

AN OCCUPATIONAL DISEASE

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AN OCCUPATIONAL DISEASE.

While acting as assistant to the London County Council Medical Officer to the Blackwall Tunnel I had somewhat exceptional opportunities of studying the symptoms resulting from working in compressed air. These symptoms have usually been grouped together and christened "Caisson Disease." The name of an illness should at least recall either some characteristic feature of the symptoms or some common factor in its causation. The term "caisson disease" does neither, and moreover it is something of a misnomer to designate these accidents as a "disease." A caisson is a cylinder and is used for the formation of the piers of bridges etc. and may be employed for convenience sake in making tunnels, it however forms no essential part of a tunnel and need not necessarily be used at all. Even when used the compressed air is not necessarily in the caisson: it may be only in the tunnel itself. The caisson has nothing more to do with the production of the illness than has the lift by which it may be approached.

It would be quite as well and equally as misleading to talk of a "tunnel disease" such a term in addition to being meaningless is not co-extensive with compressed air illness.

The illnesses of divers should be included and it is possible

that in the future some new industrial ^{or} of other occupation may be associated with similar conditions and similar mishaps.

A E T I O L O G Y.

The causation of this illness is by no means as simple and uncomplicated as we might anticipate it would be. Among the factors which influence its incidence the following three must be placed foremost:-

1. The pressure itself. - The higher the pressure the larger the amount of illness caused. This is not only what has always been observed, but what we should expect would be the case; it is so much of a truism that it is unnecessary to give figures in support of this relationship.

2. The length of stay in the compressed air. - It was by no means at first appreciated that this was a matter of primary consequence. The illness so immediately followed the exit from the pressure that attention has invariably been directed principally to the length of the "locking out" process. Although Janinet recommended at the St. Louis Bridge, the adoption of short shifts.

he yet considered the exit as the most essential cause. Mr. Eads, the chief engineer of that bridge, was the first, and as far as I can make out, the only one who distinctly recognized and stated that the length of stay in the compressed air was more

important than the shortness of the exit in determining illness. He was led to this conclusion by observing that the lock tenders entered and left a pressure of 50 lbs. to the square inch many times during a shift of two hours; and altho' their time of entry and exit was the same as that of the other men - they, indeed, accompanying the other men in and out of the pressure - they were never the subjects of this illness; whereas the other men remaining in for a shift of two hours or so, were severely and often fatally affected. The clearness and precision of this observation failed to attract the attention it deserved, and many times since it has been categorically stated that the length of the "lock-out" is the matter requiring most attention.

At the Blackwall Tunnel the shifts have been of eight hours' duration and no comparison can therefore be instituted between the results of longer and shorter shifts; though in exceptional cases where a foreman or another has remained in for the supervision of some important work longer than his usual time he has

often suffered in consequence.

In connection with some compressed air work at Glasgow a foreman on leaving the compressed air was so severely affected with pains in the limbs that he at once returned. Being relieved when in, and fearful of making the experiment again, he remained

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in, I am informed, for several shifts; when ultimately he came out he died within an hour of his exit. No account of this case has been published.

3. Ventilation. - In this connection my principal, Dr. Snell, can lay claim to the credit attached to first pointing out the close relationship which exists between the amount of illness and the ventilation of the compressed air space, and his observations led him to enunciate this in the form of a law, that the amount of illness varies inversely with the amount of fresh air supplied to the compressed air chamber. Dr. A. H. Smith appeared to specifically deny such a possibility when he said: "By increasing the number of compressors by which the air was supplied (the excess of air escaping beneath the edge of the caisson) the atmosphere was brought to such a degree of purity as to contain only one third of 1 per cent of carbonic acid as I determined by actual analysis. This amount of vitiation was found not to affect the men unfavourably. To maintain this standard, however, nearly 150,000 cubic feet of air were required per hour. The number

of men employed at one time in the caisson varied from 50 to 125 in the day time and from 15 to 30 during the night."

It is thus seen that during the day time each man was supplied with from 1000 to 3000 cubic feet of air per hour; and an atmosphere so foul as to contain $\frac{1}{3}$ per cent of carbonic acid - .06 is

the maximum which a well-ventilated space should contain - was spoken of as reaching " a degree of purity"!

Bucquoy analysed the air of the caissons used at the building of the bridge at Keke and found 2.37 per cent of carbonic acid. The statement of the analysis is followed by what would appear to be a platitude. He says "Those who had to work for a long time in the compressed air became emaciated; many labourers lost their appetite and looked as if they were just recovering from a severe illness" and then he proceeds to relate the more definite symptoms of compressed air illness.

The only writer who appears to have even hinted at the lack of ventilation as possibly being concerned in the causation of the illness is Dr. Hunter, whose thesis as far as I am aware has never been published. He remarks, concerning the Forth Bridge, "The most dangerous time for caisson workers was (1) while the soft silt was being removed owing to the excessive dampness, as well as, perhaps, to the presence of decaying animal matter; (2)

when the process of concreting was being carried on after a caisson had reached its proper depth, this being due partly to the want of a renewed supply of fresh air and partly to the development of an excessive amount of carbonic acid. The cases of ill-

ness met with during these two epochs were in number out of all proportion to those occurring during the excavation of the clay or of the rock."

Dr. Snell recorded his opinion concerning the probability of this relationship in a monthly report to the Bridges Committee of the L.C.C. This report after reviewing the precautions taken at this and other works against illness from the compressed air goes on to say "I can find no stress laid on the ventilation of the compressed air chamber; but at the same time it has seemed to me that in those works where no record has been made of the ventilation and where, therefore, the ventilation was probably neglected, the number of cases of illness has been exceptionally high. This observation has led me to direct my attention to the ventilation of the tunnel. I have calculated the amount of fresh air supplied per minute during the five months in which the compressed air has been in use. These amounts are shown in the following table which also gives the range of the average daily temperature, the range of average daily pressure and also the number of cases

of illness during every month:-

Month.	Range of ave. daily temperature.	Range of ave. daily pressure. lbs	Aver. no. of cubic feet of air per minute	Number of cases of illness.
April	82 to 85 ⁰ F	17 to 19	1700	8
May	80 $\frac{1}{2}$ to 83 $\frac{1}{2}$ ⁰	12 to 17 $\frac{1}{2}$	1800	8
Sept.	64 to 71 $\frac{3}{4}$	15 to 22 $\frac{3}{4}$	1400	16
Oct.	68 $\frac{1}{2}$ to 71 $\frac{1}{2}$ ⁰	21 $\frac{3}{4}$ to 23 $\frac{1}{4}$	2000	12
Nov.	67 $\frac{3}{4}$ to 69 ⁰	19 $\frac{1}{4}$ to 25	2500	2

"These observations are extended over so short a period of time and so many other factors need consideration that it would not be justifiable to draw any general conclusions at present. But it cannot escape attention that in the month of September when the supply of fresh air was the least, the largest number of cases of illness occurred; whereas in November when the supply of fresh air was larger than it ever had been before only two cases of illness arose, in spite of the fact that the pressure was higher than in any previous month."

We considered it so important to prove or disprove the conclusion here suggested that I kept the daily records of the amount of air pumped into the compressed air chamber, they have been obtained by calculations from the sizes of the various engines and the average speed of each on each day. I have also noted the number of cases of illness, and the time of the occurrence of each, so that the last shift preceding the illness is known in each case. It would have been better if the amounts of air had been estimated separately for each distinct shift of eight hours instead of the three being united together into one daily average for 24 hours; but as this plan was not adopted from the first it was not advisable to follow it out afterwards. I have no doubt had this been done some of the apparent anomalies would have disappeared, for it frequently happened that the amount of ventilation would vary considerably from one shift to another; and of the three shifts in one day the cases of illness would sometimes

only appear after one. The days are reckoned to begin at 6 a.m. one day and end at 6 a.m. the next day; an illness then occurring (say) at 7 a.m. on the latter day would be ascribed in the table to the preceding day. In spite of the likely source of error in estimating the amount of air supplied in one minute out of the twenty four hours the conclusion enunciated in the report mentioned above has been proved over and over again from observations extending over a period of two years. The pressure varied from day to day and from hour to hour, the changes being determined by the engineering necessity of dealing with a varying "hydraulic head" brought about by the rise and fall of the tide. In order as far as possible to eliminate pressure as a determining factor in the causation of illness, I have, in compiling the following tables selected days which could be fairly classed together as having practically the same pressure.

Thus the first table deals with 215 days during a period of nine months when the pressure reached and exceeded 20 lbs. varying in the course of each day from a few pounds below 20 to a few pounds above 20. These days are divided into four sections according to the amount of fresh air supplied each hour to each man on the average shift to each day. During these 215 days 33 cases of illness were reported and they were distributed among the days as shown below:-

Cubic feet of fresh air per man per hour in average daily shift.	No. of days.	Cases of illness.	Estimated cases of illness for 100 days.
Below 4000	56	16	28.5
From 4000 to 8000	47	9	19.1
" 8000 to 12000	71	8	11.2
Above 12000	41	0	0

"The table demonstrates conclusively I think the direct rela-

tionship between the ventilation and the prevention of illness at the pressure considered. Since the size of the three daily shifts sometimes varied considerably it appeared to me that it would be preferable to estimate the amount of fresh air supplied per hour for each man in the largest daily shift.

The following table is so constructed from all the days presenting conditions of pressure similar to those of the preceding table, occurring during a period of seven months subsequent to the nine months previously considered:-

Cubic feet of fresh air per man per hour in largest daily shift.	No. of days.	Cases of illness.	Estimated cases of illness for 100 days.
Below 4000	21	17	80.9
From 4000 to 8000	80	18	22.5
From 8000 to 12000	70	6	8.5
Above 12000	19	0	0

Thus during a period of 16 months in which over four hundred

days may be grouped together as presenting nearly similar conditions of pressure, the figures obtained by comparing the amount of compressed air illness with the amount of ventilation afford us very noteworthy results: and this notwithstanding such errors of calculation as those already suggested and in spite of numerous minor determining factors of the illness which remain to be considered later.

It would appear probable that similar results would attend a corresponding analysis of the days when the pressure exceeded 25 or even 30 lbs.; unfortunately for this purpose the pressure in the tunnel only occasionally reached 27 or 28 lbs. and it never averaged this pressure throughout a day. We are obliged therefore for this purpose to have recourse to the sinking of the caissons. Compressed air was used in the sinking of Caissons No. 1 and 2, whose depths below the ground level were 75 and 98 feet respectively. The 'hydraulic head' of water pressure to be

dealt with was therefore greater than that in the tunnel and the pressure of air sometimes went up to 35 lbs per sq. inch. But as the length of time occupied in sinking these was comparatively small it is only possible to tabulate a small number of days. For this purpose I have grouped together all those days when the pressure rose above 25 lbs. (including all pressures up to 35lbs.) There were 61 such days in all and they group themselves as follows:-

Cubic feet of fresh air per man per hour.	No. of days.	Cases of illness.	Estimated cases of illness for 100 days.
Below 4000	13	41	315.5
From 4000 to 8000	26	78	300
From 8000 to 12000	10	8	80
Above 12000	12	4	33.3

It is seen that the same relationship holds as at lower pressures, but that the percentage of cases occurring is in each case larger than with a corresponding condition as regards fresh air

supply at lower pressures. It will also be noticed that four cases occurred when the amount of fresh air supplied was very large, when if there is any truth in the proposition now being advanced, it might have been hoped that at least a smaller number than this would have been met with. On reference to the days when these four cases occurred it is seen that they occurred on two days when active work was not in progress and when only two or three men were in the compressed air at one time, that actually a smaller amount of air was being supplied than was usual when work was in progress but that the small number of men caused the amount per head to be large.

One such case occurred in the tunnel when work was once suspended: the pressure that day varied from $21\frac{1}{2}$ to 25lbs; only two men were in the compressed air, and the amount of fresh air per man per hour being pumped in was as much as 40,000 cubic feet. It appears obvious there must be some explanation for this appar-

ent anomaly. I believe it is to be found in the inadequate distribution of the fresh air supplied.

The conditions that appertain when work is suspended are just those which will not tend to help a proper diffusion of the fresh air.

The escape of the contained air is as far as possible minimized by claying-up apertures (to avoid the expense of an air-supply uncalled for by the engineering necessities;) the constant movements of a large number of men and wagons of material are absent and there is no incessant movement of the locks backwards and forwards as men and material enter or leave.

Also, it has to be borne in mind that the velocity of diffusion of a gas at a greater density is smaller than at a less density, varying as it does inversely with the square root of that density. This physical fact would appear to be the reason why candles smoke in compressed air, altho they are in an atmosphere

richer in oxygen, volume for volume; they invariably smoke. This is not the case, however, if we cause the surrounding air to reach the flame sufficiently rapidly - as when a glass chimney is held over the flame. In that case combustion goes on as it would in a more richly oxygenated atmosphere; the flame is brighter, and there is no smoke. The two men employed as watchers, when work for some reason is suspended, are not generally moving about; and unless situated near an inlet or an outlet of air may be very badly circumstanced so far as fresh air is concerned. Suppose they are at the bottom of a huge caisson 50 feet in diameter and 60 feet deep, suppose the supply pipe or pipes end 20 feet from the top and suppose that the superfluous air is escaping at the top, nothing is more certain than that the air in the vicinity of the men will be more impure than that at the top.

That the explanation of the circumstances is not imaginary was amply demonstrated at the time when the men were working in

Caisson No. 1.

The men were practically all working at the bottom; the supply pipe entered the "air-tight floor" (i.e. the roof of the chamber) and then ended. The air was nearly all escaping through the "air-tight" floor which was imperfectly caulked in order that ventilation might be assisted. Men were affected with compressed air illness at the rate of seven a day. A week after they had begun work in this caisson the supply pipe was lengthened in order to better ventilate the lower portion of the chamber. During the remaining ten days they worked here only one case occurred every two days. Of course it might be urged that the amount of air supply per man was also increased. That was so: but the improvement was maintained even on those days when the air supply

was considerably below what it had been before the supply pipe was lengthened; and with this improved distribution of the fresh air,

no case of illness occurred on any day when the supply was above 9000 cubic feet per man per hour.

I believe that probably enough has been said on this point to prove Dr. Snell's contention that the amount of illness varies directly with the lack of ventilation of the air chamber.

Other and minor causes of the disease remain to be considered.

(A) Too rapid decompression:-

Most of the writers on the symptoms caused by compressed air give this cause a foremost place. The considerations already advanced under the three previous headings have I think justified me in assigning to them the greatest influence in the production of the disease. On the other hand, Foley was distinctly in error in recommending the reduction in length of the decompression and in blaming the stay in the cold misty atmosphere of the lock during a few minutes for all the accidents that might afterwards

result. That a just appreciation of the value of this factor may be arrived at, it might not be amiss to review a few of the facts bearing on this point.

Jaminet, Smith, and many others have drawn up dogmatic durations of decompression. Jaminet decided that one minute should be allowed for each additional 6 lbs. of pressure; Smith that five minutes should be spent in the lock for each additional atmosphere; others advised lengths of time so considerable that the time occupied by the exit of the men from the compressed air would form a very formidable item in the financial estimate of an engineering undertaking. All reasonable suggestions in this respect have at different times been adopted, but whether the amount of illness has been diminished to any extent thereby remains still a matter of conjecture. I have already noted that Mr. Eads of the St. Louis Bridge noted that the lock-tenders who entered and

left the compressed air many times in the course of a two-hour shift did not suffer from illness, whilst those who remained under pressure for the whole period of two hours were very largely taken ill often with fatal results. The time of exit was the same for the lock-tenders as ^{for} the other men. At the Blackwall Tunnel each air lock was provided with two pairs of air cocks, the larger for material, the smaller for men: they were of such a size that the air of the lock with a pressure of 28 lbs. could escape in about four minutes with the smaller cock turned on fully; while by the larger one exit could take place in about 30 seconds. There was a regulation thoroughly understood by the men that the larger cocks were to be used only for material. It has come to my knowledge that the regulation was frequently disobeyed. That is, the material cock being used instead of the smaller one the men could come

out in half a minute. One man, I was led to believe made a practice of this. He has not to my knowledge suffered from compressed air illness, though he has on several occasions during the progress of the work had one or two severe illnesses. Neither has any other case, where the rules laid down on this point have been infringed, come under my notice, with a single exception which I will give under the selected cases and which was of a trivial nature.

Again where men suffering from 'bends' have been immediately recompressed in the medical air-lock the pain has invariably left; when allowed to "leak out" in 45 minutes some slight pain usually returned; where the men without seeking medical advice have recompressed themselves and come out moderately slowly (say) twenty minutes they have been rarely much improved by the process. This case is not quite analogous to those we have been considering, but it appears to show that while there

may be considerable difference in the results of decompression in four and forty five minutes respectively this is not so much marked when the difference in time is that between four and twenty minutes.

Although with no wish to under-estimate the influence of a rapid decompression in producing illness, to me it is sufficiently clear that it is not the primary factor in its causation.

(5) Personal idiosyncrasies.

There are several which appear to influence the incidence of the symptoms E.g.

(a) Fulness of habit,- this has been noted by most observers.

On this account I was instructed as far as possible to exclude men of very heavy build.

On two occasions my advice to men of this type was disregarded and their first sojourn in compressed air was followed in either case by an attack of "bends" which was effective in

enforcing my advice.

Because a man is stout it does not follow that he necessarily suffers: it can only be stated that in many cases the liability to illness is increased to a remarkable degree.

(B) Age. - It has been frequently stated that younger men are less apt to suffer than older men. It would be satisfactory to test the accuracy of this by comparing the ages of those who suffered with the ages of those employed. I am not able to do this as no account of the ages of the men employed has been kept on the works, and as it was a voluntary matter for men who had been employed on the works before my arrival to submit themselves to examination by me I have only an account of the ages of those men whom I had the opportunity of examining; as these however were very numerous the figures will give an approximate idea of the proportionate ages of the men employed.

Ages.	No. of men examined & passed	No. of men taken ill whose ages were recorded.	Proportion of illnesses to every 100
15 to 20	55	0	0
20 to 25	145	15	10.3
25 to 30	152	37	24.3
30 to 35	91	19	20.9
35 to 40	61	14	22.9
40 to 45	38	10	26.3
45 to 50	3	5	166

These figures are, I think sufficiently large to justify very valuable conclusions - viz. that before the age of 20, men are remarkably free from illness; that between the ages of 25 and 45 the liability to illness does not vary much; that between these latter ages the chances of illness are about ^{twice} ~~24~~ ³⁰ as great as between the ages of 20 and 25; the liability to illness is very largely increased. It has been said that men with grey hair or with commencing degenerative changes in the arteries are especially likely to be attacked. These causes are probably intimately associated with the influence of age.

(C) Organic Disease. - All men having any organic disease were rejected with the exception of those suffering from emphysema or an early stage of phthisis ~~but moralis~~ *pulmonalis*, so that I have no experience as to the effect of compressed air on them.

(D) Alcoholics are said to suffer from illness due to compressed air very readily. It was noticed that after a holiday, when higher pressures were reached a number of cases of illness occurred. *Lehwess* ~~Lehwess~~ of St. Petersburg denies that alcohol gives rise to any obvious mischief.

(E) It is also said that men who have just undergone severe exertion suffer more from compressed air illness. It is said that when a lift was used at St. Louis Bridge instead of ladders a diminution in the number of cases followed.

(F) It is also frequently stated that men new to the work suffer more than the old hands. It is very difficult to either prove or disprove a statement of this sort, which, when once

enunciated so easily gains credence. It is certain ^{Some} ~~such~~ men are more suitable than others. The very unsuitable will in all likelihood suffer after the first shift and discontinue the employment; and this may readily give rise to the belief.

Among other conditions which might have conduced to the [?] of symptoms are the temperature and hygrometric conditions of the compressed air-chamber ^{of} the former a daily record was kept. During the first two months the air forced in was not artificially cooled. In the process of compression the mechanical work performed on it, - to press it into a smaller space - was partly converted into heat, and the resulting temperature was uncomfortably high, being generally over 80° F. The air was after that time cooled by means of cold water pipes and the temperature reduced to just below 70° F.

No connection in our cases between the occurrence of illness and the rise or fall of the temperature can be traced.

As to the hygrometric condition - the air in the chamber was constantly saturated. This being the case the hygrometric condition of the compressed air chamber fails to account for the occurrence of illness ~~at~~ at one time and not at another, and therefore probably has nothing to do with the causation of accidents.

Summary of Symptoms:-

In the subjoined series of cases, the whole of them, with three exceptions, comprise illnesses which follow exit from the compressed air. The injuries which may be sustained by the ear during the process of entry are so obviously mechanical in their origin that they may be at once separated ^{into} a class by themselves, not only on account of their time of onset, but also because of their distinctive pathology.

The entry into the compressed air is effected by means of an air-lock in which the pressure is raised gradually.

The size of the cocks in use at Blackwall was so adjusted that the entry occupied from one to two minutes. In healthy people with moderately patent Eustachian tubes and who have acquired the knack of opening those tubes to allow the entrance of additional air to the middle ear, no inconvenience is experienced even when the air is admitted as rapidly as the cocks will allow. If however the Eustachian tubes are not as patent as they should be - as may occur during a "cold in the head" - more or less difficulty in Entry is met with. The additional pressure outside the tympanic membrane pushes that structure inwards, causing more or less pain; and if this warning be neglected the pain may become excruciating and rupture of the drum may occur: this event may happen even without excessive pain if the drum be less resisting than normally. Short of actual rupture the relative vacuum in the middle ear acts as a sort of cupping glass and produces congestion of the lining walls

of that cavity. This may last some days and be accompanied by deafness on that side. Further the congestion may be followed by actual inflammation with or without suppuration. Several cases illustrative of these stages have occurred at Blackwall and many cases of more or less permanent deafness have resulted. Also many of the men who have worked in compressed air for a long period have not that acuteness of hearing which is normal. Altho' no trouble with the ears has been experienced, it must happen that the air pressure in the middle ear is frequently a little below that in the external ear. The process of "accomodation" of the ear - if the term may be so used - to the pressure by swallowing or other means, even when effected frequently, is interrupted by intervals of seconds when the pressure outside the drum is gradually increasing and that within is stationary: in other words the effect of a cupping glass to the middle ear is frequently present to a small ~~and in~~

and, in itself, harmless degree. Nothing appears more reasonable than to suppose that this must ultimately produce a thickening of the internal or mucous lining both of the ^amembrani tympani and ^{the} ^{also} ~~of that~~ ossicles which will necessitate some impairment in the hearing. It very rarely happens that any pain is experienced in the ear on exit from the air. The narrow funnel-shaped end of the Eustachian tube, directed towards the middle ear more easily allows of the escape of air than the more trumpet-shaped opening towards the pharynx allows of the entry of air. On coming out from the compressed air the little bubbles of air can be felt leaving the middle ear and no effort is required to open the tubes.

Allied to these cases are those of pain in the forehead. It appears never to be complained of except during the presence of a nasal catarrh, when the mucous membrane lining the openings into the frontal *Sinus* is swollen and air cannot enter

or leave these cavities readily. The pain is sometimes very severe and may be followed by neuralgic pains for weeks afterwards. Similar pain may be felt in a carious tooth from the cavity being temporarily cut off from the surrounding air either on entry to or exit from, the compressed air.

One other class of cases may be anticipated to accompany entry into the compressed air viz. any ill consequence of the physiological rise of blood pressure - which then occurs.

In this class of case we might expect to meet with examples of cerebral haemorrhage or of ruptured aneurism. Happily no such unfortunate incidents occurred at Blackwall. By a systematic examination of all new employes I have attempted to eliminate those having an organic disease of such a nature that a sudden rise of blood pressure might be prejudicial

Concerning the time spent in the compressed air it may be stated generally that no ill effects are then manifested. If the sojourn be prolonged to even twenty four hours no symptomatic consequences ensue during the stay. Cases are known where mules have been retained for months in the compressed air and have apparently been in perfect health. Among the cases subjoined, two have been given because they appear to be exceptions to this rule. In the one the man is stated to have had a "fit" while under the pressure. If this condition were produced by the pressure the man having already been working for some hours in the compressed air, the case is unique .

The man had never had any fits before though he had recently been suffering some pain from his ears while entering the compressed air and afterwards; his ears having been "blocked"- the usual expression for the condition among the men. It is possible this pain was more considerable than the man represented,

and that, rather than leave off his work he had continued under great difficulties and had at last fainted.

The other case (H.C. Case VII), where pain was experienced while in the caisson to an extent which prevented the use of tools by the left hand stands quite by itself among some two hundred ^{other} cases.

It is possible that there was from some cause a more or less rapid fall of the pressure in the caisson which might be followed by the pain or it might be on the other hand that the account given by the man of the commencement of the pain had been misleading. The absence of symptoms during the sojourn of the men in the compressed air is a feature which has been put on record by every observer. Symptoms when they do occur, begin during or after decompression; they may commence immediately the exit air tap is turned, or they may be postponed until some hours have elapsed after coming out. The longest interval recorded at Blackwall is fourteen hours in a case that will be cited. The usual interval is from a few minutes

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to one hour. Where this length of time is much exceeded it has usually occurred that the man has gone home fallen asleep and has been awakened some hours after by a severe pain in one or more of the limbs. By far the most common symptom is pain in the extremities known by the men as "bends". The pain most usually affects the legs and principally the parts about the knees - though it may affect the arms especially the elbows and shoulders. It may be present in one or all of the limbs. Its onset is usually sudden becoming more and more severe for a short time afterwards. It may be only slight causing little or no inconvenience or it may be of a most excruciating character causing strong robust men to writhe in agony. The pain is differently described; sometimes as sharp and shooting "like a knife", or a dull heavy aching pain. It is sometimes located by the sufferer as deep down in the limb, or in the bone, and sometimes, as affecting the more fleshy parts and sometimes as in the

joints. It does not seem to follow any anatomical distribution such as that of the large nerves. There is generally more or less tenderness over the painful part and this tenderness is not superficial. In the large majority of cases there is no objective sign accompanying, such as swelling or heat or discoloration. A cold perspiration has been described. The pulse presents no particular characteristic.

The pain may if slight pass off in one or two hours, if more severe in as many days; in the worst cases it may persist for one or two weeks or even more. Its disappearance may be hastened by early recompression, but it tends to disappear by itself if left alone and there is no relapse. There is no rise in temperature and no albuminuria.

Epigastric pain is frequent and may be accompanied by pains in the limbs. It may be followed by vomiting or nausea merely.

In only one case at Blackwall was it really of an alarming character.

Paralysis:- The cases of this sort at Blackwall have been few and trivial compared to those reported at St. Louis and Brooklyn Bridges. We had two cases of paraplegia. One of them was cured after recompression in about 13 days, in the other there remained four months after the attack frequency of micturition and impotence. There was also one case of retention of urine of a very temporary character.

Auditory Vertigo.- Altho' Menière published his series of cases of this affection, no description of cases due to compressed air appears in any records until the first of the series of cases at Blackwall was published by Dr. Curnon in the Lancet (1894). Vertigo has occasionally been mentioned as a possible effect of compressed air, notably by Dr. Hunter of the Forth

Bridge works, who noted that it was occasionally accompanied by permanent deafness in one ear.

Among the nine cases subjoined the onset was sudden and it came on from a few minutes to a little over an hour after leaving the pressure. In six cases some amount of deafness was present: in one this was described as affecting both ears and lasting only a few seconds, in five others it was of longer or even permanent duration affecting only one ear. In four of these cases the internal ear on one side was affected, in the fifth it appeared to be the middle ear that was at fault; in the three remaining cases which were not seen until some days after the onset, no deafness existed or had been noted previously by the patients themselves. Tinnitus had been complained of in four of the patients as having occurred early; in three the symptom was very persistent. In spite of the absence of tinnitus and deafness in the three cases seen late; the vertigo has been considered by me

of auditory origin, because it was increased always by a movement of the head in one direction more than by movements in other directions - thus in some it was brought on by movements of the head backward in others by lateral movements. In the least severe it lasted several days in the more severe cases weeks or even many months. In five cases the illness was accompanied by "bends."

Of cases not coming under any of the above headings may be mentioned one of dysphagia, one of oedema of the ~~scrotum~~ ^{Scrotum} and abdomen - this latter may have been due to some organic cause that I was unable to discover. Itching of the skin was sometimes complained of after leaving the pressure, but not to the extent one would have expected after reading the reports of Foley's cases. Epistaxis or haemopt~~o~~^ysis sometimes follow^{^ S} exit from compressed air. The blood may be swallowed and haematemesis ensue subsequently. Slight bleeding from the ears may occur.

I do not consider that work in compressed air produces any de-

leterious effects on the system. Many careful examinations of the men who worked for a long time in compressed air were made without any ill effects being discovered. Dr. Snell reports that one man who had worked twelve years in compressed air had hypertrophy of the heart without any other condition of the system to account for it. "It is possible," he says "that this might be produced by the increased blood pressure which accompanies work under these circumstances."

It has frequently been recorded that men who work under conditions of pressure have a pale leaden appearance even in the open air. This was not observable at Blackwall to any extent, probably I believe to good ventilation. Examination of the blood revealed no abnormality in the amount of haemoglobin or the number of corpuscles.

P R O G N O S I S.

Of the symptoms of this occupational disease the most common is

'bends' it is also the least serious usually passing off in a few days to, in the most severe cases, a few weeks.

The ear symptoms, I need say nothing about as they are thoroughly discussed in works on diseases of the ear. The itching of the skin and the epigastric pain soon pass off. Paralysis also as a rule passes off in a few weeks unless in those cases which have bladder troubles and impotence. In cases of auditory vertigo associated with affection of the internal ear the prognosis is generally good.

D I A G N O S I S.

The diagnosis of symptoms due to compressed air pressure usually presents no difficulty and is only of importance from its medico-legal aspect.

MORRID ANATOMY.

No fatal cases occurred at Blackwall Tunnel, so that I am un-

able to add anything to what has been said elsewhere on this part of the subject .

P A T H O L O G Y.

A review of the various theories which have been advanced ~~and~~ from time to time show that they group themselves into three classes.

I. Theories suggesting exhaustion, carbonic acid poisoning, and the like as the cause.

II. Theories ascribing the symptoms to the mechanical congestion of different viscera.

III. Theories depending on an increased solution by the blood of the gases of the compressed air and the liberation of these gases on the pressure being removed.

I. All the theories of the first class depend on the presumption that a sojourn in compressed air on account of the larger

amount of oxygen contained in a given volume of that air, is necessarily accompanied by an increased amount of metabolism. Most of the supporters of these theories have considered this a necessary consequence. Vivenot and others have approached the subject from a therapeutic point of view and have been at great pains to show that an increase of chemical activity resulting in the formation of an excessive amount of carbonic acid and other products of metabolism, will accompany or follow the stay in compressed air. If this increased chemical activity can be disproved all this class of theory falls to the ground; if it cannot be substantiated they remain without any rational basis.

If an increase of metabolism occurs we should expect to find an increase in the amount of urea excreted. The estimation^{of} urea must obviously be made for a considerable time and include estimations of the average amount excreted when the compressed air is not entered. It is impossible to obtain reliable results and

accurate twenty-four^{hour} specimens of urine from the men. Dr. Snell made a series of observations on himself. He found that the average amount of urea excreted per diem was 392 grains. *The daily range varied from a minimum of 167 to a maximum of 702 grains. He found that a stay of some hours in the compressed air was not followed or accompanied by any excessive excretion of urea. With a daily range such as given ~~at one~~^{above} any increase in the amount due to compressed air would have to be emphatic in order to be appreciated; yet if an increased metabolism occurs in compressed air, of any moment, we might expect to see some evidence of it in the amount of urea excreted. On the whole it would appear that the basis on which must rest the hypotheses concerning exhaustion, ^{CO₂} poisoning and the like is without substantial proof.

II. Theories which attempt to explain the symptoms caused by compressed air on the ground that the pressure on the periphery of the body causes the Viscera to become congested.

The late Dr. Moxon in his Croonian Lectures (Lancet 1881) was so struck with the plausibility of the congestion theory of these symptoms which seemed to support his views of the functions of the cerebrospinal fluid that he ~~saw~~^{said} "It needs no experiment to show that great increase of atmospheric pressure must drive the blood away from the surface of the body and into any parts that are accessible to blood and not to air. Such parts are the interior of the cranium and the spinal canal."

Commenting on this Dr. Snell in his book says " - very strong proof must be forthcoming before such an extraordinary hypothesis can be accepted. The cranium and spinal canal are filled by substances which are incompressible. Compressed air supplies an evenly distributed pressure to the surface of the body. Why should it follow that blood should be forced into the cranium and spinal canal and cerebro-spinal fluid squeezed out? The increased air pressure is impelling the cerebro-spinal fluid to remain in its

position just as powerfully as it is urging the blood to enter and expel it. Necessarily no change can take place, and matters, in this respect at least, remain in the compressed air just as they were in the open air."

Dr. A.H. Smith is the most thorough-going of the advocates of "congestion." He ascribes all the symptoms to this condition. Even supposing one could admit the congestion he speaks of, he does not make it at all clear why an obstacle should sometimes arise to the normal redistribution of the blood on leaving the air. Why should the capillaries become "clogged ^{with} ~~into~~ effete blood?" why are the capillaries "clogged?" and why is the blood effete?

III. In regard to the third set of theories which attempt to explain the symptoms by the increased solution by the blood of the gases contained in the compressed air, there is this to be said in their favour that they take as their basis a physical condi-

tion - the increased solution of gases by the blood - to which it is difficult to refuse assent.

The law of Henry and Dalton states that the weight of a gas dissolved by a liquid is directly proportionate to the pressure. At 0°C and 760 mm. pressure one volume of water will dissolve

.02035	Volumes of Nitrogen
.04114	" " Oxygen
1.7967	" " Carbonic Acid

Double the pressure and twice these amounts are dissolved.

These are the co-efficients of absorption of these gases in water.

The co-efficients of absorption of these gases in blood are more difficult to obtain since all the gases obtained from blood by immersion of it in a vacuum are not in solution. From 100 volumes of blood may be obtained:-

	Nitrogen	Oxygen	C O ₂
Arterial Blood	1 to 2 vols.	20 vols.	40 vols.
Venous Blood	1 to 2 vols.	8 to 12 vols.	46 vols.

The larger proportion of this oxygen we know to exist in a state of chemical combination with the haemoglobin. That an increase

of the amounts of these gases dissolved takes place under increased pressures has been shown by Paul Bert though he found this increase did not exactly obey the law of Henry and Dalton. He found for instance that at increased pressures the oxygen in the blood is increased only to a small extent; and nitrogen more than either oxygen or ^OCO₂, though not to the extent that would be expected from the Law of Henry and Dalton.

It is generally clear that if the blood dissolves more free gases during the stay in compressed air, this excess of dissolved gases will be given off on or after the entry into the open air. Can this escape of gases from the blood give rise to the symptoms we have been considering? Every medical man is familiar with the respiratory troubles and sudden death produced by the entry of any quantity of air into the large veins of the thorax. What would be the result of the escape from the blood of minute bubbles of gas throughout the whole of the vascular systems? Paul

Bert made a large number of experiments on animals at high pressure - often as high as 10 atmospheres. He has caused decompression to be effected in periods varying from twenty seconds to three minutes. Sudden death frequently followed and, post mortem, were found free gases in the blood, especially in the right side of the heart. In some cases paralysis of the lower limbs appeared, and at the autopsy he often found bubbles of free air in the spinal vessels even in the smaller vessels of the spinal cord itself. When death did not take place immediately the free gas was not present, but instead, patches of softening in different regions of the cord. Occasionally he found subcutaneous emphysema; sometimes small foci of haemorrhages into the spinal cord could be seen. All of the experiments where such definite observations were noted were made at pressures over 5 atmospheres. The time of compression was never very long. Generally occupying only a few

minutes and never over two hours. It is probable that had Bert employed longer periods of compression with lower pressures he would have obtained similar results. It is impossible to suppose that the cases of paraplegia owe their origin to a different cause to that which is proved by the experiments to be responsible at higher pressures. Moreover the saturation of the whole ~~body~~ blood of the body, with its full amount of gases, or entry to compressed air, must be a matter of time; only that in the capillaries of the pulmonary vesicles can be engaged at a given moment in absorbing from the air vesicles the surplus of free gases; before the whole amount of blood of the body has received its full complement of free gases (i.e. before the acme of danger from this cause is reached) we must suppose a few hours to be spent in the pressure. We see then that this theory is fully capable of explaining cases of sudden death or of paralysis. It needs no effort of the imagination to account for the ~~fornication~~ ^{fornication} that sometimes

ensues in the same manner. It is in the highest degree improbable that the more subjective symptoms such as pains in the limbs and elsewhere are due to any other cause; that these are not due to any derangement of the central nervous system is shown by the local tenderness and the occasional swelling that sometimes accompanies them, whether the lesion is in the nerve sheaths or the peritoneum or elsewhere can only be a matter of conjecture; we should anticipate that most pain would be caused when the lesion occurs in those vessels that are surrounded by resisting structures or by sensitive nerve filaments and that no pain would occur when these conditions are absent.

This theory moreover is ^{capable} adapted to explain the principal factors in the aetiology of the disease. It explains why the danger is increased at high pressures or by longer exposure. It makes clear how a decompression extending to forty five or sixty minutes is effective in diminishing the liability to attack. It would

lead one to anticipate that those men beyond middle age or with a degenerated arterial system would be more liable to illness than those who are younger and more healthy. An adherence to this theory assists us in understanding why the symptoms are never produced on entering compressed air, why it does not come on during the sojourn in the air however long that sojourn may be prolonged, and why, if it occurs at all, it is on or after leaving the pressure. We are enabled also to understand why rapid recompression is so universally beneficial and why, if it be too long delayed, (that is if some actual injury to tissues is caused by the escaping bubbles of gas), recompression is practically useless. We are in a position to anticipate that in the absence of complications the illness will tend to disappear by itself in a few days or a few weeks, and that relapses will not occur. So well does this theory harmonize with our knowledge

of the illness that we may rest assured we are at least looking in the right direction for the true cause of the symptoms.

T R E A T M E N T.

This naturally divides itself into preventive and curative.

Under the first heading the amount of the pressure should have a foremost place. At the present time we do not know what is the maximum air pressure which may be worked in with impunity, but we know that, by our increased medical knowledge, we are able to deal with pressures of 30 and 35 lbs. with far less harm than formerly.

Next in order of importance would come the time to be spent in the compressed air. This would of course depend on the amount of pressure. Before the Blackwall Tunnel was constructed, nowhere have men worked for eight consecutive hours daily in

pressures of 30 and 35 lbs. to the square inch.

This arrangement seemed to work well, although there is little doubt that the illnesses when high pressures were reached would have been less frequent had the length of the shifts been shortened. Where the conditions are favourable, long shifts may be worked, but when illnesses are of frequent occurrence, the length of the shifts must be reduced. At the St. Louis Bridge, when a pressure of 50 lbs. was being encountered, the length of the shifts was cut down several times. Mr. Ead says that after these were reduced to one hour's duration no serious case of illness occurred.

The third important point in treatment is ventilation of the compressed air chamber. Where a tunnel is being made thro' a porous ground the ventilation will of necessity be good but where an impervious face exists, there appears the necessity of

vigilance in the daily estimation of the supply of fresh air. At the ordinary atmospheric pressure a man at perfect rest requires to be supplied with 3000 cubic feet of fresh air per hour in order that the air of his room may not contain more than .06 per cent of Co_2 and that the room may be described as well ventilated. A man engaged in heavy work requires fully three times this amount of fresh air (i.e. 9000 cubic feet) to preserve the same healthy conditions as regards the atmosphere; it is certain that nothing below this is admissible in compressed air. A glance at the tables given previously will show that up to pressures of 25 lbs. this amount, although diminishing the number of cases of illness, does not prevent them altogether, and that at higher pressure much larger amounts are called for.

In addition to securing a sufficiently large supply of fresh air, it is necessary to provide for the proper distribution of that air

throughout the compressed air chamber; this will be attained by considering the position of the chief outlets, and arranging, and, if necessary, sub-dividing the inlet in the most advantageous way. The duration of the "locking-in" process is of little moment to those who can readily accommodate^{^ w} their ears to the increasing pressure. With moderately patent Eustachian tubes, no difficulty will be found in entering a pressure of 30 lbs. in one minute. The "locking-out" process is of more importance. From what has already been said, it may be inferred that if by lengthening the process it is hoped to diminish illness to any appreciable degree, it will have to be prolonged to an extent which will be very inconvenient. At the Blackwall Tunnel the air cocks were of such a size that when turned on fully they admitted of exit from a pressure of 30 lbs. being effected in four minutes. When ventilation was efficient the illness^{^ es} were

reduced to vanishing point, so that it is impossible to ascribe any harm to this rather rapid exit.

It is possible that, at the higher pressures, it would be well to increase this 'locking-out' process to fifteen or even more minutes; although for pressures below this such a precaution would appear unnecessary .

A proper selection of men is very necessary. In order to ensure this a systematic examination of all men before commencing work and again at stated intervals should be carried out.

Careful instructions to each new man as to the method of inflating his ears, and a warning to him not to enter the pressure at any time when he has pain in his ears, should always be held essential, and would do much to prevent ear complications.

Rules should be printed, advising rest after leaving the compressed air, and as to necessity of a rapid change into warm and

dry clothing. Lighting should be effected by electricity. Candles contaminate the atmosphere by giving off CO_2 and smoke. A mild stimulant (e.g. hot coffee) should be provided for the men on leaving the cold, misty atmosphere encountered during the 'locking-out' process.

II. Curative Treatment.

If the case comes under notice soon after its commencement, the treatment which should immediately be resorted to is recompression. For this purpose a medical air lock should be constructed. This can easily be done by having an ordinary boiler fixed horizontally and a door fitted at one end. When this is fitted with bunks electric light and the requisite air connections it makes a very suitable medical lock.

The patient should be placed in this and the pressure rapidly raised until the pain is alleviated. If it is necessary to

raise the pressure to the full amount the patient has left, it should be kept up for half an hour, or until relief is obtained. If the symptoms have been present for many hours, no relief is usually met with, and it is useless continuing the pressure. The exit should be effected slowly - in fact the patient should be allowed to "leak-out" in about forty-five minutes.

Sometimes pain is so bad that hypodermic injections of morphia must be given. Ergot, Salicylate of Soda, Digitalis, and the application of the electric battery were all found to be without result. Epigastric pain is usually relieved rapidly by recompression - slighter cases yield to a carminative. Complications such as paralysis of the bladder and ~~v~~rectum must be treated as ordinary spinal cases - prolonged administration of strychnine is useful. Cases of ear disease caused by entry into compressed air in no way differ from the corresponding conditions arising from other causes. Prolonged vertigo does not yield

easily to drugs.

Dr. Snell recommends that "wherever compressed air is going to be used on an extensive scale, a small hospital close at hand should be provided. The painful necessity of conveying men sometimes dangerously ill to a distant hospital or to their homes, would then be avoided."

Short account of Fifty cases which occurred at Blackwall Tunnel.-

These cases have been selected from over two hundred similar ones of varying degrees of severity, not because they usually present peculiar or rare features, but rather to illustrate the similarity of onset and course of the most common variety of symptoms caused by compressed air. The cases of auditory vertigo are detailed because so little has hitherto been said about this symptom by writers on the subject.

CASE I. "Bends" Recompression D. left off work at 6 a.m. Dec. 22nd. after working the usual shift of 8 hours pressure 20 to 24 lbs. Twenty minutes afterwards he had pain in both knees, most severe in left knee also slightly in thighs. No swelling. Battery used. Was put in medical air lock. Pain easier but lasted for some hours. Seen at 11 a.m. No pain, No tenderness. Heart: apex, area and sounds normal pulse 84. pulse pressure 7 oz. (measured by Bathen's clinical pulse manometer) no perspiration. Liver: dulness in right nipple line was relative at 5th. rib, absolute at the 6th, and extended below to the costal margin. Has only been working in compressed air for two days. Returned to work Dec. 23rd. at 2 p.m. He felt quite well on leaving at 10 p.m.; but when in bed, at 1 a.m., Dec. 24th., he had very severe pain in the right knee, and some pain in other parts of both legs; this was so severe that he re-

turned to the works, went into the medical air lock to full pressure, but received no relief. He went in again, and came out very slowly; the pain was much easier, and he returned to bed. Seen at 11 a.m., Dec. 24th. No additional physical signs; no pain, no tenderness.

CASE II. - "Bends."

C. T., aet. 35. On Jan. 15th, left off work at 6 a.m. Pressure 20 to 25 lbs. Pain in legs, mostly in knees; came on at 6.15. This was slight at first, and he took little notice of it, but the pain gradually became worse until mid-day. He had gone to bed at 9.30 a.m.; rubbed the knees with lin. tereb. acet., and wrapped them up in flannel; but he was unable to sleep. Seen in the afternoon. No swelling of legs; no physical signs of disease.

Jan. 16th: Pain much easier, but not gone. Gets up, but feels weak on his legs.

Jan 18th: Walked to the works. Complains of weakness in lower extremities. Has had slight giddiness. No alteration of reflexes.

Jan. 21st: Returns to work quite well.

CASE III.-"Bends." Recompression.

Jn. S., aet. 31, had worked nine shifts in compressed air. No ill effects until April 7th,; he then worked from 6 a.m. to 2 p.m.* Pressure 19 to 25 lbs. A few minutes after coming out of the locks, at 2 p.m., and before he reached the warm rooms, he had sudden pain in the left arm. Went into medical air lock; was better while in, but the pain came on again when he came out, and became worse after he arrived home. Seen at 5. p.m. Very severe pain in the left arm, mostly above the elbow; no swelling; no particular tenderness. Morphia (gr. $\frac{1}{4}$) and atropine (gr. $\frac{1}{40}$) injected into the arm, and lin. terebinth acet. rubbed in. He was better in ten minutes, and

walked home. (He ascribes his illness to the warm rooms being cold, the steam being turned off on the two preceding days when he left work, and he had to return home in wet clothes.)

April 8th: Left arm better, but still painful.

April 10th: A heavy feeling in the arm remaining.

April 17th: Returns to work. The feeling of heaviness in the left arm has continued slightly until now. On re-entering the compressed air to-day this feeling entirely passed off, and did not reappear on coming out at the middle and end of the shift.

CASE IV. - "Bends." Recompression.

Geo. C., aet. 28, had worked in compressed air for about ten months; had "bends" once soon after commencing, and was away from work for three days. Active tunnelling operations were temporarily suspended on May 10th, and the "face" of the tunnel was more or less completely closed up. G. C., having fin-

ished his shift at 6 a.m., May 13th, pressure 19 to 23 lbs., had a pain in the right shoulder one hour after coming out, the pain occasionally radiating up to the right side of the neck. No swelling; tenderness in the anterior part of the left deltoid; pale complexion. The pain caused him to feel faint. Lin. terebinth acet. was rubbed in, but the pain did not become any easier during the course of the morning. At 1 p.m. the pain was severe, and he was put into the medical air lock and "leaked out". Morphia (gr. $\frac{1}{4}$) injected; ext. ergotae liq. mxx and carbonate of ammonia given by the mouth. The pain was easier in ten minutes.

May 15th: Some pain in the right arm continues, though it is much better; a sort of dull, heavy feeling remains in the whole limb. Tenderness of the muscles of the arm; in the fore-arm this tenderness is localised along the middle of the front and back of the limb. R liq. strychninae miii, ac.

nitro-hydrochl. dil. mx ex aquā t. d. s.

May 18th: Occasional shooting pains in the elbow, lasting a minute or so.

(Two other men at work on the same shift suffered slighter attacks. These were the only three cases occurring during this month.)

CASE V.--"Bends." Recompression.

J. B. was working in Caisson No. 2 with J. W. (Case VI.) from 6 a.m. to 5.30 p.m, with intermissions of half an hour for breakfast and one hour for dinner. At 6.15 p.m. he was seized with pain under the left knee-cap, "as if something was pinching inside"; it soon passed to the back of the knee, and it was difficult for him to stand; the pain also went upwards to the left hip; later, the right knee, thigh, and hip became affected. He returned home, but could get no sleep; so on July 30th he sought medical advice. He was then apparently

in great pain, which came on in paroxysms, the legs becoming painfully rigid, and the body turned to the right side and drawn downwards. The "spasms" lasted from thirty seconds to two minutes, and occurred frequently. Knee-jerks absent; no paralysis; no head trouble; pupils equal; pulse low tension, irregular in volume, and frequency. 84 per minute. He was carried to the medical lock, and the pressure raised; when this reached 5 or 6 lbs. the pain became much worse. After this, as the pressure rose, he gradually became easier. At 12 lbs. he was free from pain. The pressure was maintained at this height for thirty-five minutes, both inlet and outlet cocks being open, giving a current of fresh air. The pulse now became fuller and of a higher tension (96 per minute). The pressure was then gradually reduced. The patient could stand and move his legs without pain; the knee-jerks had returned. In thirty minutes more he left the lock, having been in sixty-five min-

utes . He was much better, and could walk unaided, although the pains had returned to a slight degree.

Aug. 1st: Much better. Walked to works from his home, a distance of over two miles.

Aug. 3rd: No pain. Returns to work Aug. 4th.

CASE VI.-"Bends."

J.W. had been working in Caisson No. 2 since the commencement of the use of compressed air there. On July 29th. he was at work in that caisson with two other men at a pressure of 32 lbs.; this was before the whole of the water from the bottom had been forced out, and before active operations by larger gangs had commenced. He remained under pressure for eleven hours, from 6 a.m. to 5 p.m. Three hours after coming out he had a sharp pain in both knees, and, after a short time, in the right shoulder and right elbow. The pain was so intense that he was unable to stand. He was seen by a doctor, and on the

morning of the next day came to the tunnel surgery. He had had scarcely any sleep. The pain was confined to the joints, and was of a sharp gnawing character. No swelling and no discoloration; tenderness on handling over the line of the articular surfaces. There was a tender spot on the outside of the right thigh 6 inches above the knee; the knee-jerks were absent; no pain in the head; no deafness; tongue slightly furred; pulse 90, very small and rapid, almost "wiry" in character. The patient attributed the attack to getting his feet wet the day before, as he had never previously felt any bad effects of air work; and he said that the pains were like "rheumatic" pains, which he had previously had. He walked very lamely, supported by a friend.

R: Phenazoni gr. xl
Sodii salicylatis ʒj
Tr. aurantii ʒj
Aquam ad ʒviii
m: Fiat mist. Sig.: ʒss. tertiis horis.

July 31st: Pain has left shoulder. Knees are slightly better. Better night. Can now walk alone with a stick.

Aug. 31st: Much better.

Aug. 3rd: Slight occasional pain in the knee.

Aug. 7th: No pain. Feels all right.

CASE VII.-"Bends." Recompression.

H. C. had worked in the compressed air of the tunnel for the three weeks previous to July 30th. when the pressure varied from 15 to 25 lbs. On that day he was transferred to Caisson No 2, where the pressure was 32 lbs., and he worked from 10 p.m. to 5.30 a.m., July 31st. Whilst in the compressed air he felt a gnawing sensation in the right shin, then in the right arm, and finally it settled in the left shoulder. This was at 3 a.m. He remained in the compressed air till 5.30, and then came out to seek medical advice, as he could not hold his tools in his left hand. The pain became worse when in the open air.

He had experienced similar pains two or three days previously, but had disregarded them. When seen there was considerable weakness of the left hand and arm, but not much pain. He was taken into the medical lock. When the pressure reached 12 lbs. the pain became worse: after this it gradually improved until a pressure of 19 lbs. was reached: pressure was then gradually reduced to nil. He was in the lock forty minutes. He could use his arm perfectly well, and only slight pain remained. During treatment in the medical lock he experienced ~~form~~ication of the left hand. (R lin. terebinth. acet).

Aug. 1st: Better. Some numbness of left arm.

Aug. 9th: Feeling of numbness gone. Returns to work.

CASE VIII.-"Bends." Recompression.

G.B. had worked in compressed air for twelve months, and never suffered from its effects. On July 31st, he was transferred

from the tunnel (pressure $16\frac{1}{2}$ to $23\frac{1}{2}$ lbs.) to Caisson No.2 (pressure 31 lbs.), and worked from 10 p.m. to 6 a.m., Aug. 1st. Half an hour after coming up he felt a pain in the right knee. He had been wearing a leaky boot on that leg. He sought medical advice soon afterwards, and was at once taken to the medical lock. Pains slightly improved after half an hour in the lock. (Lin. tereb. acct.)

Aug. 2nd: Better. Has occasional attacks of pain only; these woke him up twice in the night.

Aug. 3rd: No pain. Can walk quite well, but has some stiffness in legs.

Aug. 10th: Returns to work, but elects not to again work in the caisson.

CASE IX.—"Bends."

J. G., aet. 47, generally works in the compressed air of

the tunnel. He then worked two shifts in Caisson No. 2. He finished the last of these shifts at 10 p.m., Aug. 8th,. Severe pain came on at 11.45 p.m. in both legs, mostly in the knees. Seen at 2.15 p.m., Aug. 9th. Had had no rest during the night. No physical signs. The left popliteal space is tender, and to a less extent the whole area of the left knee joint. Right knee less tender. Morphia and atropine injected subcutaneously, and lin. tereb. acet. rubbed in.

Aug. 10th: Pain a little easier, but still severe. Complains of weakness of his legs.

Aug. 12th: Better. Some stiffness in the left calf. Returns to work to-day in the lower pressure of the tunnel.

CASE X.- "Bends." Recompression.

Jas. G., aet. 30, has been working in the compressed air of the tunnel since the commencement. The last day or two he has been in Caisson No. 2. His last shift he finished at 6

a.m., Aug 10th. At 6.30 a.m. pain came on in both legs and both shoulders - worse in the shoulders. Seen at 7 a.m. In great pain, which was not eased by rubbing with lin. terebinth. Put into medical lock, and pressure raised to 18 lbs; pain had then gone, and he was allowed to "leak out" in forty-five minutes, at the end of which time there was no return of pain in the legs, though that in the shoulders was still present to some extent. There was no swelling over the seat of pain. Friction with lin. terebinth acet. was continued, and liquid extract of ergot (m 20) given every four hours.

Aug 10th: Pain still severe; has had no sleep. Pil. opii (gr.i) at night.

Aug. 11th: Visited. He was out for a walk, but was said to be not much better, and to have had no sleep.

Aug. 12th: Better. Some pain continues in arm and leg. He

describes the arm as being swollen; no swelling can, however, be seen.

Aug. 14th: No pain. Returns to work.

CASE XI.- "Bends." Recompression.

E.H., inspector, has to be in compressed air frequently, but not necessarily for a long time together. On Aug. 10th, he was in Caisson No. 2 from 4 p.m. to 7 p.m.; pressure 32 to 35 lbs. At 7.40 p.m. pain came on in the lower portion of the back - he received a blow in the back, he explained, some months previously - and in legs, principally at a point which was also previously injured. Pain severe. Seen at 8 p.m. Put into medical air lock. Pressure raised to 18 lbs. Pain then gone at once. Allowed to "leak out" in forty minutes. Pain did not return.

CASE XII.- "Bends." Recompression.

J.B. After his last illness, on July 29th, he returned to work on Aug. 4th, working generally in the compressed air of the tunnel. On Aug. 11th, he worked his third shift in Caisson No. 2; pressure 32 to 35 lbs. Came out at 2 p.m. He then went home, and had dinner; pain came on at 3.30 in legs, right arm, and abdomen; vomited his dinner. Seen at 7.30 p.m. at the works. Put into medical lock; better when pressure reached 18 lbs; no pain. Morph. sulph. (gr. $\frac{1}{4}$) and atropin. sulph. (gr. $\frac{1}{140}$) injected hypodermically. Allowed to "leak out"; slight pain in right arm on reaching the open air. Felt giddy. No physical signs of disease.

Aug 12th: Better. Slight pain about the knees still.

Aug 17th: No pain. Returns to work Aug 19th.

CASE XIII. - "Bends." Recompression.

T.R. aet. 26 (Aug 11th,) has been working in compressed air

since the commencement, and for the last fortnight has been in the high pressure of Caisson No.2, but has not until now suffered from any bad effects. Left work at 10 p.m. On his way home, at 10.45 p.m, slight pain came on in ^{his} legs; this became worse at 1 a.m., and continued throughout the night; and he "crawled" down to the works in the morning- a distance of two miles. He was seen at 6.30 a.m. The pain was said to be very severe, though he was able to engage in a long conversation, quite ignoring for a time the pain. He was put into the medical lock. No alteration in the pain. (R. \bar{L} in. terebinth acet. \bar{C} lin. aconit. $\bar{a}\bar{a}$)

Aug 13th: Better. No pain.

Aug 21st: Is at work again in Caisson No. 2, and complains of loss of appetite.

CASE XIV.- "Bends." Recompression.

S.W., aet 44, has worked for eleven months in compressed air. Works in the tunnel left off at 6 a.m., Aug. 12th. Pain came on two hours after coming out, in both arms, neck, and chest. (He had a pain previously on coming out to supper at 4 a.m.; but went into medical lock, and was better, and returned to work.) Applies for advice at 5.30 p.m., Aug 12th. Put into medical lock, and allowed to "leak out". No improvement. Pain said to be very severe; cannot walk well. No alteration of knee-jerks; no physical signs.

Aug. 15th: Pain better, but stiffness in legs remains. Right knee-jerk brisk; no ankle clonus. Complains of numbness of feet. No anaesthesia.

Aug. 17th: Better. No pain. Returns to work Aug. 19th.

CASE XV.-"Bends." Recompression.

W.P. finished an 8-hour shift in Caisson No. 2 at 10 p.m. Aug. 16,; pressure 31 to 34 lbs. Pain came on at 10.30 in

the right thigh and both groins. Applies for advice at 8 a.m. next morning. Rubbed with lin. terebinth. Put into medical lock. Morphia (gr. $\frac{1}{4}$) injected hypodermically. No noticeable difference in the pain.

Aug. 17th: Pain continues in right groin.

Aug. 24th: Only occasional pain.

Aug. 29th: Well. Returns to work in tunnel.

CASE XVI.-"Bends." Recompression. Ergotinin.

D.E., aet. 30 (Oct 13th.) has worked in compressed air about eight months. Came out of compressed air at 10 p.m. to-day; pain came on at 11 p.m. in left fore-arm; had no sleep during the night. He returned to the works the next morning, and went into the medical air lock by himself at 6.30 a.m.; let himself out in twenty minutes, and was no better. Applies for medical advice at 7.30 a.m. Pain then very severe. Ergotinin ($\frac{1}{50}$ gr.) injected hypodermically in left arm; within six-

ty seconds of the injection he states that he is "much better."

Oct. 15th: Some pain in left arm persists; it is worse now in the left shoulder and left side of neck. Says the skin feels tight. There is no swelling. A draught of bromide of potassium and chloral is given, to be taken occasionally.

Oct. 16th: After 15 grains of pot. brom. and $\frac{1}{8}$ a drachm of syr. chloral he slept from 2 p.m., Oct. 15th, to 12.15 p.m., Oct. 16th. Returned to work to-day quite well.

CASE XVII.-"Bends."

T.J., aet. 43. Not worked in compressed air before. Examined for this work Oct 15th, and passed. He was of robust build, but not stout. Had ague some years ago in Brazil, but has otherwise been healthy. Went to work at 2 p.m.; had pains in the ears and forehead on entering the compressed air: this became easier when in; came out for tea at 6 p.m. He then

had pains in the legs; these disappeared on returning into the compressed air. Came out at 10 p.m.; pain came on at 11 p.m., first in the feet, and afterwards in the legs, affecting principally the knees. He had been wearing thin boots, and his feet had become wet. Sent for advice Oct. 16th at mid-day; he was then seen at his own home. Had had no sleep; the pain was not much easier, though he had been using turpentine liniment. No swelling of knees or other parts; no pain in ears, no deafness.

Ergotinin ($\text{gr. } \frac{1}{100}$) by mouth followed by morphia ($\text{gr. } \frac{1}{4}$) after one hour. A liniment containing belladonna, aconite, and turpentine.

Oct 17th: Pain much easier; slight pain in arms and legs. Slept well.

Oct. 18th: Better. Still some pain in arms, especially the

right.

Oct 19th: Returns to work on Oct. 21st-outside the compressed air.

CASE XVIII.-"Bends." Abdominal pain.

C.F., aet. 23 (Oct 21st,) has worked in compressed air for three months; has never has "bends," but has suffered from itching frequently after leaving the compressed air. Came out at 10 p.m.; felt well then. Had supper; went to bed; slept well until 6 a.m., Oct 22nd, when he woke up with pain in the epigastrium. This was easier in two hours, after taking some ginger. Seen at 11.30 a.m.; pain not entirely gone. A carminative mixture given. Returned to work at 2.p.m.

CASE XIX.-"Bends."

M.C., aet. 21 (Oct 23rd,) has been working in compressed air for six months; has not suffered from it until now. Came out at 10 p.m.; went home and to bed; woke up at 3-30 a.m. with

severe pain in both knees; this prevented him from having any further sleep, and he has been in great agony since. He "could not stand on his legs unsupported because of the pain." Came to works for advice at mid-day. Seen at 12-30 p.m. in medical air lock; had been helped there by two men. Considerable pain and tenderness in both knees and all round joints; no swelling. Pulse pressure 6 ozs. Raised pressure to 16 lbs.; pain a little easier; allowed to "leak out"; fell asleep while leaking out. This took forty-five minutes; he then had slight pain only. Pulse pressure 7 ozs. A liniment containing aconite and belladonna.

CASE XX. - "Bends."

W.J., aet. 45 (March 23rd.) has worked in compressed air here for twelve months; has only had one slight attack of "bends." During the last three days he has worked three shifts in Caisson No. 1; came out at 6 a.m., March 24th. Pain came

on at 7.15 a.m. severely in both legs, and to a less extent in the shoulders and arms; he could not get any sleep, and the pain was extremely severe. Sent for advice, and was seen at 2 p.m. Pain as before described, and of an excruciating character, causing him to writhe about in agony. No swelling; no physical signs of any sort, except tenderness all over the arms and legs on deep pressure.

R: Pil. opii gr. ss. st. et rep. post tertias horas s. o. s.

R: Lin. terebinth \bar{c} lin. aconiti \bar{c} lin. camph. co. $\bar{a}\bar{a}$.

March 25th: Still considerable pain.

March 26th: Much better; no pain, but considerable stiffness about legs.

March 28th: Returns to work.

CASE XXI. - "Bends." Recompression.

J.G., aet. 30 (March 25th,) has work^{ed} in compressed air for nearly two years. Has worked in Caisson No. 1 since March 22nd.

Came out to-day at 2 p.m.; pain came on at 4 p.m. in the left shoulder and left arm. Seen at 6 p.m.; no physical signs. Put into medical air lock at 6.15 p.m., and pressure raised to 20 lbs.; no improvement in the pain while under pressure, and he is allowed to "leak out" in half an hour. A rubefacient liniment.

March 26th: Not much easier. Liquid extract of ergot (m20) given every four hours.

March 28th: Better. Going to work on the 29th.

CASE XXII.-"Bends." Severe abdominal pain.

J.J.M., aet. 38. Examined for compressed air Feb 6th,. The note made at the time of the examination was: "Never worked in compressed air." Has been a diver at Vera Cruz for seven months, at depths up to 60 feet. Heavily built man ($14\frac{1}{2}$ stones.) Heart: apex, area, and sounds normal. Lungs clear. Urine:

no albumen. Pulse 84; pulse pressure about 8 ozs. Warned that he is not a suitable man for compressed air work." As he was to be employed as a foreman, and his services were supposed to be valuable, he obtained my consent to go into the compressed air for a short time on trial. He went into the pressure for six hours (divided into two parts; pressure 20 to 25 lbs.). Pain in the legs came on two hours after coming out. On the following day (Feb 7th) he went into the "air" again for three hours. The pain in his legs was easier while in the "air," but came on worse afterwards, as well as pain in the abdomen; he then sought medical advice, and was again cautioned as to his unsuitability for the work. Seen again on Feb. 8th; the pain was then much easier. On Feb. 10th he commenced his first shift of 8 hours, and finished at 6 a.m., Feb. 11th. At 7 a.m. he had very violent abdominal pain. Seen at 7.20 a.m. in medical lock in very great pain. Pressure was turned on up to

20 lbs. Morphia ($\frac{1}{2}$ grn.) and atropine ($\frac{1}{160}$ grn.) were injected hypodermically, and some hot coffee given. When first seen no pulse at the wrist could be felt. Skin cold; face very pale. He vomited once, and his bowels were open while in the lock. The compressed air was allowed to "leak out," taking thirty minutes in the process. Pain was then easier. The pulse improved in about one hour. Pain returned slightly on movement. He was wrapped in hot blankets, and hot bricks were placed to the feet. At 10 a.m. beef tea given was at once returned; a small quantity given later was retained. At no time could any physical signs of any lesion be made out. At 1 p.m. he had much improved, and was sent in a cab to the Seamen's Hospital. Seen again at the hospital at 11 p.m. He felt well, but looked very pale. Temp. 99° .

Feb 12th (evening): Practically well. Abdomen said by

Dr. Windsor, the house physician, to be "a little distended. No pain or tenderness; no signs of organic disease; slight pain in right shoulder; no head symptoms." Left the hospital on Feb. 16th well, and did not again express a wish to attempt compressed air work.

CASE XXIII.-"Bends." Recompression.

J.G.A., aet. 29, has worked in compressed air for about two years; has never had "bends" before to the smallest extent. On March 25th, he was working his third shift in Caisson No 1; pressure 25 to 26 lbs. Came out for tea at 5-30 p.m. Just before emerging from the lock he felt a pain in the left knee, which became worse on getting out. Rubbed with turpentine liniment: no better. Applied for advice at 7.15 p.m.; put into medical air lock, and pressure raised to 20 lbs.: no better; allowed to "leak out." A rubefacient and anodyne liniment was

given him, and he did not again report himself.

CASE XXIV.-"Bends." Recompression.

W.S., aet. 27, has worked in compressed air for six weeks, and for last three or four shifts in Caisson No 1. Was quite well until the end of the 8-hour shift, finishing at 6 a.m., March 27th, pressure 26 to 27 lbs., when he went home and went to sleep, but woke up at 10 a.m. with a pain in the right thigh; there was no swelling. He was put into the medical lock at 12 noon; when the pressure was raised the pain was a little easier. After "leaking out" the improvement was maintained, and he was much more free from pain. Not seen again.

CASE XXV.-"Bends," following rapid decompression.

W.F., aet. 37 (April 2nd) has worked in compressed air about two years. Has had "bends" in the knees once or twice, but this has never caused him to leave off work; was recently working in Caisson No. 1 for ten days, and then was transferred to

the tunnel two days ago (where no case of illness has occurred for over a fortnight). He worked from 10 p.m. till 6 a.m. (3rd), pressure 16 to 20 lbs. When coming out of the compressed air with several other men he had no sooner entered the lock and shut the inner door than one of these men signalled for the large cock (which should only be used during the passage of trolleys) to be opened by the lock-tender on the outside. This was done. W.F. very much objected at the time and afterwards. Soon after coming out he had pains in the knees, and he ascribes the illness to the before-mentioned circumstance. He was given a liniment, and did not again report himself.

CASE XXVI.-"Bends". Small, ill-defined area of anaesthesia.

G.C., aet 30 (March 29th,) has worked in the compressed air for about two years. Has worked in Caisson No.1 the last week; no ill effects until to-day, when, one hour after finishing

the night shift at 6 a.m. (30th), pressure 27 to 29 lbs., he had a pain in the right arm and right leg, and could get no sleep; he had also a feeling of numbness in these limbs.

Applies for advice 12.30 p.m. (31st). He has slight anaesthesia over a part of the right fore-arm, wrist, and hand, not well defined. Pain principally in the right elbow now. Has a very pale and pasty complexion. Examination of blood by haemocytometer shows 5,870,000 corpuscles in each cubic millimetre of blood; haemoglobinometer shows 100 degrees of dilution - i.e., $\frac{100}{117.4} = .84 =$ the value of a nominal corpuscle.

April 2nd: Anaesthesia gone; some aching of the fore-arm remains.

April 8th: Practically well. Returns to work.

CASE XXVII. - "Bends." (?) Crepitation in muscles.

T.J. had not previously worked in compressed air. He was examined for the work on April 8th, and rejected. In spite of

his not being passed he worked in the compressed air of Caisson No. 1 from 10 p.m. until 6 a.m. on the 9th; pressure 26 lbs. Soon after leaving work he had severe pain in the shoulders and knees, and sent for advice in the afternoon. Seen at 3.30 p.m.: apparently in great agony. There was no swelling of the painful joints, though they were tender. During the examination a slight crepitation was felt in the substance of the muscles above the right knee; this could not be felt again, and did not arise from the knee joint or its bursae.

April 11th: Better. Still has pain in thighs.

April 14th: Got out of bed for the first time yesterday. Much better, but still has pain in the left knee and left shoulder.

April 15th: Returns to work outside the compressed air.

CASE XXVIII.-"Bends." Pain in perineum, etc. Recompression.

G.C., aet. 28, has worked for months in the compressed air of the tunnel. Has been working the last two shifts in Caisson No. 2. He came out at 6 a.m., Aug. 9th; pressure 31 to 32 lbs. Pain came on in the abdomen and chest at 7 a.m.; also in both legs; afterwards it was most severe in the groins, especially the left, and in the perineum. No difficulty in micturition. Lives at Lewisham - a distance of four miles - and had returned home when the pain came on. Returned to the works later in the morning, as the pain did not cease. Seen at 2 p.m. in the medical air lock. The pain was most intense in the perineum. Air turned on, and pressure raised to 20 lbs., and lin. tereb. rubbed into painful parts. He was then allowed to "leak out", taking forty five minutes in the process; the pain was then easier, and he left to walk home.

Aug. 12th: Returns to work quite well.

CASE XXIX.-"Bends." fourteen hours after leaving compressed air.

J.K., aet. 25, was getting out of bed on the morning of Nov. 20th, - about fourteen hours after having left the compressed air - in order to return to work, when he had severe pain in the knees and calves. The calves were tender. Seen at 2 p.m. Nov 20th. The pain was less severe; he was up, and otherwise feeling well. Has never had rheumatism. Heart: apex, 5th intercostal space, $\frac{1}{2}$ inch internal to left nipple line; cardiac area of dulness normal, sounds normal. Pulse 96, regular; pulse pressure 10 ozs. Lungs healthy. No swelling or discoloration of knees or calves. He states that he had a precisely similar attack two or three months ago, This previous attack resembled the present one in coming on fourteen hours after leaving the compressed air, and in occurring in the knees and calves.

Nov 21st: Much better; no pain.

Nov 23rd: Returns to work.

CASE XXX.-"Bends." Swelling. Recompression.

J.A., aet. 38 (Aug. 16th), has worked in Caisson No. 2 for four shifts. Not worked in compressed air previously. Has had an attack of "bends" after every shift, but has not previously applied for advice. To-day he was in the caisson from 6 a.m. to 10 a.m., pressure 31 to 34 lbs., when he came out for breakfast; pain came on a few minutes afterwards in the left arm and left knee. Seen at 10.30 a.m. There is a diffused swelling of the left upper arm - tender to pressure. Put into the medical lock, and allowed to "leak out." He was considerably better after this, and was told to leave off work for a few days.

Aug 19th: Left arm still painful. There is an ill-defined, hard swelling in the left arm about the insertion of the deltoid, $2\frac{1}{2}$ inches in diameter in a lateral direction, deep in the muscles, and apparently situated between the deltoid just

above its insertion and the bone; tender on pressure. Temperature normal.

Aug 22nd: Very much better. Occasional slight "catching" pain in the left arm. Swelling in arm is still present, but is smaller. General health good.

Aug 24th: Slight pain still in left arm. Only a little thickening remains about the insertion of the deltoid.

Aug. 28th: Well.

CASE XXXI.-"Bends." Swelling near knee. Recompression.

J.H., aet. 39, has previously worked in compressed air for two weeks in Glasgow. Examined and passed for compressed air work at the Blackwall Tunnel Aug. 21st,. It was noted that he had very grey hair (he states that the greyness came on before he was 20 years old; his father was grey early, and his brother's children, under five, are beginning to have grey hairs!), and also that he smelt of spirits; against the use of these

while working in the air he was warned. He commenced his first shift at 10 p.m.; came out at 4.30 for breakfast; half an hour afterwards he had a pain in both knees. Seen at 5 a.m., and put into medical lock, and allowed to "leak out." (R lin. terebinth acet & lin. aconiti aa.) 1 p.m., pain worse again. (Pil. ipecac. co. gr. v. st.) 5 p.m., slightly easier, but has had no sleep. Has slight tumefaction on inner side of left knee. Sent to Seamen's Hospital.

Aug 27th: Came out of hospital feeling nearly well. Was treated there by morphia injections. No swelling of left knee now. On the lower and inner side of this joint is a small blue (? ecchymotic) patch half an inch in diameter.

Aug. 31st: Slight stiffness in both knees.

CASE XXXII.-"Bends." (?) Swelling.

P.A., aet. 29. Not worked in compressed air. Examined and passed March 30th,. Worked his first shift in Caisson No 1, from 2 to 10 p.m.; pressure 27 lbs. Immediately after

coming out he had severe pains in his legs, and could not walk. He remained in the warm room on the north side rubbing his legs with some liniment until 2 a.m. (31st), when he was carried through the tunnel to see me. At 2.15 I put him in the medical lock; the pain in the legs was then extremely severe. No physical signs. The pressure was raised, and he improved a little. He had half a grain of morphia; was allowed to "leak out" in forty-five minutes, and was then driven home, and recommended to use a liniment containing equal parts of lin. ter-eb. acet., lin. sap., and lin. camph. co.

March 31st: Easier, but still has some pain. Has had no sleep.

April 2nd and 3rd: Better, though there is a great deal of deep tenderness about the lower part of the left thigh; the tenderness seems to be in the bone.

April 7th: Right leg free from pain. In the left leg, 4 inches above the external condyle of the femur, is a small,

soft, ill-defined, tender swelling, quite subcutaneous, and not fluctuating, at the back of the ilio-tibial band; also tenderness at the insertions and origins of muscles about the knee.

He has been taking ergot mixture; he now has mist. *Ter.* \bar{C} . strych. He states that two years ago he had a vein blocked in the situation of the above-mentioned swelling, and he was ill in bed for a week afterwards. Throughout the remainder of the month he complains of stiffness in the legs; there is no pain. The swelling had remained as before, though the tenderness had gone; it was probably venous in origin and of long standing, though not noticed or drawn attention to at the commencement of the illness. He does not again work in compressed air.

CASE XXXIII.--Synovitis of right knee joint.

H.J.L., aet. 22, has been working in Caisson No 2 for three shifts. Not previously work in compressed air. Finished the third of these shifts at 2 p.m., Aug. 11th,; pressure 32 to 35

lbs; he then, in the afternoon, walked about Victoria Park and neighbourhood for several hours. At 5 p.m. he felt a pain in the right knee. He had not sustained any injury to the knee. Applied for advice Aug. 12th. There is excess of fluid in the right knee joint; tenderness around that joint. Is not accustomed to long walks. Wool and bandage to joint.

CASE XXXIV.-Paresis of the legs.

W.F., aet.37 (March 26th,), is a painter and decorator but through lack of employment has been working in the compressed air of the tunnel for ten weeks; he was then working in the open air for two weeks, and then for three shifts in the higher pressure of Caisson No. 1. The second day after beginning work in the compressed air he had pains in the legs after leaving work; these soon passed off, and he suffered no further ill effects while working in the tunnel. After the first two shifts in the caisson he was free from illness. The third shift was

from 10 p.m., March 26th, to 6 a.m., March 27th; pressure 26 to 27 lbs. About five minutes after leaving the lock he had pain in the abdomen, followed by numbness and weakness in the legs. After walking a little way the weakness in the legs increased; he could not walk at all, and he was carried home, a distance of two and a half miles. In the evening of that day he sent for a neighbouring medical man, and the following day for me. I saw him at 3.45 p.m.; he then had a distended bladder and incontinence of urine; had had no voluntary micturition for thirty-three hours; there was great weakness in the legs, and he could only just stand on them; knee-jerks very brisk; no ankle clonus; no anaesthesia; constipation for two days. He was catheterised, and admitted to the Seamen's Hospital. The urine then contained a trace of blood and albumen, but this disappeared in two days. He left the hospital on April 2nd; he could then walk fairly well, but had little or no control over

the bowels or bladder, and micturition was frequent. Mist ferri. \bar{c} strychn. was given and continued.

May 4th: Legs not quite so well as they were; has to "throw" the left leg forward in walking.

May 24th: Has frequently a sensation of pins and needles and numbness in left leg from knee downwards. No anaesthesia. Troubles with micturition, and defaecation slightly improved. Complains of loss of sexual power. No weakness of the legs remains.

CASE XXXV.-Paraplegia.

C.H. aet. 34 has worked in the compressed air at Blackwall all the time that it has been in use, and has never suffered from it. On Jan. 15th, he came out at 9 a.m. for breakfast (having been in a pressure of 20 to 22 lbs. for three hours). While walking to the cage he felt a pain in the situation of his belt, and, thinking the belt was too tight, he loosened it; the

pain was not altered thereby, was like a tight band round the body, and very severe. He ascended in the lift. When at the top he found he could not walk, and was carried to the medical air lock, and his legs rubbed with turpentine liniment. When seen medically he was found to have total paralysis of the legs; could not make the slightest movement with either of them; both knee-jerks absolutely absent; also the cremasteric, abdominal, and epigastric reflexes. Severe pain in the abdomen; no anaesthesia. Morphia (gr $\frac{1}{2}$) given hypodermically. Compressed air turned on. When at about 19 lbs. pressure the pain was easier, and some voluntary movements of the legs could be effected. He was allowed to "leak out," the process taking forty-five minutes. The marked improvement was maintained; he could stand, but could not walk. Slight evidence of knee-jerks on both sides. No abdominal pain. Sent home in a cab.

Jan 16th: Considerably better. Has more power of movement in the legs. Knee-jerks both present and more perceptible.

Between 11 a.m. and 12 noon yesterday, when he had been put to bed, severe pain came on in the right leg throughout its whole length; this kept him awake; also yesterday, later in the day, he had considerable difficulty in micturition, which was however, surmounted at length without medical assistance. Constipation lasted thirty-six hours. (Ext. ergotae liq. mxv. every four hours.) A rubefacient and anodyne liniment and aperient pill recommended.

Jan. 18th: Can walk, but is weak on his legs. Right leg feels to him numb, but there is no anaesthesia. Thinks that the left leg is stronger than the right. Left knee-jerk is more marked than the right.

Jan 22nd: Better. Walks well. Knee-jerks now not obtained even by Jendrassik's method. No trouble with bladder or rectum. A few days later he returns to work.

CASE XXXVI.-Retention of urine.

W.L. has been working in compressed air three or four months. Had "bends" once or twice in joints, but never sufficiently severely to prevent his returning to work the following shift. Was working Feb. 9th, from 6 a.m. to 2 p.m. Pressure 21 to 27 lbs. Applies for advice later in the day, complaining of retention of urine. No other symptoms. He is catheterised; $1\frac{1}{4}$ pints of urine drawn off; and no organic cause for the retention is discovered. Urine normal.

Feb. 11th: No further retention.

CASE XXXVII.-Auditory vertigo.

J.R., aet. 27, foreman, had worked in the compressed air at the Blackwall Tunnel since the commencement, and previously at the Hudson Tunnel. On Aug. 3rd, after working in Caisson No. 2 (pressure 30 to 32 lbs.), he was affected with pain in the "left side and front of the body" and in the limbs; also he noticed that he was deaf in the left ear, and heard noises in

that ear. He went into the medical air lock; had the pressure raised, and came out slowly. The pain had gone in two hours. He did not seek medical advice until Aug. 5th, when he came, complaining of his deafness. Watch with the right ear was heard at a distance of 2 inches, and with the left not heard at all. Loud tuning-fork on the left mastoid not heard at all in the left ear. Nothing abnormal seen by speculum. The ringing noise in the left ear has continued until now. There is slight giddiness on rapidly moving the head to the right or the left - more, ~~however~~, on moving the head rapidly backwards. Can walk perfectly straight. (He states that he had a similar, but worse, attack of giddiness while working at the Hudson Tunnel; he did not, however, then notice any deafness.) No history of previous illness of any sort. He undertook to report himself again in two days time: this he did not do. He was next seen on Sept. 9th at work in the compressed air, where he had been

working since the previous note. He "thinks the deafness is somewhat better." He has no giddiness, but continues to have noises in the left ear.

CASE XXXVIII.-Auditory vertigo from too rapid compression.

R.L. works as a fitter, and is only occasionally in the compressed air. On Aug. 2nd, he was employed fitting smaller air cocks to the lock of Caisson No. 2., the pressure at that time being 31 lbs. He had temporarily stopped up the hole, where the inner cock had been, by a plug of wood; the inner door was closed, the outer half open; he and a boy were together in the lock, and therefore under the normal atmospheric pressure only, when, either through accident or ignorance, a man on the inner side of the inner door knocked out the wooden plug. The lock was suddenly filled, through a comparatively large hole, with compressed air. He and the boy were knocked by the violence of the air against the outer door, which was thus closed, and the

pressure was raised in a very few seconds to 31 lbs. above the normal. The boy is said to have felt no ill effects. The man was temporarily affected with pain and noises in the right ear and giddiness, which soon passed off; he became also suddenly deaf in the right ear, for which he did not seek advice until Aug. 9th. There was then no tinnitus, no vertigo, and no pain. He could not hear a watch at all with the right ear, and with the left only at a distance of 3 inches. A tuning-fork on the forehead was heard "equally distinctly in both ears." Both tympanic membranes seen clearly; cones of light normal. At the upper part of the right drum was a dark area (? congestion or haemorrhage). No perforation.

Aug. 19th: Slight occasional pain the last week in the right ear. Watch: right ear, $\frac{1}{2}$ inch; left ear, 5 inches. Tuning-fork on forehead best heard on the left side. The dark patch on the right drum has disappeared. (Ext. ergotae liq. mxx. ter

die, 5 days.)

CASE XXXIX.-Auditory vertigo.

F.W., aet. 30, had worked in the compressed air at the Black-wall Tunnel since the commencement - that is, for twelve months. He had not suffered from its effects. He had had pneumonia two years before; no syphilis or other illness. On July 9th. he completed an eight-hour shift at 2 p.m. (pressure 16 to 19 $\frac{3}{4}$ lbs), and had left the works to go home. He had gone about two hundred yards, when he felt suddenly giddy, and would have fallen if he had not been caught by two other men; this occurred at about 2.45. He was brought back to the works, and seen at 3 p.m. He could not walk at all by himself; if he attempted to do so he staggered to the right. He could not hear a watch with the right ear, even when touching, nor a loud tuning-fork on the right mastoid process, except with the left ear. Slight subjective noises in right ear. Nystagmus both lateral and rota-

tory. Surrounding objects appeared to him to be moving to the left, but irregularly so. (Ext. ergotae liq. ʒj st.) He was at once taken to the medical air lock, and the pressure raised to 15 lbs. There was an immediate improvement in the vertigo, but none in the deafness. He could then stand by himself, and the nystagmus was not so pronounced. He was allowed to "leak out," taking about one hour in the process. There was no increase of the vertigo in consequence of coming out. He was then sent home in a cab. (Ext. ergotae liq. mxx. quartis horis sumendum.) No disease of the viscera.

July 10th: Watch - left ear, 3 feet; right ear, 6 inches. Tuning-fork on forehead best heard in left ear. Giddiness much less.

July 11th: No giddiness even on movement of the head in any direction. No nystagmus. The improvement was so complete that it seemed that he would soon be able to work. A relapse,

however occurred. The vertigo came on in short irregular attacks every few days or so. Slight rotatory nystagmus again appeared, and he suffered from continual headache; the deafness in the right ear became also slightly worse, and he could only hear the watch at a distance of 2 inches. On account of the nystagmus, if he fixed his eyes on an object for a minute the sight became dim. The ergot was discontinued on July 19th, and bitter tonics given, followed afterwards by iron, arsenic, and strychnine. A blister behind the right ear had no effect. On Aug. 29th. I noticed that the right pupil was larger than the left, and that there was slight external strabismus of the right eye. On further examining the eye I found that the vision on the right side was very defective, and that he could only just count fingers with that eye. He had not complained of this before, but stated that he thought the right eye had been dim for the last two days. There was no organic lesion of the fun-

dus oculi, but there was a high degree of myopic astigmatism (-6D), which one would suppose must have been of old standing. The man had been a soldier, and had used the right eye for shooting, but had not noticed that the sight was defective.

In November the headache was more severe, and he was in a very nervous and tremulous condition. When writing he was troubled by severe trembling of the right arm. Syr. ferri, quinae et strychninae phosphatis was given, 1 drachm three times daily. The vertiginous attacks were diminishing in frequency, and in January he went to the seaside for two months.

September 18th, : During the last eight months the vertigo has only been occasional, but his general health has been very much impaired, and he has suffered greatly from rheumatism. After several sojourns in the country and at the seaside, he is now fairly well. The defect in hearing on the right side continues; the giddiness is trifling and rare, and it is confidently anti-

icipated that recovery will be complete.

CASE XL.-Auditory vertigo.

G.H., aet. 36, engineer, had been working in the compressed air at this tunnel since the commencement. From the nature of his work he was not usually called upon to be under pressure for longer than two or three hours at a time. On Feb. 11th, he remained in for four hours, a longer time than ever before; the pressure was also higher than on former occasions ($26\frac{1}{2}$ to 27 lbs). He came out of the air at 3.30 p.m.; he had then had no food for seven and a half hours. He thought that he came out quicker than usual. He then had a hurried meal. I saw him at 4.10 p.m.; he was then all right. Half an hour later he felt a "deafening sort of sensation" in both ears, lasting a few seconds, and most noticeable in the right ear. He heard some ringing noises in the ears, became giddy, and would have fallen. He was at once sent home in a cab. The deafness then had gone;

the only symptom complained of was giddiness, which was worse on movement or turning round. He felt that the head was moving round to the right occasionally, when it was really stationary. By Feb. 14th. the giddiness had much improved, though it had not then disappeared. The head still occasionally felt as though it were moving to the right, especially on excitement. The right pupil was smaller than the left: this was said to be always the case. The tendency to fall was always to the right. Hearing the same on both sides. From this time the vertigo rapidly disappeared, and in three weeks had practically gone. He was advised not to again enter the compressed air; this, however, he did on many subsequent occasions, making his sojourns as short as circumstances would permit, and he did not again suffer in consequence.

CASE XLI.--Auditory vertigo.

Joseph H., aet. 24, had worked in compressed air for some

months. On Jan. 12th, at 2 p.m., he finished a shift of eight-hours (pressure 20 to 25 $\frac{3}{4}$ lbs.). He walked home - a distance of one mile; went up to his bedroom at 3 p.m. to change his clothes; he felt well at the time, but giddiness suddenly came on, and he fell down, and had to be put to bed; he felt quite helpless. There was no unconsciousness, and he was quite rational. If he sat up in bed he was giddy, and fell backwards. No malaise. Sent for medical advice on the 14th. He was seen on that day sitting up downstairs. The giddiness had lessened; there was no vertigo while remaining still; if standing erect and still, there was no vertigo and no ataxia; if the head was then moved forwards or backwards, there was no vertigo and no ataxia; if the head was then moved forwards or backwards, there was no vertigo: this only came on when the head was rotated laterally either to the right or to the left, and more especially when the movement was to the right; and then the ver-

tigo was so great that he collapsed at once into a chair behind him. The reflexes were normal. There was then no deafness, no tinnitus, and no nystagmus.

Jan. 15th to 18th: Vertigo gradually improving. Left pupil slightly larger than right; both pupils react to light and accommodation. Ophthalmoscopic examination reveals nothing abnormal.

Jan. 21st to 23rd: Can now walk any distance without assistance. Appetite has been good all the time. Advised not to work again in compressed air. He was seen by me so working on Jan. 30th: he had been so engaged for about five days, and had not suffered in consequence. His further working in the air was prevented.

CASE XLIII.-Auditory vertigo.

John H., aet. 24. Examined for compressed air work March 26th,. The note made at the time of examination ran thus:-

"Never worked in compressed air. Heart area and sounds nil. Lungs normal. Liver, relative dulness at 6th. rib, absolute at 7th. rib in left nipple line, not extending below the costal margin; cutaneous veins over the ensiform cartilage enlarged. Urine, no albumen. Has just left the service, where he has been for seven years. Six years ago he had 'ulcers on the penis,' but no subsequent constitutional symptoms." He was passed for compressed air work, and completed his first shift of eight-hours at 10 p.m., March 27th, the pressure being $20\frac{1}{2}$ to $24\frac{1}{2}$ lbs. He had some slight inconvenience with the right ear while going through the lock, but no actual pain. On arriving in the compressed air he felt giddy; the giddiness lasted two or three minutes, but was only slight. He went to his "pocket," and proceeded with his work. His nose bled a little soon after getting in, and continued to do so slightly for some time. Instead of going out at half time for his meal, to avoid becoming giddy

again he remained in the compressed air, having something to eat while there. He perspired profusely. On coming out through the lock he had noises in the right ear, but no inconvenience. He became very giddy soon after leaving the lock and before reaching the elevator. He was then assisted home by his brother; went to bed, and vomited blood (? less than a teacupful); giddiness, noises in the ear, and deafness remained. He did not send for medical advice before the morning of March 29th. He was then found in bed. The vertigo came on when sitting up or walking; there was a tendency to fall to the right. On walking on the morning of the 28th he had had pain in the right knee, which persisted more or less for twenty-four hours. Pulse 72; pulse pressure (measured by Batten's clinical pulse manometer) 9 ozs. Soft-ticking watch heard by the left ear at a distance of 1 inch; not at all with the right ear. Slight tenderness under the right external auditory meatus. Watch on right front-

al eminence heard only in left ear. Only subjective noises heard in the right ear; right drum normal. By holding nose and blowing, air is forced into left tympanum, but not into right. Knee-jerks active. Constipation. (Pil colocynthidis et hyoscyami gr. x. st.) The noises in the right ear began as soon as he came out of the lock; the giddiness commenced when he was half way towards the lift (i.e., he had walked about 100 feet). No ataxy. Optic discs normal.

March 30th: There is a subjective feeling that the head is moving to the right. Loud-ticking watch just heard when touching the right ear and when 5 inches from the left ear.

March 31st: Loud-ticking watch - left ear, 1 yard; right ear, 1 inch. Gardiner Brown's tuning-fork on bridge of nose is heard for five seconds longer than the vibrations are felt by the finger, indicating middle or external ear disease on the left side. (Potass. brom. gr. vii. ter die.)

April 2nd: Soft-ticking watch - left ear, 1 yard; right ear, $\frac{1}{4}$ inch. Gardiner Brown's tuning-fork test of left ear = 0". The giddiness is brought on by quick movements, and more by a sudden movement of the head backwards than by any other movement. There is a subjective feeling of oppression, as if a weight were hung at the back of the neck. A movement of the head suddenly to the right is more liable to bring on giddiness than a similar movement to the left.

April 11th: The giddiness is less; it only comes on when moving the head rapidly, especially backwards.

April 16th: Hearing normal in left ear; on right side it is the same as before. (Pot. brom. gr. x. ter die sum.)

April 23rd: Hearing on right side has improved; soft-ticking watch heard $\frac{3}{4}$ inch from ear. Slight improvement in giddiness.

May. 2nd: Intervals between attacks of giddiness of longer

duration.

May 8th: Tobacco smoking has brought on giddiness once or twice. Advised not to smoke. (Ext. ergotae liq. mxx. ter die sum.)

May 15th: Says he is much better since the 8th. (Ext. ergotae liq. mxv.; liq. strychninae miii.; liq. arsenicalis mii. ex aqua ter die sum.)

June 1st: No giddiness for the last two weeks.

June 8th: The tinnitus on the right side continues, but not so loudly as at first. Hearing the same. If he stoops for any length of time the giddiness returns.

June 18th: Vertigo gone. Walks out every day. (Ergot stopped.) He now resumes work again - not in the compressed air.

Oct. 13th: Has had no return of the vertigo. The deafness in the right ear has not improved; he still has noises in

that ear, but is able to disregard them.

CASE XLIII.-Auditory vertigo.

J.T., aet. 27, had worked in the Blackwall Tunnel about six months. He was on his way home after having worked in the compressed air at a mean pressure of $23\frac{1}{2}$ lbs. from 10 p.m., Oct. 18th, to 6 a.m., Oct 19th. He had covered about two miles when he suddenly felt giddy, became faint, and would have fallen had it not been for others who were walking with him. He experienced a sudden noise in his left ear, and became quite deaf in that ear; surrounding objects appeared to him to be moving round. He had a slight aching pain in his left knee. He was then taken to the Seamen's Hospital. While he remained in the hospital he came under the care of Dr. Curnow, who published an account of the case in the Lancet of Nov. 10th, from which the following extract is made:- "On admission there was no sign of organic disease of heart, lungs, or abdominal viscera. He was in a very collapsed condition, with great pal-

lor, and a cold sweat over the forehead. Pulse 66; temperature 96⁰F., and respiration hurried. He was in a tremulous condition, and unable to stand. He complained of intense giddiness, which was not influenced by position. He had loud, booming noises in his ears, particularly the left, uninfluenced by inflation of the tympanum. He vomited repeatedly when the attack came on, and the sickness lasted about twenty-four hours. There was horizontal nystagmus, especially when the eyes were directed to the right; also a small amount of vertical oscillation in both eyes. On the left side a loud-ticking watch could only be heard when touching the mastoid process; when held on the forehead it could be best heard with the right ear. Both tympanic membranes intact. No oculo-motor paralysis; pupils reacted well to light and accommodation. Ophthalmoscopic examination revealed nothing abnormal. Taste and smell unaffected; no headache. Reflexes normal; no paresis; gait

uncertain and hesitating; no ataxia. When walking the patient evinced a tendency to reel and fall. This tendency was always to the right. With his eyes closed he stood alone, but was unsteady. He remained in the hospital a few weeks. His general condition improved, but the vertigo, nystagmus, tinnitus, and deafness, did not materially diminish; he remained unable to walk across a room without support. The giddiness was always increased by rapid lateral movements of the head." After leaving the hospital his condition remained stationary for months. He went into Norfolk to live.

Nov. 9th: Considerable improvement. Could walk easily across a room without help or support, but could not walk a distance out of doors in the same way. Complete deafness in the left ear continued, and some tinnitus on the same side.

March 5th: Considerably better. Could walk long distances - e.g., ten miles - out of doors with the help of a stick.

June 30th: Has recently been acting as a night watchman at

the Woolwich Ferry, but as the rocking of the pontoon frequently occasions a return of the vertigo he has been advised to discontinue the employment. (This he subsequently did and is now in receipt of a pension, being unable to obtain light work. Oct. 1886).

CASE XLIV.-Auditory vertigo.

W.D., aet. 21, has worked in the compressed air of the tunnel for three weeks; he then worked in Caisson No. 1 for two shifts. Came out at 6.20 a.m., March 24th, pressure 20 to 22 lbs., and had a slight pain ten minutes afterwards in the right knee. He sat down in a chair on arriving home (close to the works), and thinks he went to sleep. He woke up at 7 a.m., stood up, became excessively giddy, fell down on the floor, and vomited. Sent for advice, and was seen at 2 p.m. The vomiting has persisted until now; the giddiness is slightly better, but becomes worse on moving the head backwards or to either side. No tinnitus aurium. Watch is heard in the

right ear at 1 foot, and in the left at 2 feet; placed on the forehead it is best heard in the right ear. He states that he has had a difficulty with his ears on going into the "air" the last two shifts because of a "cold in the head." This difficulty was worse the last shift - i. e., on going into the caisson at 10 p.m. (23rd)- and the pain in the right ear persisted to some extent while in the compressed air. The pain in the right knee is not severe, and there is no swelling. Pupils equal. There is slight nystagmus. No ataxy. Pulse 102; temperature normal. Digitalin ($\text{gr. } \frac{1}{100}$) given at once, and a rubefacient liniment applied to the knee.

March 25th: Vomiting has ceased, and the vertigo is not quite so severe. No appetite.

March 26th: is now sitting up. The vertigo is less, but comes on when the head is moved rapidly in any direction. No tendency to fall in any particular direction. Watch: right

ear, $1\frac{1}{2}$ feet; left, 3 feet.

March 28th: Much the same.

March 30th: Considerably better. Vertigo only occurs on moving the head rapidly to one side.

April 2nd: If after stooping he raises his head suddenly he is giddy for a moment; otherwise there is no vertigo.

April 9th: Yesterday he felt so well that he was returning to work, but the vertigo returned; he had also great pain in the back of the head. The nystagmus has now disappeared. Hearing normal. Has been taking an iron mixture for the last fortnight.

April 18th: No vertigo remains. Returns to work, but is not again allowed to work in the compressed air.

CASE XLV.--Vertigo: probably auditory.

C.W., aet. 29 (March 26th,), has worked in compressed air of tunnel eight or nine months. Recently has worked three

shifts in Caisson No. 1. After the first shift he had a slight attack of "bends," which kept him from work for one shift. After the third shift, which he completed at 10 p.m., March 26th, he had pain in the abdomen immediately on leaving the pressure (26 to 27 lbs.); also retching, but no vomiting. About one hour afterwards he had giddiness. Remained in bed until March 28th, not reporting his illness; he then caused himself to be assisted to the works. When seen he complained of giddiness only. He could not walk or even stand unassisted. There was lateral and rotatory nystagmus. A watch was heard at a distance of 3 feet with both ears. No tinnitus aurium. No albumen in the urine. No other signs of disease found. An ergot mixture was prescribed.

March 30th: Not much difference in his condition. Vertigo is made worse on moving the head round to the right or the left, but not by moving it backwards. Nystagmus slightly less.

No other eye symptom. Tuning-fork on forehead is heard equally in both ears.

April 2nd. and 3rd: Better. Can walk by himself.

April 4th: An iron mixture ordered.

April 11th: Vertigo gone. Slight headache.

April 27th: Headache persists, but is otherwise well. He goes into the country, and after a rest obtains employment there. A subsequent report states that he has quite recovered.

CASE XLVI.--Vertigo: probably auditory.

J.J., aet. 24, has worked in compressed air for six months. Had an attack of "bends" after working in Caisson No. 1 on March 25th, which caused him to lose two days' work. On April 5th he had worked about ten shifts in this caisson, and he left work at 10 p.m. At 11 15 he felt "blind and giddy," and would have fallen if not held. He went home, and ~~XXXXXXXXXX~~ re-

mained in bed until April 8th. The next day he sought medical advice. He has noticed no deafness and no noises in the ears; has had no trouble with his ears on going through the locks. Watch is now heard at 2 feet in right ear, and at 4 feet in left ear; on forehead it is best heard in right ear; no sign of disease in either ear. Vertigo is still present, and is especially brought on by lateral rotatory or vertical movements of the head. Mist. ac. sulph. dil. \bar{c} strych. given.

April 13th: Vertigo better; disappears entirely on lying down. Hearing the same, and good on both sides. No other symptom of any sort.

April 16th: Giddiness has quite disappeared.

CASE XLVII.-Temporary unconsciousness.

Jn. C., aet. 21, has worked in compressed air for nine months: recently in Caisson No. 2. Finished a seven-hour shift at 5 a.m., Aug. 24th, (pressure 32 to $34\frac{1}{2}$ lbs), and then

went to do some work outside. At 5.45 he felt a pain in the forehead, and then he appears to have become unconscious, or partly so, and "to have torn his hair." He was brought over to the south side in a boat, and put into the medical lock, where he was seen medically at 7 a.m. during the process of recompression. Pressure had then reached 3 lbs. only. He was normal in every apparent way. Pressure was raised to the full extent-about 20 lbs. He "leaked out," and then walked home. He is a teetotaler, and smokes very little.

Aug. 26th: Feels quite well, and has done so since he came out of the medical lock on Aug. 24th. Having come out of the "air" one hour earlier than usual on Aug 24th he had had no coffee; but he had done precisely the same on the previous day, and had not then suffered in consequence. He states that he has occasionally had, after returning home from working in Caisson No 2-i.e., half an hour after coming through the locks - a

slight blurring of the sight, and has seen stars; had no pain in the forehead on these occasions. Has never had any trouble with his ears.

Aug. 28th: Returns to work in the tunnel to-day, and not in the higher pressure of the caisson.

CASE XLVIII.-Oedema of scrotum and abdominal walls.

C.A., aet. 27, has worked for considerable time in compressed air both here and at the Hudson River tunnel. On Aug 5th, he applied for advice concerning oedema of scrotum, front and sides of abdomen, and slightly of legs, which he noticed on the previous day after working in compressed air. The scrotal oedema is considerable. No disease of heart, kidneys, or liver. Nothing abnormal found in the abdomen. He had an attack of "bends" on Aug. 1st, for which he did not seek medical advice, but otherwise has felt no bad effects from the pressure. He has recently been working in the high pressure of Caisson No 2,

which has varied from 25 to 32 lbs. Recommended to cease work for a short time, and to lie in a horizontal position. A diuretic mixture given.

Aug 7th: OEdeMa much less.

Aug. 9th: Without again reporting his condition he returns to work in Caisson No. 2 (6 a.m. to 2 p.m.). Afterwards he has pain in the left ankle, which lasts the whole day and the following night.

Aug. 10th: Again seeks advice. Recommended to give up working in the high pressure of Caisson No 2, and to work in the lower pressure of the tunnel on the south side.

Aug 15th: Since the above note he has worked two shifts in Caisson No. 2, and he to-day seeks advice because, after coming out and going to bed, he had a difficulty in breathing while lying down: better on sitting up. Slight hacking cough. No physical signs of disease. Promises to give up working in

Caisson No 2.

CASE XLIX.-Dysphagia, etc.

W.P. only occasionally works in compressed air. On the night of Jan. 10th, he was in for nine hours. On the morning of the 11th he felt a "sort of knot" in the middle and inside of the chest, which feeling extended back between the shoulders. No cough. Some dysphagia. No physical signs. Has often worked in compressed air before, but has never had the same experience. Applied for advice on Jan. 12th. Examined, and advised to report himself again if the feeling did not go off. Did not come again.

CASE L.-Fit (? epileptic) while in the compressed air.

J.B., aet. 28, has been working in compressed air for five months. On Feb. 26th, at 5.45 p.m., while working in the shield, he felt suddenly giddy; surrounding objects appeared to be moving towards the left. He fell down unconscious, and remained

so for about twenty minutes. During this time he was carried out, and seen by me just outside the air lock; he was then sitting upon a truck, and rambling in his speech. Pupils equal. There had been no convulsions. He was brought up by the cage to the surface. He then became very excited and quarrelsome; stated that he had lost his belt; and said he wished to be left alone, that he had just left off work, and that it was 10 p.m. Then, again, he did not know how long he had been at work, or why he had left off; was quite unreasonable, and refused to lie down. There was no sign of organic disease, except that there was a trace of albumen in the urine, and he had had no previous fits; had had a "cold" for the preceding fortnight, but had never suffered from the compressed air in any way beyond sometimes having a difficulty with his ears on entering. Seen again Feb 28th: quite well. Recommended not to work again in compressed air.