamp while working in the sewers, as they use the size of the flame as an indication of the presence of gas. Reduction of the size of the flame of a well-burning lamp is taken to indicate the presence of irrespirable gas, for example, carbon dioxide.

In the average sewer the lamp flame shows a reduction in size immediately on entry to the sewers and there is an increase in the production of smoke. The amount of light given from the lamp is small and at a distance of 10 inches from the flame the illumination is less than 0.25 foot-candle. This figure has been found to be the usual reading on the Weston Photometer which was used in the investigation of the illumination in sewers. The instrument was checked against a standard both before and during the investigation and its error was found to be negligible.

Reflection from the walls and roof of most sewers is small, though in some of the brick sewers the cleaner bricks on the roof do reflect a little light. In a few of the smaller sewers where drainage from certain chemical factories is carried away, deposits of white silt on the walls improve the illumination by reflection.

On special occasions, for carrying out repairs, use is sometimes made of portable electric lamps. They have only limited value, however, because of limitation of space and the absence of wall hooks. Furthermore, it is essential that a sewerman should have both hands free while working in the sewer. Safety lamps of the Davy type have their place, as, for example, in a recent emergency job in the west-central area of the city.

In the course of the construction of a lift-shaft in the premises of a well-known bakery, the building labourers, while excavating the basement well, noticed a marked odour of petrol. Their foreman reported the incident and smoking was prohibited in the area. The smell was traced to a small drain which had been exposed during the excavations. The Office of Public Works was informed and a squad of sewermen were sent to investigate. The direction of fall indicated that this old drain ran into the course of a burn whose course had been diverted into a nearby sewer. Parts of this burn formerly used as sewers were known to be open and to have overflow connections into several sewers. The sewermen proceeded along the nearest sewer to the position where it crossed the course of the old burn, and, through the overflow opening into the sewer, noticed the odour of petrol. Davy lamps were used thereafter and on gaining access to the old burn it was found that over 1,000 gallons of petrol were lying in the bed of the water course. Seepage from a leak in petrol storage tanks of a large garage and also from the firm's own garage were thought to have accounted for the accumulation. The petrol was pumped out through an excavation made by the sewermen, and used to drive the firm's vehicles.

Electric cap lamps with small accumulators, carried on the hip or chest, have been tried in the sewers but two snags encountered were -

(1) the weight of the lamp on the cap was much greater than the small oil lamp in working trim.

(2) The positioning of the accumulator on the hip or chest prevented freedom of movement, especially in the smaller sewers.

Another difficulty was the keeping of the accumulators dry.

Further investigations are being carried out at present into the use of an electric cap lamp which is operated by dry batteries. Breakages in electric lamps on previous trials have impressed the investigators that durability is of prime importance in the design of a lamp suitable for use by sewermen.

Chapter V.

SPECIAL MEASURES IN USE FOR THE PROTECTION OF GLASGOW SEWERMEN.

Many of the measures designed to give protection to sewermen in the course of their employment have been adapted from those proved to be of value to miners. The nature of work in sewers and in the mines is, in many ways, not dissimilar, both groups of workers being exposed to risk of accidents, gassing and leptospiral infection. Measures designed to protect against the last mentioned condition are discussed in Chapter VII.

A. Working Arrangements.

In 1937 a major alteration was made in the working arrangements of sewermen in Glasgow. Prior to that year, each team was composed of two or three sewermen and one winchman. The latter remained on the surface while the former worked underground in every shift. A winchman might work for many years before being promoted to the grade of sewermen. At the change-over all winchmen were regraded as sewermen. Each man in the team then took his turn of being winchman while the rest worked in the sewer. Duties were changed daily. This alteration had been pressed for by the Trade Union on the ground that -

(1) The winchman previously could not be of much assistance to the sewermen should they get into difficulties in the sewer, because of his inexperience of work inside the sewers.

(2) Sewermen would benefit from a turn of duty on the surface.

These arguments appeared to be sound and were adopted by the Highways Department. But other general measures had been in use for many years previously. Indeed, as long ago as 1912 a slipper bath was provided at the headquarters depot of the Sewerage Section in College Street for the use of sewermen. It is not proposed to discuss the pros and cons of this installation at this stage, but it does show an early interest in the welfare of sewermen on the part of the Corporation. Again, hours of work of sewermen were less per week than their colleagues in other sections of the Highways Department. These factors make important contributions to the welfare and safety of sewermen, although it is probable that regard was had more for the offensive nature of their employment rather than for preservation of health. No matter what was the reason for the establishment of these arrangements, one is convinced that no small contribution was made thereby to reduction of incapacity attributable to work in the sewers.

B. Protective Clothing.

The following items are supplied to each man or are available for use as required:-

(1) Engineer's overalls and jackets;
(2) One pair of socks;
(3) Leather-soled rubber thigh boots;
(4) Rubber waterproof waders and wooden clogs;
(5) One corduroy sleeved waistcoat.

These items are intended to protect the worker from wettings in the sewer and also to minimise contamination of his working clothing with sewage. In very exceptional circumstances rubber gloves have been supplied for use of those engaged in the clearance of blockages due to certain substances such as tar.

C. Washing Facilities.

Reference has already been made to washing facilities at the site of operations. Additional facilities were provided to each sewerman in the late 1930's in the form of free passes for entry to the Corporation Public Baths. At the time of their original issue, few if any of the sewermen then employed lived in houses fitted with a bath or even a running hot water supply.

D. Supplementary Rations.

Since the introduction of tea and sugar rationing, each sewerman has been able to purchase through the Highways Department six ounces of tea and eight ounces of sugar every eight weeks as a supplement to his ordinary ration of these commodities. Entitlement to a supplementary ration of cheese similar to that given to certain agricultural workers was established but few sewermen made use of this facility. It is possible that insufficient publicity may be the reason for the poor demand for this additional source of protein.

E. First Aid Facilities.

On each squad barrow there is carried a small First-Aid Box, containing bandages, cotton wool, adhesive plaster, eye lotion, throat gargle and antiseptic. A supply of disinfectant is provided to each squad. No departmental training has been given to these men on First Aid though several of them have had courses of instruction in the Services or in Civil Defence Organisations.

Sewermen in a squad quickly become well acquainted with the localities in which they are working, and, as a result, they are aware of the location of Hospitals, Clinics, Doctors' Surgeries, Police Stations and premises of other Corporation Departments whereat medical assistance may be obtained.

F. Rescue Apparatus.

Respirators and air lines are maintained at the College Street Depot. When work is being carried out in a sewer where gas is likely to cause difficulties, the respirators are kept ready for use. Ropes, hooks and a winch, being part of each squad's equipment, are always available for rescue purposes. No special stretcher gear is available.

G. Detection of Gas and its Dispersal.

In routine work the men rely on their cap lamps for the detection of gas. In Black Damp the flame is seen to become smaller, or go out completely, and the necessary withdrawal made. In the inspection of break-downs a safety lamp is lowered into the manhole and the behaviour of the flame used to indicate the presence of methane, carbon monoxide or other irrespirable gas. Most reliance, however, is placed on the opinion of the first man to inspect the bottom of the manhole and its precincts. While many of the sewermen state that they have lost their sense of smell, someone in the squad appears to be able to detect large concentrations of dangerous gases, such as hydrogen sulphide or petroleum fumes. After a quick inspection, the sewerman returns to the surface and two or more manholes are opened to aid ventilation of the section of the sewer in which work is to be done. Where gas is found to be present a petrol-driven fan is available which can be fitted over one manhole to draw out foul air while fresh air enters through adjacent manholes opened for this purpose. While work is in progress underground, an effort is thus made to maintain a supply of fresh air at the working site.

It should also be mentioned that when work is undertaken in a "gassy" sewer the working routine of the team is modified so that the spells underground are shorter and rest periods on the surface are more frequent. In a major breakdown, several teams will work in relays so that the repairs are completed as quickly as possible with the minimum of risk to the sewermen.

Chapter VI.

THE HEALTH HAZARDS OF GLASGOW SEWERMEN AS REVEALED IN RECORDS OF CERTIFIED SICKNESS ABSENCE, ACCIDENTS & DEATHS.

Sources of Information.

The statistics in this Chapter are based on information obtained from the following sources:-

(1) Official Records of the Highways Department.
(2) Interviews with Sewermen.
(3) Records of General Practitioners attending sewermen.
(4) Conversations with the City Engineer, Chief Inspector of Sewers, and the Sewerage Section Foreman.
(5) Records of District Registrars.
(6) Hospital Records.
(7) Records of the Health and Welfare Department.

Sickness Absence (Tables Nos. 10, 11 and 12).

During the five years 1945 to 1950, 445 weeks of working time were lost as the result of 47 periods of absence involving 29 sewermen. This represents four per cent. of the possible total man-hours worked by the Sewerage Section or an average annual sickness absence of two weeks per sewerman employed. These figures do not appear to be unduly high.

Further analysis, however, reveals that annually 20 to 25 per cent. of the sewermen were subject to periods of sickness absence each on the average of nine weeks' duration, indicating that the illnesses of sewermen are of a severity greater than is inferred by the sickness absence rate of four per cent. referred to above.

Causation of Sickness Absence (Table No. 13).

1. Disorders of the Alimentary Tract:

(a) Gastro-enteritis. In two sewermen this illness caused absence of three and six weeks respectively. It was noted that both men had accidentally swallowed sewage while at work, 12 to 24 hours prior to the onset of symptoms.

(b) Gastritis. This term appears to have been applied to a group of symptoms variously described by the sewermen as "indigestion", "heart-burn", "acid belching" or even "water brash". Upper abdominal pain or discomfort was associated with nausea and vomiting after meals, flatulence and the regurgitation of acid stomach contents into the mouth. Throughout this report the term "gastritis" is used to indicate this syndrome. Between 1945 and 1950, two cases resulted in losses of working time of nine and six weeks respectively. In one, there was a history of symptoms prior to employment as a sewerman. A third sewerman was absent for 14 weeks on account of gastritis and appendicitis. He states that he had two distinct illnesses and attributed the gastritis to work in a particular group of sewers.

(c) Herniotomy. One sewerman was absent for 12 weeks, during which he had an inguinal herniotomy performed. He maintains that his hernia was caused by his work in the sewers.

(d) Peptic Ulcer. Two cases of perforation occurred between 1945 and 1950, one proving fatal after only three weeks' illness. The other sewermen was off work continuously for 60 weeks during 1949 and 1950. He had two prolonged absences prior to 1945 caused by peptic ulceration. Two months after his return to work in 1950, recurrence of symptoms necessitated his removal to hospital for surgical treatment.

Discussion.

Work in the sewers involves a routine, antagonistic to the accepted regime prescribed for the control of peptic ulceration. It is difficult to decide, however, whether this ailment could be considered as attributable to employment. From time to time men working together in the same sewer have gone off work with symptoms of gastritis. Indeed, eight of the present sewermen have suffered from this condition. At least two others are known to have suffered from duodenal ulceration, while there are records of two former employees having died from carcinoma of the bowel prior to the normal retiral age of 65 years.

The evidence suggests that disorders of the upper digestive tract may be attributable to employment and that aggravation of established cases can result from working in the sewers.

2. Disorders of the Genito-Urinary System:

Between 1945 and 1950 two sewermen suffered from cystitis diagnosed in hospital as due to infection with B.coli. An ascending infection by way of the urethra could have arisen during the act of micturition in the sewers - a practice common among sewermen.

3. Infectious Diseases:

(a) Leptospirosis - Infection with the L.ictero-haemorrhagiae is discussed in Chapter VII.

(b) Other Infectious Diseases - One case of infective paratitis was recorded between 1945 and 1950. The absence of cases of typhoid fever and poliomyelitis from the records of sickness of sewermen seems surprising since sewage is recognised as a dangerous source of both infections.

4. Nervous Disorders:

In 1946 one sewerman was certified as having suffered from a "nervous breakdown", his absence lasting 30 weeks. Another man was diagnosed in hospital as a case of encephalitis and was absent for 40 weeks between 1949 and 1950 (see clinical notes of Case No.2 in Appendix).

5. Respiratory Diseases:

Influenza, coryza and bronchitis are the main respiratory infections producing incapacity among sewermen. The average period of absence due to these causes was three to six weeks per case in the five years under review. Six men were affected, one being off on two occasions. In the years prior to 1945, the records show that several sewermen had suffered from pneumonia.

Both underground and on the surface, sewermen are subject to severe soakings. Underground, the clothes may be splashed in negotiating junctions with branch sewers or house drains, or again the wetting may occur during the flushing of pipe sewers. On the surface, sewermen are exposed to rain in common with other outdoor workers. Again, because of the conditions of heat and humidity in many of the sewers, underwear becomes soaked with perspiration, and the sewermen, lacking an immediate change of clothing, are liable to catch chills on return to the surface, especially during the winter months.

Furthermore, it is the custom among sewermen to "carry" any member of a squad who is suffering from a minor ailment, such as a "cold". This suggests that the incidence of the less serious respiratory diseases is probably higher than is indicated in the records quoted above.

6. Rheumatic Conditions:

From 1945 to 1950, incapacity certified as due to rheumatic conditions included the following:-

Condition	Number of Men affected	Number of Weeks Unfit for Work
Sciatica	6	18, 16, 4, 4, 3, 1.
Fibrositis	4	10, 7, 3, 1.
Muscular Rheumatism	3	6, 6, 4.
Lumbar Strain & Myositis	2	9, 2.
Lumbago	1	3.
Arthritis	1	2.

These illnesses can be grouped thus:-

(a) Sciatica.
(b) Muscular rheumatism.
(c) Arthritis.

The sewerman's conditions of work, by subjecting various parts of the body to dampness and multiple minor traumata, predispose to the rheumatic complex. Further reference is made to this subject in Chapter IX.

7. Skin Diseases.

The illnesses referred to in Tables No. 12 and 13 include impetigo, skin sepsis and dermatitis.

Impetigo is usually considered to be a disease resulting from dirty habits, but reflection on the working environment of the sewerman, and his lack of adequate washing facilities at work, suggests that the condition could be contracted in the course of his employment.

Skin sepsis is frequently occupational in origin among sewermen. The loss of time due to this condition is exceedingly low, due, no doubt, to the fact that men with septic lesions have continued at work.

The case of dermatitis was reported to be industrial in origin and review of earlier records confirms that this disease occurs from time to time among sewermen.

Accidents among Glasgow Sewermen.

Accidents to sewermen can be listed under two main headings, namely, (a) Injuries; and (b) Gassing.

(a) Injuries: Between 1929 and 1950, seven sewermen sustained injury at work. There were two injuries due to the men falling in the sewer; two due to falling objects - one a crush injury to the testes from which there developed a hydrocoele, and the other a blow on the head from a brick dislodged from the side of a manway; two from a street accident in which a motor vehicle struck the portable shelter in which a night-shift squad were having a meal - one sewerman sustained a fractured pelvis and the other bruising of his back; and one where the sewerman was washed through a sewer during a sudden storm.

Although the potential danger of injury from falling objects, falls in sewers and crushes is great, it has been found that few major disabilities have been sustained by sewermen from these sources. Minor abrasions resulting from work in small sewers are common, but the sewermen do not stay off work on that account. Road accidents, however, must be considered as an occupational risk of sewermen, since most manholes are located in the centre of the highway.

That drowning, a grave danger in sewerwork, has claimed no victims in times of storm seems surprising. A more insidious form of this hazard is becoming more and more possible, however, in sewers where undermining of the floor has occurred. During the examination and repair of breakdowns in certain brick sewers the undermined floor may suddenly fracture and the sewerman fall into the crater. In 1939, four sewermen were trapped in the Major Street sewer by such an occurrence, the hole being twelve feet deep and containing sewage to a depth of eight feet. Rescue attempts were immediately initiated but several hours elapsed before the men were brought to safety. While no injuries resulted from this incident, the Major Street breakdown was associated with three cases of Leptospirosis.

(b) Gassing: Between 1930 and 1950, seven gassing accidents have occurred in the Glasgow sewers. Twelve men recovered and two died from the exposure. (See Appendix)

Other less serious gassing incidents have been reported from time to time. On return to fresh air, however, the "casualties" recovered. In most instances, symptoms of headache and breathlessness were first noticed. Carbon monoxide, carbon dioxide, methane and hydrogen sulphide, produced in the decomposition of sewage, can be found in certain sewers. Black Damp is present in many ill-ventilated ends of branch-sewers, its presence being detected by the reduction in size of flame in the sewerman's cap-lamp - in heavy concentrations the flame is extinguished.

Interaction of trade wastes, however, may produce dangerous concentrations of other irrespirable gases, such as ammonia, chlorine and cyanide of hydrogen.

Deaths of Sewermen.

Table No. 14 lists the known causes of death of active sewermen between 1935 and 1950. All of these men died before the normal retiral age of 65 years. It is seen that Weil's Disease took a heavier toll than any of the other causes. Ten deaths were unquestionably related to employment, namely, those due to Weil's Disease and gassing. It is possible that those due to heart disease and lobar pneumonia may have had a similar aetiology or at least have been materially aggravated by employment in the sewers.

Chapter VII.

LEPTOSPIROSIS IN GLASGOW SEWERMEN.

Of the occupational risks associated with the job of sewerman most information has been recorded on the specific infection known as Weil's Disease. It seems fitting, therefore, to examine the incidence of this disease among Glasgow sewermen and compare their experience of the infection with the results of other investigations.

Historical Introduction.

Although the first record of an outbreak of jaundice in epidemic form was made by Cleghorn in 1745 in Minorca, it was not until 1886 that Weil gave the classical description of four cases showing fever, jaundice, enlargement of liver and spleen, the occurrence of haemorrhages, and occasionally febrile relapses, to which his name has been attached. The isolation of the causal organism, the leptospira icterohaemorrhagiae by Inada and Ino in 1914, and the development of the serum-agglutination test by Schuffner in the early 1930's have contributed greatly to the accuracy of diagnosis of the disease and to the study of its epidemiology and aetiology. It is now well known that infection with the leptospira need not result in jaundice and hence the term leptospirosis is to be preferred to Weil's Disease or infective jaundice.

Aetiology.

The disease is common in rats and other small rodents, and these animals act as vectors in the transmission of the infection to man, the organism being excreted in the rat urine. Human outbreaks are attributed to contamination of wounds and abrasions with infected material, although cases are recorded where the organism is considered to have gained entry to the human body through unbroken tissue, such as the conjunctiva.

Incidence.

The disease has long been known in Japan and the Dutch East Indies where it is endemic. The infection takes a severe form, case mortality rates of 40% being recorded. Other reports show that the infection occurs in both the Old World and in the New World. In Holland, for instance, 852 cases were recorded between 1924 and 1938, there being a case mortality of 10.2%. Only 22% of the cases were attributable to occupations, bargemen ranking highest in the list of occupations affected.

Table No. 15 shows the occupational distribution of cases found by several investigators in different areas. In each series, sewermen show a relatively high incidence of the infection. Local factors, however, play a great part in the distribution of occupational incidence in this disease. In Aberdeen, for example, where the major industry is fish-handling, the disease is prevalent in fish workers; in Holland, bargemen; in mining areas, miners.

In Britain, the disease was unknown until 1922 when

Manson-Bahr diagnosed the infection in a seaman who had been immersed in the Thames four days previously. There followed in 1923 the description by Gulland and Buchanan of an outbreak of Weil's Disease among miners in East Lothian, later investigations confirming the presence of infected rats in the mines concerned. The year 1934 brought forth two reports of the disease, Davidson and his co-workers describing 18 cases among fish-workers in Aberdeen, and Hamilton Fairley's record of a fatal case in a London sewer worker. The latter investigator revealed an extensive, yet hitherto unknown, focus of Weil's Disease in London by recording his findings of eight positive reactors to the Schuffner Test on serological examination of the sewermen in that city. Alston, who followed up this investigation, reported the following year that five more cases of Leptospirosis had occurred among the sewer workers, one proving fatal. He also was able to isolate leptospirae icterohaemorrhagiae from slime and rats in the London sewers.

Incidence in Glasgow.

On investigation of the records of the Health and Welfare Department in Glasgow, some 46 confirmed cases of Leptospirosis were found. As will be shown later, these do not comprise the full incidence of the disease in the city. Glasgow constitutes the main hospital centre for Central and West Scotland. Thus, Table No. 15 includes cases notified to the Department from city hospitals, although in some of them the source of infection was beyond the city boundary. Between

1926 and 1949, 44 males and 2 females were found to be infected with the leptospira ictero-haemorrhagiae. The occupations and circumstances of infection for each patient are shown in Table No. 16.

There were six deaths in the series, giving a case-mortality rate of 13.0%.

Tables Nos. 17 and 18 show the age distribution and the seasonal distribution of the cases.

These figures correspond fairly closely with the findings of Styles and Sawyer in their survey of Leptospirosis in North America. There appears to be a general scatter of cases throughout each month with a significant rise in the summer-autumn period. While it is true that bathing is more popular during that season, this source of infection only accounts for four of the Glasgow cases and so cannot be held to explain the increase in the number of cases during these months. Smith, in a review of 214 cases of Weil's Disease occurring in the North-East of Scotland between 1934 and 1948, noted a similar rise in incidence in the month of September and suggested that it may have some relationship to the suitability of atmospheric temperatures for the survival of the leptospira, or that it may be connected with biological changes in the rat population.

<u>Leptospirosis in Glasgow Sewermen</u>.

Of the nine cases referred to in Table No. 16, seven of the sewermen were employed in Glasgow. All of these patients were treated in hospital. Serological investigations conducted by Stuart in 36 sewermen in 1938 revealed six positive reactors to the Schuffner Test, while the late Dr. Thomas McGowan of the Glasgow Public Health Department established that three sewermen had died from the disease in the preceding three years (1935 to 1937). These investigations were the first to be reported in British sewermen outside of London after Hamilton Fairley's exposure of the incidence among London sewer-workers in 1934. Further serological investigation by means of Schuffner testing carried out between 1948 and 1950 have brought to light further cases. By means of careful history taking, reference to hospital case-sheets, discussion of cases with private practitioners, analyses of medical certificates and death certificates supplied in accordance with the Corporation's Superannuation and Sick Pay Schemes, and correlation with the serological findings it has been possible to locate a further 21 cases in addition to the seven mentioned above as being included in the notified cases in Glasgow between 1926 and 1949. In all, therefore, some 28 cases of Leptospirosis have been established as having occurred among Glasgow sewer-workers, 23 of them since the beginning of 1935.

The disease appears to have been known to sewermen for a long number of years, the Glasgow name being "black jaundice". Certain sewers were considered to be more dangerous than others, but, though it was noticed that rats were prevalent in these particular sewers, they attributed the illness to a form of sewer gas poisoning. Clinical diagnosis of Weil's Disease among sewermen in Glasgow, however, was not established until 1937. Retrospective serological diagnosis, however, was made in six cases and Stuart traced the earliest confirmed infection back to an illness of a sewerman in 1910, Some of the older sewermen have been able to describe fatal illnesses among their colleagues of the pre-1935 period, and it would seem reasonable to establish a diagnosis of Weil's Disease in many of these cases.

Table No. 19 gives a list of cases among the sewermen in which the diagnosis has been established.

In this series there were eight fatal cases, giving a mortality rate of 28.6%.

From Table No. 19 it is to be noted that the four oldest patients died, but the other fatal cases were aged 34, 46 and 51 respectively. It is seen that the disease affected men in each age group and men in various stages of their service in the sewers. At one time it was thought that a certain degree of immunity could be acquired over a number of years' exposure, but it is evident that this does not occur in an occupation where some employees have contracted the disease after over 20 years' service. In two instances, risk was limited to less than one year.

The monthly and yearly distribution of these cases is shown in Table No. 20.

It is seen that the incidence of Leptospirosis follows the general seasonal rise in September and October found in other trades. Conditions of work alone cannot be held to be responsible, though in one instance three cases arose from work in one particular sewer during a period of four weeks in July-August, 1939. This sewer is located close to the Cattle Market and is known to be infested with rats.

Sources of Infection.

On analysis of the places of work presumed to be the sources of infection it is found that they are all sewers known to be rat-infested and located in the older parts of the city. Two main centres of infection lie in Calton and Kinning Park respectively, the particular sewers at fault being of the brick or stone type. Hence the disease is found to be more prevalent among that group of workers employed in brick sewers.

Stuart and others have suggested that the danger of infection is greatest where men are engaged in the cleaning or repair of storm-water overflows as these give suitable facilities for the rats to breed and nest because of the intermittent water flow. While it is true that rat-runs are not found in sewers where there is a heavy flow, there are many where the flow is not so great and where there are disused branches. It would seem that sewermen in Glasgow derived their infection from work in the latter group of sewers, and that this explains the localisation of the disease sources to the older parts of the city. Furthermore, the frequency with which "breakdowns" occur in these older sewers greatly increases the risk and hence the incidence of the disease.

Incidence of Leptospirosis among Present Group of Sewermen.

Tables Nos. 19 and 20 refer to the number of cases of the disease which are known to have occurred among sewermen in Glasgow. It is not possible to establish the case rate per total population of sewermen, as the total number of men who have been employed as sewermen between 1910 and 1950 cannot be ascertained from the method of record-keeping adopted by the Statute Labour Department of the Corporation. Furthermore, it is only since 1937 that accurate diagnosis of the disease among these men has been possible. It is significant, however, that 14 (30.4%) of the 45 men in this employment in February, 1950, showed evidence of having suffered from infection with the leptospira ictero-haemorrhagiae.

Table No. 21 shows the incidence according to the length of service in the job. It demonstrates that the longer a man works in the sewers the more likely he is to contract the disease. Four out of seven men with over 25 years' service have had the disease (that is 57.1%), while, on the other hand, not one of seven men with under five years' service have so far contracted the infection.

The Schuffner Test and its Significance.

In this test, varying concentrations of the patient's serum are allowed to interact with equal volumes of a formolised suspension (0.5%) of a young culture of leptospira icterohaemorrhagiae for three hours at 32 degrees Centigrade. Drops of the varying dilutions are examined by dark-ground illumination after incubation. In a positive result, clumping of the organisms with loss of motility is seen.

Several workers have carried out controlled experiments with this test and have found that, when properly conducted, a positive result, even in the lowest dilution, signifies previous infection with L. icterohaemorrhagiae. "Normal" sera (such as those submitted for Wasserman tests) fail to give any reaction to the Schuffner Test.

During the acute stages of the illness, a rising titre is noted, positive results ranging up to 1 in 30,000, while in convalescence a positive result is obtained in dilutions of 1 in 300 to 1 in 1,000. At intervals after infection, ranging from a few months up to as long as over 20 years, the test has been found to be positive in serum dilutions of 1 in 30 to 1 in 300. Even at a dilution of 1 in 30, a positive result is held to indicate previous infection.

This test shows the presence of agglutinins in the patient's serum. Alston and Brown (1935) proved in London sewermen that the presence of agglutinins in the serum was an indication of protective antibodies in the serum. Sera which were positive in the agglutination test were found to protect guinea pigs from the effect of injecting virulent L. icterohaemorrhagiae, while sera from the general population, showing no agglutination, did not protect the guinea pigs from the injection of leptospirae.

On the strength of these findings it seems reasonable to assume that sewermen, previously infected and now showing positive sero-agglutination to the leptospira icterohaemorrhagiae, have a certain degree of acquired immunity to further infection with the same organism.

Results of Schuffner Tests on Glasgow Sewermen at present Employed.

Table No. 22 shows the agglutination titres of the 14 men referred to above, in whom previous infection with L. ictero-haemorrhagiae has been established.

Origin of Infection in Glasgow Sewermen.

As already described, limitation of space in sewers brings all parts of the sewerman's body into close proximity with the materials in the sewers. While the feet, legs and thighs are protected by rubber thigh boots or waders and the body is clothed, the face, forearms and hands are exposed. In small sewers, abrasions of forearms, hands and shoulders readily occur and are easily contaminated with slime from the walls. In addition, however, frequent splashes on to the face, mouth and eyes occur during work under these conditions.

In the larger sewers abrasions are less frequent but there is usually a greater depth of water and splashes of mud and slime still occur. It is not uncommon for an employee to slip at work and so become immersed in sewage. Ingestion of infected material is thus a possibility.

In view of the above observations, it is reasonable to assume, therefore, that the infection is contracted while actually at work in the sewer. This view has been borne out by at least two experiences in Glasgow where two or more men have developed the disease within a short time of each other while working in the same sewer.

In other trades, men have contracted the disease as a result of contamination of carried meals. This has been suggested by some writers as liable to occur in sewermen. In the case of the Glasgow employees, the usual practice is to wash and disinfect the hands before meals. Many of the workers hold sandwiches in the wrapping paper so that food is not actually touched by their hands. If any infection by way of food did occur, one would favour contamination from the hands of the individual rather than by direct contact between food and rats. There would appear to be, however, sufficient opportunity in the course of actual employment for the infection to gain access to the body, though the men are encouraged to make full use of disinfectants which are supplied.

Methods of Prevention in Use since 1937.

Largely as a result of investigations carried out by the late Dr. Thomas McGowan of the Glasgow Public Health Department, the following measures were introduced in an endeavour to control the incidence of Leptospirosis in Glasgow sewermen:-

(1) Rat Control. In consultation with the Rodent Control Section of the Department of Agriculture a policy of rat extermination was started in the sewers. Gassing was considered to be too dangerous to human life to be attempted in the sewers. Trapping also was not a practical proposition. Accordingly, the method employed was that of poisoned bait. Small platforms were erected at the base of certain manholes and known quantities of food were placed thereon by the rodent control officers. On inspection after several hours, the number of rats feeding at each platform was calculated from the amount of food consumed. Sufficient poisoned bait to kill off the number of rats feeding at each platform was laid and a later check made to confirm that it had been removed by the rats. This method is still in use.

This practice is not followed according to any system. There would appear to be little co-ordination with reports from the sewermen as to the presence of rats in any particular sewer. As far as can be ascertained, poison was laid in some sewers but not in others, nor can it be established that heavily infested sewers are re-visited at regular intervals.

(2) Cleansing of Hands before Meals. A supply of white soap and clean rag waste is made available to each squad weekly. At the site of operations a portable shelter is erected on the roadway and on coal braziers, water for washing is kept hot in galvanised pails. Supplies of water are obtained from street hydrants or nearby domestic or factory premises. In one pail a solution of a phenol disinfectant is made up, while in another there is a supply of clean water for rinsing. Washing of the hands is done in a third pail. At each meal-break each man has been instructed to wash his hands and forearms, then disinfect, and finally rinse before drying. The majority of the men do this but a few have been found who avoid the disinfectant. It has been discovered that many of the squads have been using the disinfectant in too strong solutions. Indeed, some of the men have developed skin reaction to carbolic. Arrangements have been made to supply one of the newer disinfectants, the lid of the container being fashioned for use as a measure of the quantity required to produce the correct dilution in a pailful of water.

(3) Education of the Workers. On three occasions during the past twelve years the sewermen have been addressed by doctors from the Public Health Department on the subject of Leptospirosis and its prevention. Special personal cards were issued to each man, a sample of which is shown in the appendix. It was stressed that each man should seek medical advice

immediately on becoming ill and that he should inform his doctor of the nature of his employment.

(4) Letters to General Practitioners. In 1948, letters were sent from the Public Health Department to each sewerman's private practitioner drawing the doctor's attention to the early signs and symptoms of Weil's Disease, the facilities available in Glasgow for bacteriological and agglutination examination of blood, and explaining the special care necessary in establishing the diagnosis in sewermen.

Suggested Improvements in Methods of Prevention.

(1) Intensive and Systematic Rat Control. The existing methods appear to me to be inadequate. Systematic anti-rat treatment of sewers is desirable and should be undertaken in the city by areas. Old sewers and disused branches should be sealed off after deratisation. In known rat-infested sewers some suitable form of trapping might prove more decisive than the present form of poisoning. Each sewer in an area might be dealt with in turn at intervals of three to six months. Any anti-rat campaign in an area of the city organised by the Health Department should be closely co-ordinated with similar work in the sewers.

Each squad of sewermen might have a rat catcher added to its strength or, alternatively, the sewermen might be trained to carry out the anti-rat measures.

Rat-proofing of sewers would appear to lie in the careful maintenance of house and factory drains, matters outwith the control of the Sewage Department, but within the field of operations of the Health Department. Rat-proofing of the entrances of streams to the main drainage system, and storm water outfalls would appear to be the extent of the Sewage Department's responsibilities

(2) Employment of Positive Reactors to the Schuffner Test. The serum of positive reactors to the agglutination test is considered to give some protection to the individual against infection with the leptospira ictero-haemorrhagiae. It is suggested, therefore, that, where a sewer is known to be rat-infested, only men who are Schuffner-positive should be employed therein.

(3) Active Immunisation against L. Ictero-haemorrhagiae. Active immunisation against leptospirosis has not been tried to any great extent either in this country or in the United States of America, though it is commonly practised in Japan where the disease is endemic. It was thought that, if active immunisation could be successfully carried out in Glasgow sewermen, a grave industrial risk could be removed from that group of workers.

Dr. R. D. Stuart, lately Bacteriologist at the Glasgow Royal Infirmary, prepared a formolised vaccine from cultures of L. ictero-haemorrhagiae grown from pathological specimens from a sewerman who died in Glasgow in 1948 as a result of

Weil's Disease. Two subcutaneous inoculations of the vaccine were given to 13 sewermen who volunteered to be vaccinated. Their bloods had previously been found to be negative to the Schuffner Test. The interval between injections was four weeks. Six weeks after the second injection, sera from these men were subjected to agglutination tests against L. icterohaemorrhagiae. It was found that positive reactions were obtained in each case in dilutions of 1 in 30 to 1 in 60. It is considered that a third injection of vaccine after an interval of 12 to 18 months might produce positive serum reactions to the Schuffner Test in dilutions of 1 in 100. If this is achieved, it is presumed that sufficient antibodies will have been produced in each of these sewermen to protect at least against a fatal infection with the leptospira. Animal experiments have shown that protection was given after injection of Stuart's vaccine.

No great significance is attached to the fact that one year has passed and no case of the disease has occurred among this group of sewermen. If the latter statement can be made, say, in 10 or 15 years' time, then it would seem reasonable to claim that Stuart's vaccine was the answer to this problem.

(4) Limitation in the Use of Sewermen. As in other fields, where the problem of toxic hazards arise, it is suggested that by exploration of the avenues of engineering science it might be possible to evolve a mechanical method of sewer cleansing and thereby reduce to a minimum the exposure of human life to

the dangers of leptospiral infection.

(5) Close Supervision of Sewermen by the Health Department. As part of an occupational health service for this group of workers, it is essential that, immediately on the absence due to illness of a sewerman, he be visited at home by an industrial medical officer from the Health Department and the clinical case and the diagnosis discussed with the private practitioner. In each suspicious case, blood agglutination tests should be done as early as possible. It is for this reason that one emphasises that the Health Department Medical Officer who has shared the experience of work in the sewers and who is acutely aware of the possibility of Weil's Disease, should see each sick sewerman as early as possible in the illness. While it is admitted that penicillin has revolutionised the treatment of Leptospirosis, its exhibition can only be successful once the diagnosis has been established and only when given early in the disease.

Workmen's Compensation and Weil's Disease.

The famous case of Raeburn v. Lochgelly Iron and Steel Company, Ltd., in 1925, established a precedent in Britain whereby compensation was awarded for the death of a coal worker who had a leptospiral infection. In 1935, the Departmental Committee on Compensation for Industrial Diseases recommended that infection by L. ictero-haemorrhagiae should entitle a workman to compensation for disablement, but only if confirmed by bacteriological or serological examination. Several court cases are recorded where compensation was paid for infection gained in the course of employment in sewers.

In Glasgow, it has been the custom to pay sewermen full wages during absence due to illness or injury directly attributable to the nature of the employment. For this purpose the patient is visited by a Medical Officer from the Health Department and the necessary certificate forwarded to the office of Public Works. Leptospirosis is included in the list of conditions for which Sick Pay is paid.

The advent of the National Insurance (Industrial Injuries) Act in July, 1948, has, in practice, made no material alteration to the compensation side of this disease as far as the Glasgow Sewermen are concerned.

Chapter VIII.

THE RESULTS OF MEDICAL EXAMINATIONS.

A. General Examination.

Within the same age group little difference existed between the sewermen and the controls. The sewermen generally had paler complexions and were heavier. In the older men, the chest expansion was slightly greater in sewermen than in the control group. A feature of the general examination was the highly developed musculature of arms and forearms in sewermen, also found in some of the controls, for example, in refuse carriers.

B. Cardiovascular System (Table 26).

(a) Clinical Examination.

The quality of heart sounds of several sewermen was found to be poorer than in the controls of the same age. During exercise tolerance tests 50% of the sewermen developed breathlessness in some degree, more pronounced in the older men, and present in all age groups over 35 years. In 13 men this test was poor, the pulse taking longer than 50 seconds to return to the resting rate after cessation of exercise. Only one sewerman had lung disease sufficient to explain his breathlessness after exertion. Nine of the 61 controls aged over 30 years became breathless during the test, the pulses of seven men taking more than 50 seconds to return to the resting rate. Three of those men suffered from hypertension, while another two controls had lung disease which could account for their breathlessness on exertion.

All of the sewermen giving a poor response to the test were over the age of 45 years (Table No. 27). Length of service appeared to have an adverse effect on the exercise tolerance of sewermen, the x^2-test showing that the results in Table No. 28 were not likely to have occurred merely by chance.

On the basis that blood pressure readings over 160 mms. mercury (systolic) and 100 or over (diastolic) are abnormal, five sewermen were found to have hypertension. While they were all over the age of 50 years, it seems significant that their service in the sewers was long. Each of the three controls with hypertension had been forced to seek less arduous employment because of heart disease.

(b) <u>Blood Examinations</u>.

A pilot survey of specimens from 16 sewermen revealed an unduly high proportion of haemoglobin levels in excess of 14.8 gms. per cent. In the absence of abnormalities in the other blood components, it was decided to restrict blood examination of the full series to total red cell counts and haemoglobin estimations (Table No. 29).

(i) <u>Haemoglobin Levels</u>. The percentage distribution of the haemoglobin levels of sewermen and the control group are shown, in Chart No. 2, in relation to those of married males in Britain investigated in the Medical Research Council's

Survey during 1943. The figures in the 1943 survey cover age-groups from 18 to over 60 years and include members from all of the social classes defined by the Registrar-General.

The curve of the control group (Chart No.2) follows the trend of the M.R.C. study except that its mean is 85% compared with the 102% (Haldane Scale) of the 1943 investigation. The values of the percentage frequency distribution of haemoglobin levels in Glasgow sewermen, however, give a flattened curve which rises to a peak beyond the 110 mark (mean 95.3).

On comparing the control group with the M.R.C. Survey, the difference between their mean haemoglobin levels is 17 times their standard error of difference (Table No. 30). Similarly, there is a significant difference between the mean for sewermen and the M.R.C. Survey (married males), the difference of means being more than twice their standard error of difference. It is felt, however, that greater importance is attached to the finding that the mean haemoglobin level of sewermen is significantly greater than that of the control group, the difference in means being four times their standard error of difference.

(ii) Red Cell Counts. On comparison of the frequency distribution of red cell counts in sewermen and the control group (Table No. 31 and Chart No. 3), the difference between their means is greater than twice their standard error of difference. This suggests that the differences between the two series are unlikely to have occurred by chance. Also, there is a close correlation between the haemoglobin level and the red cell count in sewermen, the correlation coefficient being in the region of 0.8.

These are the results only of the blood examination carried out at the time of the first medical examination of each sewerman. The bloods of sewermen show higher levels of haemoglobin than those of the control group, yet their mean is lower than that of the general population (it being assumed that the 1944 M.R.C. Report still applies to the nation). In Chart No. 2 the graph for sewermen tends to be assymmetrical, suggesting perhaps that the population reviewed is not homogenious in respect of haemoglobin. Repetition of the blood examination on these men whose haemoglobin levels were high showed, in some instances, a fall, while others remained high or were raised.

Serial blood examinations were made on 14 volunteers from the sewermen, some offering blood more frequently than others. The material was obtained about one hour after cessation of work from both day- and night-shift employees, except for the consecutive specimens given by 13 of these men on the day they stopped work for their annual holiday and again three weeks' later, immediately prior to resuming work (Table No. 32) (Chart No. 4).

In nine instances there was a rise in the haemoglobin level during the three weeks' holiday, while in four cases there was a fall. One sewerman (Case No. 22) was off work for five weeks suffering from sciatica, during which time there was a rise in his haemoglobin level from 10 to 12 grams per cent. Usually a change from one sewer to another altered the general trend of the haemoglobin level.

Three men (Cases No. 1, 11 and 26) worked together on night-shift and their haemoglobin levels followed roughly the same trend. Case No. 1 did most of his work at the top of the manhole operating the winch during the major part of this period of review. Because of his age and length of service, his mates considered him unfit for the heavy work down below and so "carried" him on the surface, an extra man being available to this squad. During the course of his work in the vicinity of the manhole he inhaled a considerable amount of sewer gas.

Nine sewermen (Cases 1, 7, 11, 18, 22, 26, 32, 33 and 41) worked in brick sewers, while three (Cases 10, 29 and 35) worked in pipe sewers during this period of 45 weeks. Two sewermen (Cases 8 and 30) worked for the first part of the period in pipe sewers, but during the latter part they were transferred to the emergency squad and employed in various brick sewers. From the 8th to the 29th week, Case No. 8 had only intermittent entries into the sewers as he was being given work involving limitation of strain on his back and knees, while receiving physiotherapy at a hospital out-patient department. Thereafter he returned to the normal work of the emergency squad. Case No. 30 joined the emergency squad in the 35th week of the period. Cases 22 and 26 exchanged shifts in the 29th week.

Without exception, there was a rise in haemoglobin and red cell counts on return to the sewers after an absence. The haemoglobin rose to a level in the region of 16 grams. per cent. and then started to fall. In some instances, it remained high for several weeks, but in one case (No. 33) it fell to a level below that found at the post-holiday examination.

Discussion.

The above series of readings show just how variable can be the findings on the examination of the haemoglobin and red cell counts in sewermen. Undoubtedly, owing to the difficulties involved in obtaining blood samples from these men, many additional variations have been missed, but it is felt that there is sufficient evidence to justify the statement that these results indicate deviations from what may be termed the ordinary fluctuations in the blood components associated with health and work in a healthy environment.

Whitby and Britton (1946) quote the adult limits of normality as 13.8 to 17 grams haemoglobin per 100 millilitres and 4.2 to 5.4 millions red cells per cubic millimetre of blood. In males, the average normal figures are considered to be 15.6

grams haemoglobin per cent. and 5.5 millions red cells per cubic millimetre of blood. Various workers have shown that there is a diurnal variation in the haemoglobin level of over 10%, the minimal variation occurring between the hours of 5 and 7 p.m. In addition, there is a small reduction in the haemoglobin level in old age, the average value in males between the ages of 60 and 104 years being 14.3 grams per cent. (Miller 1939 quoted by Whitby and Britton). The 1943 M.R.C. survey records that there was a slight fall in the mean haemoglobin level of males over the age of 50 years.

Physiological factors having an influence on haemoglobin levels are -

(1) Intake of haemopoietic principles, namely, iron, vitamin C, protein, anti-pernicious anaemia factor, bile, pigments and traces of metals other than iron.

(2) Absorption of haemopoietic principles, for example, deficient absorption due to achlorhydria, dietetic excess of phytic acid.

(3) Increased demands for haemopoietic principles, such as external blood loss, pregnancy, rapid growth.

(4) Changes in plasma volume due to -

(a) exercise;
(b) changes of temperature;
(c) change of posture; and
(d) pregnancy.

In the control group the haemoglobin levels were materially below those found in the M.R.C. survey. Factors (2), (3) and (4)(d) can be excluded in their case. Because of the dietetic habits of the lower social classes in the Glasgow area, it is suggested that the lowering of the mean haemoglobin level in this group is due to lack of iron in the diet with protein intake on the low side. Previous experience in the examination of bloods of operatives in a weaving mill in the east-end of the city (where a high incidence of iron deficiency anaemia was found among the females) confirms that, in the families of social classes 4 and 5 in Glasgow, low intake of iron manifests itself as anaemia in the females and as lowered haemoglobin levels in the males. Only in a few instances among the control group were there found blood films showing gross changes of iron deficiency anaemia.

Blood examinations on five sewermen immediately before they resumed work after sickness absence revealed that their haemoglobin levels were close to the mean of the control group. During the period of this investigation there were five entrants to the job of sewerman, and serial blood examinations (including one before employment) showed changes similar to those occurring in sewermen of several years' experience (Chart No. 5). A further indication of the true base level of haemoglobin among sewermen was given by the results of the examination at the end of the annual holiday. The mean value of the 14 men examined then was 12.7 grams per cent. (85% Haldane scale), that is, the same as the mean level for the control group.

Thus, it seems reasonable to deduce that, basically, sewermen belonged to the same haemoglobin group as the series of controls, and that the conditions of work were responsible for the wide variations in haemoglobin levels observed in sewermen.

In the M.R.C. survey, there appeared to be a relationship between the mean haemoglobin levels and the occupational groups studied, and it was suggested that there is an optimum level for the type of work done. Case (1947) found that, during a course of training, the mean haemoglobin levels of substandard army recruits rose and the scatter round the mean (coefficient of variation) became considerably smaller. This he attributed to a tendency to convergence on a mean value "which is perhaps physiologically more suited to the particular mode of life for which the training was a preparatory process." In sewermen, it is not possible to establish a true value of their mean haemoglobin level on this basis, because (a) they do not work under identical conditions at the same time, and (b) variations in individual levels occur during continuous spells of work in any one sewer.

Physiological factors influencing haemoglobin levels in sewermen may be those producing haemo-concentration, namely, (a) exercise, (b) changes of temperature, and (c) change of posture. It is accepted that these factors have only a temporary effect on haemo-concentration, and, since each man had his blood examined after a period of complete rest, it seems unlikely that any of them are responsible for the changes noted above.

C. Conditions of the Lungs.

Only three men had physical signs of chest disease at the clinical examinations, while a further three showed radiological deviations from normality. These included four cases of pulmonary tuberculosis (one early, one chronic and two healed), one case of chronic bronchitis and one case of pneumonia. Clinical notes on these sewermen are included in the appendix.

Among the control group were found eleven cases with radiological defects of the lungs, clinical signs and symptoms being noted in seven. (Table No. 33).

The total incidence of chest conditions appeared to be very similar in the two groups, sewermen and controls. (Table No. 34).

D. Abdominal Defects. (Table No. 35)

The most significant feature was the large number of cases of indigestion among the sewermen. Their main complaint was the eructation of gas and acid fluid into the mouth - "heart-burn". Other symptoms were a feeling of fulness in the abdomen, the passage of flatus, and, in several instances, pain in the hypochondrium.

Case No. 42 had a history of peptic ulceration, while Cases No. 27 and 37 had been off work on account of gastritis. These three men had vague discomfort on palpation of the upper abdomen. Upper abdominal pain came on half-an-hour after most meals and was relieved by taking food. Only Case No. 42 had radiological evidence of ulceration.

Three men in one night-shift squad (Cases No. 11, 36 and 38) complained of heartburn especially in the morning following upper abdominal pain which started about midnight. Two of the men did not smoke nor drink alcohol. Frequently they were actively sick. All stated that their symptoms seemed to vary according to the sewer in which they were working. They named certain sewers where the stomach condition became worse, and mentioned that symptoms improved after transferring to work in another sewer.

Five sewermen (Nos. 6, 13, 15, 21 and 31) complained of occasional attacks of indigestion lasting from three to six weeks, sometimes of such severity as to necessitate absence from work for a few days. Each of these men was observed eructating gas and fluid into the mouth during their interviews. Two ate little meat because they thought that it aggravated their symptoms.

Three men in each group (sewermen and controls) were classified as corpulent, while a further six sewermen and five controls had slight protuberance of the abdomen due to weakness of the muscles of the abdominal wall. Each of the men with slight protuberance of the abdomen was over the age of 50 years and their appearance could be termed "middle-age spread". Of the six men classified as corpulent, all had good abdominal musculature and all were moderate beer drinkers. Visceroptosis of such a degree as to produce symptoms was not present in any of the men.

Factors influencing the production of indigestion may be listed under such headings as dietetic indiscretions, social habits, excessive tobacco and alcohol, irregularity of meals, organic and functional diseases, and, finally, occupational factors involving toxaemia. All except the last-named have an equal influence on the two groups of men under review. Only in the nature of employment do the groups materially differ, and it would appear that factors associated with the working conditions of sewermen must be held to account for the high incidence of digestive complaints among them.

E. Conditions of the Nervous System.

Special attention was paid to sense of balance, activity of reflexes and presence of tremors of the hands in the course of the examinations.

Apart from the two cases outlined in the appendix, the findings in Table No. 36 do not seem to fit in with the signs of any of the commoner neurological conditions. Not all of the cases show the same defects. Certain of the findings might be ascribed to the tension of a medical interview, though a real attempt was made to reduce this factor to a minimum by a lengthy talk with each man before any part of the examination was carried out. In Cases No. 20, 21, 22, 36, 40 and 42 a degree of excitability was present throughout the whole examination; the men were of worrying types and made complaints of frequent headaches and various other minor ailments, two being nail-biters.

In general, the main features of the examination of the nervous system were the large percentage of cases showing loss of abdominal reflexes and also the high incidence of unsteadiness when standing with the heels and toes together, especially when the eyes were closed. Loss of abdominal reflexes (Hutchison, R. and Hunter, D., 1941) is commonly encountered in the elderly, the stout and in pregnant women. In two sewermen and in three members of the control group, one cause of the absence of these reflexes could be the presence of scars of abdominal operations. In three sewermen obesity may be the cause. There remain, however, 13 sewermen where none of the above explanations can be applied.

In view of the numbers showing these defects it was felt that possible explanations might be found in a study of the environment in which the sewermen worked.

F. Conditions of the Eyes.

1. Defective Visual Acuity.

No significant difference in the incidence of poor visual acuity (less than $^{6}/12$ Snellen in the better eye) was found to exist between sewermen and the control group (Table No. 37), nor was any correlation established between the incidence of defective visual acuity and length of service in the sewers.

Two men in the control group had monocular vision, one due to loss of an eye and the other to cataract. Three sewermen had virtual monocular vision in that visual acuity in one eye was less than $^{6}/60$ Snellen, though, in each instance, form perception was present and all could count fingers with the defective eye. One of these men had a marked internal strabismus of the right eye which accounted for his defective vision.

2. Colour Vision.

One sewerman was found to be colour blind (unsafe, that is, red-green blind) on examination with Ishihara Test Types.

3. Conjunctivitis.

Five sewermen and one watchman from the control group had conjunctivitis at the time of the examinations. The lesion in the watchman was acute and of recent origin. One sewerman who suffered from blepharitis had periodic "flare-ups" which produced conjunctivitis.

The other four sewermen (Cases No. 34, 35, 36 and 37) had contracted their eye condition from the specific nature of their employment. Clinical notes on these cases are recorded in the appendix.

4. Nystagmus.

Nystagmus or involuntary oscillatory movements of the eyes were found to be present in four sewermen. In one (Case No. 2) this was one of several signs indicating a cerebellar lesion. Clinical notes on his condition are included in the section on nervous disorders in the appendix.

In the other three instances (Cases No. 4, 19 and 22) there was evidence to support the diagnosis of miner's nystagmus (see appendix).

G. Conditions of the Ears.

With regard to ear conditions the lesions found in the sewermen were similar to those seen at the routine medical examination of entrants to the Corporation's Sick Pay Scheme for Manual Workers. In more than half of the sewermen the tympanic membrane of each ear was clearly visible, while ten had wax in one ear, and, in another eight, vision of both drums was obstructed by coagulated cerumen. In one man the acuity of hearing was reduced because of wax. In Case No. 18, though both drums appeared normal, he could understand only the loudest voice at a distance of three feet. Bone conduction, however, was normal. Sewerman No. 39 had some scarring of the right tympanic membrane without any loss of hearing.

The clinical notes of three men who had active ear infections are included in the appendix.

H. Skin Conditions. (Table No. 38)

(1) Tinea Pedis.

It has been said that, whereas scabies and impetigo were attributable to squalor and dirt, tinea pedis is a disease of the cleanly, spread of the infection being associated with communal bathing arrangements. In the course of medical examinations in the post-war period, it has been common to find many cases of epidermophytosis. In Glasgow it has been our experience to find the infection in two main groups of persons, namely:-

(i) Ex-service personnel from the Second World War; and

(ii) Users of public baths, especially persons whose homes are not fitted with a bath.

The condition appears to be prevalent in all age-groups and in all social classes, though some pre-war writers found a greater incidence in the upper classes, presumably because the habit of bathing was more prevalent among them.

In the present investigation there was a higher incidence of tinea pedis among sewermen (18 cases) than in the control group (24 cases out of 92 men examined). This is probably due to (a) the employment of sewermen calls for more frequent bathing, until recently taken mainly at the Corporation's Public Baths (each sewerman being issued with a free pass), and (b) the wearing of rubber boots for a long period daily (the optimum conditions of heat alkalinity and moisture being created for the survival of the fungus).

(2) Acneiform Rashes.

In the control group five men under 40 showed evidence of acute acne vulgaris, while the sixth - a man of 63 - had extensive scarring of chest and back due to former lesions caused by this skin infection.

Walker and Percival (1939) state that the disease is confined mainly to the period of puberty and adolescence.

After the age of 30 the condition is so rare that the appearance of an eruption simulating acne vulgaris in a person over 30 should cause the examiner to investigate further the medical and occupational history. By so doing, they state, it should be possible to establish the causation of the skin condition as due to the taking of some drug or the exposure of the skin to some irritant, such as tar, paraffin, tin or oil.

Six sewermen (Cases 3, 15, 30, 36, 38 and 39) showed acute lesions similar to those of acne, namely, papules, comedones and redness. The lesions were located on the shoulders and back and on the forearms. On examination of the working clothing of three of these men (Cases 36, 38 and 39) it was found that the shoulder regions were soaked with tarry materials. These had condensed on the roof of a small sewer in which they were working and limitation of space had caused rubbing of the clothing on the tarry roof of the sewer. In the same way, the forearms had become contaminated from rubbing the walls of the sewer.

Cases 30, 15 and 3 had lesions on the face as well as on the forearms, shoulders and back. These men were engaged in the clearing of a blockage in a sewer containing trade waste from a gas works.

Each of these six men stated that they had had no skin lesions prior to following the employment of sewerman. They are all over the age of 30, and they state that the present skin condition started within the previous few months. These facts rule out the diagnosis of acne vulgaris. An occupational source for the condition was found to be present and in two teams of men they all showed skin lesions compatible with the diagnosis of occupational dermatitis due to contact with tar derivatives.

One sewerman, Case No. 2, showed pigmentation, scarring, roughness and irritation of the skin of his forearms. There was patchy hyperkeratosis and thinning of the skin in places. This man had been employed for some 15 years on the road tarring squad of the Highways Department, and during that period he had had frequent splashes of hot tar on his forearms. Of the several others in this group who did show patchy pigmentation and scarring of the forearms, none had had contact with tar outside the sewers.

Control No. 1, a watchman of 66 years of age employed by the Housing Department, was found to have a typical pre-cancerous papilloma on the back of his left hand. His occupational history was as follows:-

> Hand stoker in a gas works for 14 years prior to the first World War; Army 1917-1920; bar attendant 5 years; labourer on railways 5 years; boiler fireman 3 years; building trades labourer 5 years; attendant in public baths 7 years; and watchman 1 year.

He stated that while employed in the gas works he had frequent and considerable contact with tar and that during his employment there he had had "spots on his arms". It seems likely that this contact with tar more than 30 years ago was the factor responsible for the appearance of the wart on his hand just over two years ago.

(3) Oil Dermatitis.

Sewermen, Cases 18, 20, 23 and 37, were found to have a folliculitis and papules on forearms (extensor aspects), buttocks and shoulders. There was erythema and some of the lesions were intermingled with septic abrasions on the forearms. Two of the men (Nos. 23 and 27) stated that the skin condition had been present off and on for a number of years. Their lesions were active at the time of the medical examination and they claimed that a brown scum floating in the sewer in which they were working was causing irritation of the skin of their forearms. Analysis of the scum showed it to be mineral oil.

Cases No. 18 and 20 had more quiescent lesions at the time of the examination, but some months later when transferred to a large sewer near the centre of the city their skin conditions flared up. Case No. 20, aged 52 years, developed an acute phase of his skin condition some eight weeks after transfer to this sewer. His lesions on the extensor aspect of both forearms were erythematopapular in type and several typical comedones were visible. In addition, however, there was a scaliness with vesicle formation and consequent crusting of lesions. On investigation it was established that there were two skin conditions superimposed on one another, namely, oil dermatitis and a dermatitis medicamentosa due to overuse of the carbolic disinfectant supplied to each squad. This sewerman was removed from work in the sewers while he attended at a hospital dermatological unit for treatment.

Only one man in the control series was found to display skin reaction to contact with oil. He was a compressor operator employed by the Housing Department on a building site. (See appendix).

(4) Carbolic Skin Reactions.

Five of the sewermen complained of irritation of the skin of the forearms and backs of the hands, especially after washing. The skin was noted to be dry and scaly and felt rough. No redness was noted at the medical examinations, but on visits to the sewers it was observed that these men had a marked erythema after washing the forearms and hands. They complained of a tingling sensation when the skin was red. It was found that the source of the trouble lay in the disinfectant which was used. A cresol solution was used to bathe the hands after washing, and, in many instances, too strong a mixture was being used with the mistaken idea of preventing infection with the leptospira ictero-haemorrhagiae. The five men referred to above omitted to rinse off the disinfectant before drying the hands. Their skin lesions were, in fact, a dermatitis medicamentosa.

(5) Industrial Dermatitis.

Three sewermen (Nos. 4, 12 and 34) had a dry scaly dermatitis of shins, Case No. 34 having the same condition on the backs of his legs and forearms. Clinical details are given in the appendix.

(6) Psoriasis.

Case No. 33 had a few lesions of psoriasis on the front of both legs. No other skin blemishes were found. This man has only been employed as a sewerman for three years, but it is interesting to find that he has had no skin trouble while engaged in the cleaning of brick sewers.

I. Defects of Joints and Spine.

During the course of the medical examinations it was noted that many of the sewermen gave histories of low backache which they attributed to the nature of their work. Records of their sickness absence confirmed that there was an incidence of "rheumatic" and allied illnesses involving the back. It was deemed necessary, therefore, that every effort should be made to seek clinical evidence of lesions likely to produce symptoms in this region. In a number of cases, lesions in other joints came to light during the course of these investigations. The results of the examinations are shown in Tables Nos. 39 and 40.

The control group is not completely comparable with the sewermen, in that it tends to be weighted with the younger age-groups, for example, it includes ten persons aged 30-35 who showed no defect in the spine. X-ray plates of a further seven younger males were also negative. Thus, out of 70 members of the control population only one congenital abnormality of spine was detected radiologically and this could almost have been done clinically since it was a case of gross kypho-scoliosis of the dorsal region. On the other hand it is interesting to find, by chance, three defects of congenital origin among the X-rays of the sewermen, namely, lumbarisation of the 1st sacral segment; sacralisation of the 5th lumbar vertebra; and spina bifida of the 5th lumbar vertibra.

Certain defects were noted in the spines of both groups of men, and, in view of the age-groups involved, it is not surprising to find that osteo-arthritic changes were prevalent. The incidence of this condition varied from radiological evidence of lipping only, without symptoms, to anterior wedging of the vertibrae, ligamentous calcification and severe limitation of flexion of the spinal column, especially in the older members of the control group. Ankylosing spondylitis, Paget's disease of bone, traumatic distortion of vertebrae and herniation of inter-vertebral disc were other conditions found in the course of the examinations.

It must be stressed that the control group consisted mainly of men engaged, or formerly engaged, in heavy labouring occupations, involving the use of picks and shovels, and entailing the carrying of heavy weights (often on their backs). The postural defects, viz., kyphosis, kypho-scoliosis and scoliosis, were, therefore, largely of occupational origin and affected especially the dorsal spine.

Sewermen, who are normally recruited from the same occupational groups, were not found to have the same incidence of postural defects and their lesions tended to occur mainly in the lumbar spine. It seems most significant that pain and tenderness in the lumbar region with a positive knee-thigh test were found in only two members of the control group, whereas among sewermen these signs were predominant in no less than 14 instances. In ten cases, the men were over the age of 50 years, six of whom had spent more than ten years in the job of sewerman (See Table No. 41).

During the course of the medical examinations one was impressed by the number of sewermen who gave histories of having suffered from "low backache". Fourteen of them were found to have symptoms and signs at the actual time of examination. While only two were confirmed as having herniation of intervertebral discs, another two sewermen were suspected of having sciatic pain due to the same cause, though, in Table No. 41, they are included under the heading of osteo-arthritis because of the gross radiological evidence in their spines.

(1) Osteo-arthritis.

This has been termed by Buckley (1950) as a "wear and tear" arthritis, commonly found after middle life. The condition is progressive, and its effects are considered to be normal findings in old age. Trauma, in minor and repeated form, is a major aetiological factor. Occupation is largely responsible for the location of the lesions and, also, for the degree and extent of disability produced. Normally the condition is present for several years before the patient's symptoms are sufficiently pronounced for him to seek medical advice. Osteo-arthritis of the spine is found to occur in those engaged in heavy manual labouring. Osteophytes develop in the ligaments and by pressure on the nerve roots produce referred pains. Wedging of the vertebrae results in deformity of the spine causing stiffness and limitation of flexion. The condition frequently causes the workman to change from a heavy manual labouring job to a less strenuous occupation involving less stress on the back. Examination of a number of men in the control group who had transferred to the less arduous employment of watchman or street sweeper revealed osteo-arthritic changes comparable to those in the sewerman, yet they were free from painful symptoms. Two sewermen were so disabled with the condition that they were transferred to work involving less stooping and less heavy lifting in another section of the Highways Department. As a result their painful symptoms have settled down. It is evident, therefore, that the trauma associated with the work of sewermen is sufficient to produce disablement in men suffering from oseto-arthritis of the spine, as well as playing a part in the aetiology of the condition.

(2) Congenital Defects of Spine.

Bony defects of the spine of congenital origin are common and it is generally accepted that their presence tends to predispose to certain ailments.

Lumbarisation of the first sacral segment implies the presence of six lumbar vertebrae and four sacral segments.

Normally the condition is symptomless, but, where heavy strains and stresses are applied to this part of the spine, symptoms are liable to develop because of the reduction in stability in the lumbo-sacral region. The sewerman with this defect had clinical evidence of pressure on the right sciatic nerve root.

Sacralisation of the 5th lumbar vertebra is of three types, viz.:-

(a) Complete fusion of 5th lumbar vertebra to sacrum;

(b) Fusion of one or both transverse processes of 5th lumbar vertebra with corresponding parts of the sacrum, the bodies being unaffected;

(c) Articulation by means of a false joint between an enlarged 5th transverse process and either the sacrum or the ilium.

Generally these deformities are symptomless but in some cases pressure on the 4th and 5th lumbar posterior nerve roots is produced by the enlarged transverse processes. Backache at the end of a day's work is the typical history given and there may be referred sciatic pain. One sewerman with a history of frequent attacks of backache was found to have bilateral fusion of the transverse processes of the 5th lumbar vertebra with the sacrum. His knee-thigh test was negative.

One sewerman, aged 38 years, with seven years' service, who complained of frequent attacks of low backache and one attack of sciatica, displayed only bilateral positive knee-thigh tests. On X-ray of the lumbar spine it was found that he had a spina bifida involving the 5th lumbar vertebra.

(3) Ankylosing Spondylitis.

This disease tends to occur at an earlier age than osteo-arthritis. It is an inflammatory process and has active phases with low-grade pyrexia and constitutional symptoms. Backache and referred pains occur at rest and are aggravated by movement. There is increasing stiffness of the back, usually with flexion deformity due to osseous ankylosis of the inter-vertebral joints, and eventually the spine becomes fused into a solid mass. Ankylosing arthritis may also occur simultaneously in the hip joints. Spondylitis ankylopoietica usually starts in the sacro-iliac joint or the lumbar spine and extends upwards. In the final stages, the costovertebral joints become ankylosed and produce fixation of the chest. The blood sedimentation rate is increased. The ankylosis is visible radiologically and there is no diminution of the width of the intervertebral discs such as occurs in osteo-arthritis.

Case No. 15 among the control group is a man of 56 years who displays the typical features of the disease. On leaving school he went to work in an engineering factory and became a hammerman. In 1914 he joined the Gordon Highlanders and saw active service in the field until 1917 when he developed acute rheumatism, as a result of which he was invalided from the Services. After a period of convalescence he worked as a labourer in a foundry for just over one year. He had to give up this work on account of a return of his illness and was admitted once more to hospital. He has had frequent recurrences of pains and stiffness in his back, and, on that account, has only been able to work for a total of seven out of the last 30 years. During the past 18 months he has been able to follow regular employment as a watchman in the Housing Department. On clinical examination he had rigidity of the lower part of his spine with limitation of flexion. Sciatic pain was elicited on both sides by the knee-thigh test. Radiological examination of the spine confirmed the diagnosis. (Photograph in appendix.)

One sewerman, case No. 8 in the series, complained of pain and stiffness in his left knee at the time of first examination. The pain was located over the internal lateral ligament and was worst when rising from the sitting position. Flexion was found to be limited due to stiffness. On examination of the spine a slight limitation of flexion was present and pain was produced by bending. X-ray examination of lumbar spine and left knee joint revealed early bone changes, and the diagnosis was considered to be ankylosing arthritis. Later events have tended to confirm the original diagnosis. The erythrocyte sedimentation rate was found to be increased and a course of deep X-ray therapy improved the movement in the knee joint as well as giving relief from pain. The patient was aged 56 years and had completed 26 years' service in the Sewerage Section (24 years as a sewerman). As much of his recent service had been on pipe sewers, extra stresses and strains had been put on the knee joints and this possibly explains why symptoms were more prominent there than in the back at the time of examination. After that examination it was suggested to the Department (with the patient's consent) that he should be transferred to surface work where stooping and straining were less. Certain administrative difficulties prevented the recommendations from being carried out <u>in toto</u>, but the Chief Inspector of Sewers (a man of great understanding whose interests lie in the improvement of working conditions for his men) arranged for the patient's transfer to the emergency squad and thereby removed this sewerman from continuous work in the sewers. Instead he carried out inspections of faults associated with the sewers, as they occurred. For a period of almost six months all went well, the man being required only to enter the larger sewers occasionally. One day, however, Case No. 8 had to be sent to clear a blockage in a sewer of two feet nine inches in height. After only two days in this sewer he had to go off work because of acute backache and pain in his left knee and thigh of the sciatic type. When examined at this time he was found to be completely crippled. After six weeks' rest the condition showed signs of improvement. Arrangements were then made for this man to be transferred to a job, involving no stooping and no heavy lifting, in another section of the Highways Department.

(4) <u>Paget's Disease of Bone - Osteitis Deformans</u>.

This disease affects the whole skeleton and occurs in elderly subjects. In the first phase there is softening of the bones producing bending and deformity in those involved in weight-bearing. This stage is followed by a process of new ossification which results in thickening and sclerosis. The disease produces pains and deformities in elderly patients and predisposes to fractures. Occasionally, it may lead to the development of bone sarcoma.

One sewerman aged 50 years with five years' service (case No. 21) reported at the time of his examination that during the previous year he had had attacks of low backache and that these attacks were becoming more frequent. His occupational history was as follows:-

1913-1917 - Farm labourer engaged in ploughing, etc.;
1917-1919 - Army with service in the United Kingdom only;
1919-1944 - Service with a railway company as engine cleaner, fireman and latterly driver.
1944-1945 - Labourer in Highways Department;
1945 to date - Sewerman.

Medical history - attack of lumbago in 1943.

On examination he was noted to have a pronounced stoop; height 5 feet 9½ inches; weight 14 stones 12 lbs. No tenderness was elicited in the lumbar region but the knee-thigh test produced slight sciatic pain on both sides. Three months later he was examined again because of an acute attack of low backache. The clinical findings were essentially the same as on the previous occasion, though some tenderness was elicited in the lumber region and flexion of spine was limited. X-ray examination of the lumbar spine revealed the presence of early Paget's Disease in the right pelvis. (Photograph in appendix.) Further films of skull and long bones showed early thickening of the radial and left tibial shafts.

(5) <u>Herniation of Intervertebral Disc</u>.

Prolapse of the nucleus pulposus through the annulus fibrosus, of an intervertebral disc, towards the spinal canal may be caused by trauma or degenerative changes. Pressure effects may be produced thereby and since the protrusion occurs towards one side of the posterior longitudinal ligament, compression of the posterior nerve roots occurs. The commonest sites for the prolapse are at the 4th-5th lumbar and lumbo-sacral discs, hence low back pain and sciatica are produced. The back pain is intermittent and is affected by posture, while the sciatica is aggravated by coughing, sneezing or jugular compression. Where the prolapse occurs at a higher level, pressure on the cord may cause mild paralysis with spasticity.

Two sewermen who were examined at the beginning of the investigation were found to be exhibiting all of the symptoms and signs suggestive of prolapse of an intervertebral disc in the region of the 5th lumbar vertebra. The X-ray film of case No. 40 showed narrowing of the space between the 5th lumbar vertebra and the sacrum. The patient received out-patient treatment at an orthopaedic department for a period of over four months. His symptoms improved sufficiently to permit his return to alternative employment as a lavatory attendant for an interim period of three months. At the end of that time it was found that though his symptoms had disappeared, flexion of his spine was still limited and the knee-thigh test still produced pain in the right sciatic nerve. It was decided, therefore, to offer the man permanent employment in the alternative job. It was established that the onset of this patient's symptoms could be traced to the lifting of a loaded bucket in a sewer.

Case No. 22 was first examined while he was off work suffering from a right-sided sciatica. His disability was established clinically as due to prolapse of the 4th-5th lumbar disc. Radiological evidence of narrowing of the disc space was negative in this case. The patient made a complete recovery in six weeks and resumed work, the first two weeks of which were limited to occasional entry to the sewers and no heavy lifting. The onset of symptoms in this case was brought about by the patient slipping in a sewer and making an awkward twist in an effort to regain his balance. He was suddenly gripped. with an acute pain in his lower back and was unable to straighten his back. The pain radiated down the back of the thigh.

(6) <u>Lumbo-Sacral Strains</u>.

While no cases were found among the sewermen at the medical examination, it was observed that entrants to the job took three to four weeks to become "acclimatised". During that period low backache, probably due to lumbo-sacral strains, affected each of them, especially at the end of a shift.

J. Incidence of Orthopaedic Conditions of the Feet and Varicose Veins. (Table No. 42.)

It was found that the incidence of foot conditions in sewermen is, on the whole, little different from that in men from the same age and social classes. There might seem to be a higher proportion of cases of pes planus among sewermen, but it cannot be confirmed that this is due to the nature of the employment for Table No. 43 shows that the defect does not become more prevalent with length of service.

On the other hand, Table No. 44 reveals that there is a greater incidence of pes planus among those men working mainly in brick sewers as compared with those operating in pipe sewers. None of the men made specific complaint of actual pain in their feet, though several mentioned that they had a sensation of tiredness, especially after a day in one of the larger sewers.

Case No. 12 had loss of the terminal phalanges of the 2nd, 3rd and 4th toes of his left foot as the result of a manhole cover falling over on his foot when he was preparing to enter a sewer several years ago.

Sewerman No. 15 had deformity of the right 1st metatarso-phalangeal joint which resulted from a similar accident 15 years ago. X-ray examination of the joint showed old osteo-arthritic changes.

On reflection, it is perhaps surprising that results of accidents similar to these two were not found more frequently at the medical examinations, since the thigh boots have rubber uppers which give only limited protection against such trauma.

Chapter IX.

THE RELATIONSHIP BETWEEN MEDICAL DEFECTS AND WORKING ENVIRONMENT.

A. Posture.

1. Physiological Adaptation.

The photographs of the working posture of the sewerman illustrate the extent to which his work must be carried out at a mechanical disadvantage to many of his muscles and ligaments. Repeated strains and stresses are thus placed on certain parts of his body. Adaptability, an amazing feature of human physiology, is demonstrated in sewermen by the over-development of their arm and forearm muscles, resulting from the vast amount of short lifting and pulling associated with the clearing of silt from both pipe and brick sewers.

2. Low Backache.

Low backache, a condition prevalent among sewermen, had caused absence from work in several instances. Though various diagnoses had been certified, careful investigation confirmed that the features of those illnesses were similar to the signs and symptoms found in the lumbar region at the medical examinations.

Limitation of height in the sewers necessitates a working posture involving slight flexion of the knees, acute flexion of the pelvis on the thighs and flexion of the inter-vertebral joints especially in the lumbar region. As a result of the lifting and pulling carried out in this position, severe stresses and strains are placed on the ligaments of the lumbar spine and pelvis, especially on the lumbo-sacral ligament. Owing to the difficulty in securing a firm footing on the semi-circular floor of the sewers, sudden jarring of these ligaments frequently occurs when the sewerman slips while lifting in this awkward position. Repeated traumata, both minor as well as sudden and severe, thus arise from the same environmental conditions.

These factors are responsible for the high incidence of lumbar strains and sprains among sewermen. Furthermore, the environmental conditions fulfil all of the requirements for the production of articular rheumatism, namely, repeated trauma in a damp environment, the joints commonly affected being those most in use at work - in sewermen, the joints of the lumbar spine. Osteo-arthritis of the lumbar spine was, in fact, found to be prevalent among sewermen. This condition, however, is so frequently found in the labouring classes, especially after middle age, that, since most of the men had been employed in that capacity prior to their entry to the sewers, it cannot be established that the osteo-arthritic changes found in the lumbar spines of sewermen were solely attributable to the nature of their recent employment. Nevertheless, there is evidence to suggest that the condition can be so aggravated by work in the sewers as to produce acute symptoms. Where two men have similar osteo-arthritic changes in the lumbar spine, the one employed on the surface has negligible disability as compared with the other working in the limited space of a sewer. In the latter instance a vicious circle is set up - more stress and strain with more acute low backache.

The postural effects of work in the sewers have accentuated congenital abnormalities of the spine in three sewermen, yet it is probable that, in the ordinary course of events, had those men been employed in the average labouring job, these defects would not have produced any symptoms or signs.

Again, ankylosing spondylitis, such as that found in Case No. 8, produced a degree of disability much greater in this sewerman than the more advanced stage present in the watchman in the control group. The sewerman with early radiological evidence of Paget's Disease in his pelvis also illustrates how the posture of sewermen can aggravate the symptoms of a spinal lesion.

3. <u>Herniation of Intervertebral Disc</u>.

Cyriax (1950), when discussing the prophylaxis of this condition, lays stress on the importance of maintaining lumbar lordosis and avoiding the flattening out of the lumbar spines of schoolchildren which results from over-indulgence in exercises involving trunk flexion. He shows how the joint space between lumbar vertebrae is altered during flexion.

(Fig. 9). The back of the joint space is seen to be increased during flexion, thus permitting of backward displacement of the intervertebral disc during the lifting of heavy weights. Because of limitation of working height in most sewers, and inability to have completely free movement of the knee joints due to the wearing of thigh boots, the working posture of sewermen predisposes to this defect. Herniation of an intervertebral disc found in two sewermen was established as attributable to employment. It is probable that many of the sewermen's absences caused by sciatica could be attributed to this type of injury. It would appear, also, that in several instances low backache is the first stage in the development of this lesion.

4. Hip and Knee Joint Conditions.

Arthritic and ligamentous lesions in the hip and knee joints - joints intimately concerned with the maintenance of the sewerman's working posture - can also be attributed to the nature of the employment, or, if pre-existing, materially aggravated thereby.

5. Foot Conditions.

Long periods of standing in one position, or of treading through silt, 12 inches or more deep, wearing ill-fitting rubber thigh-boots, or waders and clogs, put a heavy strain on the feet. Additional strain on ligaments occurs from the climbing in and out of sewers on the iron rungs fitted to the walls of the manholes. All of these movements tend to produce stretching of the longitudinal ligaments of the arch of the foot and so it is possible that flat feet might be prevalent in sewermen. At the examinations, this defect was more common in sewermen engaged mainly in brick sewers than in those working in the pipe sewers, though no definite relationship could be established between length of service and incidence of the foot condition.

6. Hand Conditions.

One sewerman, aged 57 years, who had worked mostly in pipe sewers for the past eight years, showed early evidence of Dupuytren's contracture of the 4th finger of his right hand. The pulling on ropes during the hose-flushing process could play a part in the production of the contracture. His previous employment was as a labourer in the Highways Department where pick and shovel were frequently in his hands. Prior to 1920 he was a miner for 13 years. He states that he first noticed the finger stiffness only one year ago.

B. Atmospheric Conditions.

The presence of carbon monoxide, carbon dioxide, benzene, aromatic hydrocarbons, petroleum vapour, hydrogen sulphide, acetylene and chlorine has been demonstrated in certain sewers. Several of these gases have been responsible for fatal accidents in Glasgow sewers, while others have produced acute poisoning with loss of consciousness. It seems certain, therefore, that lesser degrees of intoxication can occur.

It has been established that ventilation in many sewers is inadequate and that concentrations of these gases vary. That changes in the presence and amount of gaseous material in sewers occur rapidly has been proved by the sudden high concentration of noxious material sufficient to kill sewermen before they could be rescued from the sewers. Similarly, concentrations sufficient to produce chronic intoxication may be present for long periods of the day, and, yet, when samples are taken for analysis, these may show only low readings. This variability is a factor difficult to overcome in an investigation such as this.

Certain medical defects have been found among sewermen on the one hand, and the presence of certain toxic materials has been demonstrated in their working environment, on the other. The known effects of exposure to concentrations of each of these gases are outlined below.

1. Effects of Exposure to Certain Gases.

(a) Carbon Monoxide.

Whereas acute poisoning from this asphyxiant gas is well recognised, the possibility of chronic intoxication has been for long the subject of great controversy. Various symptom complexes, which include headache, nausea, vomiting, general malaise with muscular weakness and increased fatigue, and mental dulness, have been formulated as resulting from long-continued exposure to low concentrations of carbon monoxide.

Recent investigators have added to the literature on the subject, and the evidence now available tends to suggest that ill-effects do arise from repeated small doses of this gas.

No accumulation of carbon monoxide occurs in the body, the gas disappearing from the blood within a few minutes to a few hours after cessation of exposure. Haldane (1930) found a tendency to acclimatisation to exposure to the gas, but it disappeared quickly. Killick (quoted by Alice Hamilton, 1945), in animal experiments, found this resistance to be associated with an increase of blood volume, polycythemia with reticulocytes, and enlarged spleen. In man, however, he saw increased resistance but no corresponding blood changes.

Burnham (1925) considered that chronic carbon monoxide poisoning found in garage workers produced headache, breathlessness, general nervousness, disturbed sleep, indigestion, loss of appetite, and acid belchings from the stomach. Early stages were loss of alertness, loss of muscular power, irritability and loss of judgment. Myers (1927) quoted by Hamilton (1945) mentions in addition giddiness, tinnitus, rapid pulse and rapid breathing, tremors, increased reflexes and a pallor disproportionate to the degree of anaemia which was vasomotor in origin.

In his investigation of chronic carbon monoxide poisoning among persons with a non-industrial exposure, Beck (1938) found that, although most of the symptoms were those of simple anoxaemia, others suggested organic lesions of the central nervous system, encephalitis, epilepsy, cerebral thrombosis, multiple sclerosis and tetany. Frequent findings were neuromuscular and joint pains, spasms of voluntary and involuntary muscles, nausea and vomiting, increase of red corpuscles and haemoglobin. On the other hand, the investigations carried out by the American Public Health Service into the incidence of chronic carbon monoxide poisoning among workers in the great Holland Tunnel suggested that little ill-effect resulted from exposure to an atmosphere averaging 70 parts per million for as long as 13 years. Carbon monoxide in blood was as high as 15.1 per cent. in toll collectors, the highest readings being found in heavy smokers.

More recent investigations by Lewey and Drabkin (1944) cast doubt on the results of the Holland Tunnel Report for they showed that in dogs electrocardiographs demonstrated changes in the heart muscle as early as the second week of the experiment in which dogs were exposed to a carbon monoxide concentration of 100 parts per million for 11 weeks, 6 days a week, and 5½ hours per day. Some of the dogs showed disturbances of gait and of postural and positional reflexes. At post-mortem examination these dogs were examined and degenerative changes were noted in the myocardium, haemorrhages and necrosis being found. In the brain, histological changes in the cortex of the hemispheres and the globus pallidus were located and these resembled in type and localisation those found after acute poisoning, but they were smaller, more scattered and less destructive.

The electrocardiographic results in both acute and chronic poisoning by carbon monoxide have been discussed by various writers and there seems to be little doubt that temporary lesions are produced by anoxaemia and that permanent effects are due to damage to the myocardium resulting from injury to the lining of the coronary vessels (Rastelli (1940), Caccuri (1940), and Steinmann (1937)).

Certain factors have a bearing on the amount of carboxyhaemoglobin formed in the body on exposure to carbon monoxide, namely, the concentration of carbon monoxide in the air, the duration of exposure, and the rate of respiration of the individual. Increase of temperature, humidity and carbon dioxide content of the air, or decrease in the oxygen concentration stimulate respiration and favour absorption of carbon monoxide. Concentrations of carboxyhaemoglobin in the blood below 20% cause only moderate subjective complaints, according to von Oettingen (1945), but these become serious up to 30% concentration and alarming in higher concentrations. Concentrations of 60% to 80% in the blood are dangerous to life.

The American Standards Association has laid down as the maximum permissible exposure to carbon monoxide the figure of 100 parts per million for not longer than eight hours daily. For shorter periods greater concentrations are allowed, e.g., 400 parts per million for an exposure of one hour daily.

Haggard and Henderson (quoted by Glaister) suggest that a good index is given by multiplying (t x c) and give the following equations for the calculation of the physiological response to various concentrations:-

Time (in hours) x concentration (parts per million)
= 300, no perceptible effect;
= 600, just appreciable effect;
= 900, headache and nausea;
= 1,500, dangerous.

These figures refer to a person at rest. It has been shown by Haldane that the same degree of saturation of the blood with carbon monoxide would follow one hour's exposure to 400 parts per million if the man were at rest in a normal atmosphere, to 350 if he were at rest in a hot humid atmosphere, and to 250 if he were working hard.

Smoking produces a level of carboxyhaemoglobin in the blood. Schmidt (1940) found the mean content of the blood carbon monoxide as follows:-

More than 30 cigarettes per diem	8.7% saturation (6.56 - 10.16%)
20-30	4.2% (1.55 - 7.5%)
10-20	2.7% (1.67 - 3.5%)
Up to 10	1.8% (1.27 - 4.28%)
Occasionally	0.19 - 1.23%
Non-smokers	0.1%
Pipe smokers	2.59 - 6.93%

Chernov and Liberman (1947) found that when mice were exposed to atmospheres containing carbon monoxide and benzine separately in concentrations liable to be found in the motor transport industry no ill effects arose. When the two were combined, however, a cumulative toxic effect was noted. A rise in temperature considerably increased the toxic effects.

Mayers (1937) drew attention to the fact that carbon monoxide is less toxic alone than illuminating gas, or when mixed with hydrogen sulphide.

(b) Carbon Dioxide.

This gas is an asphyxiant and produces its effects in concentrations of 5% and upwards. At 6% there is produced distinct breathlessness and palpitation and slight frontal headache. At 10% the distress is greater and stupefying effects appear, the face becoming flushed. Between 12% and 15%, cerebral symptoms appear and the patient soon becomes unconscious. He can survive in this concentration for some time. At 25%, death can occur after several hours' exposure. It is generally accepted that the presence of 16% carbon dioxide extinguishes the flame of the ordinary miner's lamp. It is thus calculated that respiration may go on unimpaired in air containing at least 10% more carbon dioxide than is required to extinguish the flame.

Chronic poisoning has been investigated in animals exposed to concentrations of 1% to 26% for periods of five to six weeks. Degenerative changes occurred in the alveoli of the lungs, kidneys and ganglion cells of the brain. In humans, exposure to concentrations of about 1% caused some increase in the depth of respiration, but at 2% the depth is increased further and the frequency is also increased. Up to 3% the carbon dioxide tension in the blood remains unaltered.

(c) Benzene.

Benzene is a narcotic poison which acts with extreme swiftness producing unconsciousness or helpless confusion in the acute form of poisoning. Chronic intoxication is, however, the more important in industry, its onset being so insidious and the symptoms so vague that diagnosis may not be made in some instances until the appearance of haemorrhages. In this form of poisoning the blood forming tissues are affected. Firstly, there is stimulation of the bone marrow with resultant high cell counts and the appearance of immature cells in the peripheral blood. There follows the true toxic effects manifest as anaemia, leucopenia and reduction of platelets. Various combinations of the effects of stimulation and depression can be found in the components of the blood.

Bowditch and Elkins (1939) when investigating the effects of chronic exposure to benzene found 12.4% of their cases to have normal blood pictures, 23.6% showed a single deviation from normal (4 out of 21 showing an elevation of the erythrocyte count), while 64% of their cases showed multiple deviations from normal.

The American Standards Association has pronounced 100 parts per million to be the maximum allowable concentration of benzene in a working environment. It should be noted that the symptoms and blood changes may not appear until some little time after the last exposure to benzene.

Chevalier and Mouther (1947) drew attention to the fact that among workers in a rubber factory who were exposed to benzene, they found a high incidence of acute gastritis which cleared up when the workers were withdrawn from the benzene. The main symptoms were vague indigestion with a sensation of epigastric heaviness, a feeling of distension, intolerance of alcohol, ready flushing and often persistent frontal or temporal headache. Gastroscopy showed some inflammation in a number of the cases.

(d) Benzine (Petrol).

Petrol is a mixture of hydrocarbons, paraffins, olefins, naphthenes and aromatics. The vapours are heavier than air. No standard has been fixed for the maximum allowable concentration, but various workers have suggested figures ranging from 150 to 1,000 parts per million. The odour of benzine is detectable at 300 parts per million; mild symptoms of narcosis appear at 1,000 parts per million in 50 minutes; while at 7,000 p.p.m. marked unsteadiness of gait occurred in ten minutes with numbness of the legs. Neuromuscular symptoms are said to begin at 900 p.p.m. and mild intoxication at 2,600 p.p.m.

Chronic intoxication produces effects primarily on the central nervous system - headache, dizziness, loss of appetite, dyspepsia, insomnia, nervousness, pains in the back, legs and heart region, weakness and dyspnoea. These symptoms make their appearance after three weeks' to several years' exposure.

Objective signs may also be present - loss of weight, tachycardia, secondary anaemia with leucocytosis, mental depression, stupor, twitchings and tremor. Some workers consider that the blood changes in benzine poisoning differ only from those of benzene in degree.

Experiments carried out by Drinker, Yaglou and Warren (1943) showed that exposure to low concentrations for long periods (0.027% for 8 hours) caused coughing and irritation of the eyes,

Sequelae to acute poisoning include mild neurasthenic symptoms (headache, sleeplessness, anorexia), organic changes in the nervous system, such as epilepsy, and lesions simulating disseminated sclerosis.

2. Discussion - The Relationship between Medical Defects and Sewer Gases.

As far as acute intoxications are concerned the diagnosis has been established in each of the accidental poisonings occurring in the sewers. Petroleum vapours, benzene and "black damp" have been responsible for several accidents, some of which have been fatal. In the present investigation, however, attention has been directed to the chronic intoxications as possible causes for certain deviations from normal found in the sewermen.

(a) Cardiovascular and Blood Changes.

The syndrome of breathlessness, poor exercise tolerance and raised blood pressure could be attributed to anoxaemia.

The fact that raised haemoglobin levels and increased red cell counts were found to exist in a number of the sewermen would tend to confirm the fact that the cause was anoxaemia. In view of the large experimental error likely to arise in attempting to estimate the atmospheric content of oxygen in the sewers, this analysis was not carried out. It is possible that the pressure of oxygen in the atmosphere of several sewers was reduced but one does not consider that any such reduction was so great or so constant as to produce the effects noted above.

Carbon monoxide does produce features such as those outlined above when exposure to lower concentrations is continued over long periods. Furthermore, its effects are cumulative. In each of the analyses carried out it was found to be present along with carbin dioxide and in two instances with benzene in addition. In other two sewers, petroleum vapour detectable by its odour was found along with the two gaseous oxides of carbon. These accessory gases each have a synergistic effect on the toxicity of carbon monoxide so that, while its concentration in a sewer may be below the accepted toxic level, when present in this combination at the temperature and humidity of the average sewer, its effects could have been increased to such a degree as to have an effect on those men engaged in heavy physical work in that atmosphere.

In the serial blood examinations it was noted that, in several instances, where the sewermen remained in the same sewer for several weeks, there was an initial rise in the haemoglobin level and in the red cell count, then a fall, and this fall continued to well below the man's base level for these blood components. The continued downward trend was halted usually by the transfer of the man to a sewer in a different part of the city where the working atmosphere was different. When that occurred the haemoglobin level rose to the base level again.

As has already been shown, the atmospheric conditions can vary so much from hour to hour in the sewers that it is difficult to get a true indication of the extent to which those men are exposed to noxious fumes and gases. The method of sampling by water displacement almost certainly gave analytical results erring on the low side and there is no guarantee that the concentrations of the various gases were at their highest when samples were taken. If allowance is made for such errors then it is highly probable that, during the normal working day of six hours underground, the sewermen are exposed to concentrations of carbon monoxide above the recognised permissible limits. While it is agreed that the exposure to carbon monoxide is intermittent, its effects, however, are cumulative. Because of the nature of the job, whereby squads are transferred from one sewer to another after three to five weeks, or move from section to section of the same sewer at similar intervals, variations in degree of exposure occur. In many instances, such a transfer to a part where there may be no carbon monoxide gas acts as a safety measure and so prevents the development of more obvious clinical symptoms and signs.

Beck and Fort (1924) when discussing the diagnosis of chronic carbon monoxide poisoning warn against the making of such a diagnosis without a history of exposure to gases containing carbon monoxide. A noteworthy feature of their investigation was the finding of pallor resembling a high grade anaemia with a group of symptoms suggestive of anaemia, yet the red cell count was more than 5,000,000. This condition is considered by several authorities, including Beck, to be of high diagnostic value and some go so far as to consider it pathognomonic of chronic absorption of carbon monoxide.

The pallor, together with breathlessness and tiredness prevalent among sewermen, it could be argued, might arise from lack of exposure to sunlight since they work in the darkness of the sewers. Others, however, had the weather-beaten faces of open-air workers, this latter feature being present in those men who worked mainly in residential areas of the city. Again, red cell counts over five millions was a feature uncommon in the control group composed of men from the same social class as sewermen. This adds greater significance to such findings in sewermen. It would seem, therefore, that the alteration in the blood picture in sewermen could be attributed, at least in part, to carbon monoxide and that these changes simulating anaemia could be diagnosed as due to chronic exposure to this gas.

Further evidence was forthcoming when the squad working in sewer No. 1 had their bloods examined for evidence of carbon monoxide. Sewermen Nos. 10, 41 and N.S.A. had samples of their blood examined before starting work and again one hour after finishing work. The analyses were carried out by means of the Hartridge reversion spectroscope, the micrometer readings in Angstrom units being converted to percentage saturation of the blood with carbon monoxide by means of a standardised graph. As it was thought that the graph, though accurate for readings over 20%, might not be without error at lower readings, the City Analyst verified the findings by chemical analysis of the same samples. The results of both methods were found to correspond to within 0.2%. (Table No.45)

On the day of this investigation the concentration of carbon monoxide in this sewer at 11 a.m. was 12 parts per million, while a sample taken on the street surface six feet to windward of the manhole showed no evidence of the gas. Judging by the results obtained in the bloods of the sewermen there is suggestive evidence that the concentration of this gas had been greater than that shown in the test sample. Furthermore, one hour elapsed between the men leaving the sewer and having their bloods examined. In that interval of time the blood saturation of carbon monoxide had an opportunity to fall. Just how quickly it fell is not possible to assess, but it is generally accepted that the gas quickly leaves the blood after removal from the exposure. Once again, therefore, the findings are considered to be on the low side.

Reference has already been made to the fact that carbon monoxide can be found in the blood of smokers, especially cigarette smokers who inhale the smoke. Case No. 10 is a pipe smoker in moderation; Case No. 41 smokes ten cigarettes per day; while Case No. N.S.A. is a non-smoker. On the day of the investigation, Case No. 41 was working on the surface at the top of the manhole, Case No. 10 at the working face some 40 yards from the bottom of the manhole, while N.S.A. was engaged in dragging full buckets of silt to the bottom of the manhole and there hooking them on to the rope of the winch operated by No. 41 at the surface. Case No. 41 was inhaling the sewer atmosphere as the odour of the burning oil lamps and the smell of petrol could be detected in the air over the manhole. Higher CO saturation levels were found in the two men working in the sewer than in the man working on the surface, and, of the two underground, the smoker had the higher blood saturation. Another factor, however, can play a part in the production of this blood picture in the man at the "face" of the sewer. When silt accumulates in the bottom of a sewer a relatively hard crust forms on its surface over a period of time and when this is broken bubbles of gas can be seen coming to the surface, especially in a slow-running sewer. This fact, well known to sewermen, has been demonstrated to me on several occasions. Decomposition of vegetable and animal matter under the crust is responsible for this gas production and since oxygen is lacking a proportion of carbon monoxide is produced. The sewerman who is shovelling the silt has his face quite close to the surface of the sewage and so can inhale greater quantities of the gas than his mate operating further back in the sewer. This explanation is considered to account for a proportion of the increased blood saturation in the "face" worker.

On leaving this sewer at the end of the day's work, all three men complained of headache, dizziness, breathlessness and weakness of the legs. Irritation of the eyes occurring periodically throughout the shift appeared to be due to intermittent passage of petroleum and paraffin along the sewer. It should be mentioned that this team had been working in Sewer No.1 for some ten weeks prior to this analysis, and serial blood analyses had shown an initial rise in haemoglobin level and red cell count during the first five weeks and then a progressive fall. At the time of this study their blood readings were as shown in Table No. 46.

The normal levels for each of those men is shown in brackets, the figures for Cases No. 41 and N.S.A. being those just prior to the start of their employment as sewermen in 1950. In the case of No. 10, the figure given in brackets was that found at the end of his annual holiday. It is clear that, compared with the base level of each man, there is an increase in haemoglobin and red cell count which is compatible with a diagnosis of carbon monoxide absorption.

In view of the fact that American investigators had found certain concentrations of carbon monoxide in the streets of several American cities and shown that saturation levels up to 5 to 6% could occur in the bloods of city dwellers, quite apart from the effects of smoking, it was decided to analyse samples from Glasgow streets. The highest atmospheric concentration in Glasgow streets was found to be 12 parts per million at a busy street-crossing in the centre of the city. This concentration occurred at a height of three feet from the ground in the centre of the street. The source of this carbon monoxide was from the exhaust gases of motor vehicle engines. Higher concentrations were found in the New York survey, but these were probably due to the poor ventilation of the streets produced by the surrounding high buildings. Among a control group of 12 non-sewermen in Glasgow, the blood saturations varied from nil to 2%, the latter figure being found in six cigarette-smokers. Since no evidence of gas leakages were found in the homes of the three sewermen, it seems almost certain that the cause of the carbon monoxide saturation of the blood in these men could only have occurred in the course of their employment.

Proved sources of carbon monoxide in the sewers are:-

(i) Decomposition of organic matter in the sewers.
(ii) Trade waste from gas works.
(iii) Trade waste from breweries.
(iv) Leakage of gas into a sewer from a fractured gas main.

The presence of carbon monoxide is often not detected until an accident occurs - either a sewerman is overcome by the fumes or the manhole covers are blown off as a result of an explosion in the sewer, causing injury, occasionally, to unsuspecting pedestrians. After such an occurrence, sewermen using safety lamps endeavour to trace the source of the gas. Sometimes the source is quite distant from the site of the accident. This happened in a recent instance where the trouble was due to leakage from a fractured gas main almost half-a-mile from the place where the explosion occurred. In such emergencies lifelines and respirators are used.

With regard to the effects of benzene on the blood, no changes were found in the white cell components nor did blood films reveal the presence of immature red cells. Benzene in dangerous concentrations was found only in one set of sewers and these drained the trade waste from a large coal gas and chemical works. As inspections only were being carried out in these sewers there was insufficient exposure to produce the typical blood changes associated with chronic benzene poisoning. Half-an-hour's exposure did produce headache, irritation of the eyes and cough in two sewermen and myself when a visit was paid to two sections of Sewer No.3. Several years ago two men lost their lives and several more were overcome by the fumes in this sewer.

(b) Defects of the Nervous System and Digestive Disorders.

Disturbance of balance in the form of giddiness was the most constant feature of the examination of the nervous system. Several theories may be put forward as to the method of its causation. That posture does play a part is undoubted, the mechanism being that the long spells in the stooping posture cause the vertical semicircular canals to take on the job of transmitting sensations of horizontal movements of the head and the horizontal to transmit vertical changes. When the normal posture is resumed on leaving the sewer, the lag in return to normal functioning of these canals causes the disturbances of balance noticed in the sewermen. If this were the sole reason for the giddiness then one would expect that the dizziness would disappear within a short time of leaving the sewer, just as giddiness from rapid spinning passes off in a short time. But the giddiness was found to persist in many of the sewermen for some considerable time after leaving the sewers; indeed, it was found to be present in some of the men just before they started their day's work in the morning. Thus, other causes for this defect must be sought.

The condition was found to be more prevalent in men working in certain sewers, and others stated that they had had giddiness after working for a time in specific sewers. Analysis of the gaseous content of several of these sewers showed that carbon monoxide was present as well as benzene and petroleum vapour.

Indigestion, associated with one or more of the following, dizziness, exaggerated knee jerks, tremors of the hands, and headache, was found to exist in no less than 15 sewermen at the time of the medical examinations. Investigation of their sites of work over the previous four months revealed that there was a common factor in the environmental condition, namely, that petroleum vapours were frequently present since garages were located in the drainage area of these sewers. In all of these sewers the odour of petrol was obvious. Chemical analysis demonstrated the presence of carbon monoxide in concentrations of 10 to 25 parts per million in each sewer. In several, irritation of the eyes and acute throbbing headache occurred after a short time below the ground, but these effects were usually intermittent and related to the heat of the atmosphere and the flow of petrol along the sewer. In men engaged in these sewers the symptoms and signs could be attributed to the exposure to petrol fumes, but among the other men it was not possible to decide whether carbon monoxide or petrol or their combination had produced the effects. It seems highly probable that a mixture of the gases was responsible.

One interesting feature of the examination of the nervous systems of sewermen was the extraordinary large number of them who had lost their sense of smell. In many ways this was perhaps fortunate because of the nature of their calling, but it certainly was a handicap when it came to the recognition of odiferous toxic gases, such as hydrogen sulphide & petroleum.

In the higher concentrations of petrol, however, those men experienced an irritation of the nose as well as the throat. This loss of smell appeared to be due to an olfactory fatigue rather than due to damage to the olfactory nerve or damage to the nasal mucosa, for the return of the sense of smell was noticed by several of these men during convalescence from illness which had caused absence from work. All of them recovered their sense of smell during the annual holiday.

Two of the men included in the above references went off work during the period of the investigation with the symptoms of acute gastritis. Both had complained of irritation of the eyes and of severe headaches just prior to going off with the digestive symptoms. In these two instances it appears probable that the illness arose out of working in an environment containing a mixture of carbon monoxide and petroleum vapour for a period of several months.

Quite apart from the question of atmospheric contaminants being active in the production of dyspepsia, the working posture with compression of the abdomen must interfere with the normal functioning of the digective tract. Carried meals too must also have an influence.

It is true to say that the job of a sewerman is certainly not one for a man who has suffered from a stomach disorder. There is sufficient evidence from the records of sickness absence over the years to justify the statement that gastritis is common in sewermen, and the investigations of the environmental conditions reveal that agents are present from time to time in sufficient concentration to produce these disorders.

There is insufficient evidence to prove that peptic ulceration has been caused by the nature of the work of sewermen. Several confirmed cases have been found in sewermen in Glasgow in previous years and it would seem probable that this condition may be merely the final stage of the progression from dyspepsia, through gastritis, to frank peptic ulceration.

At the time of the examinations different squads displayed different stages of that progress, for example, one night-shift squad had three men almost at the stage of acute gastritis, while in one day-shift squad three men were mainly troubled with flatulence.

(c) Respiratory Tract Infections.

Especially during the winter months, the warm humid atmosphere of the sewers is in direct contrast to the cold of surface conditions. After perspiring heavily in the sewers the men come to the surface and sit, at break-times, in draughty shelters or try to keep warm close to the brazier set up at the roadside. It has been shown that rapid changes of temperature also occur in the sewers. Thus, sewermen in the course of their employment are exposed to conditions which are known to predispose to chills and rheumatic infections.

Head colds are not uncommon among these men but few stay off work for more than a day or two, and the proportion of the total sickness absence due to this cause is exceedingly small. It is surprising to find that as far as coryza is concerned the percentage loss of time due to this disease compares favourably with that found in most factories and workshops. In the recent influenza epidemic in Glasgow only one sewermen was off work due to that infection.

As far as chest conditions are concerned, only one case of chronic bronchitis was found and that sewerman had had 15 years' service in the sewers. Three cases of tuberculosis were found, one active and two quiescent, while a fourth man developed pleurisy with effusion during the course of this investigation. It would be difficult to draw any definite conclusions from these findings as to the attributability of these diseases to the specific conditions of work. Bronchitis could undoubtedly arise from exposure to concentrations of such a gas as chlorine, but in that case a definite source could be traced. The particular sewerman affected gives no such history. Again, in a city such as Glasgow, where pulmonary tuberculosis is so prevalent, the chances of the source being extra-occupational are too great to warrant the suggestion that the condition arose out of and in the course of the employment of sewermen. Reduction of resistance due to toxaemia caused by such work may play a part but how great that part may be it is not possible to estimate.

Whereas in lead intoxication, pulmonary tuberculosis is a recognised complication, the same correlation has not been found with intoxications from carbon monoxide, benzene or petroleum.

(d) Rheumatism.

According to the records of certified sickness absence of sewermen, rheumatic conditions claim a high proportion of cases. When these are analysed, however, it is found that they include many cases more correctly diagnosed as influenza, lumbar strains and sciatica. Fibrositis (4 cases) and arthritis (1 case) remain in this group and it is doubtful if they are all rheumatic in origin. Muscular and articular rheumatism do occur but doubt exists nowadays as to whether fibrositis can be included in the rheumatic diathesis.

At the medical examinations only one man was found to have fibrositic nodules and these were located in the muscles of the shoulder group. One case of ankylosing spondilitis was isolated while osteo-arthritic changes were present in many of the lumbar spines X-rayed.

The rheumatism complex does seem to occur in sewermen but the disabilities arising therefrom seem to depend more on trauma rather than on the stage of the infection. The conditions of work of sewermen, both postural and environmental, are such as to predispose to osteo-arthritis, especially in the lumbar region, even more so than those of many other heavy labouring jobs. The same conditions also tend to aggravate a pre-existent lesion of the same type.

C. Contact with Solids, Liquids and Vapours.

1. Skin Conditions.

In the course of the work of sewermen, contact is made with a large variety of chemicals in the three physical states. Many of these substances, having gained access to the sewers as trade wastes, are irritants to the body surface. In addition to the factor of individual sensitivity, the special conditions under which the contact is made with these substances play an important role in producing lesions. Limitation of working space in many of the sewers leads to abrasion of the skin of the elbows and forearms on the walls of the sewer, while the continuous contact with moisture and grit creates a degree of maceration of the hands which renders the skin more prone to infection. Furthermore, the high bacterial content of sewage makes skin sepsis an ever-present complication.

Among known skin irritants which have been isolated from the Glasgow sewers are coal-tar and allied materials, petroleum, mineral oils, sulphuric acid, alkaline waste materials from chemical works, various oxides and salts of iron, zinc, chromium and copper. The concentration of these substances varies considerably according to the distance from the source of entry to the sewer. Dilution plays an important part in whether skin effects will be produced. Where, however, chemical reaction in the sewage has caused the precipitation of a solid irritant, trouble may arise when the silt is being removed. This has happened in several sewers where all members of a squad have developed a contact dermatitis.

In addition to contact dermatitis, conjunctivitis may arise either from contact with a gaseous irritant, such as petroleum vapour, hydrogen sulphide, chlorine and ammonia, or from splashing of an irritant into the eye.

In each of the cases of dermatitis and conjunctivitis mentioned in a previous chapter a definite relationship to a particular irritant in a particular sewer was established. One feature brought out by the medical examinations was that of complication of the original skin picture by secondary infection and mutation to an eczematide which was excited into activity by a material completely different from the original irritant.

Some of the sewermen who had been formerly employed in road repair squads showed evidence of previous small burns on the forearms sustained while handling hot tar, but, apart from these, gave no history of having contracted any skin lesions while in that employment. During their period of employment in the sewers, however, several of them mentioned that various blemishes had appeared on their skin from time to time and their description of the lesions suggested that they might have been caused by contact with tar or oils. On investigating still further it was found that the lesions had appeared while working in certain sewers, and a visit to these sewers made it possible to decide whether tar or oil had been to blame.

(a) Skin Lesions due to Contact with Mineral Oil.

Skin reactions due to contact with mineral oil have long been known to occur among workers in the cotton spinning and shale oil industries. In recent years similar lesions have been found to occur in the engineering industry and indeed Cruikshank and Squire (1948) have established cases among engineers where the stage of malignancy has been reached.

Both cutting and lubricating oils were found to produce the lesions. Other writers have shown that similar lesions occur in garage workers due to lubricating and diesel oils. In Glasgow, acneiform rashes due to contact with mould oils were found to be prevalent among certain workers in the concrete pre-casting industry.

With regard to the causation of skin reactions due to contact with mineral oils, it has been established that there are two distinct factors in the oils, namely, a dermatitic factor responsible for the production of the comedones, folliculitis, pustular dermatitis and simple erythema, and a carcinogenic factor responsible for the dermatitis papulare, dermatitis erythematosa and epithelioma. The dermatitic factor is responsible for much of the skin reaction to contact with oils, which is found among industrial workers, but it is only in a minority of cases that it causes disability to such an extent as to necessitate absence from work. The carcinogenic factor, however, is an important element in the production of industrial cancer. Researches in recent years have shown this factor to be composed of polycyclic hydrocarbons allied to 1:2:5:6 - dibenzanthrene, the first cancer producing hydrocarbon which was isolated by Kennaway in 1925. The use of fluorescence spectroscopy by Mayneord, and later by Hieger, in the study of carcinogenic substances opened up a new field which led to the discovery of 3:4 benzpyrene as the carcinogenic substance in pitch. Many other aromatic condensed ring compounds have been tested and found to be carcinogenic.

Twort and his colleagues have shown that the carcinogenic factor in many oils can be removed by treating the oils with liquid sulphur dioxide. Substitution of these oils in the cotton industry are proving to be satisfactory in the spinning mills.

(b) Skin Reactions to Contact with Tar.

"Tar" refers to a complexity of substances produced from the destructive distillation of coal in gas-works or iron and steel works. By distillation of the crude tar various grades of oil are separated as shown in Table No. 47.

The various components of tar produce similar skin conditions to those resulting from contact with mineral oil, namely, acneiform rashes, folliculitis and comedones; dermatitis erythematosa, and, finally, epithelioma. In addition, however, fumes of tar produce a light sensitisation reaction or "tar flashes" or "the smarts", as the reaction is known to the workers. The lesions in this reaction appear when the worker emerges into the open, particularly when the sun is shining or when a wind is blowing.

The symptoms consist of smarting in the exposed skin of the arms, hands and face, while the eyes have a burning sensation and there is photophobia. The skin in the affected area becomes erythematous and may go on to marked oedema and dermatitis similar to what occurs in severe sunburn. Pigmentation develops in the affected areas and persists for some time. In some individuals an allergic eczematous dermatitis appears and conjunctivitis may be severe.

As in the case of mineral oil skin reactions, malignancy does not appear in the skin until after middle life and not usually until after a long period of exposure. In some instances, however, the epitheliomatous lesions only appear long after the worker has ceased to be exposed to the skin irritant.

Discussion.

Sewers draining gas works and coke ovens carry a trade waste which contains products of the various grades of distillates. They are constantly present though their concentration varies according to the routine at the works. These particular sewers have their walls covered with tarry condensate and the atmosphere almost constantly contains fumes of these tar compounds. Varying degrees of tar erythema occur and on leaving the sewer the man is conscious of smarting of the eyes and the skin of the face. In sewermen, repeatedly in and out of these sewers, the typical reactions are seen.

Into one sewer, a large quantity of heavy tar was discharged from a steel works and caused a serious breakdown in the pumping machinery of the main low-level sewer in the south side of the river. Six sewermen with auxiliary labour from the Sewage Department were set the task of removing thousands of gallons of this tar from the pump wells and from a long section of the sewer. Within forty-eight hours of starting on this job in the middle of the summer, all made complaint of tar "smarts". Both day-shift and night-shift workers were affected. The lesions varied from simple redness of the exposed parts of the body to gross oedema of the face, forearms and hands, and in three of the auxiliary workers a weeping allergic eczematous dermatitis occurred. The condition was controlled by the use of protective barrier cream, rubber gloves, and the wearing of a tannic acid cream when going out into sunlight after the day's work. By these measures the tar smarts disappeared but pigmentation remained in several of the men for two to three months. Eye conditions were troublesome from tar splashes entering the eyes. The wearing of perspex eyeshields helped to reduce the incidence of conjunctivitis. The sewermen in this group who were removing the tar from the sewer developed the typical acneiform rash not only on the forearms but also on the body and shoulders. This was due to the saturation of their clothing with tar from the walls of the sewer and also from the tar vapour percolating through their garments. This emergency job lasted for several months and typical comedones were seen in each of the sewermen in addition to papules and folliculitis.

In some of the older men who had worked in these tarry sewers from time to time over many years there was deep pigmentation of the forearms with patchy redness and pale areas and the skin was dry and scaly. There were suggestive patches of hyperkeratosis.

Fluorescent spectrograms of the tars present in the sewers showed that they contained polycyclic hydrocarbons allied to benzpyrene spectroscopically and therefore must be considered as carcinogenic.

With regard to the mineral oils present in sewers, the evidence that they produced the skin reactions in the form of acneiform rashes seems established, though only one of these men had to leave his employment because of the development of a secondary dermatitis of an infective nature.

Another source of skin reaction due to tar products was that dry scaliness which arose on the forearms and backs of the hands of many of the sewermen as a result of continued misuse of carbolic disinfectant. This crude disinfectant was being used in excessive concentration to wash the hands and forearms after leaving the sewers in order to prevent leptospirosis. The men actually stated that they experienced tingling and numbness of the fingers for a short time after its use. This reaction was found to be counteracted by an application of methylated spirits in a test case. The reaction seemed to be due to excess of carbolic in the disinfectant solution.

A wide variety of skin conditions appear to be liable to occur from work in the sewers, but the most prevalent lesions are definitely established as due to tar and mineral oil. Evidence was found of industrial dermatitis having caused absence from work, but in these instances trade wastes from the chemical industry were to blame.

The potentialities of serious dermatitis of occupational origin are ever present, but no prior warning of the dangers seems possible except in the case of those sewers known to contain tars and mineral oils. Samples of oil floating in the sewers were also found to be carcinogenic on spectroscopic analysis. (See appendix.)

(2) Conjunctivitis.

Conjunctivitis of occupational origin in sewermen can occur as a result of contact with fumes or through splashes into the eyes. Ammonia, chlorine, hydrogen sulphide, tar fumes, and petroleum vapours have been found to produce conjunctivitis in sewermen. In such instances the eye condition forms part of the general effects resulting from exposure to an atmosphere containing these fumes. Splashes of tar compounds, acids, alkalis, and mineral oils form another source of the condition. Trade wastes from paint works, chemical works, paper mills, because of their suspended solid content, can cause irritation of the eyes either through splashes or the rubbing of the eyes with contaminated hands.

There are thus numerous agents liable to cause conjunctivitis in sewermen. Direct contact with the irritant is the initial factor in the setting up of the condition, but it is readily realised that, because of the bacterial content of sewage, secondary infection of a persistent nature is liable to ensue, just as happens in the case of skin conditions.

(3) Infections due to Contact with Solids, Liquids and Vapours.

Reference has already been made to the onset of gastro-enteritis following the accidental ingestion of sewage by sewermen. The bacterial content of the atmosphere in sewers has been shown to be high and several investigators have cultured B.typhosus from sewer air, especially in regions where splashing of sewage occurs, such as at the entrance of a branch sewer to a main. At the medical examinations no skin nor eye conditions of a primary infective nature established as having been contracted in the sewers were found. In the medical histories, however, it was found that impetigo had been contracted at work.

Leptospirosis, already discussed in a previous chapter, is the most serious of the infections arising from contact with liquid.

D. Lighting in Sewers.

Miners' Nystagmus.

This illness has long been known to occur in miners. Various theories were formulated as to the causation of the disease, but it is now generally accepted to be a psychosomatic illness with eye symptoms, and is related to prolonged work under emotional stress in an awkward position in the dark (Stern 1948). Campbell, Harrison and Vertigen (1948) suggest that in cases of nystagmus there is breakdown of binocular vision under conditions of low illumination.

It has been established in recent years that miners' nystagmus is due to working in a poorly-lit environment, and it has been found that the minimum illumination to prevent the disease is 0.4 foot-candle. In countries such as the United States of America, where the standard of illumination is well above that level, no cases of nystagmus have occurred.

Discussion.

Of four sewermen showing oscillatory movements of the eyeballs, only one had other signs and symptoms suggesting a purely organic cause for his eye condition. Of the other three men, two were ex-miners of over 15 years' experience and both had more than five years' service in the sewers. Both had giddiness and headache, and one showed alteration in temperament. The fourth man had psychoneurosis associated with slight nystagmus and other eye symptoms. His service totalled 28 years as a sewerman.

These three men could be considered as early cases of nystagmus, though certain of the symptoms such as giddiness and headache could be accounted for by other environmental defects found to exist in the sewers. There was no doubt, however, of the existence of an alteration in their mental outlook, and the presence of a mild degree of anxiety neurosis. When it is considered that each of these men has had over 20 years in employment involving awkward working positions in illumination of low intensity, it seems possible to establish a cause and effect. Proof that the illumination of the sewers can be held responsible for the production of the syndrome would seem to be given in the case of the sewerman with 28 years' service. His only exposure to illumination of less than 0.4 foot-candle and poor working conditions in an awkward posture has been during his service in the sewers. In the other two cases it is possible that previous working in the mines had predisposed to the eye condition and that return to similar or worse conditions in the sewers had caused progression of an otherwise latent tendency.

In all of the cases, the condition is mild, but it is suggested that miners' nystagmus must be considered seriously as a possible diagnosis in these instances.

Chapter X.

THE EFFECT OF ENVIRONMENT ON ENTRANTS.

During the course of this investigation, four men entered employment as sewermen. Their histories are shown in the Appendix. Three of these men were fresh to the work in sewers but Case N.S.D. had had some experience of sewers in that for nine years he was responsible for the control of the flow of sewage in a section of the main drainage system. He operated the penstocks controlling the storm water overflows. In that job he had to enter into the penstock control chambers to carry out weekly oiling of the machinery as well as raising or lowering the barriers as conditions demanded. He was thus exposed for short intervals to the atmosphere present in these 8-9 feet diameter waterways. One other man should really be classified as a new start, viz., Case No. 41, since he had only 14 days' service in the sewers when he was examined in the course of this investigation. Thus, under the heading of new starts there are three men with no previous contact with sewers, one man with a fortnight's experience, and the fifth with nine years of limited service in the main drains.

All except Case No. 41 were medically examined before they were started in the job of sewerman. The examination was similar to that conducted during this investigation, including blood analysis and X-ray examination. This was of great value, for the findings at that examination could be used as a standard for each man to detect any deviations at later examinations. (Case No. 41 had his blood examined on the first day of his employment in the sewers.)

Fortnightly blood examinations were carried out for a period of three months in each case, and the trends were found to follow those already described for sewermen of several years' service. The results are shown in Chart No.5.

Sewerman N.S.A. has been employed in brick sewer No.2 for three months and then in sewer No.1 for the next three months. Within three weeks of the start of his employment he complained of giddiness on leaving the sewer, but this was found to last only for about half-an-hour. Breathlessness after exertion developed in the second week but he quickly recovered. This was most apparent while he was climbing out of the sewer.

Case N.S.B. spent his first three months working on pipe sewers in the suburbs and in the centre of the city. After the annual holiday he went on to night-shift and worked in both pipe and brick sewers in the centre of the city. Giddiness on leaving a sewer was complained of occasionally but no breathlessness troubled the man. During a spell in a brick sewer on night-shift, headache and irritation of the eyes occurred during the two weeks employed in that sewer.

Case N.S.C. has worked along sewer No.1 since starting as a sewerman. He developed giddiness three weeks after first entering this sewer and a week later he had breathlessness when climbing out of the manhole. This feature has persisted and is lasting up to a quarter-of-an-hour after reaching the surface. After a month in this sewer he developed a few oil papules on his forearms.

Case N.S.D. has completed two months in sewer No.1 and has now developed symptoms similar to those of the previous sewerman. His skin showed some reaction to contact with oil three weeks after he started this type of work. Headache has been troublesome, particularly towards the end of a shift.

Case No. 41 has been employed entirely in brick sewers, firstly for three months in the north of the city, then in the west, and finally in sewer No.1 in the east end. In the course of his first year he has not had any sickness absence, though in the past few months he has had attacks of indigestion occasionally, a symptom hitherto unknown to him. He reports a feeling of lightheadedness on reaching the surface after a spell in a sewer.

On medical examination of all of these men after three months, no alteration was found in their general condition and no change had taken place in their clinical findings. At six months a slight unsteadiness in balance was found in cases No. 41 and N.S.A., while at the end of one year case No.41 showed slight fine tremors of hands.

No change was found in the levels of the blood pressure in these men, but the exercise tolerance tests produced slight breathlessness at each of the examinations, though there was no change in the time taken for the pulse to return to normal rate.

Sense of smell was reported to have become poorer in two instances.

It is seen that certain of the more acute symptoms common to sewermen appeared quite early in their career though no radical changes were found at medical examination. Evidence was found of absorption of carbon monoxide in the bloods of three of these men, the readings being 8.5, 6.0 and 4.5 per cent. saturation at the end of a shift.

With regard to the blood changes, it is interesting to note that a rise in haemoglobin level was noted in three cases within the first fortnight of starting this work. In the other two instances, no rise was noted in the first fortnight (cases N.S.D. and 41). In Case N.S.D., it was noted that his pre-employment haemoglobin level was higher than any found in the control group and was more in keeping with some of the readings common to sewermen. This, no doubt, was due to the fact that as a patrolman in the main drainage system he had been exposed to atmospheric conditions allied to those found in sewers. His later readings, however, show the variations found in sewermen. Case No. 41 worked on the surface for the major part of his first fortnight and this accounts for the absence of changes in his blood. During the rest of the year his blood varied in like manner as his mates.

An interesting feature of these entrants was the time taken for their bodies to adapt themselves to the posture of their new jobs. In the first week all complained of backache which became worse as the day went on. In the second week the aching became less and by the end of the third week the back muscles had reacted sufficiently for this complaint to disappear.

Chapter XI.

THE LONG-TERM EFFECTS OF WORK IN THE SEWERS WITH SPECIAL REFERENCE TO THE AGE OF RETIRAL.

Perusal of available records has shown that, for various reasons, it is unusual for men to reach the normal retiral age of 65 years while still employed in the sewers. These records also reveal that few sewermen, once started in the job, ever leave it because of dissatisfaction. Such labour turnover as exists does not arise from the usual causes. On the contrary, vacancies in the staff of the Sewerage Section arise mainly as the result of deaths or through the enforced retiral of a sewerman due to medical incapacity for this type of work. A review of the lengths of service of the men at present employed bears out this fact, that long service is the rule among sewermen. Almost half of the present number have over ten years', while fully 34 out of 42 have over five years' service.

How long can a Sewerman remain in this Employment?

Among the present group of men, six have over 25 years' employment as sewermen, the longest period being 28 years. Since the average age of entry to this occupation is found to be just under 38 years, almost half of the men cannot hope to complete more than 25 years in this type of work, even if they reached the age of 65 years and were still actively working as sewermen. Thus it can be said that, provided the age of starting work as a sewerman is low enough, it is possible for the job to be followed for over 25 years.

It is understood that in the past a few men have been employed in the Sewerage Section for over 30 years, but some doubt exists as to whether all of that service was in the capacity of sewerman, for the practice prior to 1937 was for men to be employed as winchmen for a number of years before graduating to the more specialised job of sewerman. In the present investigation, only service as a sewerman has been counted, though a few of the men had a short spell as winchmen before becoming sewermen. Again, although two of the foremen have close on 30 years' association with the sewers of Glasgow, and still have to enter sewers periodically, only a proportion of that long service has been spent in full-time employment within the sewers.

Factors influencing Length of Service.

Apart from the age-qualification at entry referred to above, the following factors have an influence on the duration of a man's service in the sewers:-

(a) Accidents. Sewermen, in common with those gainfully employed, are subject to injuries as a result of accidents at work. These untoward occurrences may result in serious or minor injury, and, in some instances, the outcome may be a fatality. Death may result from direct violence, drowning or gassing. So far there have been no deaths among the sewermen from direct violence, though serious injuries such as fracture of the pelvis have occurred. Drowning has occurred and a number of deaths from gassing have been recorded from time to time.

Disablement from an accident or gassing in the course of employment does occur among sewermen and a number of retirals have been enforced on this account. The dangers of accidental injury in this employment are increased because of the location of manholes in the middle of roads and streets.

The longer a person works in the capacity of sewerman the greater is his chance of injury or gassing. Thus, out of eight men with over 20 years' service, four have been gassed, and other two have had major injuries in the course of their work.

(b) Leptospirosis. This infection could also be considered as an accidental occurrence depending on the sewer to which a man is posted for work. The chances of contracting the disease, therefore, will increase as the years of service advance. Three of the men with over 20 years' service have suffered from this disease. They recovered and were able to continue at work, but eight of 23 sewermen contracting this infection have died since 1935, while at least one man was unable to return to work because of disability resulting from that illness.

(c) The Type of Sewer in which Work was mainly carried out. The incidence of injuries and leptospirosis has been found to be much greater in brick sewers than in pipe sewers. The most difficult problem arising in a pipe sewer is the clearance of a blockage, and where other methods fail, the road can be opened, the blocked section of the pipe removed and a new section laid in its place. In the case of brick sewers, breakdowns take a different form and most of them can be dealt with from within the sewer. Thus, in emergency work, where the risk is greatest, the chances of injury, gassing and leptospirosis are greater in brick than in pipe sewers.

Because of the fact that men can crawl into the brick sewers, additional effects can be produced from environmental conditions. In the pipe sewers the men work at the bottom of the manholes, for instance, and so can straighten their backs and change their posture much more readily than in the brick sewers. Again, because of the larger volume of sewage in the latter tunnels, there is a greater chance of encountering industrial trade wastes due to the larger drainage area served. In brick sewers there are fewer artificial aids to ventilation compared with the forced draught produced by the watet jet for washing silt along to the manholes in pipe sewers. For this reason, workers in brick sewers are more exposed to fumes and gases present in the atmosphere of their working environment. Effects of this exposure lead to certain defects which may produce incapacity and cause premature retiral from employment.

(d) Teamwork in a Squad. Where a sewerman has developed certain disabilities it frequently happens that his mates in the squad will "carry" him by taking over some of his duties in order to make the work lighter for him. This practice, well-known in industrial establishments, amounts to a modified form of medical rehabilitation. The patient's fellow workers in the mill or the factory will carry him as a passenger for a time until he is better able to pull his weight in the team. Where progress is not made, the team-spirit gradually disappears and the patient has to give up his work. In sewermen there is a remarkable loyalty to each other in the squads, a common finding among men exposed to danger. Instances have been found where disabled sewermen have been "covered" by their mates for several years. The oldest sewerman in the group, Case No.1, has rarely been inside a sewer in the past six years; he has worked as a winchman on the surface all of the time in a five-man night-shift squad. At clinical examination he was relatively symptom-free, but, on closer investigation, he was found to have a markedly raised systolic and diastolic blood pressure with poor exercise tolerance. There was limitation of flexion of the spine due to osteoarthritis, and it was felt that, had he been entering the sewers daily, persistent backache and progressive breathlessness would soon have enforced his retiral on medical grounds. Even when working on the surface, he had to have the assistance of a mate to do the lifting of heavy buckets of silt. Furthermore, he had a large hydrocoele which almost certainly would have restricted free movement in the confined space of small sewers. Thus, while this employee will have completed, in a few months' time, over 28 years' service as a sewerman, his effective service is probably less than 22 years.

The Effects of Long Service in the Sewers.

While the total number of retirals on medical grounds is not known for the period 1935 to 1949, it has been established that cardiovascular degeneration accounted for three sewermen, pulmonary tuberculosis and rheumatism for two each, and Weil's Disease, peptic ulceration, and carcinoma of the bowel for one each. Two men left the job on account of skin disease during that period. During the same interval of 15 years, eight sewermen reached the normal age for retiral.

The clinical findings on examination of those men with over 20 years' service are tabulated in the Appendix (Table No. 48). It is to be noted that their weights lie close to the mean for the whole group.

(a) Skin Conditions. Three men (Cases Nos. 1, 5 and 22) showed pigmentation and pale patches on the forearms, with evidence of scarring. Two had patches of early hyperkeratosis and all had ichthyosis of the forearms. These lesions could be attributed to long exposure to tar and oil products.
Case No. 22, whose service in sewers known to carry trade wastes containing tar products had been longer than the others, showed the most marked changes. Some three years ago he had a wart removed from his vocal chords. Investigation at the hospital concerned has revealed that doubt existed as to the carcinogenicity of this growth. It is possible that this lesion may have been due to the inhalation of carcinogenic fumes, such as tar, over a long period.

Two main features of those men with long service were found to be a degree of cardiovascular degeneration and the incidence of symptoms and signs related to the lumbar region of the spine. Symptoms of gastritis were found to be persistently present in four of these men, while a permanent disturbance of balance existed in varying degrees among five of the eight men in the group. With regard to temperament, several displayed a degree of anxiety with regard to entry into many of the sewers. This was obviously related to previous incidents in those sewers involving either members of the group or their squad mates.

(b) Cardiovascular Degeneration. Cardiovascular degeneration appears to affect some sewermen after a number of years in the job. Breathlessness after exercise appears quite soon after starting this type of work, especially in brick sewers. A falling off of tolerance for exercise follows and, after a long number of years, a deterioration in the quality of the heart sounds is noted at clinical examination of these men. In some of the men an upward trend is found in both the systolic and diastolic blood pressures and eventually frank hyperpiesia can be diagnosed. In other instances there is a tendency to low blood pressure.

Reference to those cases where sewermen in the past have had to retire due to heart conditions suggests that these patients had struggled on at work until some intercurrent illness, such as influenza, coryza, or acute bronchitis, had put that strain on the myocardium which produced sudden onset of cardiac failure. Almost overnight these men had become chronic invalids, and, although there was partial myocardial compensation, they were unfit to return to work. Each of the three men had fifteen or more years of service as sewermen.

(c) Conditions of the Lumbar Spine. Three of the above men with over twenty years' service have defects of the lumbar spine of such a degree as to limit their entry to the sewers. In other words, their efficiency as sewermen has been reduced to an occasional examination at the bottom of a manhole. A day's shift inside a sewer is quite outwith their capabilities. This incapacity has been recognised in two instances by the foreman and they had arranged for these two men to operate as additional members of certain squads. Cases Nos. 1 and 25 were thus passengers on account of advanced osteo-arthritis of the lumbar spine which caused severe backache on attempting to work in the sewers. These men both had limitation in flexion of the spine and both had frequent acute attacks of sciatica. Case No. 8 has already been referred to as a case of ankylosing spondylitis involving the lumbar spine. He was "carried" at headquarters for only six months and then had to give up the job of sewerman. Case No. 22 has been off work twice in the past few years with lumbago. At the time of his medical examination he was recovering from right-sided sciatica which was attributed to a herniation of an intervertebral disc. The condition responded to rest, but it has been noted that he has had a slight recurrence of symptoms towards the end of several shifts, more especially when he has been working in a small diameter brick sewer. It is probable that further attacks will arise and that sooner or later Case No. 22 will have to be withdrawn from active work in the sewers.

Two of the men show marked osteo-arthritic changes in the lumbar spine (cases Nos. 15 and 18). These two men had limitation of flexion only, though Case No.15 had radiological evidence of lumbar kyphi-scoliosis with marked distortion of the 1st and 2nd lumbar vertebrae and case No.18 had a marked kyphosis. Both are aged 51-52 years. Case No.15 worked in pipe sewers, while case No.18 has been employed mainly in brick sewers. For several months prior to the examination he had been working in large diameter sewers on the south-side of the river. This probably accounts for the absence of symptoms related to the back at the time of the examination. His main complaint was of exhaustion at the end of a shift.

Thus, out of the eight men, the only two sewermen, cases Nos. 23 and 28, who displayed no evidence of damage to the spinal column in the lumbar region had been employed mainly in pipe sewers. All of the cases showing osteo-arthritis were of a degree more marked than any found among the control group, many of whom had been employed for comparable periods in heavy labouring work, but not in confined spaces. Since osteo-arthritis is the result of repeated minor traumata to the joint concerned, and since the condition is found commonly among the joints most frequently in use at work, it seems reasonable to conclude that the presence of the condition in the lumbar spines of men, the major part of whose working life has been spent in sewers, can be taken as attributable to the nature of the employment. That the condition can progress to such a degree to cause incapacity among certain of the sewermen is demonstrated in the cases outlined above. Not only are the radiological findings more gross among sewermen with long service, but the incidence of acute symptoms is much greater than among older men employed in other trades.

Even if it is argued that the extent of the osteo-arthritis in many of the sewermen could be attributed to their age, then it must be admitted that the incidence of symptoms and signs of low backache common among sewermen cannot but be related to the radiological signs of disease in the spine and the nature of the employment.

The radiological findings are more advanced among sewermen mainly employed in brick sewers than among those whose employment has been mostly in pipe sewers. Furthermore, among brick sewermen in the same age-group, the osteo-arthritic changes are more extensive in those with the longer service.

(d) Digestive Disorders. Half of those men with long service complain of indigestion with upper abdominal pain related to meals. As has been shown earlier, indigestion associated with a particular sewer is common among sewermen, but the symptoms disappear on transferring to another sewer. In the case of the long-service men, they all give histories of having had several short attacks of indigestion while working in several sewers, but four state that in recent years the condition has been present almost continuously. Other men with upwards of ten years' service make similar complaint of indigestion, as do two of the foremen with long service. Although a number of these men have had radiological examination after a barium meal only one case was established as peptic ulceration (Case No. 42 with 15 years' service). While the majority showed no radiological abnormalities in the stomach and duodenum, two of the cases were established as gastritis, while a third case was known to suffer from gastritis before he became a sewerman. Records show that several men have had to retire because of peptic ulceration and chronic gastritis during the past twenty years. In addition, several men have died from conditions thought to be cancer of the stomach.

The presence of so many cases of indigestion among a small group of men suggests a common cause, and that can be found in their employment. The development of symptoms which can progress to true ulceration at an age past middle life, as has happened to two men within the past two years, conflicts with the generally accepted symptomatology found in peptic ulceration of idiopathic origin. It is more usual for symptoms attributable to hyperchlorhydria to disappear after the age of forty. Among sewermen the symptoms tend to get worse. Several sewermen state that the symptoms are worse after eating fatty foods, while a few state that meat causes stomach upsets in their cases. The possibility of permanent liver damage after leptospirosis suggests that this may be the causative factor among sewermen developing symptoms after eating fats, but only the minority of this class have had the infection. The possibility of a toxic factor cannot be overlooked, and the presence of vapours known to produce digestive disturbances has already been shown to exist in Glasgow sewers. This appears to be the most likely cause of the trouble. Alcohol and tobacco seem to play a negligible part in the production of gastritis in sewermen. A few of them consume beer, especially at the weekends, and most are smokers of moderate consumption, but the same symptomatology with regard to digestive disorders is found to exist in non-smokers and non-drinkers among the sewermen.

Retirals in 1950.

One sewerman died during 1950, his death being attributed to perforation of a peptic ulcer, after an illness caused by myocardial insufficiency. He was in his late forties and had been in the employment of sewerman for over 12 years.

Four men had to give up the job because of medical unfitness, namely Case No.2 due to cerebellar damage, Case No.8 to ankylosing spondylitis, Case No.20 to dermatitis, and Case No. 40 due to herniation of an intervertebral disc. All of these men were fitted into other jobs in the Highways Department where their defects would cease to be handicaps to employment. All but the last-named had ten years' or more service

Reference has already been made to Case No.5 who in my opinion is unfit for his present duties on account of low-grade phthisis plus gross osteo-arthritis in the lumbar spine.

Case No.40 (aged 47 years) and the man who died are the only two of the six men referred to above who are under fifty years of age. The reasons for their retirals from the work of sewermen are typical examples of incapacitating disabilities arising in the course of this employment.

Age and the Working Period in the Sewers - Their Influence on Retiral.

Few men with really long service appear to reach the normal retiral age of 65 years while still actively engaged in the work of sewerman. Reasons for the enforced retiral of many of the men have already been given. But, early retirals seem to be relatively common at the 55 to 60 age period, even in men with much shorter service than twenty years or over. In this period past middle life, senile change has already begun and the heavy wear and tear imposed by the conditions of work in sewers seem to be less easily tolerated after 55 years of age. Those men starting the job of sewerman for the first time at the age of 50 or thereabouts have already lost much of the pliability in their joints and muscles, and hence are less able to adapt themselves to the requirements peculiar to this type of work. In some who have already spent a substantial part of their working life in jobs demanding heavy expenditure of energy, there may already be a degree of disability (latent at that time) which is quickly brought out in the new type of job. For example, osteo-arthritis of the spine, a development through wear and tear, may have produced no symptoms in the previous job, but after a few years in the sewers it may be a crippling disability. Again, the myocardium may not be able to maintain its efficiency under the strain, not only of the heavy work but also the toxicity of the atmosphere of the sewers.

Previous reference has been made to animal experiments which proved that myocardial damage resulted from exposure to low concentrations of carbon monoxide over a period of time. That similar effects occur in man has also been established by several investigators. Thus, it can be said that some of the myocardial degeneration established as occurring in sewermen after a number of years' service is attributable to the working environment. This damage is more severe in the older men because it is usually superimposed on damage from other causes. In youth such exposure produces damage which can be got over by compensatory mechanisms in the human body. After middle age these mechanisms are not only more sluggish but also less complete and hence the danger of breakdown is greater.

Service and Age of Retiral.

The established method of selection of employees suitable for work has been to choose known and tested men from other sections of the Highways Department. The selection has been carefully carried out by the inspector and his foreman, particular attention having been paid to the man's ability as a worker, to his courage and to his reliability in carrying out instructions. Initiative and adaptability were other requirements sought in the prospective sewerman. By watching men employed in other branches of the Highways Department for a number of years, the selectors were able to select good types of recruits to the ranks of the sewermen. The increase of pay associated with the job was an attraction to the employees of the other sections. Largely on account of the latter there has always been no difficulty in obtaining the required number of sewermen and so the foremen could afford to take pains to get the types of men they wanted. Their views on the age of recruits are of interest. They held that men under the age of thirty had not settled down in life sufficiently to take a reasoned and sensible approach to the work in the sewers. Boisterous behaviour at work would be dangerous not only to themselves but also to their mates. Self-discipline was really only developing at the age of thirty. Thus, the selectors tended to choose older men for the job and put no real upper limit on the starting age of sewermen. In the present group of workers, quite a number entered the job after the age of fifty.

In the years prior to 1937, there were two grades of workers in the sewers, namely, underground workers, i.e., sewermen and surface workers or winchmen as they were called. Between 1935 and 1937, particular interest was taken in sewermen during the investigations into the incidence of leptospirosis among them. These investigations were being conducted by the Trade Unions so that evidence could be submitted to justify the inclusion of Weil's Disease in the Scheme of Workmen's Compensation. Representations were made by the Trade Unions to the employing authorities that winchmen should be included as sewermen in the squad and take a turn in the work underground. The argument was that the man on the surface, if he had experience of the sewers, could be of great assistance in rescuing his mates should there be an accident involving one or more of the underground workers. Each man in the squad could have his turn on the surface.

In many ways this development in 1937 was a good thing, for it meant that in a squad of three men, each would work underground on only two days out of three instead of every day. This reduced by one-third the amount of exposure to the sewer atmosphere and the postural discomfort of each man. Against that, however, the change has gradually resulted in the recruitment of older men. Winchmen were recruited sometimes in their early twenties, and after several years would be promoted to the rank of sewerman, often before they had reached the age of thirty. Nowadays there is no period of adjustment such as that obtained in the job of winchman between a man leaving a labourer's job in the streets and entering the sewers.

Chapter XII.

RECOMMENDATIONS DIRECTED TOWARDS THE IMPROVEMENT OF THE WORKING CONDITIONS AND THE PREVENTION OF DISABLEMENT IN GLASGOW SEWERMEN.

The Ideal.

The ideal method of preventing disablement is to remove the sewermen from work inside the sewers and substitute the machine for the manual worker. This has been done in many difficult jobs in industry, and, at the present time, that transition is taking place in work very similar to that of sewermen, namely in the mines.

More locally, in the public services, the Cleansing Department is making rapid progress in the use of mechanisation in many of its processes. Not only are new refuse disposal units being constructed which are almost completely mechanical, but mechanical street sweepers and street washing machines are now in daily use. Even more revolutionary suction methods of street sweeping are contemplated, while research is being conducted into the possibilities of mechanisation in the method of transference of refuse from bins into lorries.

These changes in the method of refuse collection and disposal already have done much to safeguard the health of the employees as well as improving the efficiency of the Department. Twenty years ago these methods were considered to be quite impossible as practical propositions, yet now they are in everyday use.

In view of these advances, it would seem not impossible that mechanical methods applicable to the clearing of silt from sewers could be developed by engineers. Limitation of space, a great hazard to sewermen, presents many obstacles to the designing of suitable mechanical appliances. One does feel, however, that it might be possible to use suction apparatus or mechanical scrapers and conveyors, similar to those used for the dredging of river beds. The important feature of any such apparatus must be that it is transportable and must be capable of being used in the various diameters of sewers.

Other possibilities are the incorporation of grit settlement tanks at various points along the sewers, into which the silt might be washed and then removed mechanically without the necessity of men actually entering into the sewers. Large access manways would facilitate the removal of this silt.

Another important ideal is the prevention of entrance to the sewers of trade wastes likely to be harmful to sewermen. This would involve the setting up of trade waste disposal units at certain factories and, in addition, a special force of inspectors to supervise the disposal of waste from industrial premises. Attempts are already being made to achieve this end by means of the new Rivers Pollution Boards which are shortly to be set up throughout the country.

It is fully realised that for economic and other reasons, few, if any, of the above suggestions are possible at present, but it is stressed that there is a great need for examination and review of the whole problem of water-borne waste and its disposal in the Glasgow area. In such an investigation, attention should be directed to the utilisation of methods less likely to cause injury and disability to the small group of men who are responsible for the maintenance of efficiency in the network of sewers which lies below the streets of Glasgow.

Where manual methods of sewer maintenance must be continued along present lines, and it is realised that present methods must of necessity continue for many years to come, the following recommendations are considered as absolutely essential if an honest endeavour is to be made to improve working conditions of sewermen and thereby attempt to reduce the incidence of disablement among them, proved to have arisen in the past.

I. Measures directed to improve the Environment.

For obvious reasons it is impossible to beautify the working environment along the lines generally used in industry. Nevertheless, in two main respects the environment can be improved, namely, by the institution of measures designed to improve the ventilation in sewers and by the introduction of better methods of lighting.

(a) Ventilation.

(i) General Ventilation of Sewers. Because of complaints of nuisance by residents in certain districts the manhole covers have been sealed over so that offensive fumes are prevented from annoying the public. Over a period of years there has been a gradual reduction in the amount of natural ventilation of sewers.

During the same period there has been a continuous expansion of industry with a resultant increase in the volume of trade wastes emitted into the sewers. The effect of this policy has been to cause increased concentration of fumes and gases in the sewers. In order to counteract this, it seems essential that ventilating shafts be introduced at suitable points along the sewers in such a way as to achieve ventilation of sewers without causing nuisance to the public.

(ii) Local Ventilation in Working Areas. The Sewerage Section has a mechanical ventilating fan which can be used to draw foul air from a section of a sewer. Its use is restricted to known danger points, but it is felt that its efficiency is poor. Indeed, on calculation of the air movement in a sewer where this fan was in use, it was found to be only some 40 feet per minute IN THE OPPOSITE DIRECTION from which it should have been, had the fan been working properly. To gain the best atmosphere, baffles must be used to cut off fumes from adjacent sections of the sewer, and a satisfactory inflow of fresh air established naturally or mechanically where necessary. There is sufficient evidence to justify the use of mechanical ventilating aids in all work done inside sewers.

In this way fresh air would be drawn in at one manhole and foul air withdrawn at the next. In "blind ends", fresh air should be introduced at the furthermost point from the manhole so that the sewermen in the section can be sure of a supply of fresh air.

Air pipe-lines from an air compressor machine, such as is used to supply power for pneumatic drills in the carrying out of road repairs, would be satisfactory for this purpose, provided care is taken to ensure that exhaust gases from the diesel engine come nowhere near the air intake of the compressor. This method was used successfully for the ventilation of the pump wells at the breakdown resulting from the discharge of tar into the low-level sewer on the south side of the river.

(b) Lighting in Sewers.

The present method of illumination in sewers, namely, by the use of primitive oil cap-lamps is to be condemned, not only from the point of view of poor illumination but also from the smoke and fumes emitted by the lamps. These lamps not only use up oxygen but also add to the fumes and vapours in a sewer.

Electric lighting offers most possibilities and further trials should be given to various methods using this source of power.

General lighting from a number of lamps fixed to portable standards could be used in the larger sewers when work involving several days was to be carried out. Low voltage current from a small petrol driven generator of the type commonly used on R.A.F. airfields during the War would meet the requirements of these larger sewers. Alternatively, the source of this current could be from the street lighting circuit, use being made of a suitable transformer.

In the small sewers and for short inspections, the electric cap lamp operated from a small accumulator hitched to the man's clothing would be a considerable advance. A trial of this type of lamp is at present in progress. The headpiece is of plastic and light in weight. It is operated from a small three-volt accumulator enclosed in a water-tight case of aluminium alloy which can be attached to the belt or strapped to the chest. The perspex front of the lamp is moulded so that some light is thrown laterally, as well as being directed forwards by the reflector. At ten inches from the eyes, the intensity of illumination with this lamp is 14 foot-candles at the centre of the beam and four foor-candles at the edge of the beam. This is a vast improvement on the oil lamps which were found to give only 0.25 foot-candle at the same distance. Improvement in the reflector to give less concentration of light is suggested, and the use of a polarising filter to reduce reflection from the fluid surface.

The use of electric lamps is meeting with some opposition at present. This experience also occurred in the mines when similar changes were made in the method of illumination there. The advantages of the improved method of lighting, however, far outweigh the disadvantages of inability to detect concentrations of irrespirable gases by means of reduction in size of the flame of the oil-lamp.

Irrespective of the method of illumination used, not only must its intensity be increased considerably, but, also, there must be much greater attention paid to testing of the atmosphere for the presence of dangerous gases. One safety lamp of the type shown in Fig. No.8 is available in the Sewerage Section, but its use is mainly in the detection and tracing of coal gas leaks into the sewers.

The oil lamp is lit and the flame adjusted so that its tip just reaches between metal pointers 'A'. In the presence of methane the halo round the flame of the safety lamp reaches higher and heats the brass container 'C', from the inside of which the heat causes a spiral wire to expand out to touch terminal 'B'. When the circuit is thus completed the electric bulb is lit and shows through the red glass window. The electric lamp is set to go on at a concentration of 3.5 per cent. methane in the atmosphere. Normally the lamp is slung from the chest when used in mines, but in the sewers it is lowered down the manhole, and if the electric bulb lights, the red light from the glass window is viewed from the surface by means of the side reflector.

There are various tests for other gases commonly found in sewers. These tests which involve the staining of a suitably treated blotting paper could be used with advantage in many of the sewers and the sewermen taught to interpret the colour changes so that they could retire from the sewer when dangerous concentrations were indicated. Carbon monoxide, for instance can be detected by the brown staining which it produces on palladium chloride paper. Similarly, lead chloride paper can be used for the detection of hydrogen sulphide.

II. Protective Measures applicable to the Sewermen.

(1) Protective Clothing.

One bad feature of the present protective clothing is that, being composed mainly of rubber, it does not permit of the evaporation of perspiration from the skin surface of a large part of the body, especially where waders are worn. The upper part of the body is only feebly protected from drips from the roofs of sewers and from the splashing at branch entrances. The corduroy waistcoats occasionally supplied tend to be rather warm and are not really waterproof. It is suggested that an upper protective garment which is waterproof yet permitting of evaporation of perspiration should be supplied to sewermen.

Materials of this type were developed for use in the Royal Navy during the recent War, and were of such a type that, while normal evaporation of sweat was permitted, sea water could not penetrate the fabric for some 36 hours. Suits of such material proved of use when immersion in the sea resulted from enemy action. The material must be of such a type as would also stand up to the hard wear and friction against walls liable to occur in sewers.

In the past, protective gloves have not been worn by sewermen. There would seem to be a place for these in this type of work, especially in oily and tarry sewers. The gloves must be pliable and fitted with washable linings. Some of the heavier plastic materials would be suitable for this purpose. The gloves should have long armlets, capable of being attached to the sleeves of jackets in such a way that the junction is waterproof without causing constriction of the forearms.

At present the sewermen wear the usual type of working clothing to their work. With only ordinary engineer's overalls as an overlay (apart from the area covered by thigh boots or waders), it is readily understood that soiling of personal clothing frequently occurs. In some sewers this soiling can be quite extensive. Because of the source of the soiling, the odour can be exceedingly offensive. At present, sewermen are issued with two sets of overalls and these are replaced by the issue of a new set every six months. No special arrangements are made for the cleaning of soiled overalls and other personal clothing. These have to be taken home and washed there. Many of the men feel that they cannot ask their wives to tackle the washing and so do it themselves, often with very poor domestic facilities.

This arrangement seems to be most disgusting. Having had one's own clothing soiled in visits to the sewers, one appreciates very much the discomfort not only of travelling on public transport with such offensive odours clinging to one's person, but also the problem of cleansing of the soiled garments. It is recommended most strongly that not only should the outer garments worn by sewermen be provided by the employers, but also that special arrangements should be made for the regular laundering of those garments including overalls.

(ii) Washing Facilities for Sewermen.

Closely linked with the clothing problem is the question of adequate washing facilities for sewermen. On the site the facilities must needs be primitive in the absence of piped supplies of hot water. The present method of issuing free passes for entry to the public baths is not the answer to this problem, for few of the men actually have a bath before going home from their place of work.

A scheme similar to that being introduced to the Cleansing Department is recommended. In the various parts of the city, baths, changing rooms and lockers are being fitted up on the lines of the pit-head baths provided for miners.

It is most desirable that similar facilities be provided at suitable points throughout the city for the various squads of sewermen. In this way, not only would filth from the sewers be kept out of the homes of these men, but also, where skin irritants were present in the sewer in which they were working, a more complete removal of these from the skin would be achieved.

That sewermen should be able to dissociate their homes from their work by such an arrangement would have a marked effect on their mental outlook and family life.

(iii) Protective Creams.

Protective creams have only a limited place in the protection of the skin from irritants found in the sewers. Recommendations have already been made in favour of the use of gloves but there are occasions where the bare hands will still have to be used. Only then have barrier creams a limited use, and that is where the irritant is water soluble. Water resistant creams could then be used, but as far as oil and tar are concerned, since creams resistant to these substances are water soluble, no protection could be given by their use in sewers where water is ever present.

(iv) Protection against Leptospirosis.

Recommendations have already been made in Chapter VIII.

(v) Transportation of Equipment to and from the Working Area.

The loaded hand-cart used by sewermen weighs approximately 13½ cwts. In the past the various teams of three men have manhandled these vehicles from the depot to the working area and back daily. On many occasions these journeys have involved heavy pulls up-hill. In the past few years two ex-army motor trucks have been used in certain emergency jobs, but, in the main, each team proceeds to and from the working area on foot (complete with barrow). In this era of efficiency in industry it would appear advantageous to experiment in the use of jeeps and trailers for the more rapid and less tedious transportation of men and materials to the working site.

III. Pre-Employment and Periodic Medical Examination of Sewermen.

In the past, few if any pre-employment medical examinations were carried out on recruits to the job of sewermen. The method of selection tended to ensure that quite good types of men, both physically and mentally, were recruited. It does not follow that those men were free from physical defects which might break down as the result of work in the sewers.

In the light of the early findings of this investigation, it was recommended that pre-employment medical examinations should be carried out on men selected by the foremen as otherwise suitable for the job. Out of ten men sent for examination, four were turned down, one because of hyperpiesis, one on account of perforated ear-drums and a history of gastritis, one on account of varicose eczema, and the fourth because of his age and osteo-arthritis of the lumbar spine. This last man was grossly overweight and was considered generally to be a bad risk in a sewer.

The pre-employment examination was similar to that carried out on the sewermen and included X-ray of chest and lumbar spine, and a full blood examination. The advantage of the pre-employment examination is that a record is then available for comparison should the man have to be examined in the course of a subsequent illness. Such a record would have been of infinite value when one was called out to see two sewermen who were ill prior to the start of this investigation. In these instances the family doctor was unable to give much help because these men had only recently moved to a new housing area in the city with consequent change of doctor.

Periodic examinations would be useful at six-monthly or yearly intervals in giving an assessment of minor deviations in health. Where special work has to be done in an environment known to have a toxic hazard, special examinations could be conducted more frequently. Again, those examinations could be used as a guide in determining whether a man was still fit for employment as a sewerman when he was nearing the end of his service. If a defect were found in such a case and it was likely to cause incapacity in the job of sewerman, then it would be possible to have the man transferred to some other suitable employment before he was seriously disabled and forced to retire on medical grounds. It should be possible in this way to reduce the effects of disabling illnesses which have been so common among sewermen in the past.

Again, included under the heading of periodic medical examinations would come a medical examination, before their return to work, of all sewermen who had been off ill. This is considered to be an essential part of the medical service because work in the sewers is not suitable for the rehabilitation of the convalescent. An arrangement must be made whereby sewermen can be rehabilitated in other work for several weeks after a serious illness before they go back to their former job. A sewerman not fully recovered from an illness, or one suffering from a defect to such a degree as to be a passenger in the squad is not only a danger to himself but also a danger to his mates. In "carrying" one man, the other members of the team have to do longer periods underground, thereby greatly increasing their risk of injury, and, should an accident occur, the passenger on the top, in attempting to rescue his mates, may get into difficulties himself and hence a greater tragedy can result.

IV. Age of Recruitment and Retiral Age.

It has been shown that the job of sewerman calls for the expenditure of great physical effort under very difficult conditions. The human body once adapted to the needs of special conditions can continue to work efficiently under those conditions for a prolonged period. Since the human machine operates most efficiently between the ages of 20 and 35 years, it seems desirable that men should be recruited to the work in the sewers as early in that period as possible. The work in itself cannot under any circumstances be considered attractive, but an effort must be made to recruit men at least under the age of 35.

Men in their 50's have got beyond the stage of adaptibility and cannot be expected to survive long the trauma and physical strain of their new job in the sewers. Even men in this age-group well adjusted to the work after years of experience show signs of break-down in their capacity for work in the sewers.

It has been shown in the previous chapter that 20 to 25 years as a sewerman produces certain defects in the body which render a man less able for his job. One is convinced that no man beyond the age of 55 years should be employed in the daily work of maintenance within the sewers. Beyond this age he is a liability to himself and to his mates.

In other jobs demanding similar courage and endurance, as in the Fire Service, steel erectors, the Services in wartime, and the police, certain age-limits are laid down beyond which a man is considered to be unfit for service, Some men are still capable of continuing the particular type of work even when they reach the retiral age, but, since experience has shown that efficiency deteriorates quickly at ages beyond that optimum, it is the recognised procedure to pension all men on reaching the upper age limit.

In the case of sewermen, one is of the opinion that 55 should be the upper age limit. Again, 15 years' service as a sewerman seems to be the maximum length of service possible without causing minor disablement. After that service the incidence of defects rises so that by the time the 25 years' service mark is reached major defects are relatively frequent among these men. Twenty-five years' service is recommended as the outside limit of the effective working time of a sewerman. At the end of that time he should be given a small pension in recognition of his services, and transferred to a less arduous job elsewhere in the Corporation's service. This procedure is recommended in preference to retiral on pension, for it is important that those men should continue in suitable employment until the normal retiring age of 65 or later.

Difficulty has arisen during the past two years in the placement of sewermen unfit to continue work in the sewers. The number of jobs in the Highways Department suitable for these men is very limited, and hence some of the disabled sewermen have had to be allowed to retire on pension and seek employment elsewhere. On the whole, the various Corporation Departments are separate employing units and it is not easy to persuade one Department to recruit disabled employees from another. Again, even although an employee's unfitness for his former work is attributable to the nature of the work and he is transferred to a suitable job, it does not follow that his wage level will remain the same as formerly. It is more usual for the employee to be paid the rate for the job in his new employment. In a few instances, the Disability Pension paid by the Ministry of

National Insurance brings the new wage up to the level of that of the former employment. This, however, does not happen in all cases.

Again, in order to avoid unrest among employees in a particular grade of work, it is unwise to have several scales of wage-rates for the same work. Accordingly, it has been the experience of several sewermen to find that when they became unfit to continue work in the sewers they were offered alternative employment at a reduced weekly wage. In some instances this led to domestic financial hardship.

The suggestion of a special pension to men who have completed 15 to 20 years' service as sewermen would ensure that when the employee was transferred to alternative employment there would be no fall in income. There are, however, possible difficulties and delays in achieving the necessary amendments to the present superannuation scheme.

An alternative method of securing a solution to this problem would be for a certain group of jobs to be reserved for sewermen who had completed the required service in the sewers or had to retire from that employment prematurely on account of disability attributable to the nature of that work. Jobs which might be suitable for scheduling as fitted for former sewermen are weighman in the Weights and Measures Department, swing-bridge attendant.

The number of posts in these categories is small, and thus in the course of a few years when filled by retired sewermen there would be no problem of differential rates of pay. Sewermen would then be able to continue in the Corporation's employment at the same remuneration until they reached the normal retiral age of 65 or later. Thereafter they could retire on full superannuation pension.

Conclusions.

In carrying out this investigation one has had the opportunity of studying life in an underworld, known only to a few workers in the cities and townships throughout the civilised world. That men should have to work under such conditions and with such primitive methods in this Twentieth Century seemed at first unbelievable, but with more study of the working environment it readily became apparent that major obstacles lay in the path to early improvement of these conditions.

By studying the environment it was possible to define certain factors likely to make an impact on the body mechanisms of these workers. The medical examinations conducted on the sewermen revealed various defects which have been discussed in the previous chapters. In establishing that the cause of many of these defects was intimately connected with the environment in which the work was done, a relationship between health and occupation was proved in the case of Glasgow sewermen.

An opportunity has been taken to make certain recommendations designed to improve the working conditions and thereby the health of these underground workers. It surely is not too much to ask that these few men, on whom depends the smooth running of the city's drainage system, be given facilities and conditions of service comparable with those made available to workers in many branches of industry at the present time.

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THE RELATIONSHIP BETWEEN OCCUPATION AND HEALTH AS SHOWN BY AN INVESTIGATION INTO THE HEALTH OF SEWERMEN IN GLASGOW.

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December, 1951.

PART II.

PART 11.

M A P S.

MAPS.

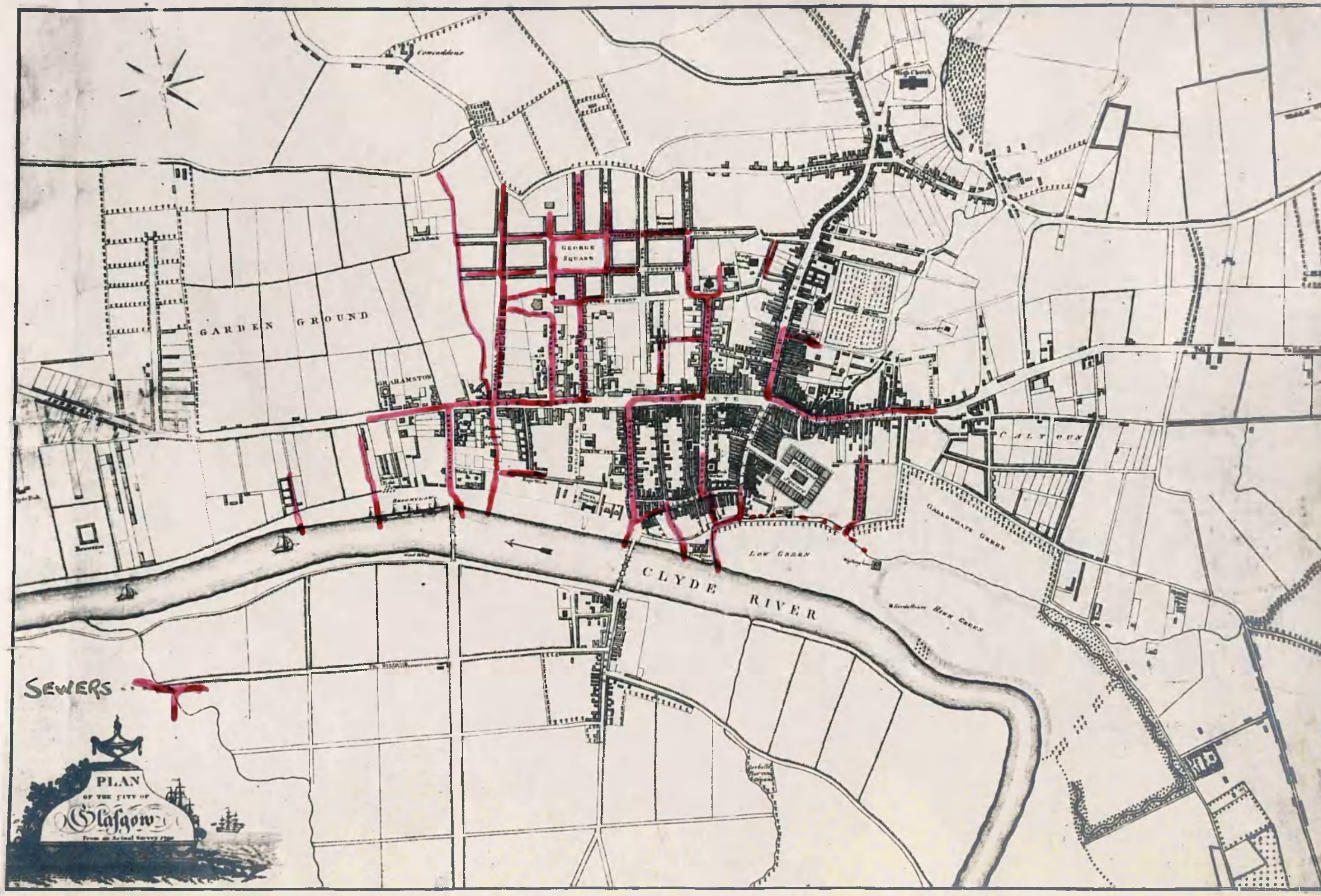
No. 1. Common Sewers in Glasgow in the Year 1816.
The location of sewers is shown in red on a photostat copy of a Plan of Glasgow dated 1790, housed in the People's Palace, Glasgow Green.

No. 2. Glasgow Main Drainage System (1911).
Additional intercepting sewers have been constructed in the new housing areas but these are tributaries of the main system shown in this Map.

No. 3. Location of Glasgow sewers where the atmosphere is known to be dangerous.

No. 4. Location of sewers known to harbour rat vectors of leptospiral infection.

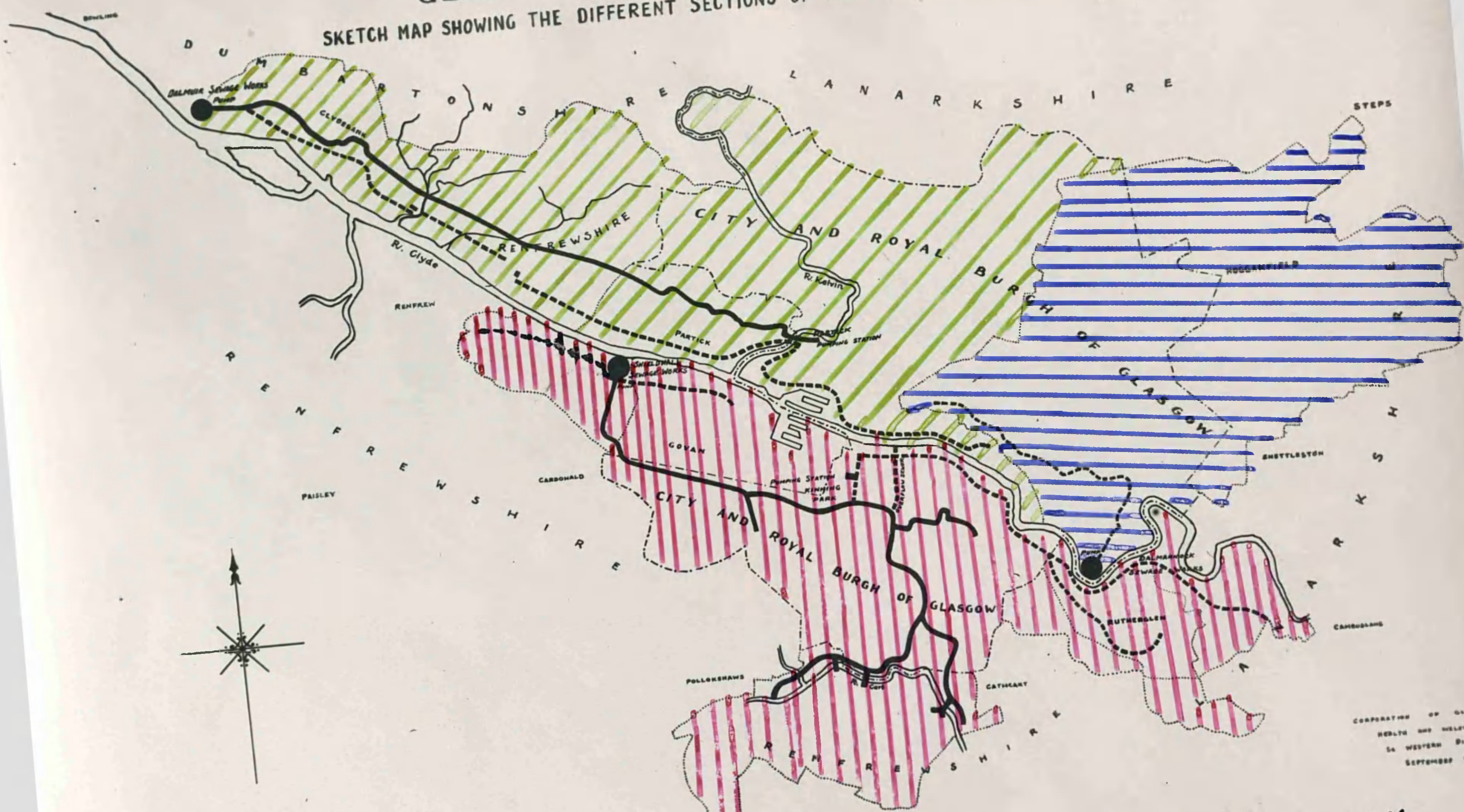
No. 5. Plan of Glasgow (1948). Sewers are located below every street in the city.



MAP No. 1. GLASGOW SEWERS – 1816.

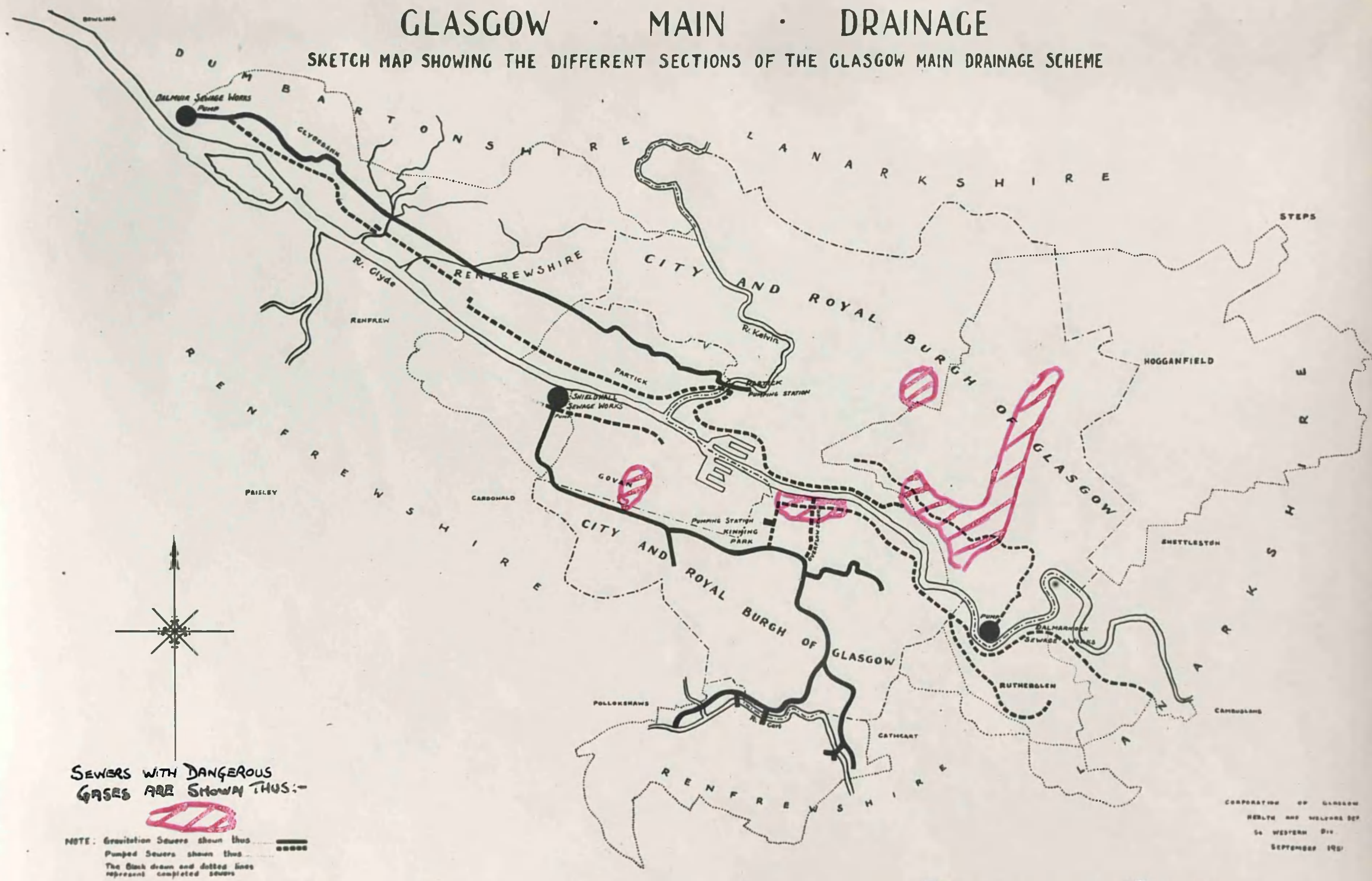
GLASGOW · MAIN · DRAINAGE

SKETCH MAP SHOWING THE DIFFERENT SECTIONS OF THE GLASGOW MAIN DRAINAGE SCHEME

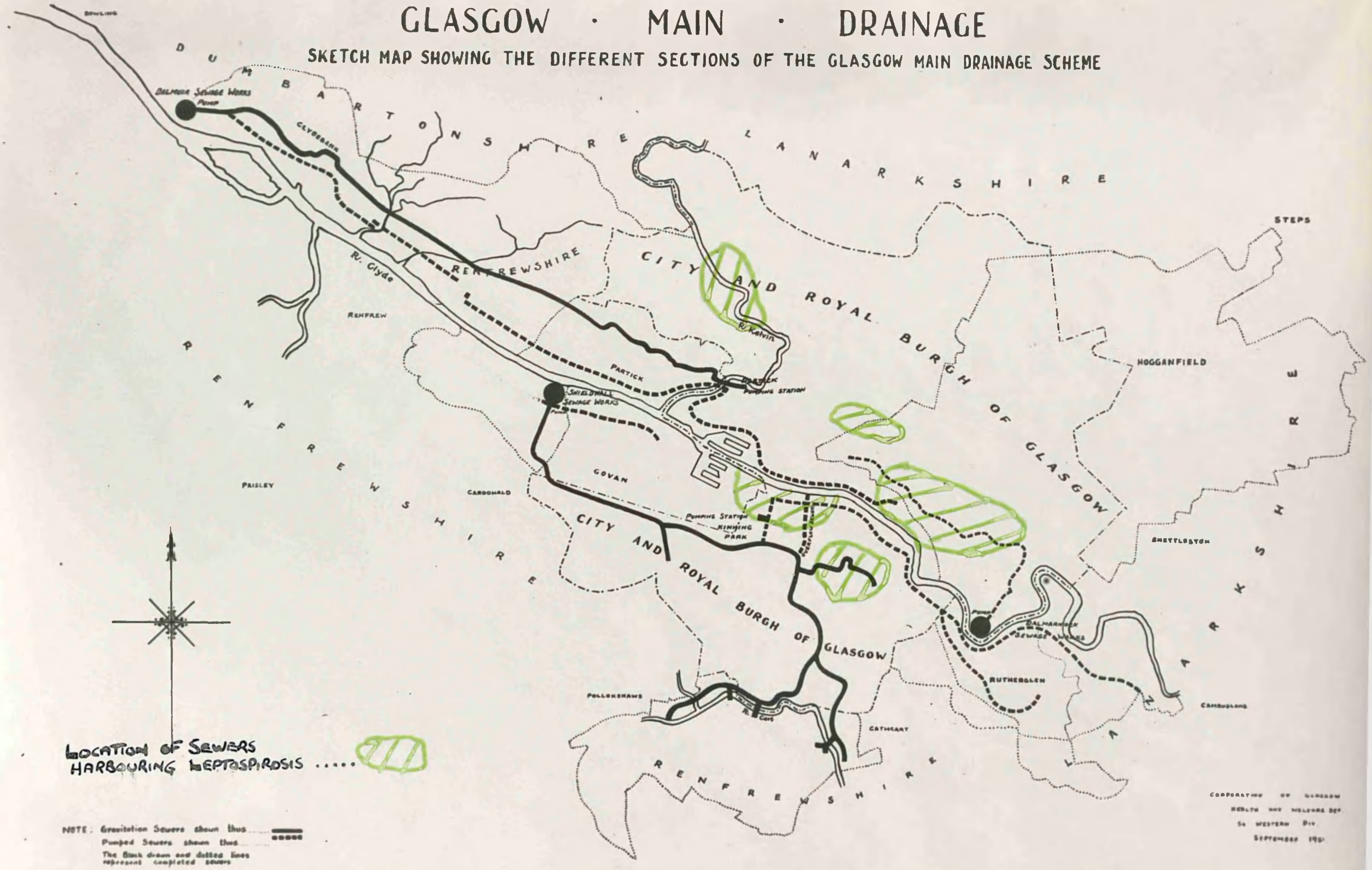


NOTE: Gravitation Sewers shown thus
Pumped Sewers shown thus
The Black drawn and dotted lines represent completed sewers
SEWAGE DISPOSAL WORKS ...

MAP No. 2. GLASGOW MAIN DRAINAGE – 1911.



MAP No. 3. GLASGOW SEWERS — DANGEROUS AREAS.



MAP No. 4. GLASGOW SEWERS HARBOURING LEPTOSPIROSIS


PLAN OF THE COUNTY OF THE
CITY OF GLASGOW
CENTRAL GLASGOW
MAP No. 5
CITY OF GLASGOW – 1948

Map No. 1.

List of Common Sewers in Glasgow previous to April, 1816.

Extract from Cleland's "Annals of Glasgow".

The following is a particular description of the Common Sewers, which were formed within the Royalty previous to April, 1816:-

Albion Street (North) - The sewer in this street originates at the Canon Street Sewer and terminates at the north side of the Independent Chapel.
Argyle Street - A sewer commences in this street, about sixty yards east from Robertson Street, and runs east till it joins the sewer in Jamaica Street. Another sewer commences at Miller Street, and runs west till it joins the Jamaica Street Sewer, crossing underneath St. Enoch's Burn.
Bridgegate Street - A sewer thirty yards long is formed on the north side of the street, terminating in the Stockwell Street Sewer. A similar sewer is formed on the south side of the street, terminating in the Merchants' Hall Lane Sewer.
Brunswick Street - A sewer commences at Wilson Street and terminates at Brunswick Place.
Buchanan Street - The sewer in this street receives the water from George's Street Sewer and carries it down to Argyle Street
Candlerigg Street - The sewer runs along the whole length of this street.
Canon Street - A sewer originates at the Candlerigg Street and terminates 10 yards east from North Albion Street.
Charlotte Street - The wide part of this street has a small sewer which terminates in the Camlachie Burn.
Cochrane Street - The sewer in this street commences at the east side of Frederick Street and terminates at the entry to the George Inn Stables (City Chambers).
Frederick Street (South) - The sewer in this street communicates with the sewer in the south side of George's Square.
Gallowgate Street - A sewer commences at the Cross and runs down to the Molindinar Burn.
Gallowgate Street - A sewer is formed in this street from the Molindinar Burn to the east side of Campbell Street.
George's Street - A sewer commences at the east side of Balmano Street and runs west to St. George's Church.
George's Square, east side - A sewer is formed behind the Buildings, it runs from George's Street to Cochrane Street Sewer.

George's Square, south side - The sewer in this street originates at the Queen Sttreet Sewer and terminates at the east side of Frederick Street.

George's Square, north side - A sewer is formed in front of the Buildings, and also between the Buildings and Offices; the latter runs to North Hanover Street.

Hanover Street (south) - A branch from the sewer in Ingram Street, runs northwards, and terminates about the centre of Manhattan Buildings.

Hanover Street (north) - A sewer is formed in this Street, from the upper end of the Buildings, and terminates in the sewer, north side of George's Street.

High Street - A sewer from the Tontine Court runs down till it joins the Gallowgate Sewer on the north side of that street.

Howard Street - The sewer in this Street originates at St. Enoch's Burn, and terminates a little to the east side of Maxwell Street.

Ingram Street - A branch from the upper sewer in Queen Street runs along Ingram Street, to the east side of Hutcheson Street.

Jamaica Street - The sewer originates at the River, at the east side of the Bridge, and terminates in Argyle Street.

King Street - The sewer in this street originates at the Markets, and terminates at the Market Lane Sewer.

Market Lane - This sewer originates at the Bridgegate Street, and terminates at the Molindinar Burn.

Merchants' Hall Lane - A sewer is formed in this Street from the Bridgegate Street to the River.

Miller Street - A sewer is formed in this Street from Ingram Street to Argyle Street.

Montrose Street - The sewer in this Street commences at the north side of Cochrane Street, runs down to Ingram Street, and joins the Candlerigg Street Sewer.

Queen Street - A sewer commences about sixty yards south from Ingram Street and joins the sewer in Argyle Street. Another sewer in Queen Street commences at the north end of the west side of George's Square and runs down to twenty yards south of the Theatre; it then runs across in an oblique direction, and joins the Buchanan Street Sewer at fifteen yards north from Gordon Street.

Queen Street (north) - A sewer commences at the north end of this Street, and terminates in the George's Street Sewer.

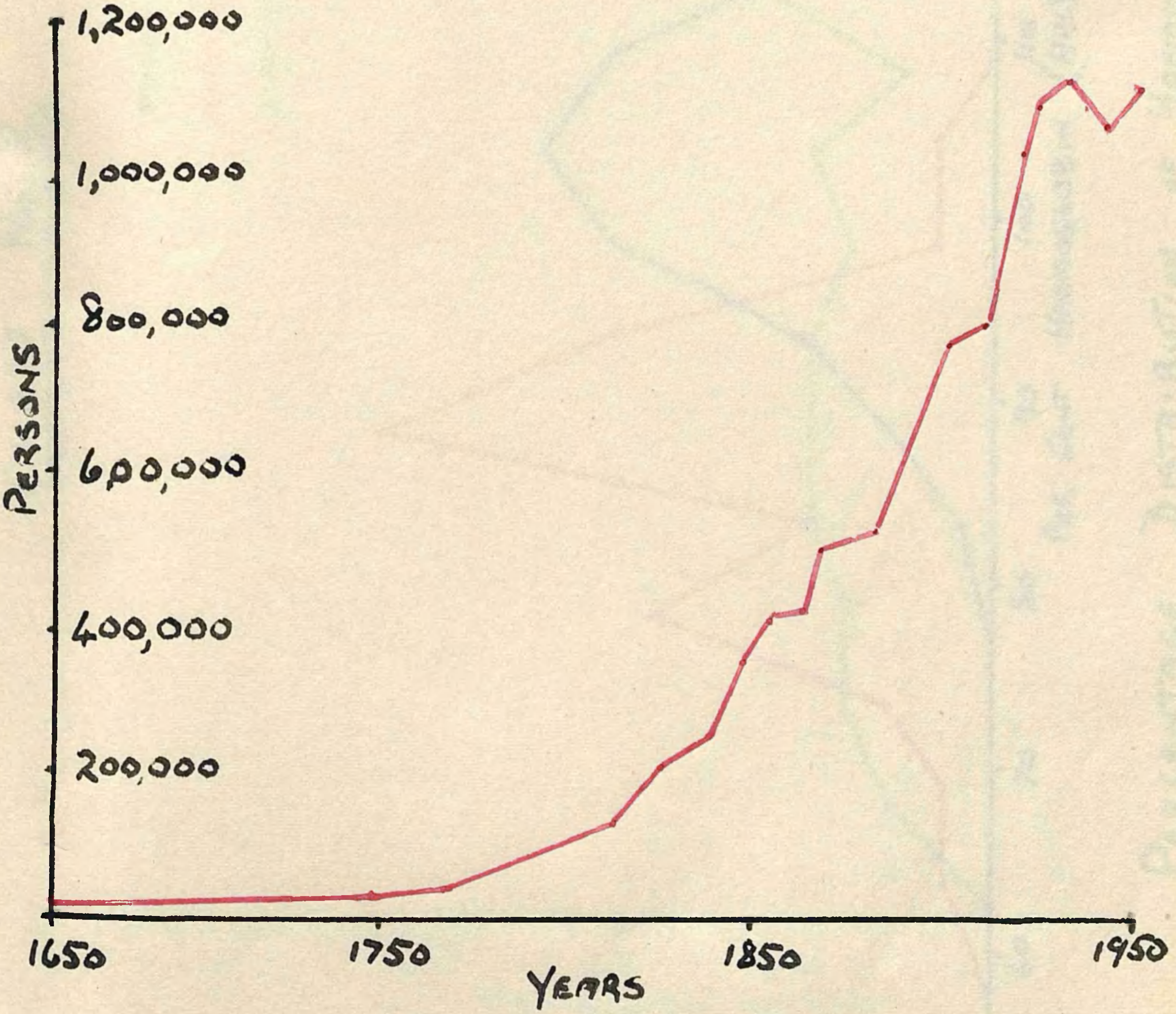
Robertson Street - The south end of this sewer is connected with the River, and terminates about forty-two yards north from the plane of the buildings of Trafalgar Place.

Saltmarket Street - The sewer in this street originates at the north side of the Bridgegate Street and terminates in the Molindinar Burn.

St. Enoch's Burn - The Burn is arched and made into a sewer, from Gordon Street northwards to fifty yards south from Bath Street, and from Gordon Street southward, one hundred and ninety-two yards.
St. George's Place - A branch from the Buchanan Street Sewer runs along the south side of St. George's Place.
St. Nicholas' Street - The sewer in this Street commences a little to the west of Weaver Street, and terminates in a Garden, on the east side of Kirk Street.
St. Vincent Street - The sewer in this Street commences at the east side of St. Vincent Lane, and terminates in the Buchanan Street Sewer.
St. Vincent Street (West) - Two branches from Buchanan Street Sewer are formed in this Street; they terminate nearly at St. Enoch's Burn.
Slaughter House - The whole Lanes or Passages leading to the Killing-Rooms have sewers formed under them.
Stirling's Road - A sewer is formed in the hollow ground, a little to the south of the Road; it runs eastward towards Taylor Street, one hundred and ninety-two feet.
Stockwell Street - The sewer in this Street connects itself with the River at the west side of the Bridge.
Town's Hospital Lane - A sewer originating at the River runs along the east boundary of the Hospital.
Trongate - A sewer is formed in this Street from Stockwell Street to Candlerigg Street.
Wilson Street - The sewer in this Street commences at the Candlerigg Street Sewer, and terminates at the centre of Brunswick Street.
York Street - The south end of this Sewer is connected with the River and terminates about 40 yards south from Anderston Walk.

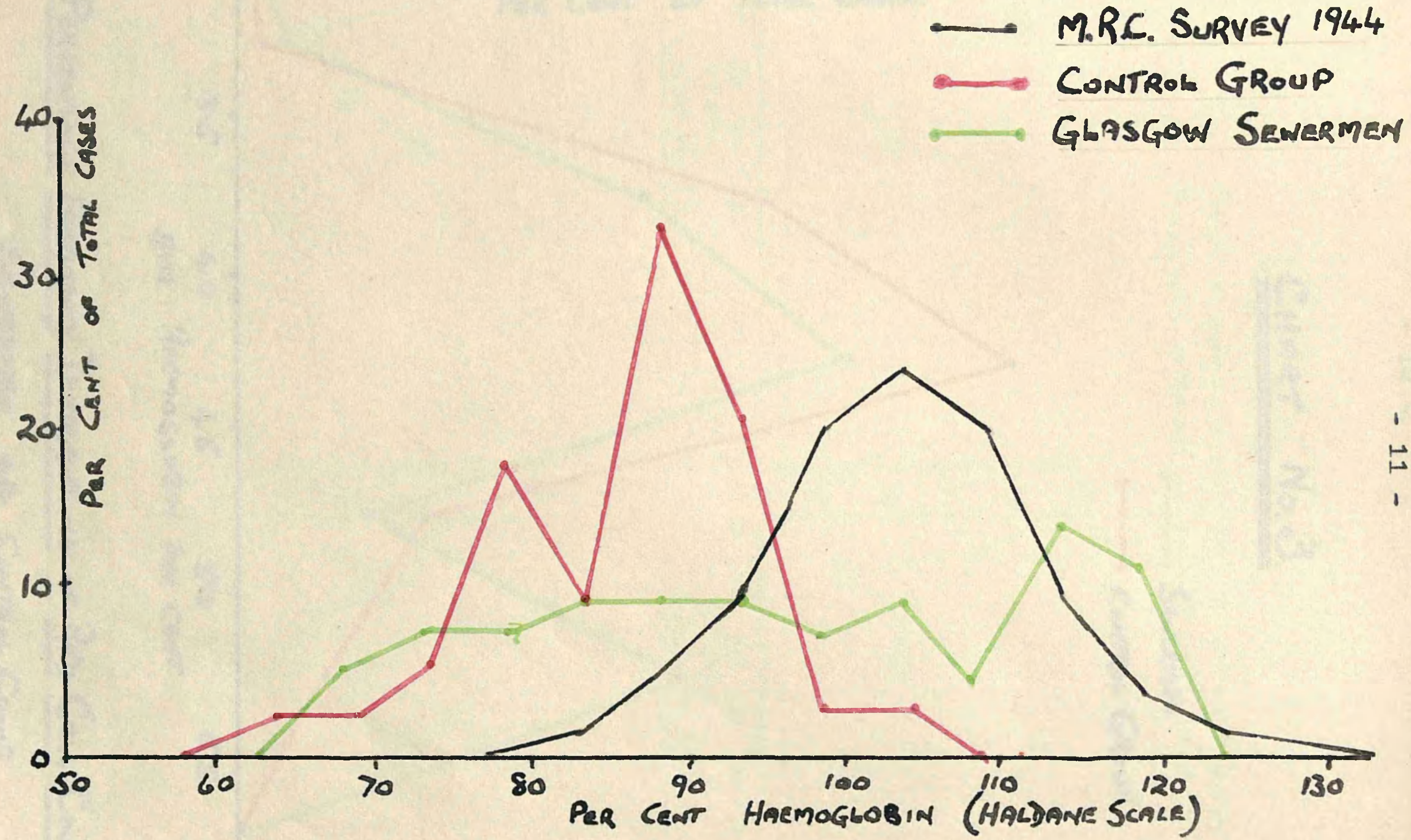
CHARTS.

CHART No. 1



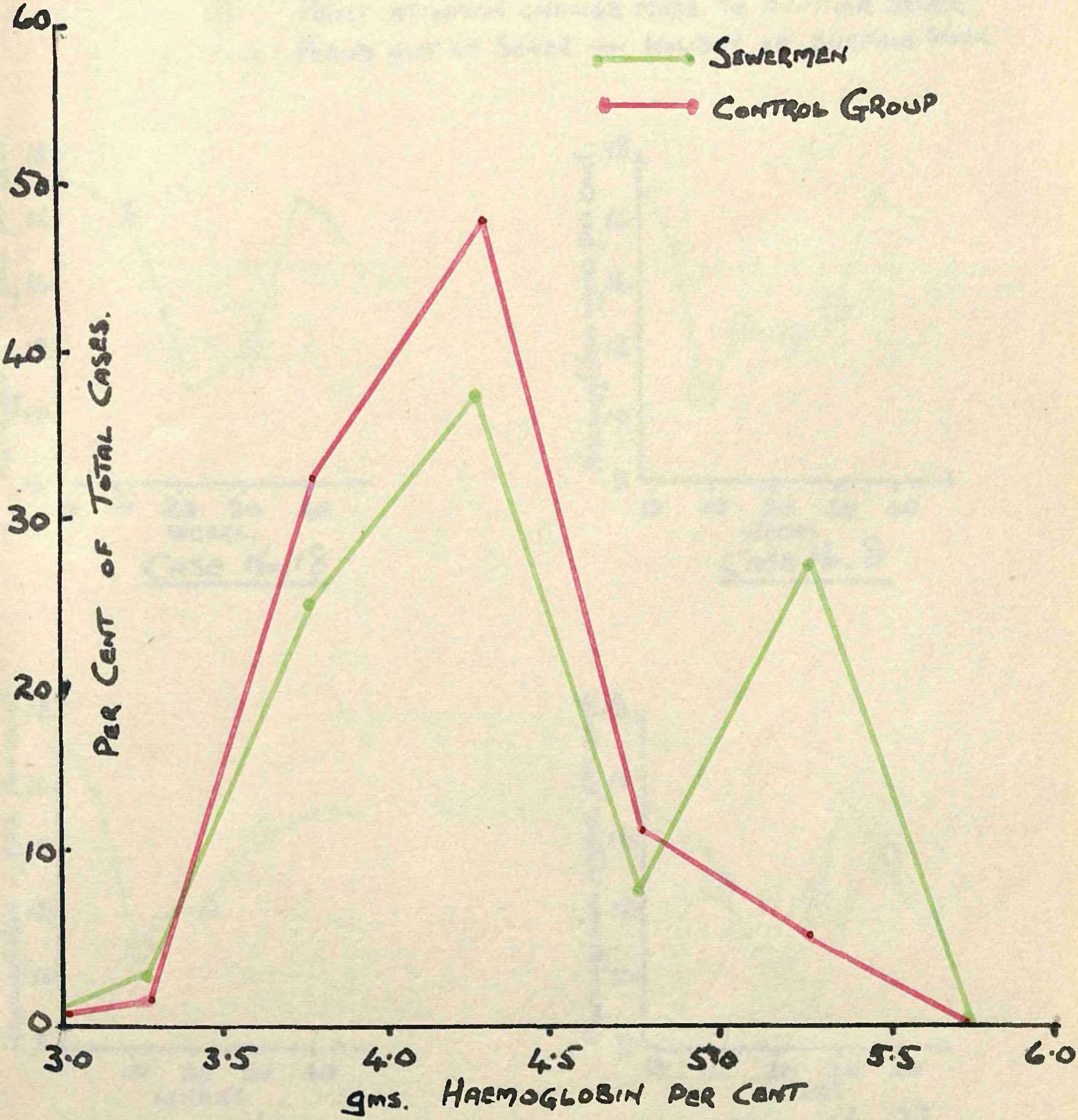
POPULATION OF GLASGOW 1650 - 1950

CHART No. 2.



PERCENTAGE DISTRIBUTION OF HAEMOGLOBIN VALUES

CHART No. 3.

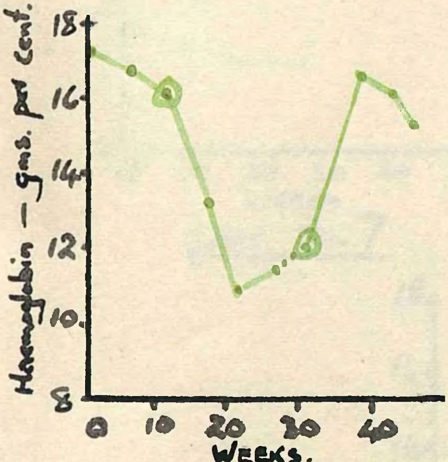


PERCENTAGE FREQUENCY DISTRIBUTIONS OF RED CELL COUNTS
SEWERMEN AND CONTROL GROUP

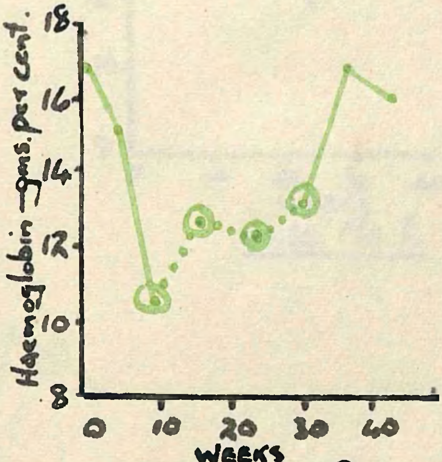
CHART No. 4.

◎ POINT AT WHICH CHANGE MADE TO ANOTHER SEWER

······· PERIOD OUT OF SEWER — HOLIDAY OR SURFACE WORK.



CASE No. 18



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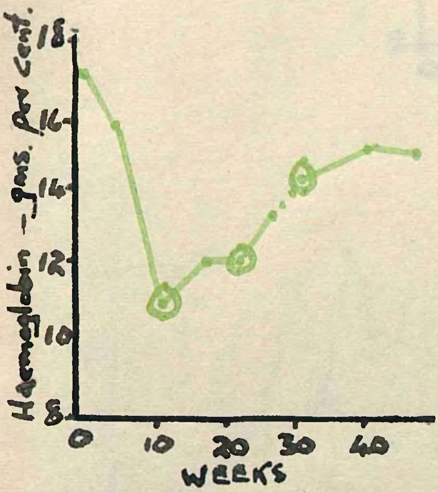

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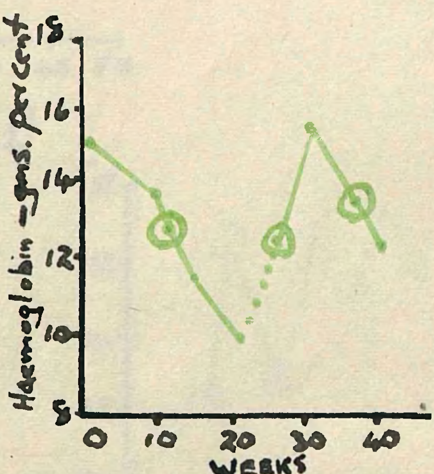
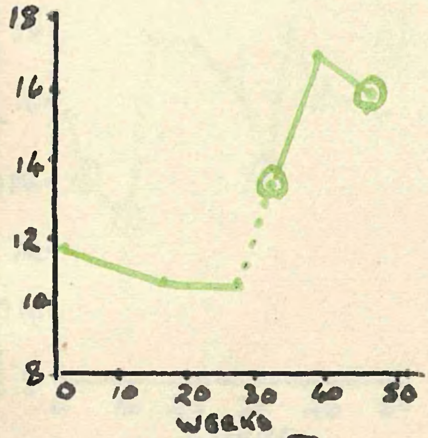


CASE No. 22

SERIAL HAEMOGLOBIN LEVELS — SEWERMEN

CHART No. 4 (Continued)



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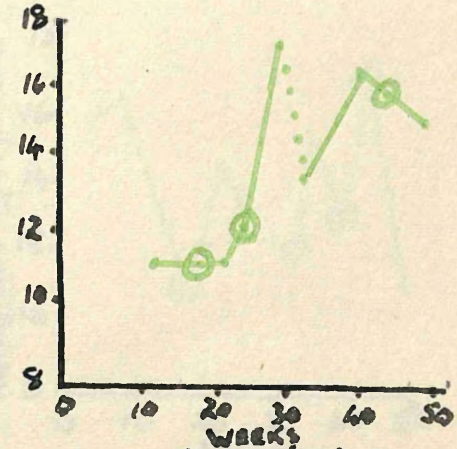

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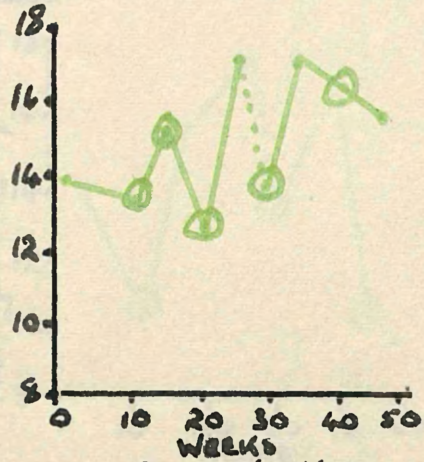

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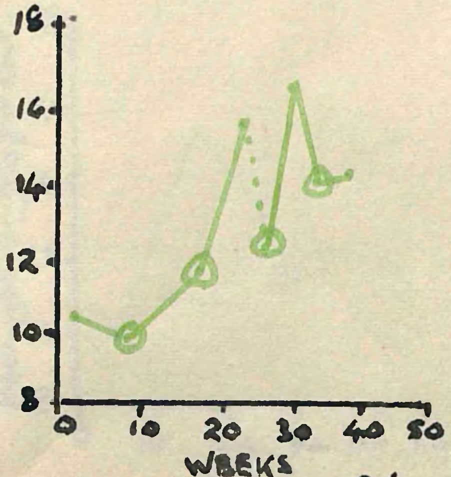

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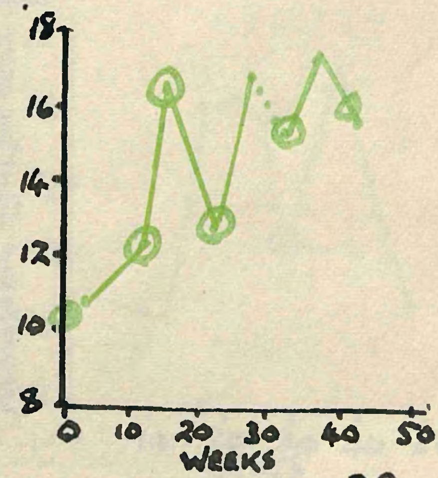
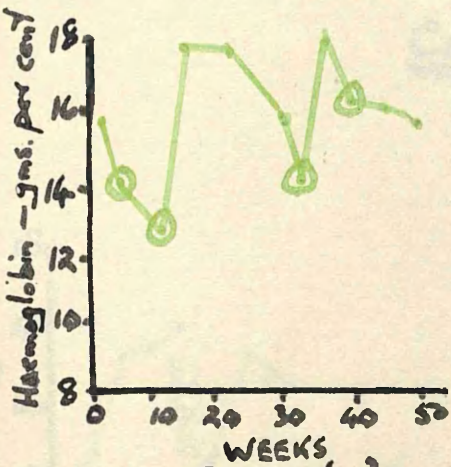


CASE No. 29

CHART No. 4 (Continued)



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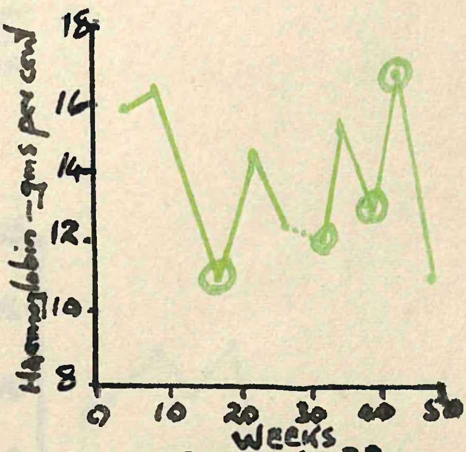

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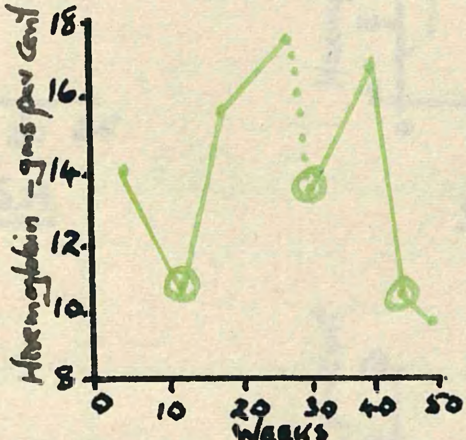

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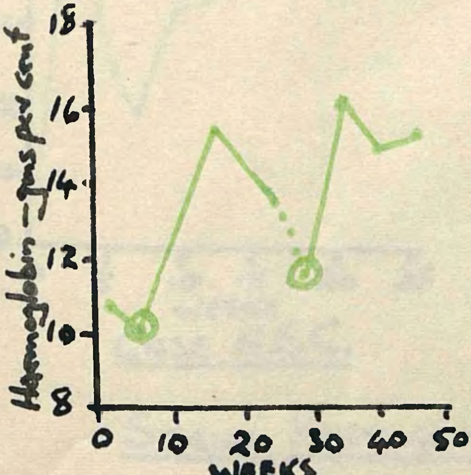

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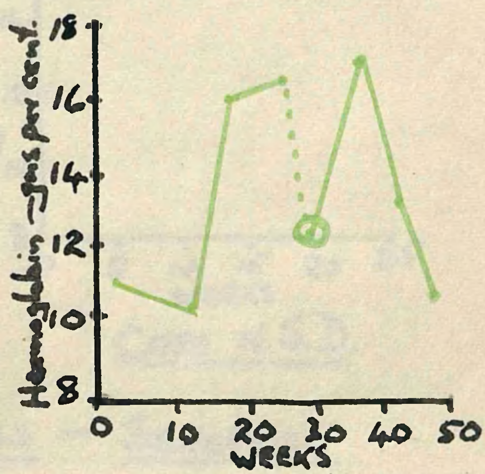
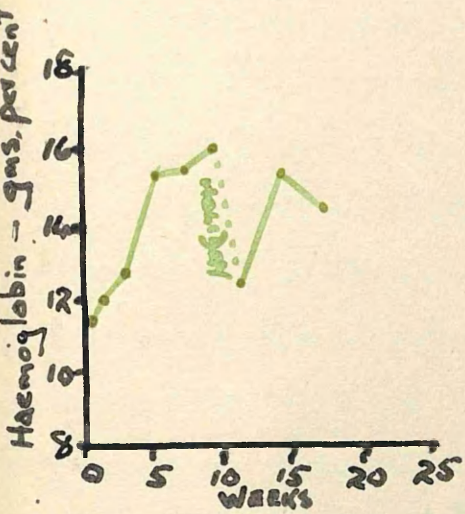
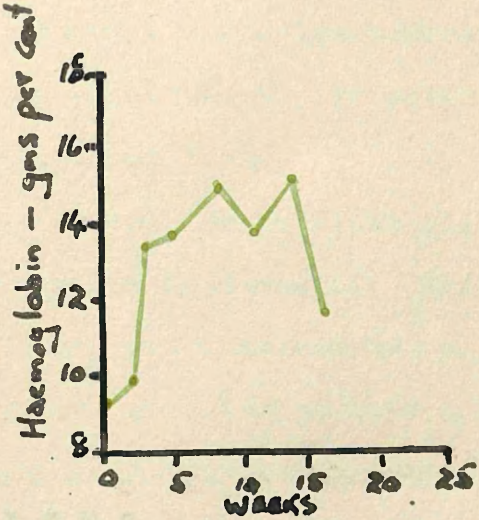


CASE No. 41.

CHART No. 5



CASE N.S.A.



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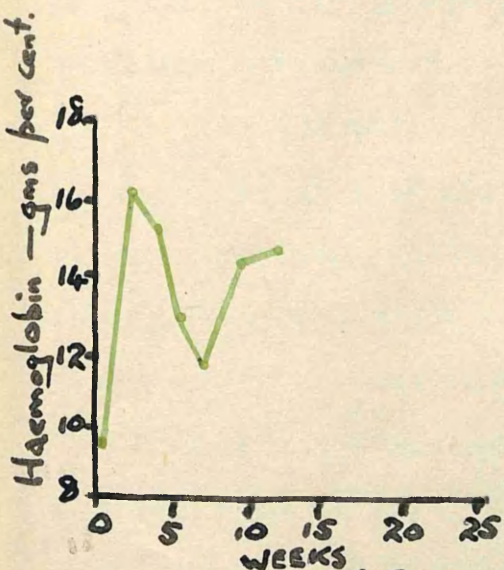
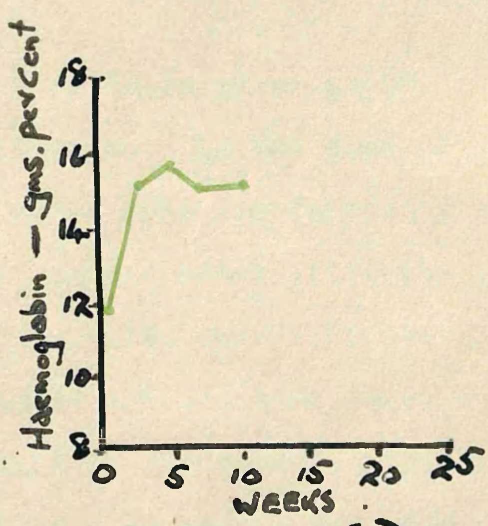


CASE N.S.C.



CASE N.S.D.

SERIAL HAEMOGLOBIN LEVELS - SEWERMEN

ENTRANTS

A P P E N D I C E S.

Appendix A - Chapter IV.

ATMOSPHERIC STUDIES IN SEWERS.

Method of Investigation.

The equipment used consisted of a globe thermometer, wet and dry bulb thermometer, sling psychrometer, silvered kata thermometer, stop-watch, and thermos flask.

A piece of wood was wedged across the sewer as high as possible and to this was slung the globe thermometer. Similar wedges were fixed for the wet and dry bulb thermometer and the katathermometer. The instruments were adjusted so that their bulbs were suspended at approximately halfway between the level of the sewage and the roof of the sewer. In the majority of instances the investigations were carried out in sewers in which men were working.

The thermometer readings were taken by means of illumination from an electric hand-torch. In the case of the silvered katathermometer, the silvered bulb was carefully held into the thermos flask containing boiling water until the upper reservoir of the instrument was two-thirds full with the alcohol. The silvered base was carefully dried and the time taken for the alcohol level to fall from 130° to 125° Fahrenheit, measured on a stop-watch. In the first few trials an effort was made to take the average of five readings on the kata, but this was found to be impracticable as it was found that conditions in a sewer changed so rapidly that these readings bore no close approximation to each other. Exactly the same technique was followed in each series of readings. The kata reading was taken first, then the sling hygrometer, the wet and dry bulb thermometer, and, finally, the globe thermometer (when it was used). The apparatus was set up as already described and allowed to stand in the sewer for about half-an-hour before any readings were taken. The cover over the manhole at each end of the section in which readings were being taken was removed throughout the proceedings.

The calculation of the various results from the readings recorded was carried out by means of the technique outlined in M.R.C. War Memorandum No. 17 (Environmental Warmth and its Measurement).

Appendix B - Chapter VI.

ACCIDENTS TO SEWERMEN.

(a) Injuries.

(1) 1929 - One sewerman sustained a crush injury to his testis caused by the falling-in of the wall of a sewer. Arising therefrom he developed a hydrocoele. This condition still requires periodic treatment.

(2) 1931 - One man was washed through a sewer as the result of a sudden rush of storm water. He escaped with only slight abrasions and shock.

(3) 1939 - A sewerman sustained bruising of the ribs as the result of falling in the sewer in which he was working.

(4) 1941 - While working at the bottom of a manhole a sewerman was hit on the head by a brick which fell from the wall. He suffered from concussion and was off work for one week.

(5) In 1944, while a night-shift squad were having a meal in their portable shelter in Gordon Street, a motor van crashed through the shelter causing one sewerman to have a fracture of the pelvis and another sewerman to sustain bruising of his back.

(6) In 1949 a sewerman fractured a rib as the result of falling in a sewer.

(b) Gassing.

(1) 1930 - One sewerman gassed in Watson Street Sewer. Patient was off work for one week thereafter.

(2) 1935 - One sewerman overcome by gas in Ardgowan Street Sewer. Removed unconscious to Victoria Infirmary where he was detained for two days.

(3) 1937 - One sewerman gassed in St. Rollox Sewer. The symptoms suggest that the gas here was hydrogen sulphide.

(4) 1942 - Two sewermen died and five were affected by gassing while repairing a breakdown in Barrowfield Street Sewer. Two of the men were detained in the Royal Infirmary for a period of 14 days. Carbon monoxide, ammonia, benzene, and other volatile hydro-carbons appear to have been the cause here as the sewer drains trade waste from Provan Gas and Chemical Works.

(5) 1943 - Milnpark Street Sewer was responsible for one case of sewer gas poisoning. The patient had haematemesis and melena during the acute stage of his illness in the Western Infirmary.

(6) 1944 - Two men were gassed in Cromwell Street Sewer and were detained in the Western Infirmary for ten days. They had been clearing a chokage in the sewer. It was established that the fumes arose from benzol which had entered the sewer from a nearby garage.

(7) 1950 - One sewerman was overcome and two slightly affected by fumes while working in Nelson Street Sewer at night. The fumes were thought to have originated from trade waste entering the sewer from a flour mill.

Appendix C - Chapter VII.

PREVENTION OF LEPTOSPIRAL INFECTION.

Sample of Card issued to Glasgow Sewermen:-

CORPORATION OF GLASGOW

INSTRUCTIONS TO MEN WORKING IN SEWERS

Name: Address: Occupation:

Precautions against Risk of Leptospiral Jaundice.

1. After leaving a sewer, the hands and forearms should always be thoroughly washed with soap and warm water*. This should also be done before taking any food or drink. On no account should food or drink be handled before washing the hands.

2. Particular care should be taken to wash thoroughly any cut, scratch or abrasion of the skin as soon as possible, whether the injury was sustained on the work or not. Immediately after washing, an antiseptic should be then applied to the affected part with a clean piece of cloth or cotton wool and the wound protected with a strip of gauze completely covered with adhesive plaster. The wound should be kept covered until it is quite healed. Suitable antiseptic gauze and adhesive plaster are supplied for use.

3. Avoid rubbing nose or mouth with the hands during work.

4. See that your food is properly wrapped up in a clean paper before leaving for your work and never open the parcel of food until the hands have been thoroughly washed and disinfected.

5. Keep this card in a safe place and when you have occasion to go to your doctor or to a hospital on account of illness, show the card and make sure that those attending you know your occupation.

A.S.M. Macgregor,
Medical Officer of Health.
January, 1938.

Thomas Somers,
M.O.W. & City Eng.

*The water should be heated on the chauffer in the utensil provided for that purpose.

Appendix D - Chapter VIII.

CLINICAL EXAMINATION OF SEWERMEN.

(a) Method of Blood Examination.

Two millilitres of whole blood were withdrawn from the median basilic vein of each man and collected in a bottle containing four mgm. Wintrobe's Solution in crystalline form, with which the sample was carefully mixed. The syringes, needles and bottles were dry sterilised in an autoclave before use, and compression of the arm was maintained only for a few seconds to permit of easy entry of the needle into the vein. Each man had been completely at rest for half-an-hour before the blood was removed. The samples were removed between three and four p.m. in the day so that at least two hours had elapsed since the consumption of a meal. All of the specimens were examined within 12 hours - in the majority of instances, the interval between obtaining the specimens and their examination was less than two hours.

The haemoglobin was estimated by means of a Spekker Absorbiometer, using the alkaline haematin method. 0.05 ccm. of blood is mixed with 4 ccm. of N/10 Hydrochloric Acid and left at room temperature for 40 minutes and then diluted to 5 ccm. with N/1 Sodium Hydroxide solution. This preparation of the blood is carried out in the 5 ccm. glass cell of the Spekker apparatus. By means of the Chance green filter light, the absorption of the solution is measured on the micrometer scale. By reference to the standardised graph for the apparatus the haemoglobin content in grams per cent. is read off for the appropriate micrometer reading.

(b) Form used for recording results of Medical Examination.

.... Department

MEDICAL EXAMINATION

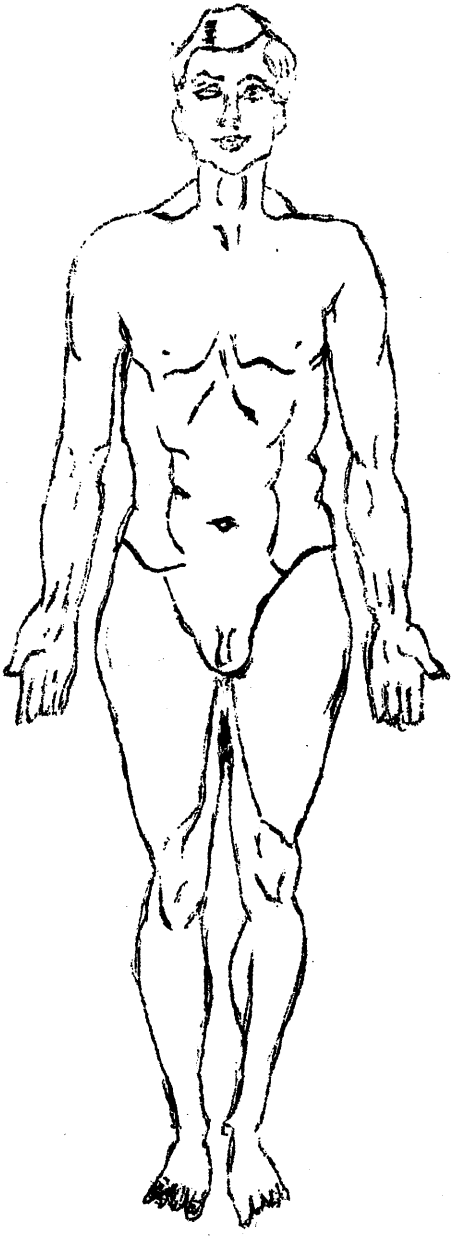
Name: Age:
Address: Present Occupation:
Shift: Length of Service:
Married State: Wage:
Size of House: No. of Occupants:
Bath in House:
Baths (when taken):

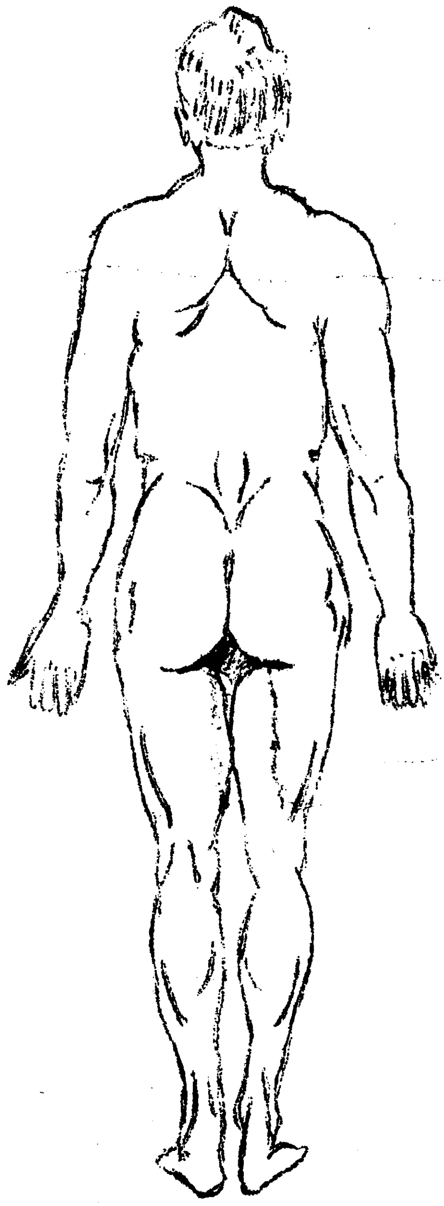
Previous Medical History:
History of Weil's Disease:
History of Back Strains:
Occupational History:

Height: Weight: Chest Expansion:
General Appearance:

Heart:
Blood Pressure:
Exercise Tolerance Test:
Lungs:
Digestive System: Mouth: Tongue: Teeth:
Abdomen:
Hernia:
Indigestion: Meals:
Nervous System: Reflexes:
Balance Test:
Tremors:

Urine: Albumen:
Sugar:





Locomotor System:

Muscular Development, etc.
Lumbar Pain
Deformity of Spine
Feet

Veins: Varicose
Haemorrhoids

Eyes: Visual Acuity - R. L. without glasses
R. L. with glasses
Colour Vision - R. L.
Ophthalmoscopy - R. L.

Ears: T.M. R. L.
Discharge
Hearing

Skin:

X-ray of Chest:

Blood Examination:

Protection against Leptospirosis:

Date of Inoculation with Leptospiral Vaccine:

1st Dose 2nd Dose 3rd Dose

Schuffner Tests (Dates and Results)

Present Physical Condition:

Name and Address of Private Practitioner:

(c) Chest Lesions in Sewermen - Clinical Notes.

Case No. 4 had clubbing of the fingers and apparent prominence of the left clavicle. There was impairment of the percussion note in the right apex and diminished respiratory murmur in the right apex. The left side of the heart was difficult to outline by percussion. X-ray showed some fibrosis at the right apex of doubtful activity, while the left basal pleura was thickened. Examinations of sputa from this patient failed to reveal any tubercle bacilli and the erythrocyte sedimentation rates were normal. X-ray examination one year later has revealed no change in the fibrosis.

Case No. 5 was noted to be pale at the time of examination. The percussion note was limited in the right upper zone and adventitiae were present on auscultation. Chest movement was reduced on the right side. X-ray examination showed active tuberculosis in the right upper quarter. The lesion appeared to be of the chronic fibroid type with small cavitation. Sputum examination revealed the presence of tubercle bacilli after several specimens had been negative. In view of this patient's age (namely, 57 years) and the evidence suggesting that a low grade infection had been present for a long period, it was considered that no benefit to the patient could be achieved by surgical interference and a stay in a sanatorium. In any case, his domestic circumstances ruled out any possibility of being able to persuade him to go into a chest ward for treatment. His wife, a diabetic, had contracted gangrene of the feet and was more or less bed-ridden. There was no family. As this man was handicapped by sciatic pain due to osteo-arthritis in the lumbar spine, emphasis was placed on this lesion rather than on his chest as a reason for his leaving the job of sewerman. As a fall in wages would probably result from a change to another job, he refused to co-operate in the suggestion. As he had just under four years' service to complete before becoming entitled to retire on full pension under the Corporation's Superannuation Scheme, it was felt desirable that some arrangement should be made to ease this man's burden. His foreman agreed to transfer him to a job at the headquarters yard, where his entries to the sewers would be considerably reduced. As these medical examinations were conducted on a purely voluntary basis, no official action could be taken without the consent of the sewerman, and, as no consent was forthcoming in this instance, it would have been a gross breach of faith to have done more than the steps outlined above.

Case No. 14 displayed clubbing of the fingers and was fairly thin. Clinical examination of his chest revealed scattered rhonchi in the lower zone of each lung. He denied having had any previous chest illness and stated that he had only a smoker's cough in the morning. X-ray examination of chest showed chronic bronchitic changes in both bases.

The chest X-ray film of Case No. 15 showed some fibrosis above the right root, but his general condition was quite good.

Case No. 32, a sewerman aged 44 years, was found to have no clinical signs of chest disease, though his X-ray showed a small area of soft infiltration in the left apex. Repetition of the X-ray one month later showed no change in the condition. Sputum tests were negative for tuberculosis, while the erythrocyte sedimentation rate was not increased.

Case No. 33 had had a "cold" some ten days prior to examination. Clinically there was nothing to suggest any defect in the chest, though there was early clubbing of the fingers and he stated that he had a morning cough of the type found in smokers. His X-ray showed some loss of translucency in the left lower mid-zone. This lesion had disappeared one month later when he was re-X-rayed.

(d) Industrial Dermatitis - Clinical Notes.

(1) Sewermen.

Case No. 4 had an acute dermatitis contracted while working in the Govan area in 1946, for which he received treatment in hospital. The condition was attributed by the dermatologist to contact with an irritant while at work. The condition was quiescent at the time of the examination.

Cases Nos. 12 and 34 contracted the dermatitis while working in different sections of the same pipe sewer in Govan. Rubber boots were not usually worn while cleaning this small sewer, The work involved the removal from the manhole of a white silt washed down from the distal section of the sewer. Splashing of the legs occurred frequently and several men have developed skin conditions from contact with this white silt which is understood to contain spent carbide from the manufacture of acetylene - this evidence is based on the odour from the sewer at this point. The acute phase of the skin condition had occurred in one case eight years ago and there were areas of pigmentation at the sites of healed lesions, overlying parts being dry and scaly. In the other case, the acute phase occurred just over one year ago.

A sewerman aged 47, with ten years' service in the sewers (including four years in the Army), gave a history of having been in hospital for three months early in 1946, suffering from an acute dermatitis which he contracted while working in a large sewer near the city boundary. Silt from a large chemical factory was being removed from the sewer when he contracted an acute skin condition on his forearms. Redness and burning were features of onset. Blisters appeared and when these ruptured his arms became raw. The condition spread to the face, body and legs. Treatment cleared the condition from all but the skin at the back of both knee joints. At the medical examination he displayed thickening and redness of the skin in these flexures. It would appear that posture at work and friction caused by the wearing of thigh boots and waders were the factors causing the persistence of lesions in this site.

One of the foremen sewermen, aged 46 years, gave the following history:- He left school at 14 years and worked as an apprentice moulder for one year. From 1919 till 1931 he was a miner in the Ayrshire coalfield, being engaged mainly in mine-driving and tunnelling. After three months of unemployment he became a steel erector for one year, then followed periods of casual employment as a labourer in a timber yard. In 1934 he became a labourer to a stone-mason in the Highways Department. In 1938 he was selected for work as a sewerman and followed that employment until 1942 when he was called up for service in the Royal Marines. In 1943 he was invalided from the Services because of a knee injury sustained while playing football. He was able to resume his employment as a sewerman, however, and was promoted to foreman in 1946. In the course of his duties as foreman he has to enter sewers where breakdowns have occurred and assess what type of repairs will be required in each instance. This entry into the sewers occurs two to three times weekly or oftener depending on the frequency with which faults develop.

When he was being medically examined in the course of this investigation it was noted that he had raised inflamed plaques of a dusky hue on the back of his neck, just at the collar margin area. The lesions simulated those of psoriasis but no silvery scales could be produced on rubbing. He stated that the skin condition first appeared on his left forearm in 1941 while he was clearing a blockage in a small sewer in the north of the city. A weeping dermatitis developed on the forearm and lasted for six months. Thereafter, the skin condition healed but reappeared the following winter on the chest. In succeeding winters it reappeared on the right thigh, right knee and for the past five years it has recurred in its present form each winter on the neck. He maintains that the condition started as a result of his work in the sewer draining Robroyston Hospital. The condition was diagnosed as a psoriasiform eczematide primarily due to his former occupational dermatitis, the recurrences being due to soiling of the collar of his shirt from drips from the roofs of sewers. The condition has been slow to respond to treatment at the out-patient department of a city hospital.

(2) <u>Control Group</u>: <u>Case of Oil Dermatitis - Clinical Notes</u>.

This man was employed as a compressor operator in the Housing Department. His lesions, consisting of macules and papules, were extensive on both forearms, especially the right, right shoulder and chest, fronts and inner sides of thighs and legs, and on the buttocks and inner sides of calves. He was aged 22 years, and from 1942 to 1944 he had been employed in various jobs as an errand boy. From 1944 to 1947 he had been a locomotive driver on a light railway on a Corporation building site. After two years in the Army he returned to the Housing Department in 1949 as a compressor operator. A diesel engine drives the compressor unit. Fuel oil has to be carried from oil barrels in pails and is poured into the machine's tank, which is located above the engine. In this way the diesel oil has to be poured into the tank inlet well above the shoulder level of the operator. No filling funnel is used in the operation, and hence oil is spilled in the process and splashes on to the operator. This is particularly liable to happen on windy weather. This man often carried the pail of oil on his right shoulder and hence the prevalence of lesions on that site. The absence of lesions on the dorsum of each foot is accounted for by the fact that he wore rubber boots at work.

(e) Disorders of the Nervous System.

Clinical Notes on Sewerman Case No.2. This sewerman, aged 58 years, started his working life as a farm labourer and later was employed in a carpet factory. He served in the Army at home and overseas from 1908 until 1921, his only illnesses being an attack of malaria in Bombay and a compound fracture of the right humerus in Mesopotamia in 1916. After six months' employment in a steel works he became a Highways Department labourer in a tar spraying squad. He followed this employment until he became a sewerman in 1941.

In 1943 he contracted Weil's Disease while working in a sewer near the Meat Market and was off work for 2½ months. This illness started like an attack of influenza with aching in the limbs and he later became jaundiced. There were no haemorrhages. Previously, in 1942 while helping to rescue several sewermen who had been overcome by fumes in a sewer, he was hit on the head by a brick dislodged from the top of the manhole. The only other illness reported was an attack of left-sided sciatica some 20 years ago.

In the course of the review of Schuffner reactions of the bloods of Glasgow sewermen in 1949, his serum caused agglutination in a dilution of 1 in 30. This was taken as confirmation of his previous leptospiral infection in 1943.

Towards the end of November, 1949, he slipped while working in a sewer, not only straining his back, but also swallowing some of the sewage. He managed to scramble out and go home. He returned to work for two days, but collapsed and was taken to hospital where he was detained for a few days, the diagnosis being recorded as gastro-enteritis. He resumed work in three weeks' time but a month later he collapsed again. He was treated at home for neuritis of the left leg. His symptoms resembled those due to herniation of an intervertebral disc in the lower lumbar spine, though it was noted that his knee jerks were grossly exaggerated. His nausea, vomiting and occasional loose stools persisted. During this stage, there was no jaundice nor was the urine dark in colour. He was referred to a hospital out-patient department for a neurologist's opinion and attended there for observation for two weeks. His condition deteriorated and his walking became so unsteady that it was decided to take him into hospital for investigation. He now had a spastic paraplegia, rhombergism, nystagmus, intention tremor, exaggerated knee and ankle jerks, and his plantar reflex was extensor especially on the left side.

In view of his occupation, a Schuffner test was done and found to be positive at a titre of 1 in 1,000. Largely on the strength of this finding, his condition was diagnosed by the hospital staff as secondary to an attack of Weil's disease. They considered that he had an encephalitis. His blood Wasserman and Khan reactions were found to be positive, but these were thought to be pseudoreactions since he gave no history of specific infection.

On his dismissal from hospital one had his Schuffner test repeated, i.e., three months after the 1/1000 finding, and the reaction was found to be negative. The examination was done by the same bacteriologist as had conducted the investigation of the specimen submitted from hospital.

In view of the fact that this man showed a positive reaction to the Schuffner test some six years after his leptospiral infection in 1943, it would seem reasonable to expect that, if he had had a second attack in November, 1949, and his Schuffner gave a positive reaction in 1/1000 dilution two months after the onset of the condition, then three months later a positive agglutination would be found in a dilution of at least 1 in 100. That this last test should be negative tends to dispute the diagnosis of a second attack of leptospirosis.

Then again, various workers in the field of leptospirosis have shown that there is no relationship between the Wasserman and the Schuffner reactions. Indeed, in establishing that a positive Schuffner test, when properly conducted, gave a true indication of previous leptospiral infection, even if only in the lowest dilutions, various workers showed that "normal" sera, such as those submitted for the Wasserman test, did not produce any agglutination with the leptospira icterohaemorrhagiae.

The presence of symptoms and signs suggesting an encephalitis is not doubted but one does not feel that the diagnosis of the preceding "Weil's Disease" was satisfactorily established. One wonders whether other causes for the symptoms and signs could not be found in the sewers. Table No. 36 includes this sewerman's two workmates (Cases Nos. 6 and 32), one of whom has coarse tremors and a poor balance test, while the other shows only fine tremors. Furthermore, what significance is to be attached to the Wasserman and Khan Reactions which are both strongly positive and remain so after a course of treatment? This patient has now resumed work in the capacity of lavatory attendant, after a period of nine months' convalescence.

<u>Control Case No. 10</u>. Case No. 10 among the controls is also a patient worthy of special mention. He is aged 59 years and has been employed in the Cleansing Department for the past 39½ years (28 years as a refuse carrier, 11 of which were spent on the night-shift). When it is considered that he weighs only 8 stones and 7 pounds and that his height is 5 feet 5 inches, 28 years as a refuse carrier is no mean feat for one of such small build. On night-shift, refuse carriers work on piece-work rates and have been known to move as much as 12 tons per man per shift. It is usual to find, however, that with advancing years the man finds that he is unable to cope with such continuous heavy work and so seeks a transfer to the less strenuous job of street sweeper.

Case No. 10 was no exception, and for the past $11\frac{1}{2}$ years he has been employed as a sweeper, formerly on streets and more recently in back-courts. His medical history revealed that he had suffered from several severe strains of the back, and in 1948 had been off work for two months on account of rheumatism of the back and legs. He had been off work for the six weeks prior to the examination, complaining of weakness in the legs and lower back. It came out in the course of the examination that the real trouble had been the onset of pains in the legs which became so severe after walking only 50 yards that he had to limp and finally stop for a rest. He was a highly nervous subject and appeared to be suffering from neurosis. He had coarse tremors of both hands and his knee jerks were greatly exaggerated. He had a stutter which became worse as he became excited. On examination it was found that the tibial pulse was absent in both ankles. A diagnosis of intermittent claudication was made in this case. He was offered treatment at a neuro-surgical unit but he refused to attend there. One other feature of this case was his marked kypho-scoliosis which undoubtedly was of occupational origin.

(f) Conditions of the Eyes.

1. Clinical Notes on Cases of Nystagmus in Sewermen.

Case No. 4 had been employed as a miner for 13 years between 1907 and 1921, and from 1943 had been employed as a sewerman. He was aged 57 years. He had been employed mainly on pipe sewers, though in the past year he had spent most of his time in brick sewers. His visual acuity was $^6/24$ right and $^6/60$ left. In bright sunlight his vision was poor and he complained of giddiness and headache at the end of his day's work. He appeared to have changed his mental outlook to his work after an attack of Weil's disease in 1946, for his foreman stated that he had been an exceptionally reliable worker prior to that date but that since then he had lost his "nerve" somewhat. Oscillations of the eyes were rotatory-lateral.

Case No. 19 displayed rotatory nystagmus along with a visual acuity of $^6/12$ right and $^6/18$ left. Apart from giddiness and headache at the end of a shift, he made no other complaints. On examination it was found that he quickly lost his balance when attempting to stand on one leg. He was employed as a miner from 1913 till 1929 and became a sewerman in 1945.

Case No. 22 has been a sewerman since 1922. In 1939 he had Weil's Disease. In recent years he is said to have become introspective and at the time of examination showed evidence of a psychoneurosis. He complained of difficulty in seeing, especially when working underground, and of pains in his eyes when coming into daylight from a manhole. His visual acuity was found to be $^{6}/12$ in both eyes and there was slight nystagmus which was seen only when the patient looked upwards. Photophobia was marked in this case, and self-balancing was poor.

2. Clinical Notes on Cases of Conjunctivitis in Sewermen.

Sewerman Case No. 34 developed an acute conjunctivitis some 18 months previously as a result of a splash into the right eye while working in a sewer. It would seem that the condition failed to respond to treatment and had become chronic, for at the time of the examination he was found to display early ectropion and thickening of the conjunctiva.

Two sewermen working in the same squad on night-shift (cases Nos. 35 and 36) were found at examination to have acute conjunctivitis which had occurred only two days previously as the result of exposure to a pungent gas which appeared in the sewer. One of the men had been overcome by the fumes and his mate had had to pull him up the manhole to safety. Investigations proved the gas to be chlorine which had been evolved by the interaction of two trade wastes from factories drained by the sewer in which they were working.

Case No. 37 was found to have an acute conjunctivitis as the result of exposure to fumes while working in the manhole of a pipe sewer. When he was removed to another sewer his eye condition quickly cleared up.

(g) Conditions of the Ears in Sewermen.

Three men had active infections of the ear, viz.:-

Case No.26 - External otitis of the left ear with some aural discharge. The condition had been present for only a few days in this instance but previous attacks had occurred at intervals.

Case No.7 - The right tympanic membrane was slightly reddened suggesting infection of the middle ear. As the patient was just recovering from a "cold", the ear condition was thought to be an extension of the throat infection. When examined again a few weeks later, this condition had subsided.

Case No.41 - This man had only been employed as a sewerman for a fortnight before he was examined. He had a large perforation of the right drum with surrounding granulation. A perforation was present in the left drum and a thin mucopurulent discharge was present. It was suggested to this man that he should seek work in another section of the Highways Department as one considered that a certain amount of danger surrounded him because of his ear condition. The potentialities of splashes from sewage carrying in a B.coli or other infection into his ears were great. As the examination was voluntary, nothing stronger than persuasion could be used in this instance and as the man refused to co-operate it was suggested that he wear ear plugs of cotton wool spread with vaseline to protect himself.

Appendix E - Chapter X.

OCCUPATIONAL HISTORIES

SEWERMEN - ENTRANTS.

Case No. N.S.A.

Age 39 years; married with 5 children; lives in 4-apartment Corporation house with bathroom (post-war); present wage £4:14s. per week.
No previous history of illness. Non-smoker.
Left school at age of 14 years and worked as coal carrier until 1935.
1935 - 1941: Worked with haulage contractor.
1941 - 1945: Army with overseas service in India and Burma.
1945 - 1946: Refuse carrier in Cleansing Department.
1946 - 1950: Surfaceman in Highways Department.
April, 1950: Sewerman.

Case No. N.S.B.

Age 43 years; married with three children; lives in 2-apartment house - no bathroom; present wage £4:14s. per week.
History of one short absence from work due to a back-strain many years ago.
Left school at age of 14 years and worked as an errand boy for one year.
1921 - 1938: Worked as labourer in various industries, e.g., foundry, mineral water contractor, gas-works (driver of small locomotive). During this period he had altogether some 2½ years of unemployment.
1938 - 1940: Labourer in Highways Department.
1940 - 1943: Munitions worker.
1943 - 1946: Served in trawlers in Royal Navy.
1946 - 1950: Gulleyman in Highways Department.
October 1950: Sewerman.

Case No. N.S.C.

Age 34 years; married with two young children; lives in one-apartment of four-roomed house, with no bathroom; present wage £4:14s. per week.
No history of previous illness. Non-smoker and non-drinker.
Left school at 14 years and became a haulage hand at a pit in Yorkshire.
1933 - 1945: Royal Navy.

Case No. N.S.C. (Contd.)

1945 - 1947: Labourer in engineering shop.
1947 - 1949: Labourer in steel works (engaged mainly in greasing).
1949 - 1950: Labourer in Highways Department.
August 1950: Sewerman.

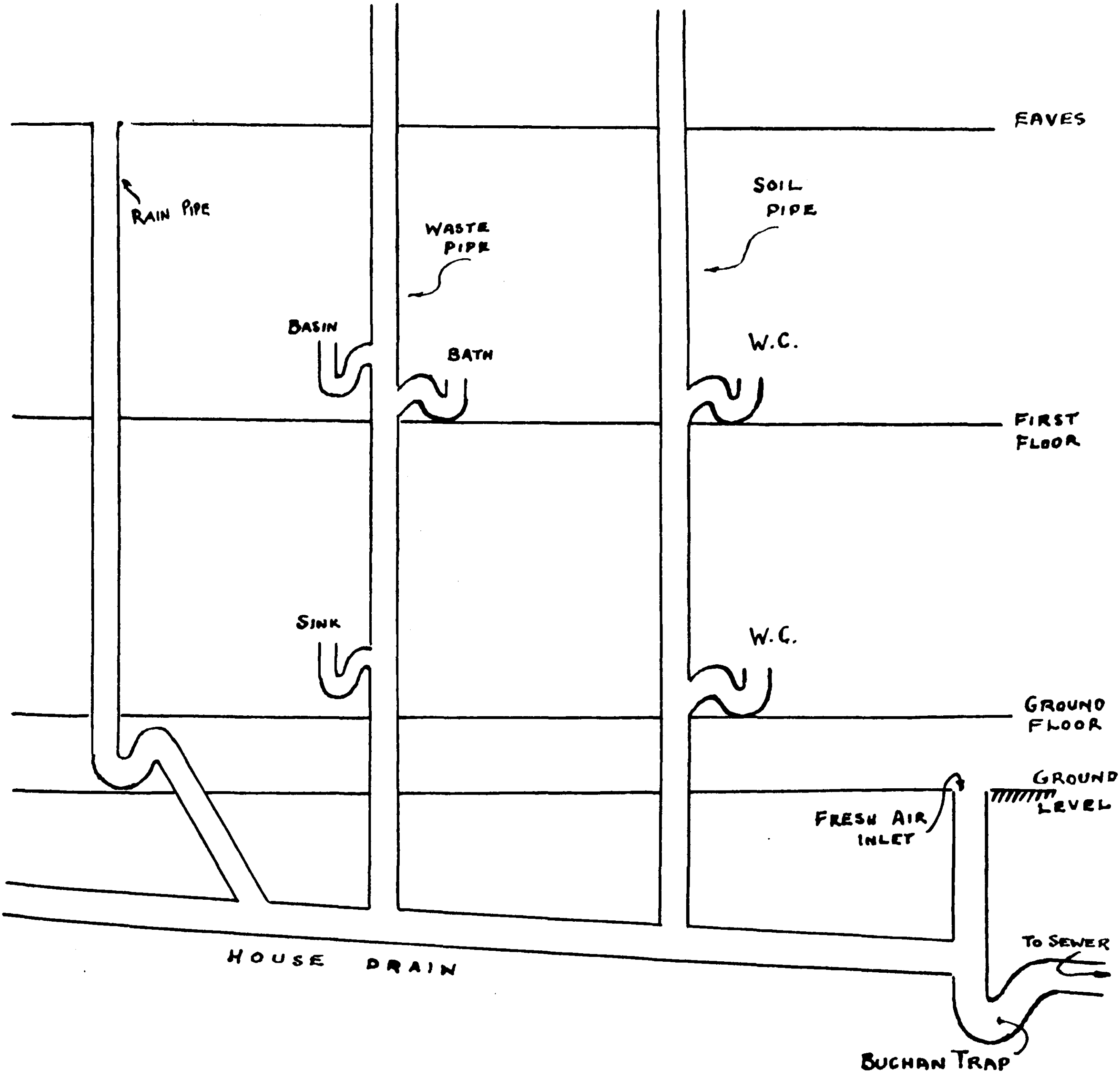
Case No. N.S.D.

Age 46 years; married with two children (aged 14 and 11 years); lives in three-apartment house with no bathroom. Wage £4:19s. per week.
Previous illness - influenza 1948.
Left school at 14 years.
Farm labourer - 7 years.
Farming in Canada - 7 years.
Labourer in building trades - 3 years.
Labourer in Sewage Works, 1936-1941.
Patrolman in Sewage Department - 9 years.
November 1950 - sewerman.

FIGURES.

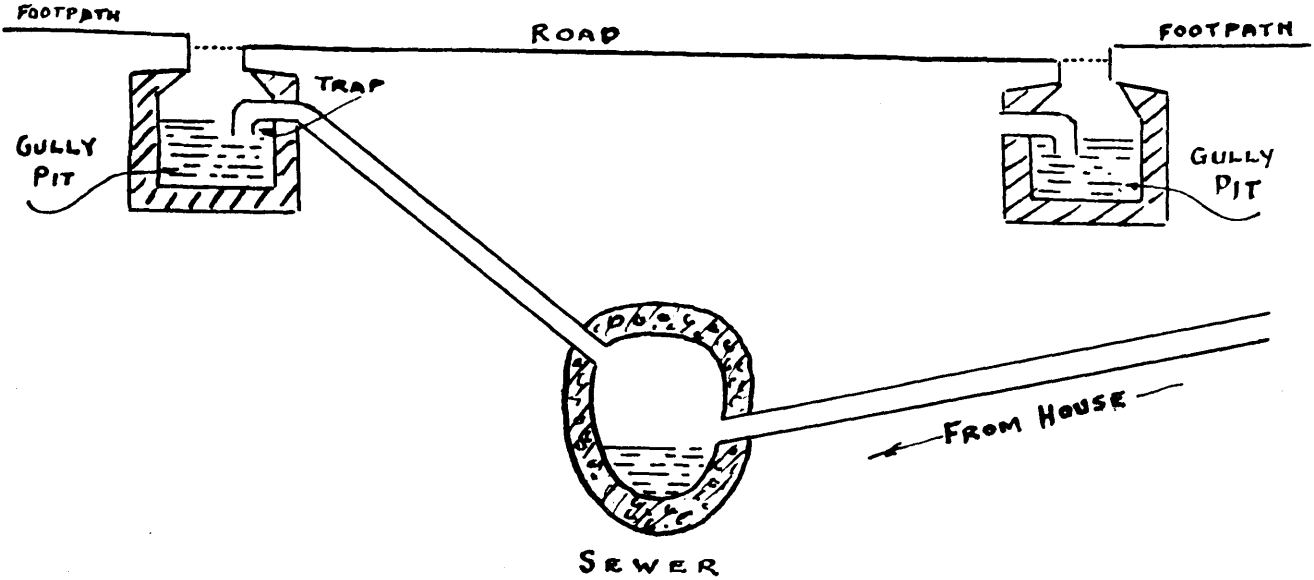
DIAGRAMS.

FIGURE Nº 1



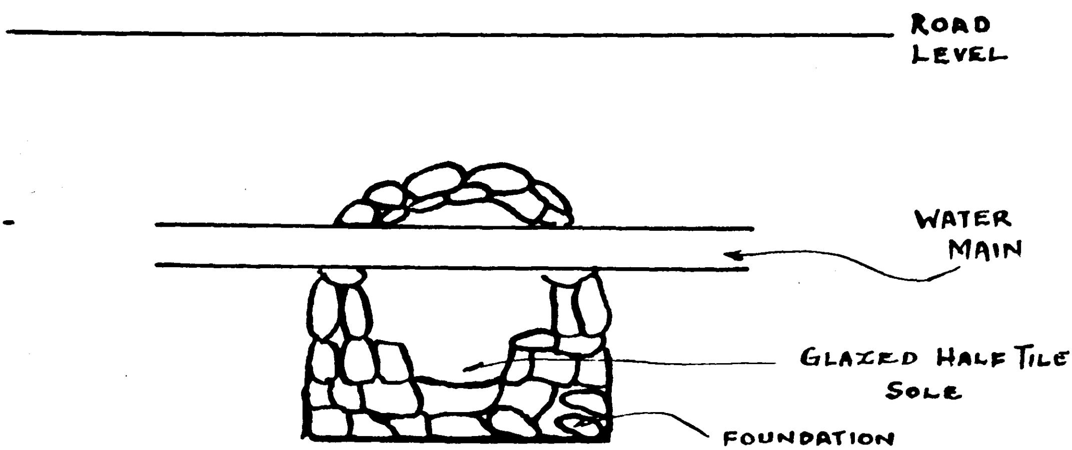
DOMESTIC PLUMBING CONNECTIONS

FIGURE No. 2



SEWER CONNECTIONS

FIGURE No. 3



SECTION OF STONEWORK SEWER

OLD STONE BUILT SEWER - BRIDGETON

FIGURE No 4

DIAGRAM OF 9" CONCRETE PIPE SEWER AT POSITION OF MANHOLE

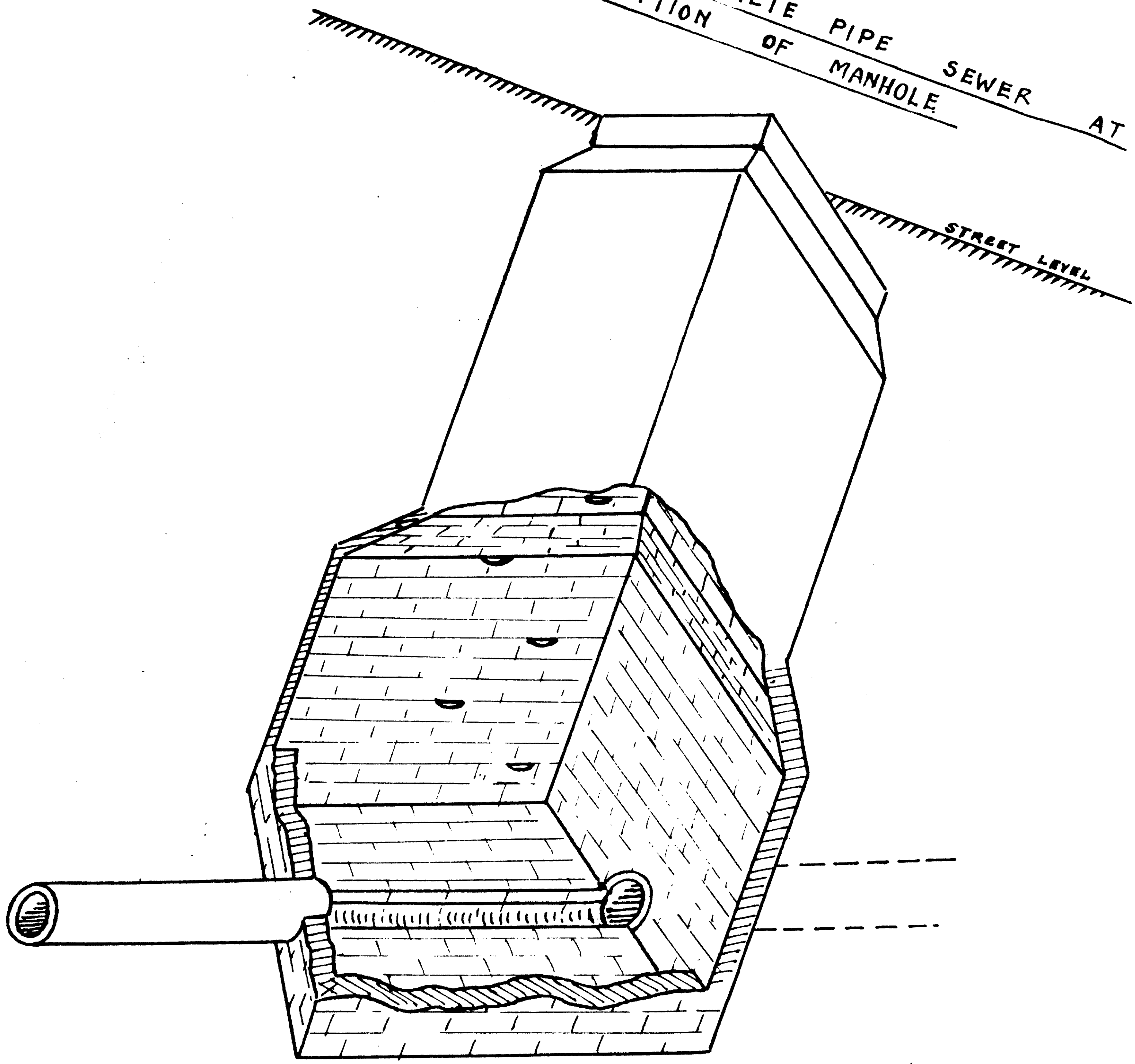
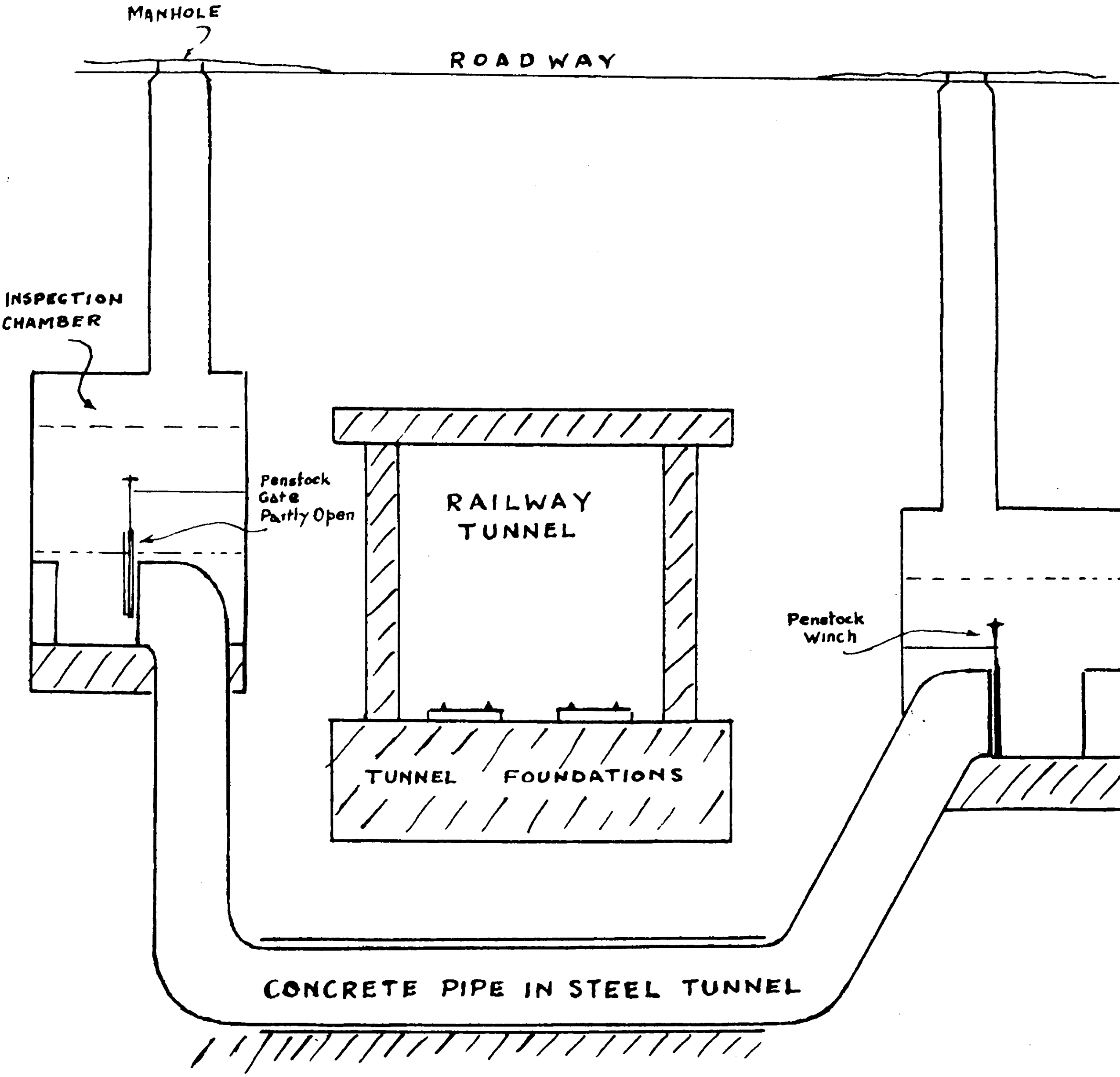


FIGURE No. 5

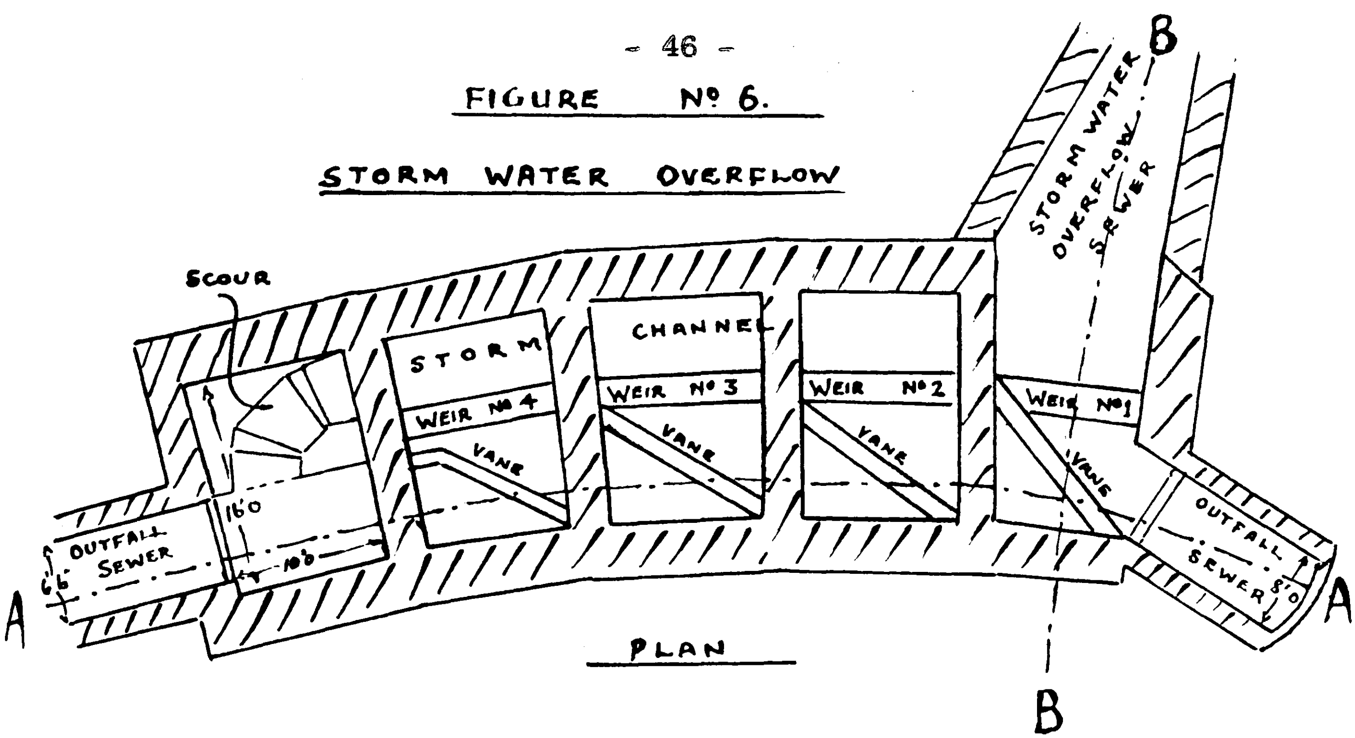


INVERTED SYPHON

MAIN DRAINAGE SYSTEM - GLASGOW.

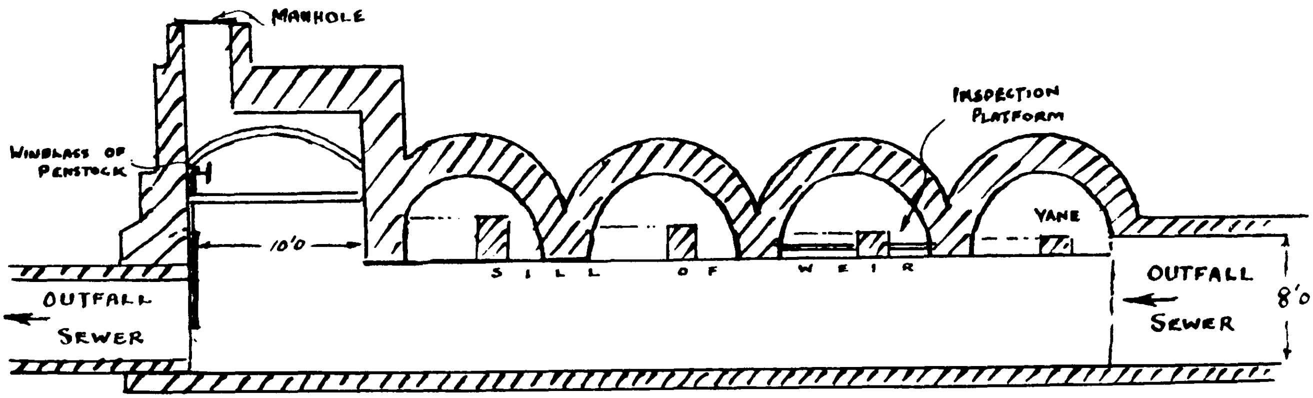
FIGURE No 6.

STORM WATER OVERFLOW

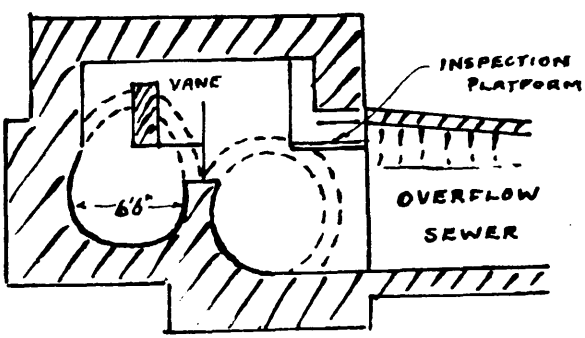


PLAN

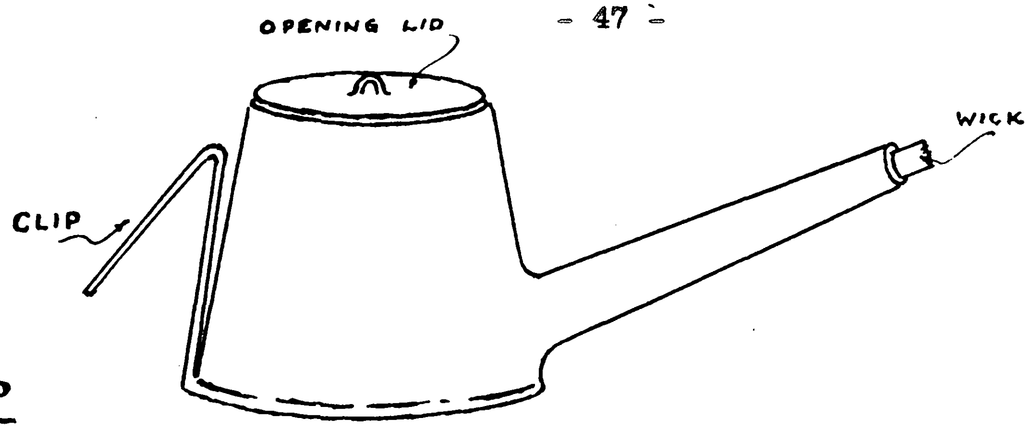
OVER-FLOW CHAMBER AT ST. ANDREWS ROAD



SECTION ON A–A



SECTION ON B–B



CAP LAMP

FIGURE No. 7

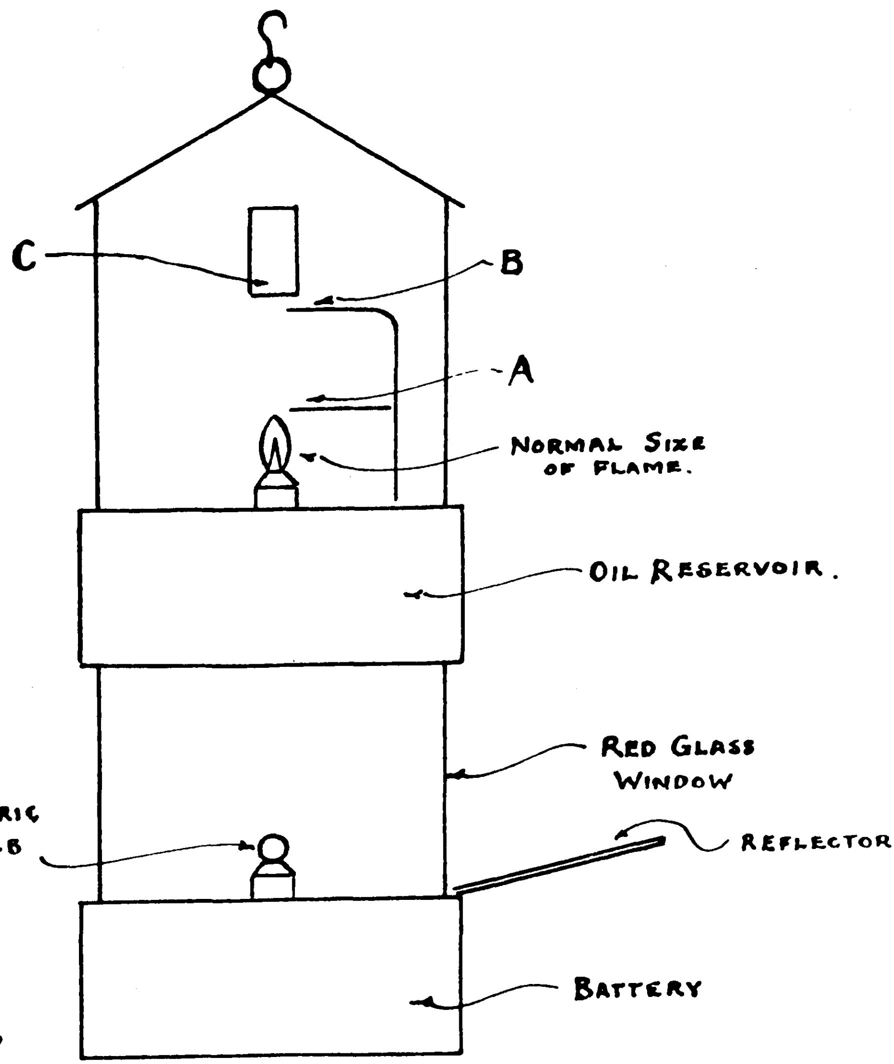
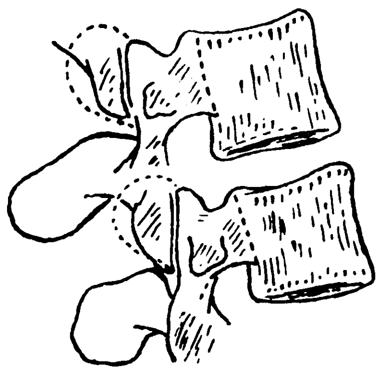


FIGURE No 8

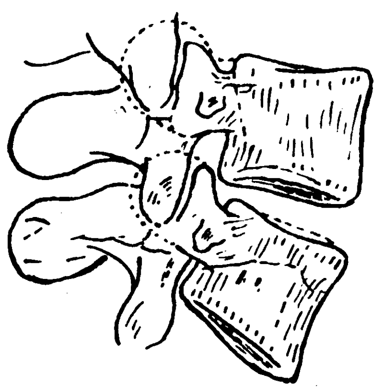
SAFETY LAMP

FIGURE N° 9

JOINT SPACE BETWEEN VERTEBRAE - LUMBAR REGION - CYRIAX (1950) BMJ



(a) POSITION OF FLEXION



(b) POSITION OF EXTENSION

1 Inch

P H O T O G R A P H S.

PHOTOGRAPHS.

Fig. 1. : Working Site [Surface].

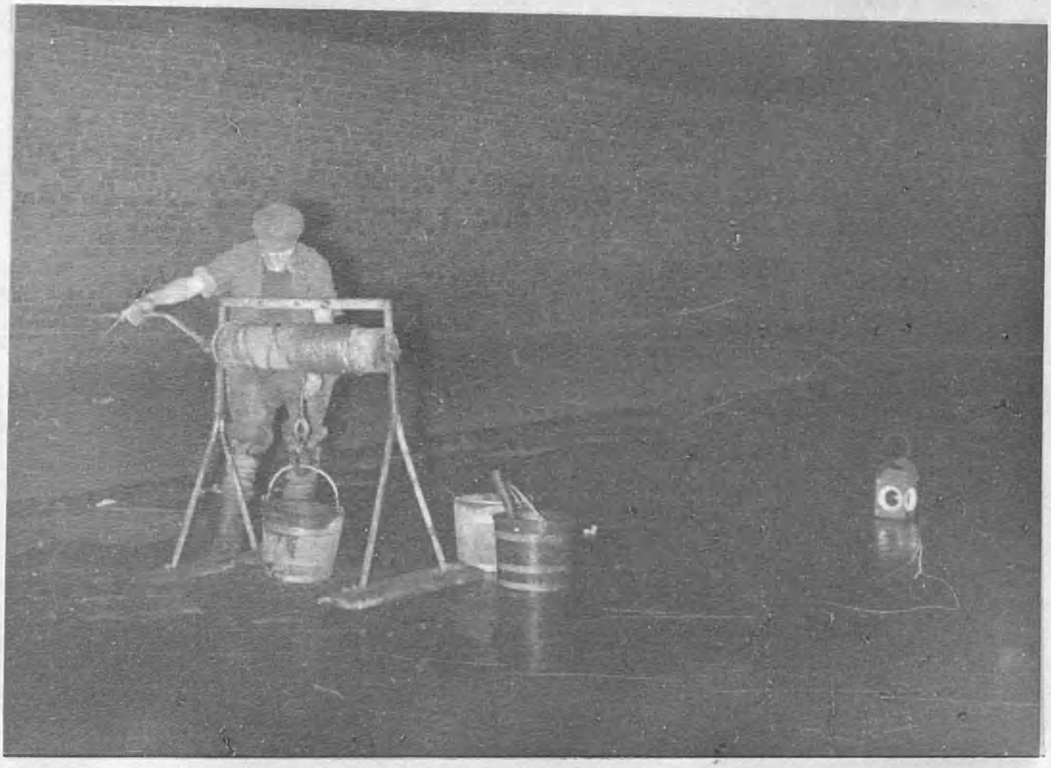


Fig. 2: Winchman.

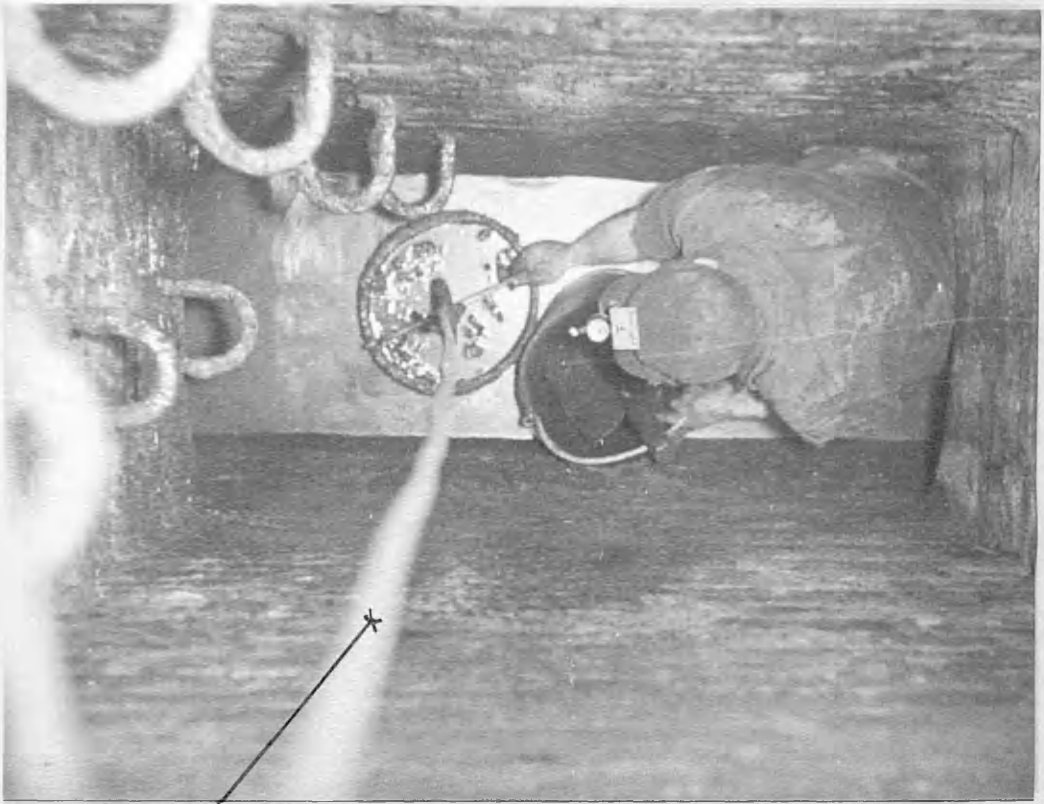


Fig. 3 : Raising of Loaded Bucket.

Rope from winch.

This photograph was taken from street level, looking down the manhole.

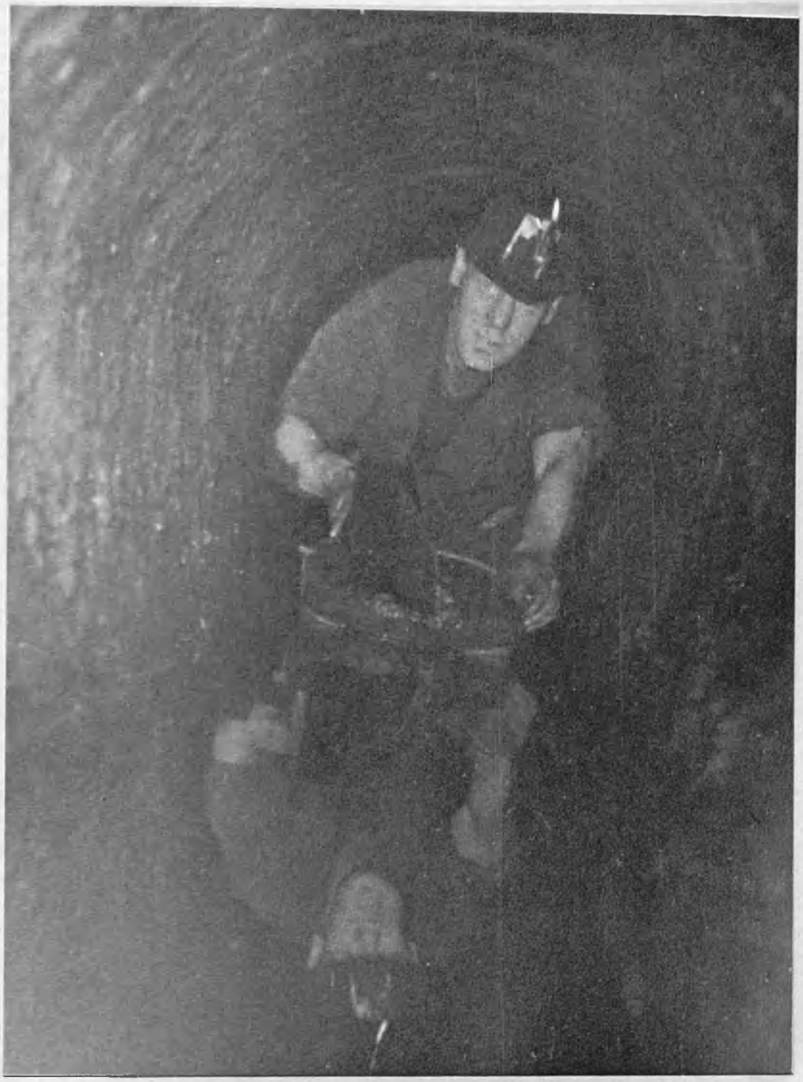


Fig. 4 : Filling Bucket [Front View].
(3'-6" Sewer)

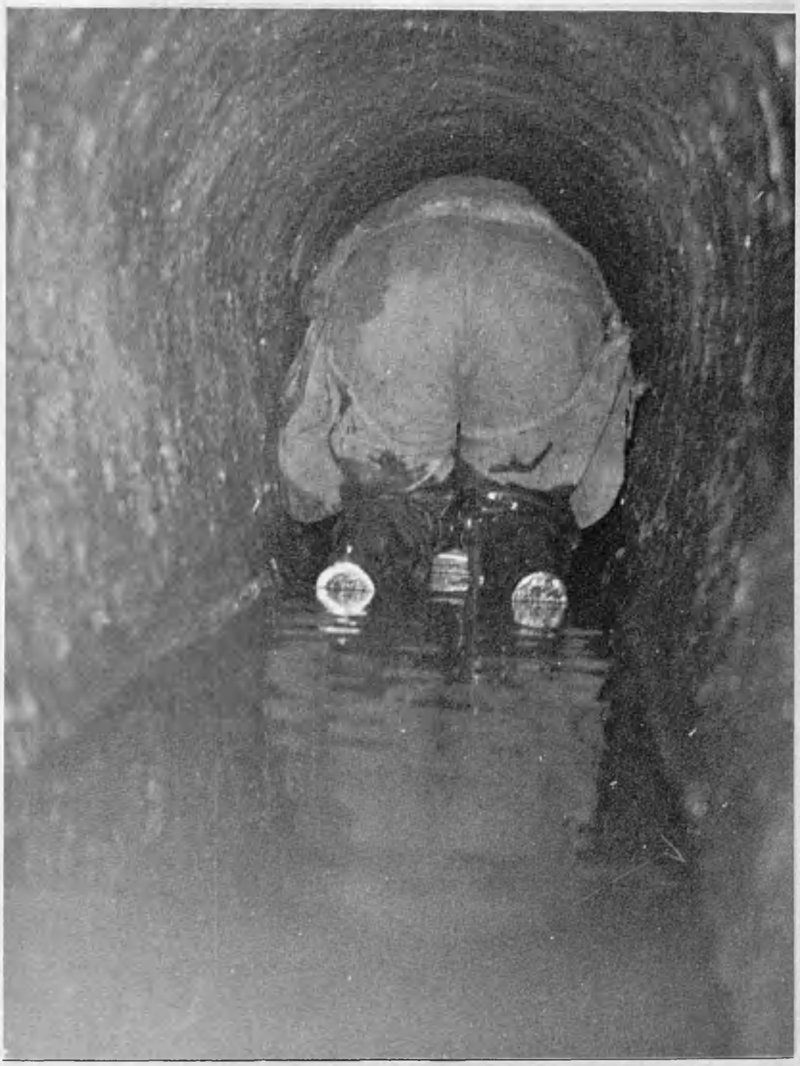


Fig. 5 : Filling Bucket [Back View]
(3'-6" Sewer).

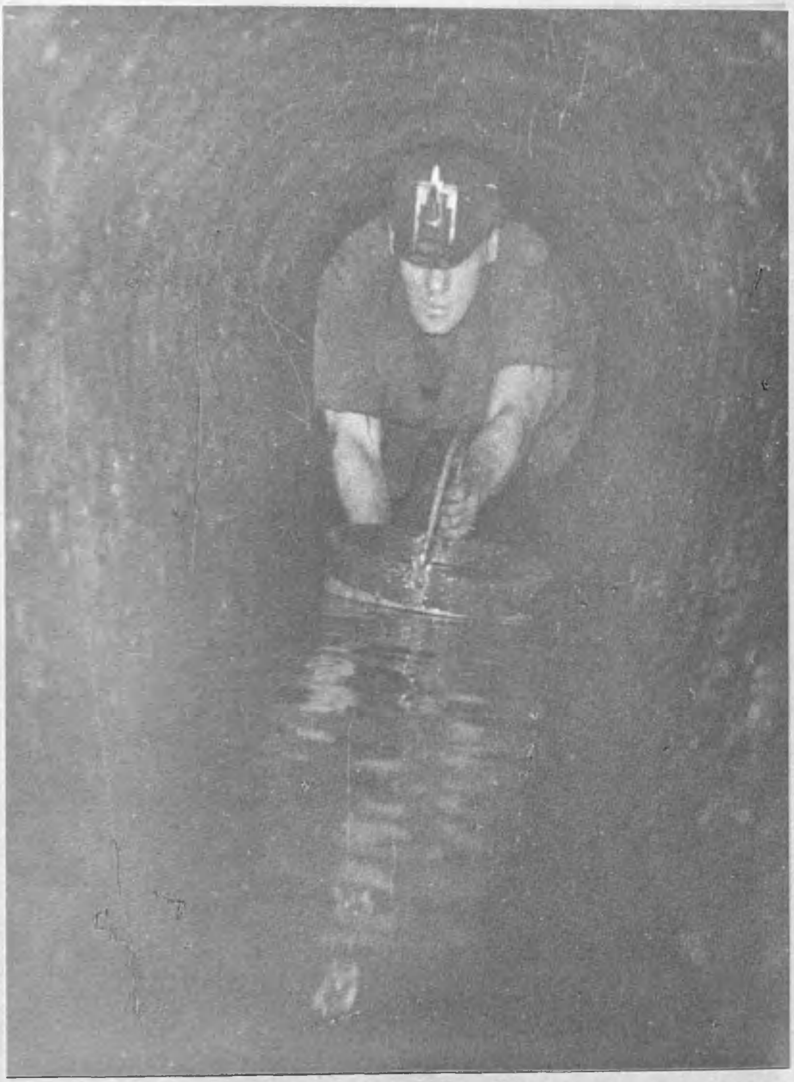


Fig 6 : Passing Bucket to Bottom of Manhole.
(3'-6' Sewer)

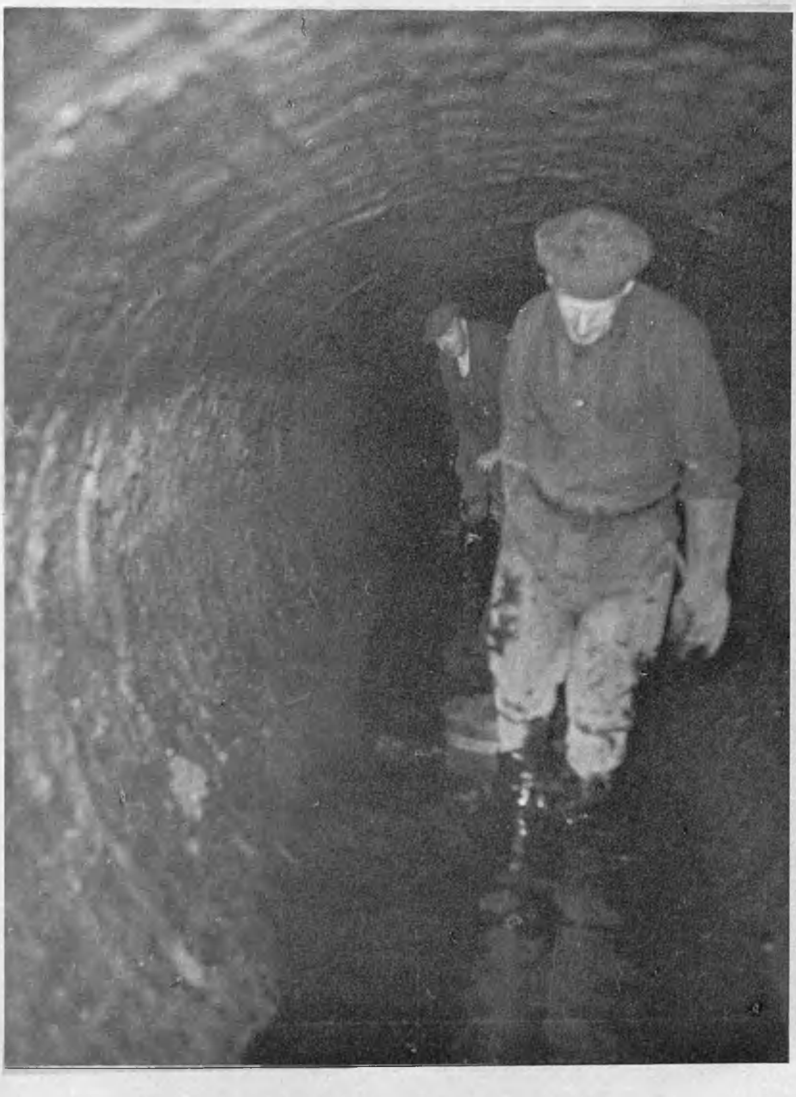


Fig. 7: Work in 5'-0" Sewer.

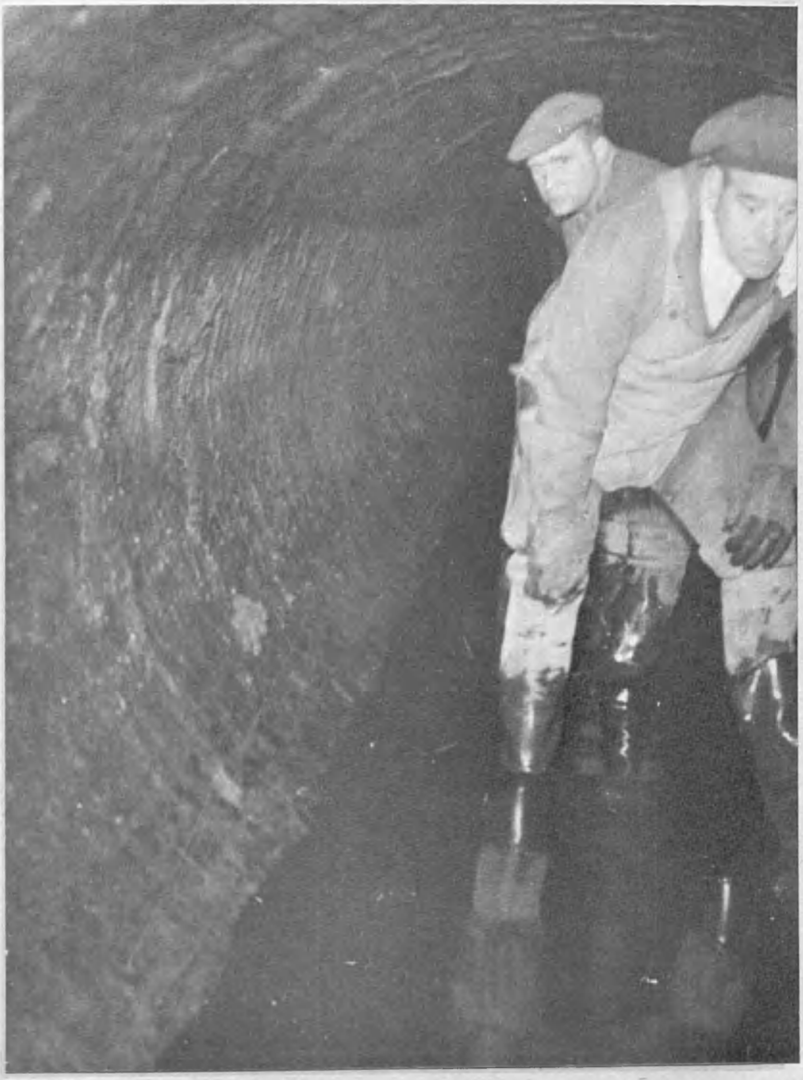


Fig. 8: Work in 5'-0" Sewer.

PHOTOGRAPHS OF X-RAY PLATES:

SPINES.

PHOTOGRAPHS OF X-RAY PLATES:

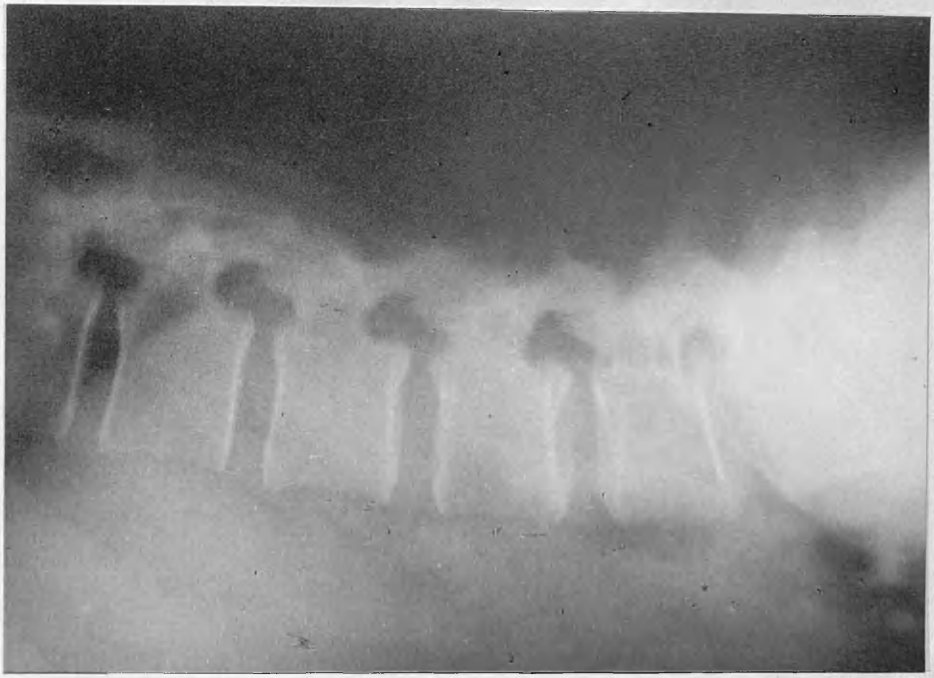
SPINES.

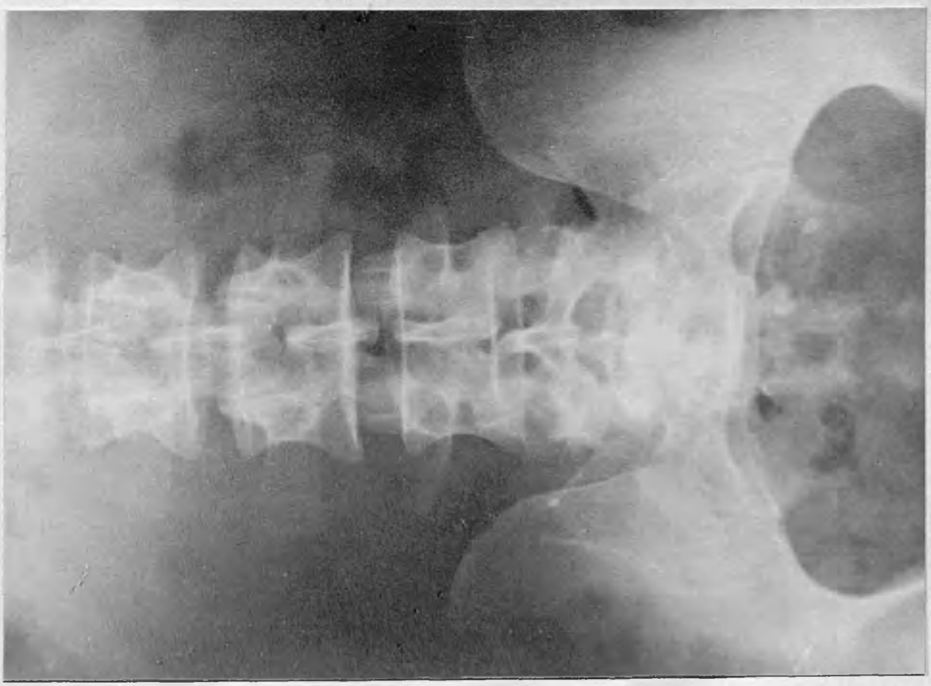
(a) Sewermen.

Case N.S.B.	Normal Lumbar Spine.
Case No. 3.	Lumbarisation of First Sacral Segment.
Case No.15.	Osteo-arthritis with Distortion of 1st and 2nd Lumbar Vertebrae.
Case No.20.	Osteo-arthritis; Sacralisation of 5th Lumbar Vertebra.
Case No.21.	Paget's Disease of Bone (Pelvis).
Case No.30.	Osteo-arthritis.
Case No.36.	Spina Bifida of 5th Lumbar Vertebra.

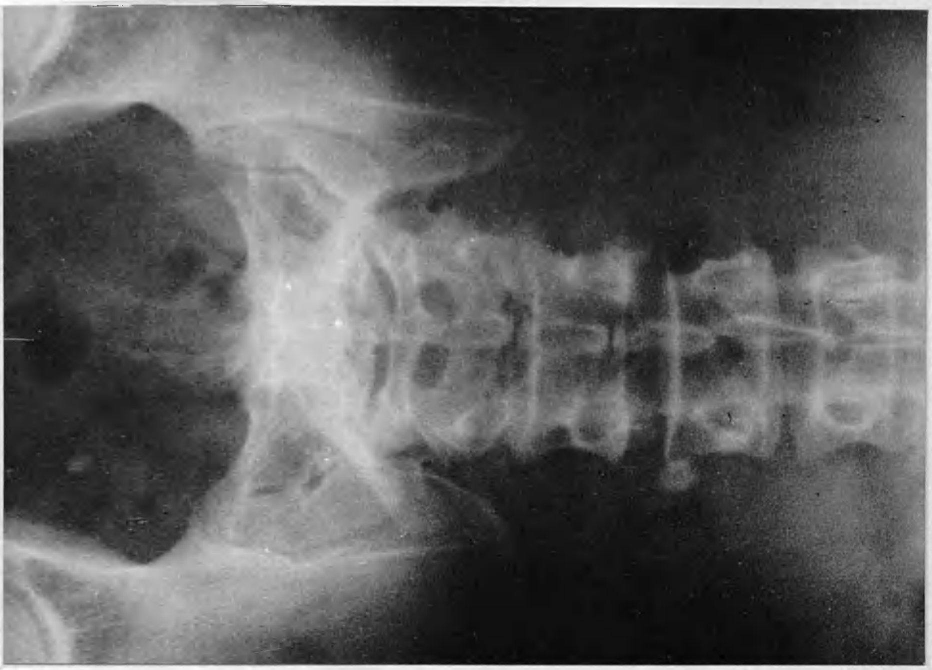
(b) Control Group.

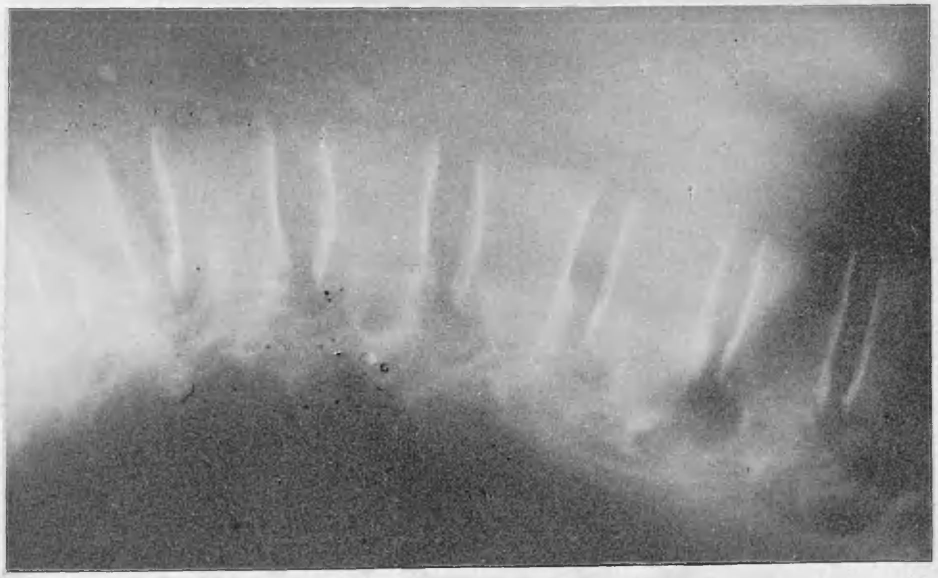
Control No. 15.	Ankylosing Spondylitis.
Control No. 38.	Congenital Abnormality of Spine.
Control No. 40.	Healed Tuberculosis of Cervical Spine.





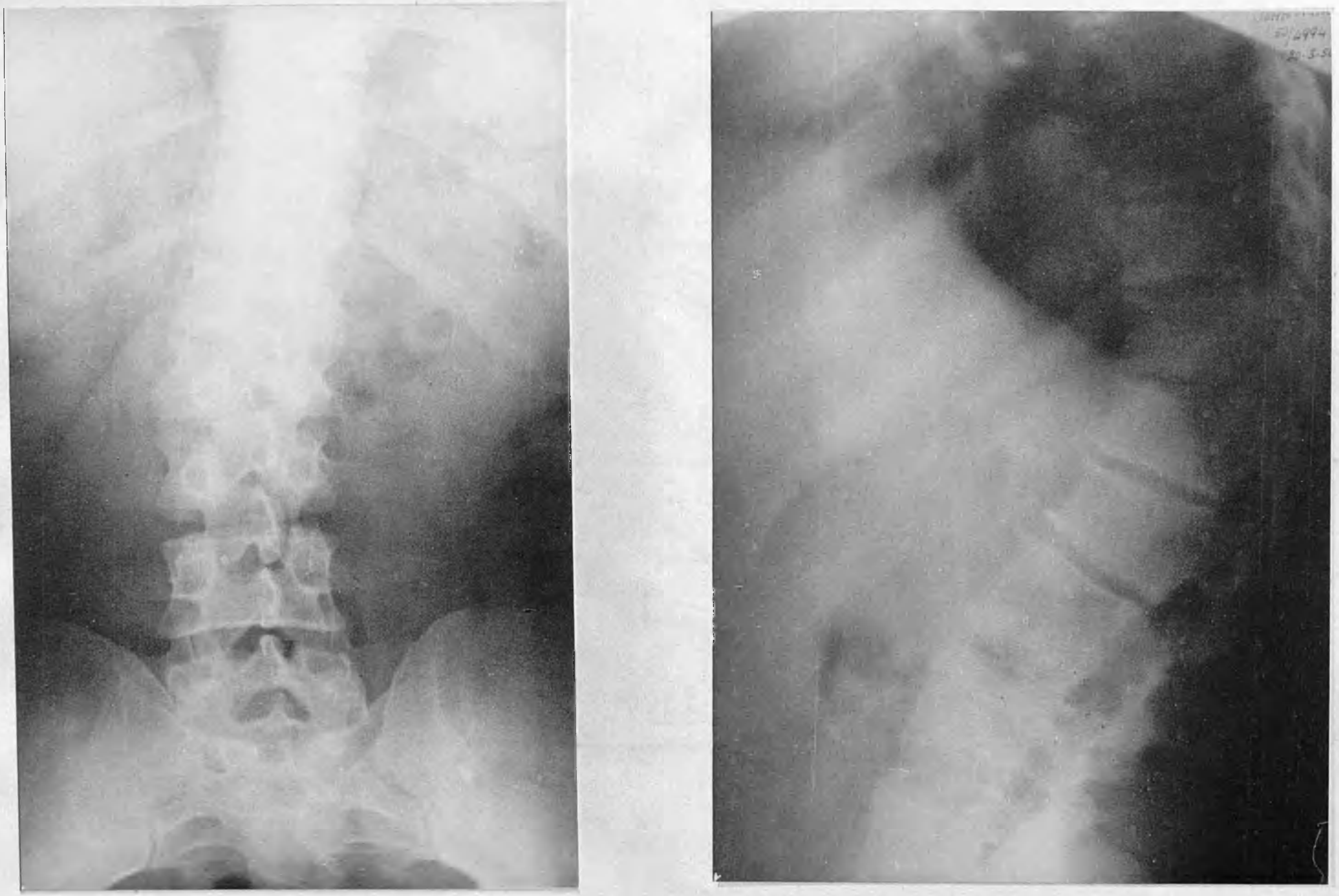
Control N.S.B. : Normal





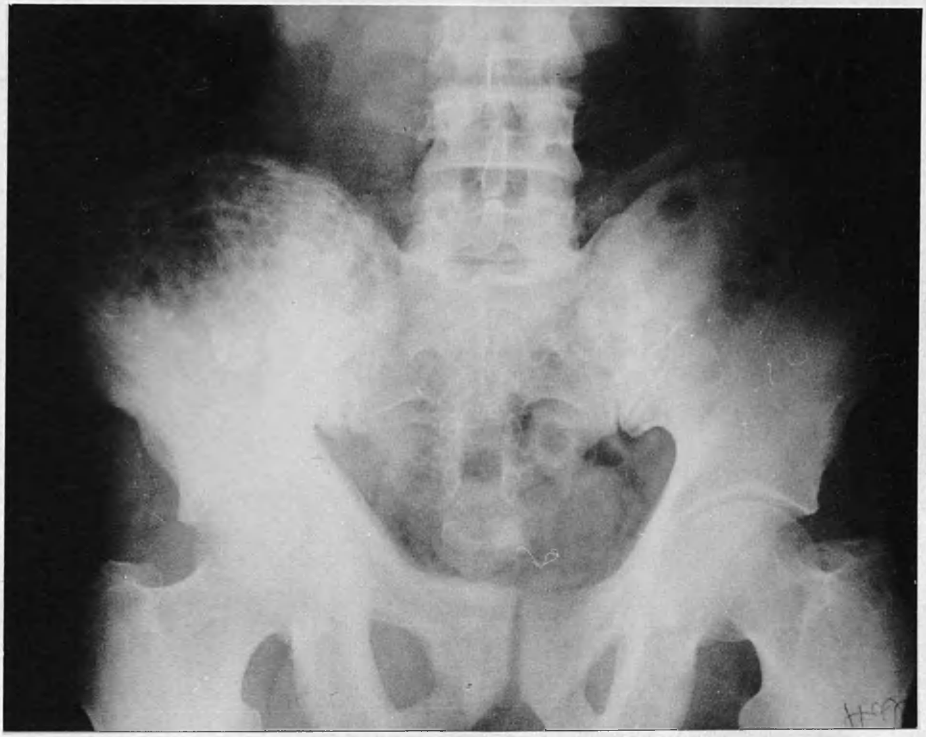
Case No. 3. : Lumbarisation of 1st Sacral.

10+11

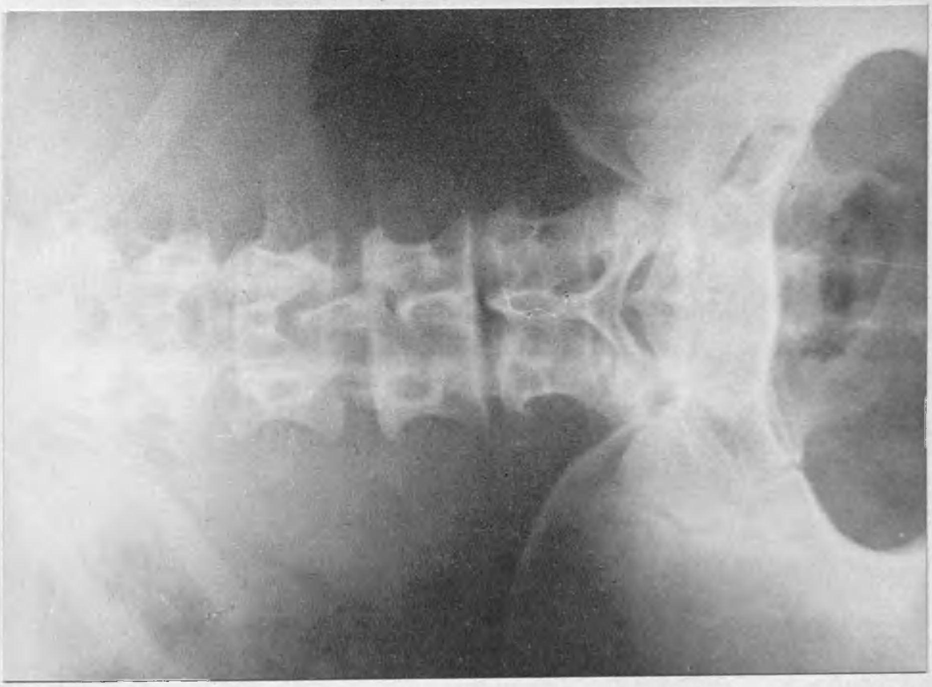


Case No. 15 : Osteo-arthritis with distortion of L.1 and 2.

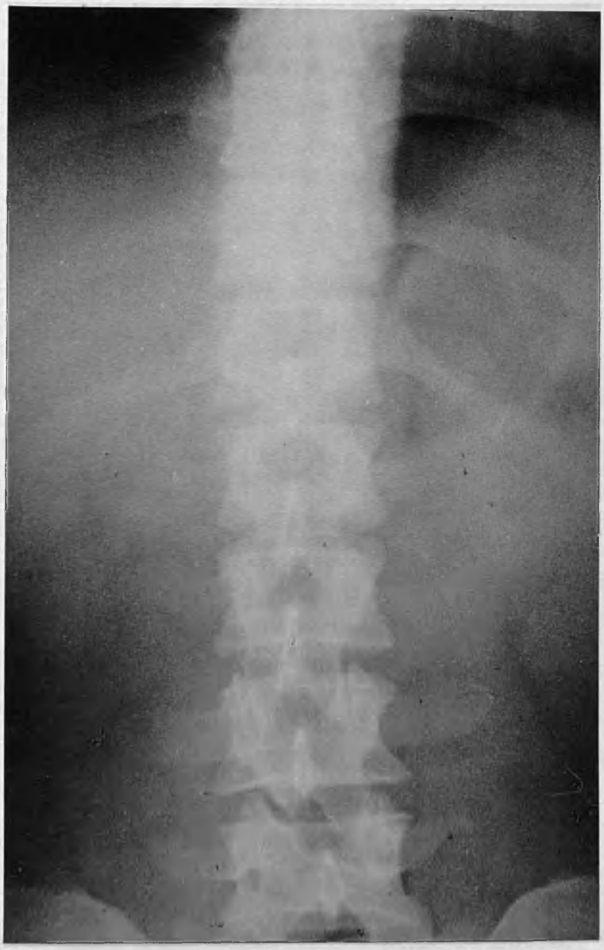
Case No 20: Osteo-arthritis.
Sacralisation of 5th Lumbar.



Case No. 21 : Paget's Disease of Bone [Pelvis].

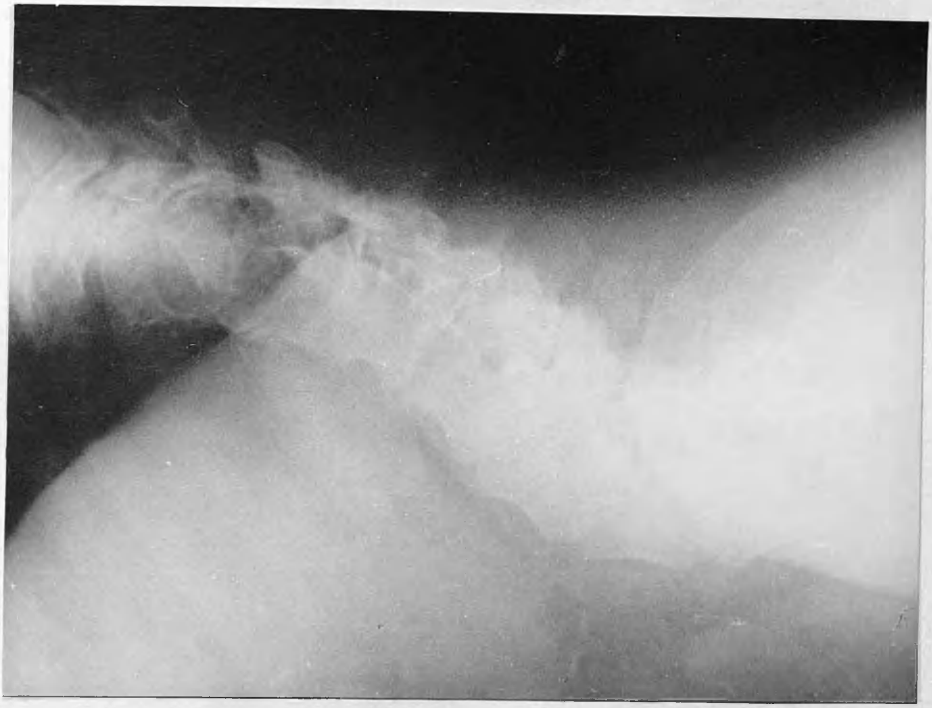


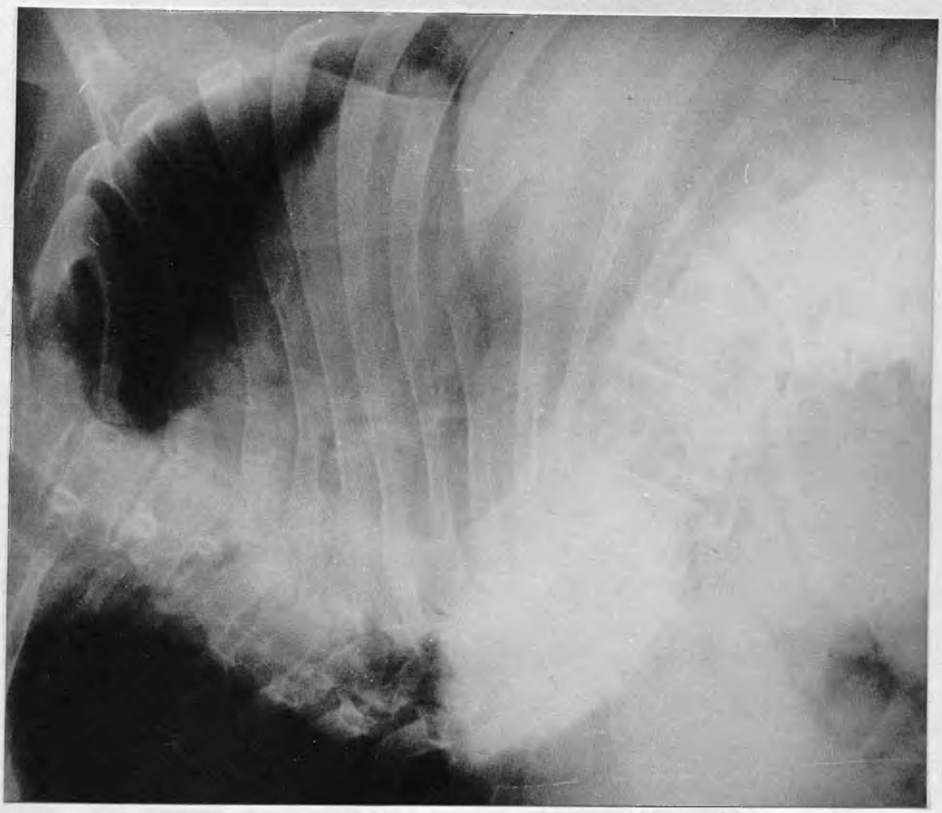
Case No. 30: Osteo-arthritis.



Case No. 36 : Spina bifida, 5^{th} lumbar.

Control No. 15 : Ankylosing Spondylitis.





Control Nº 38: Congenital Abnormality.

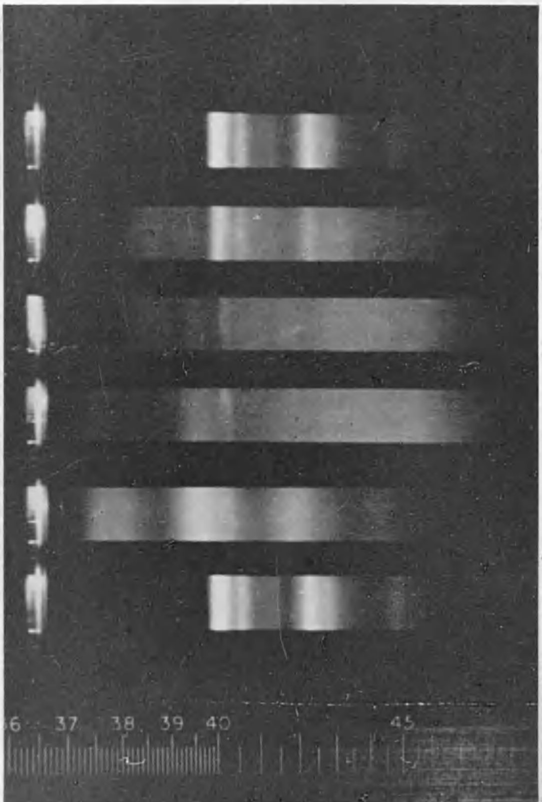
Control N°40: Old T.B. Cervical Spine.

FLUORESCENCE SPECTROGRAMS.

Oils and Tar Compounds recovered from

Glasgow Sewers.

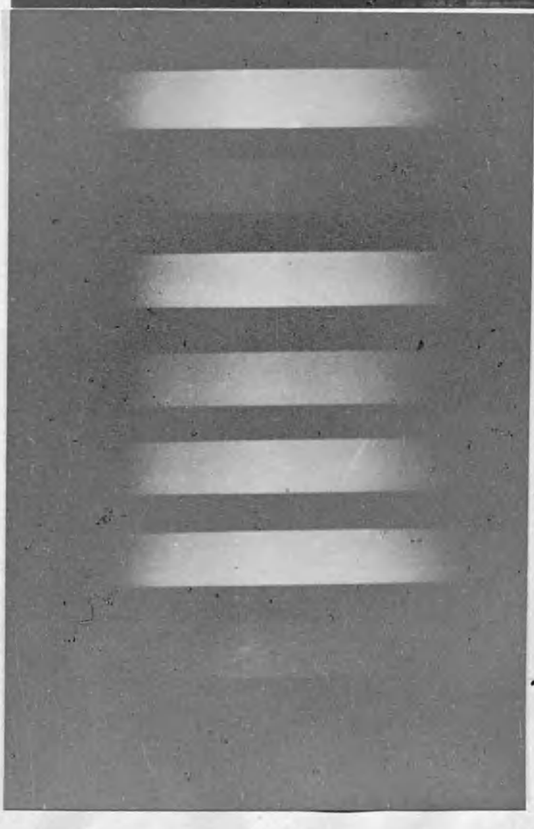
U.V. SPECTRA.



3:4, Benzpyrene [Control]

Coal Tar Fractions.

3:4, Benzpyrene [Control]



Mineral Oils.

T A B L E S.

Table No. 1.

LENGTH OF PUBLIC SEWERS IN GLASGOW
1790 - 1948

Year	Length of Public Sewers in Miles
1790	First public sewer constructed
1816	$4\frac{1}{2}$
1818	5 to 6
1849	40
1863	$62\frac{1}{2}$
1869	69
1873	83
1879	91
1883	96
1889	99
1893	104
1900	$124\frac{1}{2}$
1948	800

Table No. 2.

GLASGOW'S MAIN DRAINAGE SYSTEM
INTERCEPTING SEWERS.

Locality of Sewer	Size according to Height		Gradient	Velocity of Liquid when running full	Discharge when running full
	Ft.	In.		Ft./Min.	Cub.Ft./Min.
From Yoker Penstock (1)	8	2	1 in 2,062	265	13,890
House to Dalmuir: (2)	8	6	1 in 2,810	232	13,164
Glasgow Intercepting Sewer, Pointhouse Road:	5	6	1 in 2,635	180	4,250
Partick Intercepting Sewer, Castlebank Street:	5	0	1 in 2,000	193	3,790
Clydebank Intercepting Sewer:	5	6	1 in 2,000	206	4,887
South Side Sewer No.1 Cardonald:	9	0	1 in 1,760	305	19,427
South Side Sewer No.4					
(1) Rutherglen end:	4	6	1 in 2,000	180	2,862
(2) St. James' Street:	7	6	1 in 2,000	253	11,176

Table No. 3.

EXAMPLES OF RESULTS OF EXAMINATION OF CRUDE AND SETTLED SEWAGES.

(From "Treatment and Disposal of Industrial Waste Waters", R.A. Southgate, H.M.S.O. 1948.)

Results in Parts per 100,000 (except pH)	Town with Mixed Industries		Mainly Residential District	Town in which Metal working is Chief Industry	Military Camp	
	Crude	After Sedimentation	After Sedimentation	After Sedimentation	Crude	After Sedimentation
Free and Saline Ammonia (as N)	8.6	4.1	4.4	3.7	6.0	6.6
Biochemical Oxygen Demand in 5 Days at 18.3°C.	53	25	18.3	17.5	85	40
Oxygen absorbed from N/80 Acid Permanganate in 4 Hours at 26.7°C.	16.3	8.5	5.2	9.2	30.7	11.8
Suspended Solids	42	6.2	8.4	8.2	41	12.2
pH Value.	7.4	7.2	7.4	-	6.2	7.2

Table No. 4.

SOME SOCIAL FACTORS - SEWERMEN.

No.	Initials	Age in Years	Children	Size of House in Apts.	No. of Occupants: Ad.	Ch.	Bath in House	Wages £	s.	d.
1.	D. McA.	64	6	3	3	-	No	6:	4:	5
2.	A. McK.	58	4	4	5	1	Yes	5:	15:	-
3.	P. H.	57	4	4	5	-	Yes	5:	15:	-
4.	T. W.	57	1	2	3	-	No	5:	15:	-
5.	W. L.	57	Nil	2	2	-	No	5:	15:	-
6.	T. D.	57	7	3	4	-	Yes	6:	7:	-
7.	J. M.	57	4	1	5	1	No	6:	-:	1
8.	F. McF.	56	3	4	5	1	Yes	5:	8:	5
9.	J. T.	56	11	2	4	-	No	6:	10;	-
10.	J. L.	53	4	2	3	3	No	6:	1:	5
11.	T. M.	53	1	2	3	-	No	6:	5:	-
12.	N. R.	53	4	2	4	-	No	6:	1:	-
13.	J. F.	52	3	2	5	-	No	6:	13:	5
14.	G. McG.	52	4	5	6	-	Yes	6:	1:	4
15.	J. McA.	52	1	2	2	-	No	5:	14:	-
16.	T. S.	52	Nil	2	4	-	No	5:	13:	-
17.	R. G.	52	6	4	5	-	Yes	6:	13:	-
18.	J. McC.	51	2	3	4	-	Yes	5:	15:	-
19.	J. C.	51	2	2	3	-	No	5:	15:	1
20.	F. E.	51	2	2	4	-	No	5:	15:	-
21.	H. H.	50	10	5	8	4	Yes	6:	1:	5
22.	G. M.	50	4	3	3	-	Yes	5:	16:	4
23.	F. B.	50	11	3	6	4	No	6:	1:	5
24.	R. McL.	50	4	1	6	-	No	6:	1:	5
25.	J. B.	49	3	3	5	3	Yes	5:	17:	5
26.	E. S.	48	5	3	5	2	No	6:	5:	8
27.	C. D.	48	3	3	3	2	Yes	6:	12:	-
28.	C.D.	47	2	2	3	-	No	5:	15:	5
29.	W, McK.	47	1	2	3	-	No	5:	19:	5
30.	J. S.	46	5	5	6	1	Yes	6:	1:	5
31.	B. McD.	46	2	3	3	1	No	6:	1:	5
32.	J. H.	44	3	4	4	2	Yes	6:	1:	3
33.	A. M.	43	6	3	4	4	Yes	6:	1:	-
34.	R. K.	43	3	2	2	3	No	6:	1:	5
35.	J. S.	40	3	2	3	2	No	6:	1:	-
36.	J. K.	38	Nil	2	2	-	No	5:	16:	-
37.	R. O.	36	4	2	2	4	No	6:	1:	6
38.	T. B.	34	5	2	2	5	No	6:	13:	-
39.	J. O.	33	3	2	2	3	No	6:	12:	-
40.	R. I.	47	4	2	2	-	No	6:	12:	-
41.	R. M.	38	1	2	5	1	No	5:	16:	7
42.	W. B.	56	3	3	3	-	Yes	5:	15:	-
Averages:		49.4	3.7	-	-	-	-	6:	1:	-

Table No. 5.

OCCUPATIONAL HISTORY - SEWERMEN.

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment in Chronological Order.
1	64	27	37	Platers' mate 3 years; Merchant Navy 9 years; boiler fireman 5 years; Army 4 years; Highways Department 2 years; Sewerman since 1923.
2	58	$9\frac{1}{2}$	48	Farm worker 2 years; carpet factory labourer 1 year; Regular Army 13 years; steel-works labourer 9 months; Highways Department labourer 19 years; sewerman since 1940.
3	57	14	43	Telegraph messenger 2 years; platers' mate in shipyard 25 years; paviour's labourer - Highways Department - 4 years; sewerman since 1937.
4	57	7	50	Lanarkshire miner 13 years; Army $1\frac{1}{2}$ years; Highways Department labourer 22 years; sewerman since 1943.
5	57	26	31	Errand boy 2 years; farm labourer 6 years; Highways Department labourer 10 years; sewerman since 1924.
6	57	6	51	Miner 20 years (Lanarkshire and Stirlingshire) (Brusher 6 years); paviour's labourer, Highways Department 18 years; sewerman since 1944.
7	57	7	50	Farm labourer 13 years; building trades labourer 8 years; Highways Department labourer 14 years; Sewerman since 1942.
8	56	24	32	Errand boy 2 years; apprentice machineman in sawmill $3\frac{1}{2}$ years; sawmill labourer 2 years; Army 3 years; unemployed 6 months; engineer's labourer 2 years; unemployed 1 year; Highways Department labourer 2 years; winchman in Sewerage Section $1\frac{1}{2}$ years; sewerman since 1925.

Table No. 5 (Contd.)

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment
9	56	4	52	Left school at 10 years in Ireland; farm labourer 6 years; blacksmith's striker 2 years; building trades labourer 23 years; unemployed 1 year; Highways Department labourer 9 years; sewerman since 1946.
10	53	9	44	Farm labourer 16 years; grave digger 6 months; labourer on railways 6 months; labourer in shipyards 3 years; Public works contractor's labourer 5 years; Highways Department labourer 7 years; sewerman since 1941.
11	53	6	47	Miner in Lanarkshire 14 years (brushing and drawing); Merchant Navy 1 year; labourer in U.S.A. in cotton printing works 2 years; labourer in railway (wire-brushing and red-leading) 2 years; labourer in Highways Dept. 6 years; sewerman since 1943.
12	53	12	41	Catch-boy with riveter's squad in shipyards 4 years; Army 1915-1920 (wounds right forearm and back); unemployed for about 1 year; apprentice riveter in shipyards 5 years; Highways Department labourer 11 years; sewerman since 1938.
13	52	18	34	Labourer in tube factory 6 years; Army 2 years; labourer in tube factory 5 years; casual labouring during next 7 years with periods of unemployment; sewerman since 1932.
14	52	15	37	Left school at 14 years; grocer's assistant 6 years; builders' labourer 5 years; labourer to public works contractor 5 years; labourer in Highways Department 8 years; sewerman since 1935.
15	52	22	30	Barman 5 years; Army $2\frac{1}{2}$ years; barman 3 years; Highways Department labourer 7 years; sewerman since 1928.

Table No. 5 (Contd.)

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment
16	52	11	41	Errand boy 1 year; shipyard labourer 3 years; Army 5 years; cement worker 3 years; electrician's labourer 2 years; Parks Department labourer 6 months; unemployed 1 year; Highways Department labourer 13 years; sewerman since 1939.
17	52	$4\frac{1}{2}$	48	Left school at 16 years; shoemaker 1 year; engine- cleaner on railway 1 year; Army 4 years; labourer on railway 6 months; ovensman in bakery 1 year; claymill worker in pottery 6 years; unemployed for 5 years apart from occasional casual work; Highways Department labourer 9 years; sewerman since 1945.
18	51	27	24	Butcher's boy and butcher 6 years; Army $2\frac{1}{2}$ years; unemployed 9 months; sewerman since 1922.
19	51	$4\frac{1}{2}$	47	Miner in Lanarkshire and Northumberland 16 years (brusher, drawer and coal-getter); tram-driver 10 years; labourer in forge 6 years; sewerman since 1945.
20	51	14	37	Messenger in printing works 6 years; builders' labourer 7 years; Highways Department labourer 1 year; sewerman since 1936.
21	50	5	45	Agricultural worker 4 years; Army 2 years; railway worker 25 years (engine cleaner, fireman and driver); Highways Department labourer 1 year; sewerman since 1945.
22	50	28	22	Iron-works machine-boy 3 years; Army 4 years; unemployed $1\frac{1}{2}$ years; sewerman since 1922.
23	50	27	23	Apprentice tool-maker 1 year; carter 3 years; Army 2 years; unemployed $1\frac{1}{2}$ years; labourer in Highways Department $1\frac{1}{2}$ years; sewerman since 1922.
24	50	16	34	Pit-head boy (picking) 3 years; miner 1 year; Army 1 year; miner (drawer) 7 years; builders' labourer 3 years; unemployed apart from casual work 3 years; sewerman since 1932.

Table No. 5 (Contd.).

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment
25	49	7	42	Apprentice engineer 3 years; Air Force 5 years; unemployed 7 years; builders' labourer 10 years; Highways Department 1 year; Army 2 years; Highways Department labourer 1 year; sewerman since 1943.
26	48	15	33	Maintenance labourer in factory 5 years; Highways Department labourer 14 years; sewerman since 1935.
27	48	2	46	Rivet-heater in shipyards 2 years; labourer in brick-field 3 years; general labourer 20 years; steel- works labourer 1 year; Army 4 years; Highways Department labourer 2 years; sewerman since 1948.
28	47	21	28	Errand boy 6 months; barman 4 years; sewerman since 1921 (winchman 7 years).
29	47	6	37	Butchers' assistant 9 years; Highways Department labouter 2 years; sewerman since 1939 apart from 4 years in Army.
30	46	11	35	Errand boy 6 months; rivet heater 4 years; builders' labourer 17 years; sewerman since 1939.
31	46	10	36	Bakers' vanman 4 years; Public works Contractor's labourer 18 years (tunnel driving, etc.); sewerman since 1940.
32	44	5	39	Errand boy 4 years; oncost haulage worker in pits 5 years; clay-digger in brick works 3½ years; unemployed for 2 years apart from occasional casual work; Highways Department labourer 6 years; R.A.F. 6 years; sewerman since 1945.
33	43	3	40	Quarry lugger 6 years; unemployed 7 years; labourer in odd jobs 3 years; labourer in Highways Department 3 years; Army 5 years; Highways Department 1 year; sewerman 4 years.

Table No. 5 (Contd.).

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment
34	43	5	38	Barman 8 years; munitions worker 2 years; unemployed 1 year; barman 6 years; ammunition worker 3 years; fire-tender crash-driver at aerodrome 4 years; sewerman since 1944.
35.	40	9	40	Apprentice engineer 3 years; Regular army 8 years; sewerman since 1935 apart from 6 years in Army during recent War.
36	38	7	31	Errand boy 2 years; railway worker (engine cleaner) 3 years; unemployed 3½ years; labourer in Highways Department 6 years; sewerman since 1940 apart from 3 years in Royal Navy.
37	36	8	28	Riveter's mate in shipyards 6 months; van-boy 1 year; unemployed 2 years; machine operator in bakery 9 years; labourer in Highways Department 6 months; sewerman since 1942.
38	34	5	29	Errand boy 6 months; labourer in hat factory 2 years; builders' labourer 5 years; stoker in Navy and Merchant Navy 7 years; sewerman since 1944.
39	33	4	29	Van-boy 3 years; van driver 4 years; dumper driver in public works 4 years; R.A.F. 4 years; sewerman since 1946.
40	47	4	43	Tram conductor 1 year; hide porter 1½ years; Royal Navy 3 years; furnaceman in chemical works 3 years; policeman 2½ years; furnaceman in chemical works 4 years; trawler fireman 2 years; furnaceman in chemical works 2 years; public works labourer 5 years; Army 5 years; labourer in Electricity Department 2 months; labourer in Highways Department 6 months; sewerman 1946 to date.
41	38	2/12	38	Errand boy 2 years; moulder's helper 4 years; unemployed 5 years; labourer in Highways Department 4½ years; sewerman since January 1950.

Table No. 5 (Contd.).

No.	Age in Years	Service in Years	Age at Entry	Nature of Previous Employment
42	56	15	41	Left school at 14 years; miner 9 years; dyke builder and agricultural drainer 1 year; agricultural worker 9 years; refuse carrier (night shift), Cleansing Department 1929-1934; labourer Highways Department 1934-35; sewerman since 1935.

Table No. 6.

GLASGOW SEWERMAN

GROUPING ACCORDING TO LENGTH OF SERVICE.

Years of Service	Number of Sewermen	Percentage Distribution
Under 5	8	19.05
-10	15	37.71
-15	7	16.67
-20	4	9.52
-25	3	7.14
25 and over	5	11.91
Total in all Groups:	42	100.00

Table No. 7.

ENVIRONMENTAL TEMPERATURES IN SEWERS

EXAMPLES FROM EIGHT GLASGOW SEWERS.

Sewer No.	Dry Bulb °F.	Wet Bulb °F.	Relative Humidity %	Kata 't' Secs.	Cooling Power	Air Movement Ft./Min.	Effective Temp. °F.	Surface Temp. °F.
1	65	61	80	40	11.6	90	62	54
	61	57.5	82	32	14.8	148	56	54
2	63	57	69	35	19	280	54.5	48
3	68	63	78	35	13.5	140	63	38
4	62	58	79	46	10	54	59	44
5	68	55	83	58	8	15	57	34
6	65	62	85	36	13	110	61	40
7	66	57	58	47	9.8	45	62	58?
8	61	58	84	32	14.5	130	56	50

Table No. 8.

ENVIRONMENTAL CONDITIONS IN SEWERS.

SEWER No. 2.

VARIATIONS AT 15-MINUTE INTERVALS OVER PERIOD OF TWO HOURS.

Interval	Dry Bulb °F.	Wet Bulb °F.	Relative Humidity %	Kata 't' Secs.	Cooling Power	Air Movement Ft./Min.	Effective Temp. °F.	Surface Temp. °F.
Start	63	57	69	25	19	280	54.5	48
1	63	53	51	35	13	110	58	
2	59	54.5	75	38	12	85	56	
3	55	53	82	31	15	106	51	
4	67	58	58	33	14	150	61	
5	65	62	85	58	8	25	63	
6	73	63	58	65	7.25	25	68.5	
7	67	57	54	47	10	60	63	
Finish	60	56	75	42	11	55	58	

Table No. 9.

ATMOSPHERIC CONDITIONS IN SEWERS:
CHEMICAL ANALYSES IN GLASGOW SEWERS.

Sewer No.	Carbon Monoxide Parts per Million	Carbon Dioxide Parts per 10,000	Benzene and Other Aromatic Hydrocarbons. Parts per Million
1	19	9.1	Present
	12	8	Not done
	3	6.9	do.
	13	15	do.
	25	13.6	do.
2	14	15.8	Nil - Hydrogen sulphide present.
3	19	10.5	333.33
	20	8.4	500
5	Nil	103	Not done
	Nil	151	do.
Sample of Air (Boden Street)	Nil	4.2	Nil
Sample of Air (Glasgow Cross)	12	4.5	Not done

Table No. 10.

SICKNESS ABSENCE - GLASGOW SEWERMEN.
OCTOBER 1945 TO OCTOBER 1950.

Disease Group	No. of Cases Involved	No. of Periods of Illness	Absence in Weeks
Accidents	1	1	3
Alimentary Tract	8	8	115
Genito-Urinary System	2	3	18
Infectious Diseases -			
(a) Leptospirosis	5	5	90
(b) Infectious Parotitis	1	1	9
Nervous Disorders	2	2	70
Respiratory Diseases	6	7	24
Rheumatic Conditions	16	17	99
Skin Diseases	3	3	17
All Groups	44	47ø	445

ø See note at Table 12.

Table No. 11.

SICKNESS ABSENCE - GLASGOW SEWERMEN.

Distribution of Sickness Periods according to Length of Absence

1945 - 1950.

Length of Period in Weeks	1	2	3	4	5	-10	-20	-40	-60	-80	Total
Number of Periods	4	5	11	4	1	13	5	2	1	1	47

Table No. 12.

SICKNESS ABSENCE - GLASGOW SEWERMEN.

Annual Distribution of Disease Groups October 1945 to October 1950.

Disease Group	1945 Oct-Dec.		1946		1947		1948		1949		1950 Jan-Oct.	
	Per	Cas	Per	Cas	Per	Cas	Per	Cas	Per	Cas	Per	Cas
Accidents	-	-	-	-	-	-	3	1	-	-	-	-
Alimentary Tract	-	-	3	1	-	-	23	2	56	3	33	3
Genito-Urinary	-	-	-	-	10	2	-	-	-	-	8	1
Leptospirosis	19	2	57	3	13	1	1	1	-	-	-	-
Other Infections	-	-	-	-	9	1	-	-	-	-	-	-
Nervous System	-	-	30	1	-	-	-	-	9	1	31	1
Respiratory System	-	-	7	2	6	1	6	2	5	2	-	-
Rheumatic Disorders	3	1	-	-	33	5	12	2	24	5	27	4
Skin Diseases	-	-	3	1	12	1	-	-	2	1	-	-
Total	22	3	100	8	83	11	45	8	96	12	99	9

Total for Period Oct. 1945 - Oct. 1950:- No. of Periods ... 445
No. of Cases 51ø

N.B. Per = Period of Sickness Absence.
Cas = Number of Cases.

ø The discrepancy between Tables Nos. 10 and 12 in the total number of cases of absence is accounted for by the fact that a sewerman having a continuous absence extending from one year into the next is included in the total for each year.

Table No. 13.

SICKNESS ABSENCE - GLASGOW SEWERMEN.

Percentage Loss of Time and Percentage Number of Cases due to Disease Groups. 1945 - 1950.

Disease Group	Percentage of Total Absence	Percentage of Total Cases
Accidents	0.7	2.3
Alimentary Tract Disorders	25.8	18.2
Genito-Urinary System	4.0	4.5
Infectious Diseases -		
(a) Leptospirosis	20.2	11.4
(b) Infectious Parotitis	2.1	2.3
Nervous Disorders	15.7	4.6
Respiratory Diseases	5.4	13.6
Rheumatic Conditions	22.3	36.3
Skin Diseases	3.8	6.8
All Groups	100.0	100.0

Table No. 14.

KNOWN CAUSES OF DEATH IN GLASGOW SEWERMEN.

1935 - 1950.

Cause of Death	No. of Deaths
Leptospirosis	8
Gassing Accidents	2
Cancer of Bowel	2
Tuberculosis (Pulmonary)	2
Heart Conditions	3
Lobar Pneumonia	1
Perforation of Peptic Ulcer	1
Total	19

Table No. 15.

OCCUPATIONAL INCIDENCE OF LEPTOSPIRAL INFECTIONS.

Occupations	Percentage Distribution of Cases				
Miners	29	13.8	6	-	17.4
Sewer Workers	19.5	8.5	11	10.6	19.5
Fish Workers	19.5	58.5	7	8.0	13.0
Farm Workers	4	-	12	5.0	-
Scavengers	3	-	-	8.0	-
Butchers	3	-	-	-	19.5
Canal Workers	1	-	11	14.0	-
Brewery Workers	1	-	-	-	-
Piggery Workers	1	-	-	-	-
Other Occupations	15	12.7	11	16.0	15.4
Non-occupational	-	-	-	9.4	2.2
Bathing or Accidental Immersion	4	6.5	7	22.0	13.0
Services	-	-	29	-	-
Source Unknown	-	-	7	7.0	-
Total Number of Cases in Series	99	246	195	73	46
Case Fatality Rate per cent.	31.3	-	-	-	13.0
Place of Survey	England	N.-E. Scotland	England + Services	U.S.A.	Glasgow
Years	1919-1935	1933-1939	1940-1946	1905-1940	1926-1949
Investigators	Various	Davidson & Smith	Broom & Alston	Styles & Sawyer	Public Health Records

N.B. Services cases included patients invalided from overseas with leptospirosis.

Table No. 16.

INCIDENCE OF LEPTOSPIROSIS IN GLASGOW

Notified Cases: 1926 - 1949.

Source of Infection (Occupational unless otherwise stated.)	No. of Cases	Percentage of total
Sewermen	9	19.5
Meat Market Employees	9	19.5
Miners	8	17.4
Fish Market Workers	6	13.0
Apprentice Iron Worker	1	2.2
Apprentice Glass Worker	1	2.2
Asphalt Worker	1	2.2
Bricklayer's labourer	1	2.2
Plumber	1	2.2
Tannery Worker	1	2.2
Paper Mill Machinist	1	2.2
Seamen	2	4.4
Bathing in infected Water	4	8.6
Male at Holiday Camp who ate contaminated bread	1	2.2
Total No. of Cases:	46	100.0

Table No. 17.

LEPTOSPIROSIS IN GLASGOW.

Age-Distribution of 46 Notified Cases (1926 - 1949).

Age Group in Years	Males	Females
Under 15	2	-
- 20	7	-
- 25	2	2
- 30	4	-
- 35	2	-
- 40	4	-
- 45	6	-
- 50	6	-
- 55	5	-
- 60	5	-
60 and over	1	-
All Ages	44	2

Table No. 18.

INCIDENCE OF LEPTOSPIROSIS IN GLASGOW.

Seasonal Distribution of 46 Cases (1926 - 1949).

Month	Number of Cases		Total for Three-Months
	Males	Females	
January	5	-	
February	1	-	8
March	2	-	
April	1	1	
May	4	-	9
June	3	-	
July	6	-	
August	5	-	21
September	9	1	
October	2	-	
November	5	-	8
December	1	-	
Total	44	2	46

Table No. 19.

Cases of Leptospiral Infection in Sewermen.

No.	Year	Month	Age	Service Years	Symptoms of Onset: Headache	Vomiting	Fever	Influenza	Source of Infection	Pains in Limbs	Jaundice	Haemorrhage	Meningeal	Deaths	Duration of Incapacity
1	1910	-	36	3	x	x	x	-	-	-	x	-	-	-	10/52
2	1927	Oct.	33	2	-	-	x	x	-	x	No Jaundice	-	-	-	12/52
3	1927	Oct.	47	25	-	-	x	-	-	x	x	Epistaxis	-	-	(?)
4	1931	-	40	9	-	-	x	-	-	x	x	-	-	-	(?)
5	1931	-	51	22	-	-	x	x	-	x	No	No	-	-	3/12
6	1935	-	44	10	-	-	-	-	-	x	x	-	-	-	5/12
7	1935	Sept.	60	(?)	x	-	x	x	-	x	x	-	-	Died at home	7 days' illness
8	1937	Sept.	34	4	x	ø	x	x	-	x	x 6th	Epistaxis 5th	-	Died in hospital	11 days' illness
9	1937	Sept.	51	(?)	-	-	-	x	-	-	x 4th	Haematemesis 5th	-	Died at home	11 days' illness
10	1937	Oct.	56		-	-	-	-	-	-	x	x	-	Died at home	
11	1939	May	39	10	x	x	x	-	Royal Cres.	x	x 4th	Epistaxis 5th & Haematemesis	-	-	4/12
12	1939	July	37	4	-	x	x	-	Major Street	-	x 3rd	-	-	-	7 weeks
13	1939	July	42	5	-	x*	x	-	Major Street	-	x 3rd	-	-	-	5 weeks
14	1939	-	60		-	-	-	-	-	-	x	-	-	Died at home	
15	1939	Aug.	45	8	x	x	x	-	Major Street	-	x 5th	-	-	-	4/12
16	1942	Mar.		4	x	x	x	x	Cathedral St.	x	-	-	x	-	3/12
17	1942	Mar.	49	18	-	-	-	-	Barrowfield St.	-	x	-	-	-	3/12
18	1943	July	51	3	-	-	-	-	Watson Street	x	x	-	-	-	
19	1943	Oct.	60		-	-	-	-	-	-	-	-	-	Died at home	
20	1943	Nov.	42	10/12	x	x	x	-	St. Enoch Sq.	-	x 3rd	Epistaxis 5th	-	-	4/12
21	1944	May	40	5	x	x	x	x	Cromwell St.(?)	x	No	-	-	-	6/12
22	1944	Sept.	46	12	x	-	x	x	-	x	x	-	-	-	4½/52
23	1944	Nov.	46	22	x	x	x	x	Allison St.	x	x	x	-	-	6/12
24	1945	Oct.	48	7	-	-	-	-	Stagg Street	-	-	-	-	-	6/12
25	1945	Nov.	51	1½	x	x*	x	-	Blackburn St., Kinning Park	-	x 4th	-	-	-	1 6/12
26	1946	Feb.	40	6/12	x	x	x	x	-	x	x	No	-	-	3/52
27	1946	Aug.	35	4	-	-	-	-	-	-	-	-	-	Died at home	
28	1948	Oct.	46	10	x	x	x	x	Heron Street	-	x 5th	Haematemesis	x	Died 7 days after onset in hospital	

* and abdominal pains; ø constipated.

Table No. 20.

LEPTOSPIROSIS IN GLASGOW SEWERMEN.

Monthly and Yearly Distribution of Cases: 1910 - 1950.

Month	No. of Cases	Year	No. of Cases
January	-	1910	1
February	1	1927	2
March	2	1931	2
April	-	1935	2
May	2	1937	3
June	-	1939	5
July	3	1942	2
August	2	1943	3
September	4	1944	3
October	6	1945	2
November	3	1946	2
December	-	1948	1
Unknown	5		
Total	28	Total	28

Table No. 21.

LEPTOSPIROSIS IN GLASGOW SEWERMEN, 1910 - 1949.

Incidence according to Length of Service.

Length of Service in Years	Number of Men in Group	Number with History of Leptospirosis	Percentage
Under 10	23	5	21.7
20	13	5	38.5
20 and over	9	4	44.4
All groups	45	14	30.4

Table No. 22.

LEPTOSPIROSIS IN GLASGOW SEWERMEN.

Results of Serum-Agglutination Test (Schuffner Test).

Case No.	Initials	Age in Years	Interval since Infection in Years	Titre
2	C. McD.	56	23	1/100
11	G. M.	50	11	1/300
12	E. S.	48	11	1/300
13	G. McG.	53	11	1/100
16	P. B.	49	8	1/100
17	W. L.	59	8	1/100
18	A. McK.	58	7	1/30
20	J. B.	49	7	1/100
21	J. S.	41	6	1/300
22	J. F.	52	6	1/100
23	J. McC.	52	6	1/100
24	N. H.	53	5	1/100
25	T. W.	56	5	1/300
26	J. H.	44	4	1/300

Table No. 23.

CONTROL GROUP - SOME SOCIAL FACTORS

No.	Age in Years	Work	Department	Size of Family in House	Size of House (Apartments)	Bath in House	Wages £	s.	d.
1.	66	Watchman	Housing	Single	3	Yes	4:	16:	-
2.	65	Watchman	Housing	Widower	1	No	4:	16:	-
3.	63	Watchman	Housing	Married	1	No	4:	16:	-
4.	62	Watchman	Housing	M. + 3	3	Yes	4:	16:	-
5.	62	Watchman	Housing	Married	1	No	4:	16:	-
6.	60	Sweeper	Cleansing	Married	2	No	4:	16:	-
7.	60	Cement Worker	Gas	Married	3	Yes	4:	19:	-
8.	59	Watchman	Housing	Married	3	Yes	4:	16:	-
9.	59	Watchman	Housing	Married	1	No	5:	-:	-
10.	59	Sweeper	Cleansing	Married	2	No	5:	-:	-
11.	58	Watchman	Housing	Widower	1	No	4:	16:	-
12.	58	Watchman	Housing	Married	2	No	4:	16:	-
13.	58	Wash-house Attendant	Baths	Widower	3	Yes	5:	2:	-
14.	56	Joiner	Gas	Married	3	Yes			
15.	56	Watchman	Housing	Married	1	No	4:	16:	-
16.	56	Sweeper	Cleansing	M. + 9	4	Yes	5:	-:	-
17.	55	Sweeper	Cleansing	Married	1	No	5:	-:	-
18.	53	Sweeper	Cleansing	M. + 3	2	No	5:	-:	-
19.	52	Labourer	Highways	M. + 1	3	Yes	4:	16:	-
20.	52	Sweeper	Cleansing	M. + 4	2	No	5:	-:	-
21.	52	Watchman	Housing	Widower	1	No	4:	16:	-
22.	50	Refuse Carrier	Cleansing	M. + 1	2	No	6:	-:	-
23.	49	Sweeper	Cleansing	Single	3	Yes	5:	-:	-
24.	49	Refuse Carrier	Cleaning	M. + 6	1	No	6:	10:	-
25.	48	Clerk	Water	M. + 3	2	No	5:	-:	-
26.	48	Gas-fitter's Mate	Gas	M. + 4	1	No	4:	19:	-
27.	48	Rat-catcher	Health	Single	4	Yes	6:	10:	-
28.	45	Sweeper	Cleaning	M. + 2	1	No	4:	16:	-
29.	45	Attendant	Halls	M. + 3	3	Yes	5:	4:	-
30.	45	Attendant	Halls	Single	2	Yes	5:	8:	-
31.	45	Painter	Health	M. + 2	3	Yes			
32.	45	Labourer	Highways	M. + 2	3	No	4:	5:	-
33.	44	Labourer	Housing	Married	1	Yes	6:	15:	-
34.	44	Slater	Housing	Married	3	Yes			
35.	44	Labourer	Gas	M. + 3	1	No	6:	10:	-
36.	44	Remand Home Assistant	Children's	M. + 2	3	Yes	6:	13:	-

Table No. 23 (Contd.)

No.	Age in Years	Work	Department	Size of Family in House	Size of House (Apartments)	Bath in House	Wages £	s.	d.
37.	43	Cleaner	Markets	Single	4	Yes	5:	2:	-
38.	43	Watchman	Highways	M. + 2	2	No	4:	16:	-
39.	42	Gas Fitter	Gas	Married	1	No	6:	6:	-
40.	42	Watchman	Highways	Single	2	No	4:	16:	-
41.	41	Labourer	Sewage	M. + 3	1	No	5:	14:	-
42.	41	Compositor	Printing	M. + 2	2	No			
43.	41	Plumber	Gas	M. + 3	3	Yes	6:	12:	-
44.	41	Driver	Cleansing	M. + 2	2	No	5:	10:	-
45.	40	Meter Tester	Gas	M. + 4	3	Yes	5:	18:	-
46.	39	Refuse Carrier	Cleansing	M. + 3	3	Yes	6:	14:	-
47.	39	Labourer	Highways	M. + 2	3	Yes	4:	5:	-
48.	39	Compositor	Printing	M. + 2	4	Yes	6:	15:	-
49.	38	Labourer	Highways	Married	2	No	4:	5:	-
50.	36	Gas-fitter's Mate	Gas	Married	1	No	5:	2:	-
51.	35	Labourer	Highways	M. + 2	2	No	4:	15:	-
52.	35	Labourer	Sewage	M. + 1	2	No.	5:	2:	-
53.	35	Labourer	Highways	M. + 2	1	No	4:	15:	-
54.	34	Labourer	Highways	M. + 4	1	No	4:	13:	-
55.	32	Plasterer	Housing	Married	1	No	6:	7:	-
56.	33	Labourer	Housing	M. + 1	2	No	5:	10:	-
57.	33	Plumber	Gas	Single	4	Yes	6:	10:	-
58.	32	Remand Home Attendant	Children's	M. + 2	2	No	5:	12:	-
59.	31	Refuse Carrier	Cleansing	M. + 3	1	No	6:	18:	-
60.	30	Labourer	Sewage	Single	3	Yes	5:	2:	-
61.	30	Remand Home Attendant	Children's	M. + 2	2	No	5:	18:	-
62.	29	Labourer	Sewage	Single	1	No	5:	2:	-
63.	29	Engineer	Water	Single	4	Yes	7:	10:	-
64.	29	Refuse Carrier	Cleansing	M. + 2	2	No	5:	1:	-
65.	28	Sweeper	Cleansing	Married	4	Yes	4:	8:	-
66.	28	Labourer	Gas	M. + 2	2	No	4:	9:	-
67.	28	Turner	Sewage	Single	2	No	4:	19:	-
68.	27	Fireman	Sewage	M. + 1	1	No	5:	15:	4
69.	26	Labourer	Sewage	Single	2	No	5:	2:	-
70.	26	Timekeeper	Highways	M. + 2	3	Yes	6:	-:	-
71.	26	Plumber	Gas	Single	3	Yes	6:	10:	-
72	24	Carter	Cleansing	M. + 2	1	No	5:	1:	6
73	24	Labourer	Highways	M. + 2	1	No	4:	10:	-

Table No. 23 (Contd.)

No.	Age in Years	Work	Department	Size of Family in House	Size of House (Apartments)	Bath in House	£ s. d.
74.	23	Labourer	Highways	Single	2	No	4: 5: -
75.	23	Labourer	Highways	Single	1	No	4: 10: -
76.	23	Gas-fitter	Gas	Married	1	No	5: 18: -
77.	22	Labourer	Gas	Single	2	No	5: 12: -
78.	22	Compressor Operator	Housing	Single	5	Yes	5: 12: -
79.	22	Plumber	Gas	M. + 2	2	No	5: 18: -
80.	22	Labourer	Sewage	Single	3	Yes	5: 2: -
81.	21	Engineer	Water	Single	4	Yes	7: 10: -
82.	21	Labourer	Highways	Single	3	Yes	4: 10: -
83.	20	Libraries Assistant	Libraries	Single	4	Yes	
84.	20	Libraries Assistant	Libraries	Single	4	Yes	
85.	20	Apprentice Sanitary Inspector	Health	Single	4	Yes	
86.	19	Clerk	Office	Single	4	Yes	
87.	18	Libraries Assistant	Libraries	Single	4	Yes	
88.	18	Assistant Librarian	Libraries	Single	4	Yes	
89.	16	Clerk	Office	Single	3	Yes	
90.	16	Clerk	Markets	Single	3	Yes	
91.	44	Labourer	Highways	M. + 3	2	No	4: 10: -
92.	40	Labourer	Highways	M. + 5	4	Yes	4: 14: -

Table No. 24.

GENERAL EXAMINATION OF SEWERMEN

Case No.	Age in Years	Service in Years	Height in Inches	Weight in Pounds	Chest Measurement: Expiration in Inches	Chest Measurement: Inspiration in Inches
1.	64	27	60	125	33.5	36
2.	58	9.5	65	153	34	37
3.	57	14	62.5	130	34.5	36
4.	57	7	63.5	139	33.5	35.5
5.	57	26	66	154	37	38.5
6.	57	6	64	143	35.5	38
7.	57	7	67	138	34	36
8.	56	24	62	154	36	38
9.	56	4	67.25	172	38	41
10.	53	9	67	189	40	42
11.	53	6	63.5	131	36	38.5
12.	53	12	64	152	34	36
13.	52	18	67.5	155	35	37
14.	52	15	66.5	118	32	34
15.	52	22	62.5	142	37	39
16.	52	11	64	134	33	35
17.	52	4.5	63.5	160	34.5	36.5
18.	51	27	65.5	128	32.5	34
19.	51	4.5	65.75	132	33	35
20.	51	14	64	154	36	38
21.	50	5	69.5	208	42	46
22.	50	28	65.5	138	33	36
23.	50	27	62	168	36.5	38
24.	49	16	65.5	152	39	41
25.	49	7	66	143	33	35
26.	48	15	61	128	33	35
27.	48	2	66	123	32	35
28.	46	21	62.5	142	35	37
29.	46	10	64.5	140	35	37
30.	46	11	65	147	36	38
31.	46	10	62	140	33	35
32.	44	4.5	65.5	151	34	36
33.	43	3	65	154	36	38
34.	43	5	63	132	35	37
35.	40	15	64.5	147	36	38
36.	39	7	68	176	38	40
37.	36	8	62.5	147	35.5	37.5
38.	34	5	62	126	32	34
39.	33	4	69	180	36.5	39.5
40.	47	4	68	165	36	38
41.	37	2/52	68	156	36	38
42.	56	15	69	152	35	39.5
Means			64.8	148	34.90	37.32

Table No. 25.

MEAN VALUES OF GENERAL EXAMINATION RESULTS.

SEWERMEN AND CONTROL GROUP.

Age Group Years	No. in Group	Mean Values: Height in Inches	Weight in Pounds	Chest Circumference in Inches: Full Expiration	Full Inspiration	Difference
		(a) Sewermen				
Over 60	1	60	125	33.5	36	2.5
50 - 60	23	65.01	150	34.87	37.5	2.63
40 - 50	13	64.5	143.4	34.85	36.92	2.07
30 - 40	5	65.9	157	35.6	37.8	2.2
Mean Values for all Ages:		64.8	148	34.90	37.32	2.42
		(b) Control Group				
Over 60	7	65	144.7	34.86	37	2.14
50 - 60	15	64.36	141.63	34.2	36.47	2.27
40 - 50	25	65.04	131.72	33.02	35.36	2.34
30 - 40	16	65.25	141.44	33.84	36.8	2.96
20 - 30	24	65.9	136.33	32.7	35.7	3.0
Under 20	5	67.6	130.2	32.7	35.6	2.9
Mean Values for Ages over 30 years:		64.93	138	33.71	36.17	2.45
Mean Values for all Ages:		65.32	137.12	33.39	36.01	2.62

Table No. 26.

RESULTS OF EXAMINATIONS OF CARDIOVASCULAR SYSTEMS.
GLASGOW SEWERMEN.

No.	Age in Years	Service in Years	*Quality of Heart Sounds	Blood Pressure Systol. mms.Hg.	Blood Pressure Diastol. mms.Hg.	Exercise Tolerance Test "t" Secs.	Exercise Tolerance Test Breathless	Arteries
1	64	27	3	190	110	90	Yes	Arteriosclerotic
2	58	9½	2	180	110	60	Yes	do.
3	57	14	1	160	100	70	Yes	do.
4	57	7	1	140	90	70	Yes	do.
5	57	26	2	150	90	?	Yes	do.
6	57	6	3	150	90	50	Slightly	-
7	57	7	0	150	80	20	Nil	-
8	56	24	1	130	80	65	Yes	-
9	56	4	0	145	90	35	-	-
10	53	9	0	150	90	25	-	-
11	53	6	1	140	90	30	-	-
12	53	12	3	140	75	120	Markedly	-
13	52	18	0	150	80	50	Slightly	Slightly arteriosclerotic
14	52	15	2	130	80	35	-	-
15	52	22	3	150	90	40	Slightly	-
16	52	11	0	120	70	30	-	-
17	52	4½	0	140	80	30	-	-
18	51	27	3	140	90	80	Marked	-
19	51	4½	0	130	80	30	-	-
20	51	14	3	200	125	55	Slightly	Arteriosclerotic
21	50	5	0	140	90	65	Marked	-
22	50	28	2	120	80	40	Slightly	-
23	50	27	4	180	110	65	Yes	Arteriosclerotic
24	50	16	1	130	70	60	Slightly	-
25	49	7	0	140	75	30	-	-
26	48	15	0	150	90	20	-	Early arteriosc1.
27	48	2	0	130	60	35	-	-
28	47	28	0	140	80	35	-	-
29	47	6	0	130	70	20	-	-
30	46	11	1	120	60	30	-	-
31	46	10	3	120	80	65	Marked	-
32	44	5	0	140	80	20	-	-
33	43	3	0	140	90	15	-	-
34	43	5	1	130	75	45	Slightly	-
35	40	9	0	130	80	30	-	-
36	38	7	1	120	80	45	Slightly	-
37	36	8	0	130	90	20	-	-
38	34	5	0	130	75	20	-	-
39	33	4	0	120	70	20	-	-
40	47	4	1	150	90	50	Slightly	Arteriosclerotic
41	38	2/12	0	135	80	30	Slightly	-
42	56	15	0	130	80	35	-	-

*Quality of Heart Sounds - Code: Average for age - 0
Slightly below average - 1
Moderately ,, ,, - 2
Greatly below average - 3
Unsatisfactory - 4

Table No. 27.

Exercise Tolerance Test in Sewermen:

Grouping according to Age.

Age Group	Number of Men showing Breathlessness	Number of Men showing Poor E.T.T.	Total Number of Men in Group
60 and over	1	1	1
-60	6	5	9
-55	9	6	15
-50	2	1	8
-45	1	0	4
-40	2	0	3
-35	0	0	2
All Age Groups	21	13	42

Table No. 28.

Exercise Tolrance Test in Sewermen:

Grouping according to Length of Service.

Years of Service	Number of Men showing Breathlessness	Number of Men showing Poor E.T.T.	Total Number of Men in Group
25 and over	5	4	5
-25	2	1	3
-20	2	1	4
-15	4	4	7
-10	6	3	15
5 and under	2	0	8
All Groups	21	13	42

$$x^2 = 12.08$$

Table No. 29.

BLOOD EXAMINATIONS - SEWERMEN AND CONTROL GROUP

Sewermen				Control Group			
Case No.	Haemoglobin in gms. %	Haemoglobin Haldane %	Red Cells in Millions per c.mm.	Case No.	Haemoglobin in gms. %	Haemoglobin Haldane %	Red Cells in Millions per c.mm.
1.	11.4	77	3.9	2.	11.8	80	3.9
				5.	12.6	85	4.1
2.	12.4	84	4.1	6.	11.2	76	3.9
				7.	13.2	89	4.3
3.	10.6	72	3.8	8.	14.0	94	4.6
				9.	13.2	89	4.4
4.	16.8	113	5.2	10.	10.6	72	3.7
				14.	12.2	82	3.8
5.	16.8	113	4.0	16.	13.2	89	4.1
				17.	12.2	82	4.1
6.	13.0	88	4.1	18.	12.6	85	3.9
7.	11.6	78	3.9	20.	11.8	80	4.1
				21.	14.0	94	4.4
8.	17.0	115	5.4	22.	13.6	92	4.8
				23.	14.8	100	5.0
9.	14.8	100	4.7	24.	11.6	78	3.8
				26.	11.8	80	3.9
10.	16.4	111	5.2	28.	12.6	85	3.9
				29.	15.2	103	4.1
11.	13.6	92	4.3	30.	14.0	94	4.5
				32.	11.2	76	3.9
12.	11.9	80	4.2	33.	9.5	64	4.2
				34.	12.8	86	4.2
13.	12.2	82	4.1	35.	14.0	94	4.6
				36.	11.0	74	3.8
14.	12.4	84	3.7	39.	13.0	88	4.4
				41.	13.4	90	4.6
15.	11.2	76	3.9	42.	12.8	86	4.1
				43.	11.2	76	3.6
16.	16.6	112	5.1	44.	13.2	89	4.6
				45.	13.0	88	4.2
17.	16.6	112	5.0	46.	12.6	85	4.2
				47.	12.2	82	4.6
18.	17.2	117	5.2	48.	12.0	80	4.4
				49.	14.0	94	4.0
19.	15.6	105	3.7	50.	11.8	80	4.1
				51.	13.0	88	4.3
20.	17.6	119	5.4	52.	13.2	89	4.4
				53.	9.6	65	3.7
21.	14.2	96	4.1	54.	12.4	84	3.8
				55.	11.6	78	3.7

Table No. 29 (Contd.)

Sewermen				Control Group			
Case No.	Haemoglobin in gms. %	Haemoglobin Haldane %	Red Cells in Millions per c.mm.	Case No.	Haemoglobin in gms. %	Haemoglobin Haldane %	Red Cells in Millions per c.mm.
22.	15.0	101	4.2	56.	10.4	70	3.9
				57.	12.6	85	3.9
23.	17.0	115	5.3	58.	14.6	98	5.2
				59.	11.4	77	3.9
24.	14.8	100	4.1	60.	11.0	74	3.9
				61.	13.4	90	4.3
25.	16.8	113	5.2	62.	13.2	89	4.3
				63.	14.0	94	4.1
26.	10.0	68	3.3	64.	13.0	88	4.1
				65.	12.6	85	4.1
27.	14.2	96	4.6	66.	11.6	78	4.1
				70.	14.0	94	4.6
28.	13.8	93	4.2	71.	12.8	86	4.3
				72.	11.8	79	4.1
29.	10.2	69	3.6	73.	11.8	79	4.0
				74.	13.0	88	4.2
30.	15.8	107	5.1	75.	13.0	88	4.2
				76.	12.2	82	3.8
31.	12.8	86	4.3	77.	13.2	89	4.1
				79.	14.0	94	5.0
32.	15.4	104	4.0	80.	11.2	76	3.6
				81.	10.6	72	3.9
33.	13.6	92	4.2	82.	13.0	88	4.2
				83.	13.6	92	4.8
34.	12.8	86	4.3	84.	12.8	86	4.0
				85.	14.4	97	5.1
35.	11.0	74	3.9	86.	13.0	88	4.1
				87.	13.6	92	4.4
36.	13.0	88	3.9	88.	14.0	94	4.1
				89.	11.2	76	3.7
37.	13.6	92	4.2	90.	12.2	82	3.8
				91.	9.0	61	3.2
38.	14.4	97	4.6	92.	11.4	77	3.9
39.	17.0	115	5.3				
41.	10.6	72	3.8				

N.B. - Cases 40 and 42 were off work for six months at this time and hence their blood results are not included.

Table No. 30.

Percentage Distribution of Haemoglobin Levels
Mean, Standard Deviation and Standard Error.

	Married Males M.R.C. Survey	Control Group	Sewermen
Number of Cases	3,406	74	40
Mean Haemoglobin Level (% Haldane Scale)	102.1	85	95.3
Standard Deviation	8.66	9.07	15.17
Standard Error of Mean	± 0.296	± 2.1	± 4.8

Table No. 31.

Frequency Distribution of Red Cell Counts:
Sewermen and Control Group.

Number of Red Cells in Millions per Cubic Millimetre	Sewermen		Control Group	
	Number	Percentage	Number	Percentage
3.0 - 3.5	1	2.5	1	1.4
3.5 - 4.0	10	25.0	24	32.4
4.0 - 4.5	15	37.5	36	48.6
4.5 - 5.0	3	7.5	9	12.2
5.0 - 5.5	11	27.5	4	5.4
All Groups:-	40	100.0	74	100.0
Mean	4.4125		4.1892	
Standard Deviation ..	0.5935		0.3935	
Standard Error of Mean	± 0.939		± 0.0457	
Standard Error of Difference between Means .... ± 0.1044				

Table No. 32.

Case No.	Results of Blood Examinations in the Weeks between January and November, 1950.										
1.	10th	15th	19th	22nd	26th	29th	35th	45th			.... Weeks
	11.4	11.4	11.2	12.0	17.0	12.4	16.0	14.6			.... Hb gms. per cent.
	3.9	3.9	3.7	3.9	4.1	4.4	5.1	4.8			.... r.b.c. millions per cmm.
7.	2nd	13th	26th	29th	33rd	40th					
	11.6	10.8	10.8	13.0	16.4	14.8					
	3.9	3.4	3.3	4.1	5.1	4.2					
8.	1st	4th	8th	14th	19th	26th	29th	33rd	39th		
	17.0	15.0	10.4	12.6	12.2	12.4	12.8	16.4	16.0		
	5.4	4.8	3.7	4.7	4.4	4.6	4.7	5.1	5.2		
10.	1st	4th	10th	15th	20th	26th	29th	39th	44th		
	16.4	16.0	10.2	11.3	11.8	12.8	14.0	14.8	14.8		
	5.2	5.0	3.5	3.6	3.8	3.9	4.6	5.2	5.2		
11.	1st	10th	14th	20th	26th	29th	33rd	39th	45th		
	13.6	12.8	14.8	12.4	17.2	13.2	16.4	15.8	15.0		
	4.3	3.9	4.6	3.8	5.1	5.0	5.2	5.4	5.2		
18.	2nd	5th	10th	14th	20th	26th	29th	35th	39th	45th	
	17.2	16.6	16.0	13.0	10.8	11.2	11.4	16.4	16.2	15.2	
	5.2	5.0	4.8	4.8	3.7	3.9	3.9	5.4	5.4	5.1	
22.	2nd	11th	14th	20th	25th	30th	40th				
	15.0	13.6	11.6	10.0	12.2	15.6	12.2				
	4.2	4.7	3.9	3.5	4.6	5.0	4.8				
26.	4th	10th	20th	26th	29th	31st	35th	40th			
	10.0	9.6	11.2	15.2	12.0	16.4	13.6	13.8			
	3.3	3.2	3.8	5.0	3.9	5.2	4.8	4.8			
29.	3rd	10th	14th	19th	26th	29th	33rd	40th			
	10.2	12.0	16.0	11.8	16.8	15.0	17.0	14.8			
	3.6	4.2	5.1	4.3	5.2	5.0	5.4	4.8			
30.	2nd	6th	10th	13th	20th	26th	29th	32nd	35th	40th	45th
	15.8	13.2	11.8	17.0	16.6	15.0	13.2	17.0	15.2	15.2	15.0
	5.1	4.7	4.1	5.6	5.4	4.9	4.1	5.4	5.1	5.1	5.0
32.	2nd	6th	15th	20th	26th	29th	32nd	36th	39th	44th	
	15.4	15.8	10.4	14.0	12.0	11.6	15.0	13.2	16.8	11.2	
	4.0	4.2	3.6	4.6	3.9	4.2	5.0	4.4	5.2	4.4	
33.	4th	10th	13th	26th	29th	36th	40th	44th			
	13.6	10.2	15.0	17.0	13.0	16.4	10.0	9.4			
	4.2	3.5	4.8	5.6	4.0	5.2	3.7	3.2			
35.	3rd	7th	17th	26th	29th	34th	39th	44th			
	11.0	10.0	15.8	14.0	11.8	16.4	15.2	15.4			
	3.9	3.5	5.0	4.2	4.4	5.2	5.1	5.0			
41.	2nd	12th	16th	26th	29th	34th	39th				
	10.6	10.0	16.0	16.2	12.0	16.8	12.8				
	3.8	3.6	5.2	4.8	4.2	5.4	4.0				

N.B. In the above Table the top line of each set of readings indicates the number of the week between January and November in which the examination was made. The figure beneath "weeks" shows the haemoglobin level in grams per cent., while the lowest figure indicates the number of red cells in millions per cmm.

Table No. 33.

DEFECTS OF LUNGS IN CONTROL GROUP.

Case No.	Age	Clinical Examination	X-ray Findings	Diagnosis
2	65	Signs of emphysema with scattered rhonchi.	Chronic bronchitic changes.	Chronic bronchitis
4	62	Rhonchi in both bases.	Increased vascularity both bases.	Do.
6	60	Evidence of emphysema, clubbing of fingers.	Chronic bronchitis changes.	Do.
19	52	Nil.	Increased vascularity.	Probably chronic bronchitis.
84	20	Pidgeon-chested with flattening anteriorly on right side. Few rhonchi.	Chronic bronchitic changes.	Chronic bronchitis.
86	19	Breath sounds harsh; no adventitiae.	Tuberculosis right base controlled by pneumo-peritoneum	P.T.
21	52	Scattered rhonchi and rales throughout both lung fields. Limitation of chest movement.	Fibrosis in right upper and middle lobes and in left lower lobe. Multiple cystic changes in these areas.	Bronchi-ectasis.
11	58	Nil - apart from scars of gun-shot wounds in right chest.	Bilateral cyst formation in both upper quarters. The appearance is indistinguishable from bilateral pneumothorax. There are old united fractures of the right 4th, 5th, 6th and 7th ribs.	Probably old traumatic pneumothorax due to gun-shot wounds in first World War.
12	58	Rales in left lower zone.	Cystic changes in left base with some atelectasis.	Bronchi-ectasis.
25	48	Nil	Little fibrosis in right mid zone probably due to healed primary tuberculosis.	
33	44	Nil.	Pleural thickening in left base.	

Table No. 34.

INCIDENCE OF CHEST CONDITIONS BY AGE GROUPS.

SEWERMEN AND CONTROL GROUP.

Chest Disease	Age Groups												Total all Ages	
	Over 60		50-60		40-50		30-40		20-30		Under 20			
	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.
Trauma	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Chronic Bronchitis	-	3	1	1	-	-	-	-	-	1	-	-	1	5
Pulmonary Tuberculosis -														
(a) Active	-	-	1	1	-	-	-	-	-	-	-	1	1	2
(b) Quiescent	-	-	1	-	1	-	-	-	-	-	-	-	2	-
(c) Healed	-	-	1	-	-	1	-	-	-	-	-	-	1	1
Pleurisy (Healed)	-	-	-	-	-	1	-	-	-	-	-	-	-	1
Bronchiestasis	-	-	-	1	-	-	-	-	-	-	-	-	-	1
Acute Inflammation	-	-	-	-	1	-	-	-	-	-	-	-	1	-
Total No. of Cases	-	3	4	4	2	2	-	-	-	1	-	1	6	11
Total No. of Men in each Age Group	1	7	23	15	13	25	5	16	-	24	-	5	42	92

N.B. S. - Sewermen; C. - Control Group.

Table No. 35.

ABDOMINAL DEFECTS.

SEWERMEN AND CONTROL GROUP.

Condition	Sewermen	Control Group
Herniae -		
(a) Inguinal	1 (Case 7)	3 (Cases 1, 20, 44)
Herniotomy Scars	1	4
(b) Femoral	1 (Case 29)	-
(c) Umbilical Herniotomy	-	1 (Case 33)
Appendicectomy Scars	2 (Cases 5 and 36)	3
Hydrocoele	2 (Cases 1 and 7)	1 (Case 15)
History of Indigestion	18 (Cases 5,6,8,10,11,13,15 18, 21,27,30,31,32,36,37,38, 40 and 42)	3 (Cases 12, 68, 90)
Operation Scar (Peptic Ulcer)	-	1 (Case 11)

Table No. 36

DEFECTS OF THE NERVOUS SYSTEM.

(a) SEWERMEN.

Case No.	Age in Yrs.	Service in Years	* Balance Test	Reflexes		Tremors of Hands
				Knee	Abdominals	
2	58	9½	3	+++	Absent	Marked plus intention tremor.
1	64	27	1	+	+	Nil.
4	57	7	2	+	Absent	Nil.
5	57	26	3	+	Absent	Nil.
6	57	6	1	+	Absent	Coarse
7	57	7	1	+	+	Coarse
8	56	24	1	+	+	Present
10	53	9	3	+	Absent	Nil.
12	53	12	1	+	Absent	Present
13	52	18	3	++	Absent	Nil.
15	52	22	0	+	Absent	Nil.
16	52	11	3	++	Absent	Nil.
18	51	27	1	++	Absent	Nil.
19	51	4½	1	+	+	Nil.
20	51	14	3	++	Absent	Fine
21	50	5	2	++	Absent	Coarse
22	50	28	2	++	Absent	Present
26	48	15	0	+	Absent	Nil.
32	44	4½	0	+	+	Present
36	39	7	2	+	Absent	Slight fine
37	36	8	2	+	Absent	Nil.
38	34	5	2	+	Absent	Slight fine
40	47	4	3	+	Absent	Coarse
42	56	15	3	++	Absent	Slight fine
			(b) CONTROL GROUP.			
79	22		0	+	Absent	Slight fine
5	62		2	+	Absent	Nil.
6	60		1	+	+	Nil.
10	59		1	++	+	Fine
11	58		0	+	+	Slight fine
21	52		0	++	+	Slight fine
33	44		0	+	Absent	Nil.
40	42		1	+	Absent	Nil.
36	44		0	+	Absent	Nil.
45	40		0	+	Absent	Nil.
92	40		1	+	Normal	Slight fine

*Balance Test - Code: Steady - 0
Steady at 3rd Attempt - 1
Slightly unsteady ,, ,, - 2
Markedly ,, ,, ,, - 3

Table No. 37.

NUMBER OF MEN WITH VISUAL ACUITY LESS THAN 6/12 (SNELLEN) IN AGE GROUPS

Sewermen and Control Group

Age Group in years	Sewermen		Control Group	
	Total	Number with Defective Visual Acuity	Total	Number with Defective Visual Acuity
60 and over	1	-	7	3
- 60	24	8	15	6
- 50	12	2	23	5
- 40	5	-	16	2
All Ages	42	10	61	16

Table No. 38.

INCIDENCE OF SKIN CONDITIONS

Sewermen and Control Group

Skin Disease	Number of Cases	
	Sewermen	Control Group
Acneiform Rashes	6	6
Infective Alopecia	-	1
Herpes Simplex	-	1
Psoriasis	1	1
Pruritus Ani	1	1
Pityriasis	1	-
Seborrhoea Corporis	1	-
Folliculitis	1	-
Tar Wart of Hand	-	1
Carbolic Reaction	5	-
Oil Dermatitis	4	1
Occupational Dermatitis	5	-
All Conditions	25	12

Table No. 39.

DEFECTS OF JOINTS AND SPINE

SEWERMEN

Case No.	Age in Years	Service in Sewers	Symptoms and Signs of Lesions in the Lower Back	Radiological Signs in Lumbar Spine
1.	64	27	Some limitation of flexion. No symptoms.	Osteo-arthritic.
2.	58	$9\frac{1}{2}$	Tenderness in region of 5th lumbar vertebra.	Osteo-arthritic spine and elbows.
3.	57	14	Tenderness to right of 4th and 5th lumbar vertebra. Knee-Thigh Test positive on right side.	Lumbarisation of 1st sacral segment.
4.	57	7	Low back pain elicited on flexion. Also has pain in 3rd finger of right hand and Dupuytren's Contracture of 4th right finger.	Early osteo-arthritic changes. Similar changes in 3rd right metacarpo-phalangeal joint.
5.	57	26	Pain in right side of lumbar spine on flexion and on direct pressure. Tenderness on inner sides of knee joints. Knee-Thigh Test positive on right side. Marked disability.	Marked osteo-arthritic changes, spine and knees. Narrowing of lumbo-sacral joint.
6.	57	6	Tenderness over 4th lumbar vertebra.	Osteo-arthritic.
7.	57	7	-	Osteo-arthritic.
8.	56	24	Pains in back on flexion which is limited. Pain and tenderness in left knee and complaint of knee giving way on rising. Ankylosing spondylitis.	No gross lesions evident.
9.	56	4	-	Osteo-arthritic.
10.	53	9	-	Osteo-arthritic.
11.	53	6	Kyphosis with limitation of flexion.	Osteo-arthritic.
12.	53	12	-	Osteo-arthritic.
13.	52	16	-	No abnormality.
14.	52	15	Kyphosis - limitation of flexion.	Osteo-arthritic.
15.	52	22	Kyphosis.	Distortion of L.1 and L.2 vertebrae and lumbar kypho-scoliosis.

Table No. 39 (Contd.)

Case No.	Age in Years	Service in Sewers	Symptoms and Signs of Lesions in the Lower Back	Radiological Signs in Lumbar Spine
16.	52	11	Limitation of flexion. History of frequent attacks of backache.	Osteo-arthritic lower dorsal and upper lumbar spine.
17.	52	4½	-	Osteo-arthritic.
18.	51	27	Kyphosis.	Osteo-arthritic.
19.	51	4½	-	Osteo-arthritic.
20.	51	14	History of backache.	Osteo-arthritic. Bilateral sacralisation of 5th lumbar vertebra.
21.	50	5	Frequent low back pain. Pain on Knee-Thigh Test. Kyphosis.	Early Paget's Disease in right pelvis and thickening of radial and left tibial shafts.
22.	50	28	Recent sciatica. Clinically disc lesion.	No abnormality.
23.	50	27	-	No abnormality.
24.	50	16	Tenderness in lumbar region.	Osteo-arthritic.
25.	49	7	-	No abnormality.
26.	48	15	-	Early osteo-arthritic.
27.	48	2	-	Early osteo-arthritic.
28.	47	21	-	No abnormality.
29.	47	6	-	No abnormality.
30.	46	11	-	Osteo-arthritic.
31.	46	10	-	Osteo-arthritic.
32.	44	5	Tenderness in region of D.12 vertebra. Sciatic pain elicited in Knee-Thigh Test.	Osteo-arthritic. Narrowing of space between D.11 & D.12.
33.	43	3	-	Early osteo-arthritic.
34.	43	5	-	No abnormality.
35.	40	9	Occasional backache.	Early osteo-arthritic.
36.	38	7	Knee-Thigh Test positive on both sides.	Spina bifida 5th lumbar.
37.	36	8	-	Early osteo-arthritic.
38.	34	5	-	No abnormality.
39.	33	4	-	No abnormality.
40.	47	4	Symptoms of sciatica. Knee-Thigh Test elicited pain down right sciatic nerve. Pain to right of 5th lumbar vertebra on pressure. Herniated inter-vertebral disc.	Narrowing of joint space between L.5 and S.1.

Table No. 39 (Contd.)

Case No.	Age in Years	Service in Sewers	Symptoms and Signs of Lesions in the Lower Back	Radiological Signs in Lumbar Spine
41.	38	$^{2}/_{12}$	-	Osteoarthritis with flattening of upper lumbar vertebrae.
42.	56	15	Pain in left hip-joint when lying on left side. Slight limitation in flexion of spine and of left hip-joint. Kyphosis.	Osteo-arthritic spine and left hip-joint.

Table No. 40

DEFECTS OF JOINTS AND SPINE

Results of Examination of Sewermen and Control Group
(Aged over 30 years)

	Sewermen	Control Group
No symptoms, signs nor radiological defect of spine.	8	28 *
Kyphosis only.	-	3
Kyphosis with pain on flexion.	-	1
Kyphoscoliosis.	-	1
Scoliosis only.	-	1
Osteo-arthritic changes radiologically -		
No symptoms.	13	10
Limitation of flexion only.	4	5
Pain on flexion of spine	2	-
Tenderness in lumbar region.	4	-
Positive Knee-Thigh Test.	1	-
+ Kyphosis.	2	5
+ Kypho-scoliosis.	-	1
Anterior wedging of vertebrae (D.11 & 12).-		
with kyphosis	-	2
without kyphosis	-	1
Healed Tuberculosis of cervical spine.	-	1
Ligamentous calcification in spine -		
with limitation of flexion only	-	1
with lumbar tenderness and positive Knee-Thigh Test	-	1
Ankylosing Spondylitis.	1	1
Congenital Defects of Spine -		
No symptoms	-	1
With clinical signs	3	-
Traumatic Distortion of vertebrae.	1	-
Paget's Disease of Bone.	1	-
Herniation of intervertebral disc.	2	-
	42	63

* 10 aged 35 years and under.

Table No. 41

BONE, JOINT AND SPINAL LESIONS PRODUCING PAIN

Sewermen and Control Group

Disease	Number of Cases	
	Sewermen	Control Group
Ankylosing Spondylitis	1	1
Ligamentous Calcification of spine	-	1
Herniation of Intervertebral Disc	2	-
Congenital Defects of Spine	3	-
Osteo-arthritis	7	-
Paget's Disease of Bone	1	-
Total	14	2

Table No. 42.

ORTHOPAEDIC FOOT CONDITIONS AND VARICOSE VEINS

Sewermen and Control Group

Analysis by Age Groups

Defect	Number of Cases													
	Over 60		50-60		40-50		30-40		20-30		Under 20		All Ages	
	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.	S.	C.
No Lesions	1	2	10	10	4	19	2	11	-	21	-	5	17	68
Callosities	-	5	5	4	2	2	2	2	-	-	-	-	9	13
Pes Planus	-	-	3	1	5	1	1	2	-	2	-	-	9	6
Hammer Toe	-	-	3	-	-	-	-	-	-	-	-	-	3	-
Pes Cavus	-	-	1	-	-	-	-	-	-	-	-	-	1	-
Hallux Valgus	-	-	-	-	1	3	-	1	-	1	-	-	1	5
Injuries	-	-	2	-	-	-	-	-	-	-	-	-	2	-
Varicose Veins	-	1	4	3	1	7	-	-	-	-	-	-	5	11
Number of Men in Age Group	1	7	24	15	12	25	5	16	-	24	-	5	42	92

N.B. S. - Number of Cases among Sewermen.
C. - Number of Cases among Control Group.

Table No. 43.

INCIDENCE OF FOOT DEFECTS AND VARICOSE VEINS IN SEWERMEN

Grouping according to Length of Service

Defects	Service in Years						Total
	25 & Over	-25	-20	-15	-10	Under 5	
Callosities	2	-	1	1	3	2	9
Pes Planus	-	1	2	1	1	4	9
Hammer Toe	1	-	-	2	-	-	3
Pes Cavus	1	-	-	-	-	-	1
Hallux Valgus	-	-	-	-	1	-	1
Injuries	-	1	-	1	-	-	2
Varicose Veins	-	-	1	2	2	-	5
Number of men with no defects	1	1	2	1	10	2	17
Total Number of Men in Group	5	3	5	6	15	8	42

Table No. 44.

INCIDENCE OF FOOT CONDITIONS AND VARICOSE VEINS IN SEWERMEN

Relationship of Lesions to Type of Sewer Worked

Defects	Type of Sewer in which Work mainly carried out			
	Brick	Brick and Pipe	Pipe	Total
Callosities	4	1	4	9
Pes Planus	7	1	1	9
Hammer Toe	2	1	-	3
Pes Cavus	1	-	-	1
Hallux Valgus	-	-	1	1
Injuries	-	-	2	2
Varicose Veins	3	1	1	5
Number of Men with no Defects	12	2	3	17
Total Number of Men in Group	26	5	11	42

Table No. 45.

CARBON MONOXIDE IN BLOODS OF SEWERMEN

Percentage Saturation

Case Number of Sewermen	Percentage Saturation of CO in Blood	
	Before Work	After Work
10.	2	12.20
41.	2	6.0
N.S.A.	2.2	8.5

Table No. 46.

BLOOD EXAMINATIONS OF SEWERMEN

Results Following Exposure to Carbon Monoxide

Case Number of Sewermen	Haemoglobin in gms. (%)	Red Cell Count millions/C.mm.
10.	14.8 (14.0)	5.2 (4.6)
41.	12.8 (10.8)	4.4 (3.8)
N.S.A.	15.2 (11.4)	4.8 (3.9)

Table No. 47.

DISTILLATION OF CRUDE COAL TARS

Temperature Degrees Centigrade	Compounds Produced
170	Light oils, benzol, toluol, xylols.
170 - 230	Middle oils, phenols, cresols, naphthalene.
230 - 270	Creosote oils, tar oils.
270 - 400	Anthracene oils.
	Residue - pitch.

Table No. 48.

DEFECTS FOUND IN SEWERMEN WITH OVER 20 YEARS' SERVICE.

Case No.	Age in Years	Service in Years	Type of Sewer	Cardiovascular System			Quality of Heart Sounds (See Code at Table No.26)	Visual Acuity		Condition of Lumbar Region
				B.P. mms. Hg.	E.T.T.	Breathlessness		R. (Snellen)	L.	
1	64	27	Brick	190/110	Poor	Yes	3	6/12	6/12	Osteo-arthritis kyphosis
5	57	26	Brick	150/90	Poor	Yes	2	6/24	6/24	Severe osteo-arthritis.
8	56	24	Pipe & brick	130/80	Poor	Yes	1	-	6/18	Ankylosing spondylitis.
15	52	22	Pipe	150/90	Fairly good	Slight	3	6/12	6/5	Osteo-arthritis, traumatic distortion. L.1 and D.12.
18	51	27	Brick	140/90	Poor	Marked	3	6/6	-	Osteo-arthritis.
22	50	28	Brick	120/80	Fairly good	Slight	1	6/12	6/12	Disc lesion.
23	50	27	Pipe & brick	180/110	Poor	Yes	4	6/6	6/6	Nil.
28	47	21	Pipe	140/80	Good	Nil	0	6/12	6/9	Nil.

Case No.	Conditions of the Feet	Chronic Indigestion	Defects in the Nervous System			Chest Conditions
			Balance (See Code at Table No.36)	Tremors	Temperament	
1	-	Nil	1	Nil	Easily excited	Nil. Expansion 2.5"
5	Pes cavus	Present	3	Nil	Worrying	Chronic Pulmonary T.B. Expansion 1.5"
8	-	Present	1	Yes	Easily excited	Nil. Expansion 2.0"
15	Deformity due to Trauma	Present	0	Nil	Normal	Fibrosis right root. Expansion 2.0"
18	Callosities	Present	1	Nil	Excitable	Nil. Expansion 1.5"
22	Hammer Toes	Nil	2	Yes	Worrying	Nil. Expansion 3.0"
23	Callosities	Nil	0	Nil	Normal	Nil. Expansion 1.5"
28	Pes planus	Nil	0	Nil	Normal	Nil. Expansion 2.0"