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**COAL-MINERS' NYSTAGMUS.**

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Thesis submitted for the M.D. Glasgow

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## Introduction.

The condition known as miners' nystagmus is particularly interesting because of its occurrence in coal miners only, no case of miners' nystagmus ever having been recorded in a miner in other than a coal mine (Elworthy, B.M.J. Nov. 19th, 1910).

Practically all men working in a coal mine are liable to be affected with it, though those engaged in particular kinds of work in the mine appear to be more liable than others. It has been stated that 20% of the men working in coal mines are constantly affected either consciously or unconsciously (Nuel, Bull. de la Soc. Belge d'Ophth. 24, p. 46). Its onset, in a large proportion of cases is insidious producing no symptoms at all, or at least these are so slight that the miner does not seek medical relief and the condition is perhaps only noticed by a careful observer when consulted for some totally different cause.

Dr. Court of Staveley (Miners Nystagmus, pamphlet published by the Derbyshire Miners Union), found that out of a total of 1097 men who were not selected but simply invited to submit themselves for examination, 221 or 20.1% were affected. Ramière (Bull. de la Soc. Belge d'Ophth. 25, p. 76) has found as high a percentage as 65. A condition at one time unknown -

it was first described in 1861 - it is becoming more and more common in proportion as the number of deeper and less safe mines in which safety lamps are used increases. It is seldom, or at any rate much less frequently, met with in those working in the shallower mines where the open light is used.

Further attention has recently been drawn to the condition owing to the fact that it has been placed on the list of Industrial diseases under the Workmens' Compensation Act, 1906, whereby any workman suffering from it, however slightly, is entitled on demand to a weekly payment of anything up to £1. My experience has shown that, if a man has been receiving compensation for nystagmus, his employers are very unwilling to retain him afterwards as a regular workman underground. He is discharged at the first opportunity and very often experiences difficulty in obtaining employment underground at any other colliery.

Many theories have been advanced as to its causation, no single one of which can be said to fully explain the condition. That the etiology is of the greatest importance there can be no doubt since upon an accurate knowledge of the origin of the condition must depend our appreciation of the nature and effects of the diseased process, thereby affording us a reasonable guide to our treatment and prognosis.

As the condition is of great interest and the

etiology still obscure and the treatment both prophylactic and curative of great importance, I have thought the subject suitable for a thesis having been for some years in practice in a colliery region and having had the opportunity of observing a good number of cases.

In the present thesis, I propose to discuss the recent developments in connection with this disease based on 12 cases.

The disease is characterized by a peculiarly insidious onset, the patient being usually well at the time of the attack, and the disease is usually fatal. It is a disease of the colliery workers, and is especially prevalent in the superior class of colliery workers. The disease is characterized by a peculiarly insidious onset, the patient being usually well at the time of the attack, and the disease is usually fatal. It is a disease of the colliery workers, and is especially prevalent in the superior class of colliery workers.

Dr. [Name] (1887) wrote in the British Medical Journal associating it with the position assemblage and associating it to cerebral aneurysm. The aneurysm produces a peculiar disease, especially of the brain, which derives its origin from the [Name] position, i.e. the position of the [Name] position.

## Historical Outline.

The earliest recorded cases of miners' nystagmus are two mentioned by Decondé in 1861 in a paper dealing with nystagmus generally and his experience was gained amongst the Belgian miners.

The first in England to investigate the condition was the late Mr. Simeon Snell, F.R.C.S. of Sheffield, whose recorded work dates from 1875 and whose views were supported by Dransart in France. These men associated the condition with the position assumed by a portion of the colliers at their work and regarded it as a myopathy having its seat in the recti muscles - especially the superior Bell Taylor (1875) regarded the condition as an occupational neurosis, strictly analogous to writer's cramp.

Jeaffreson (1887) wrote in the British Medical Journal associating it with the position assumed at work and ascribing it to cerebral anaemia. "The cramped position on the haunches produces a cerebral anaemia, chiefly of the parts which derive their supply from the basilar arteries, i.e. the occipital lobes; this is caused by the pressure of the tentorial ring, when the head is thrown far back, on the upper part of the pons. The cramped position leads to a 'dissociation of naturally associated centres.'"

Peters also connects it with the position of the miner at his work and advances a theory to show that it is caused by afferent impulses from the semi-circular canals, whose functions have been modified by the position of the miner at his work.

Dr. Court of Staveley concluded, on behalf of the Derbyshire Miners Association, an investigation into the subject to clear up, if possible, the causation of miners nystagmus, and especially with a view to determining the part played by illumination. He produced figures which showed a striking preponderance in the percentage of cases of nystagmus in safety lamp mines as against candle mines.

Wilbrand was the first to associate nystagmus with derangement of "a" centre in the brain. Sir W. Gowers also associated it with a brain centre and developed a theory based on the experiments of Professor Sherrington with "spinal" animals.

Reid extended Gower's theory - he accepts the existence of an eye equilibration centre and assumes that it is affected in a functional manner which is in the direction of suspension of its functions by

- (a) Poor illumination - abolishing the superior macular image;
- (b) The constant tendency to disturb the equilibrium of the body entailed by the nec-

essary swinging movements of the arms with the pick, with the jar at the end of the stroke.

Barany has recently done work in connection with the ears and found that he could produce nystagmus by injecting hot or cold water into the ears.

Duane has classified nystagmus according to the character of the movements and Romièe and Zur Nieden have observed the rate of them.

The character of the movements of the eyeballs in the various kinds of nystagmus of the eyes is separated into three main varieties.

(1) The searching nystagmus of Byrd. The movements are of the nature of a series of jerks performed by the eye in its passage from near the one center to the other, to return in a long sweeping movement. The movements are apparently purposeful and may take place in any direction and occur in a variety of diseases of the eye and brain. It is a common feature of the disease known as strabismic nystagmus.

(2) The periodic nystagmus. This is a form of nystagmus in which the movements are of a regular, rhythmic character and are usually of a slow, oscillatory nature.



### Causation.

Nystagmus, or oscillation of the eye-balls, is a phenomenon which manifests itself in a great number of circumstances, the great majority of which are of an abnormal nature.

The variety of nystagmus met with in workers in coal mines differs very materially from other varieties for, whilst the other varieties are of great diagnostic service as evidence of organic disease in the structures related to the ocular muscle-reflex centre, that variety met with in miners occurs without organic disease affecting any of these structures.

The character of the movements of the eyeballs is the dividing line whereby tremor of the ocular movements is separated into three main varieties.

(1) The searching nystagmus of Sym. The movements are of the nature of a series of jerks performed by the eye in its passage from near the one canthus to the other, to return in a long sweeping movement. The movements are apparently purposeful and may take place in any direction and occur in adults with total blindness or when the power of central fixation has been destroyed.

(2) Pseudo nystagmus, which has been distinguished from true nystagmus by Duane, occurs when the

eyes are near the limit of movement in any direction and is characterised by a series of jerks by which the eyes are carried beyond the point of fixation but in returning do not repass it. These jerks evidently represent an extreme effort to keep up the original excursive movement of the eyes, the smooth steady pull of the muscle that is carrying the eye along being converted into a series of discontinuous, spasmodic jerks.

(3) Nystagmus. In true nystagmus the eyes make a series of very regular, short, quick, smooth oscillations about the time of fixation of the eyes. The movements are oscillations to and fro about a central point, may take place when the eyes are in the primary position or near it, and are smooth and regular not bespeaking effort.

The movements met with in the eyeballs of men suffering from miners nystagmus are of the last variety and the rate of the oscillations varies within wide limits - from 100 per minute to 360 per minute (Zur Nieden) or to 500 per minute (Romée, *Étude sur le nystagmus des Houilleurs*, Liège, Bertrand, 1892). The oscillations may be to and fro, or rotatory, or the two may be combined, but the rotatory movements are seldom, if ever, absent and a miner frequently

describes the lamp as appearing to move rather more in an eclipse than in a circle. The nystagmus is arrested by turning the eye downwards. On the other hand, if the man fixes an object, held so that the eyes are turned upwards a little, the movements may be seen as soon as he fixes it. Often no movements are seen if he is still and only appear after making him bend up and down quickly.

The onset of miners' nystagmus is, in the majority of cases, insidious and the patient is for a time quite unaware that he has anything wrong with his eyes although nystagmic movements may be quite obvious and definite - there are no symptoms to direct the patient's attention to the condition of his eyes. Sooner or later, however, symptoms develop and their onset in some cases may be determined by such causes as accident or illness. When the symptoms develop naturally the first to come on may be a sensation as of the lights in the mine dancing or becoming blurred or headache and giddiness may be the first.

When movements are well developed everything seems moving about and he becomes giddy and staggers. Bending down, or sudden movements, increase the trouble. A man may be able to walk about the street

well enough, but, if anyone shouts at him, he is immediately lost in a fog and staggers about, quite unable to see what is coming or where he is going. Hence the danger of such men working in mines.

Snell has established the fact that a coal worker suffering from miners' nystagmus is unable to recognise the "cap" which forms on the light of a safety lamp in the presence of fire-damp and consequently is a menace to the safety of the mine.

The age at which men are affected has been stated variously, but the condition seldom manifests itself until the miner has been working underground for a number of years. The average age of Snell's cases was 39.2 years and the average number of years worked underground before the condition manifested itself was 21.8 years. Elworthy of Ebbw Vale, gives his figures as  $35\frac{1}{2}$  years and  $21\frac{1}{4}$  years, while my own cases work out at 38.8 and 24.4 respectively. The earliest cases recorded by Snell are two aged 16 years and 18 years, the latter of whom had worked in the mine for 5 years, whilst Elworthy's earliest case was 15 years of age, after 3 years' work in the mine, but he suspects it was hereditary. The earliest case I have come into contact with was 22 years of age and had worked underground for 8 years but these early

cases are exceptional.

The majority of cases of miners' nystagmus have very fair vision and there is no contraction of the visual field in any direction.

As regards refractive errors, 8 out of 134 of Snell's cases presented errors of various kinds, and my own cases have been most emmetropic, with a few cases of presbyopia in the older men.

Snell has seen nystagmus in association with exophthalmic goitre and spasmodic torticollis in miners. Miners' nystagmus is met with in workers in coal mines only, Elworthy's enquiries regarding its incidence amongst the lead miners of the Isle of Man and the tin miners of Cornwall having proved negative.

There are two views as to the cause of miners' nystagmus. Snell held strongly the view that it was due to strain of the extrinsic muscles of the eye, especially of the elevator muscles, due to the position of the miner when at work at the coal face. On the other hand, Court attributes it to eye-strain due to working in a badly lighted space with black light-absorbing surfaces.

Snell's position depends on the following points.

- (a) The position of the miner.

(b) The strain on the elevators of the eyeball, and  
(c) The consequent weakness of the elevators, and  
he was supported in his views by Dransart in the North  
of France and Nieden in Germany. As these men regard  
the actual work of the miner as the prime cause of the  
nystagmus, it is well to know something of the many  
various kinds of work in progress in a coal mine.

The two main divisions of men employed in a  
coal mine are

- (1) Those who "get" the coal, and
- (b) Those who depend on the labour of the  
coal-getter.

The coal is got by "hewing" or by "holing."  
The "hewing" consists of removing the coal by the  
direct action of the pick.

The "hol-ing" is divided into "top-holing" and  
"bottom-holing," of which the latter is by far the more  
common.

By "holing" is meant the removal of a thin  
layer of coal from the top or the bottom of the seam  
preparatory to getting it down. In the act of "hol-  
ing" the miner works lying on his side and strikes  
the coal with a horizontal swing of the pick. The  
layer of coal thus removed varies from 18" to 24" in  
height at the commencement of the act. The under-  
cutting proceeds for a distance of 2 feet to 8 feet

and the miner has gradually to insinuate his body into the narrow cleft he is excavating, so it is easy to understand that the "holer" works in a very constrained position.

The other men engaged in a coal mine are mainly concerned with removing the coal from the "face" to the "bank" and are constantly moving in low passages with the body bent and the gaze frequently upturned to the roof.

"Deputies" have the care of the ventilation of the mines and the safety of the passages and working places. They frequently have to examine the workings for gas and the roofs for faults, both of which duties involve looking upwards.

Thus all underground workers put a large amount of strain on the elevators of the eyes.

It is to the position assumed by the miner in the act of "holing" that Snell ascribes the occurrence of nystagmus. In this work the miner is lying on his side, cramped into an awkward and uncomfortable position and looking upwards and to one side. There is no doubt that the miners who develop nystagmus are mainly those who work at the coal face and Snell's whole force was concentrated in proving that the "holers" were the vast majority of the cases. He says,

"With few exceptions the miners have been those whose work has been done on their sides as "holers." He also states: "The men described as working straight forward "cutting" or "heading" do not, except they also do "holing", according to my observation, suffer from nystagmus. The occasional instances met with in fillers will readily be explained when analysed, and will be found not to be at variance with my contention that miners' nystagmus is associated with the work called "holing" or one necessitating a somewhat analogous attitude of the eyes."

Snell's photographs are all made to show this position but the miner, although in the act of "holing" he works on his side, like anyone else at work, looks at the object of his work, which in his case is the patch of coal at which he is aiming his pick.

T. Harrison Butler says: "Nystagmus is not, as Snell and Dransart would have us believe, confined to "holers" i.e. those men who lie on their side and undercut the coal; it is more common in these men, but is often seen in all men who work in the pit. I have recently met with a pronounced case in a man working in the Griff Colliery, which is mainly a candle mine, who had done no "holing" for years."

Jeaffreson states that nystagmus is common in



Durham, where no holing is done.

J. Court, in the pamphlet which describes his investigations, admits the large percentage of cases in "holers" and part-time "holers," but attaches no importance to the position. He says the position has little, if anything, to do with it.

Reid, of Nottingham, found nystagmus in Yorkshire where no "holing" was done.

Tatham Thompson, in his experience of South Wales mining, says he finds nystagmus more common in those who work in the house coal seam which is much thinner and where "holing" is done.

H. S. Elworthy writes: "As to the theory that nystagmus is produced by working while lying down, I can give no opinion, as the great majority of Ebbw Vale colliers, I am told, work in the upright position; and besides, other underground workers get nystagmus, such as hauliers, timbermen, and repairers in coal mines."

My own experience, confined to South Wales, agrees with that of Court, Elworthy and Tatham Thompson, i.e. whilst the workers at the coal face form the majority of the cases, no class of adult worker is immune and that the disease is more common in those working in steam coal than in those working in the house coal seam.

The part played by the ocular muscles in the pathology of miners' nystagmus is expounded by Snell as follows:-

"Miners' Nystagmus is, I believe, a myopathic disease. It is, indeed, a local affection, and as a result of prolonged strain in an unusual and constrained position, often for long and frequently recurring periods, chronic fatigue in the ocular muscles, is brought about, and atony being induced, oscillation of the globes is caused."

"This kind of nystagmus is another instance of muscular disability induced by overwork. Its pathology is similar in this respect to writers', pianists', and other forms of professional neuroses."

This is the view also taken of the pathology of the disease by Dransart.

"The myopathy," he says, "will have its principal seat in the superior rectus and inferior oblique muscles; it occasions merely a weakness in these organs. The pair of elevators having an acquired feebleness cannot overcome its antagonist by a single effort, it is obliged to attempt it several times by means of a series of little successive and rapid contractions. It then produces nystagmus, or rather gives occasion to vertical oscillations. To explain the horizontal oscillations which are noticed in min-

ers' nystagnus we must have recourse to the paresis of the internal recti and the accommodation. The impotence of the internal recti can suffice to explain the horizontal oscillations; they are produced by the same mechanism as the vertical ones; But the accommodation contributes to increase the muscular disorder by virtue of the relations which exist between convergence and accommodation, or in other words between the ciliary muscle and the internal rectus."

The arguments regarding the strain of the elevators of the eyes and the consequent weakness or fatigue thus brought about in them may be met as follows:

The experienced miner does not find it necessary to keep his eyes fixed on the roof, i. e. in elevation, during his passage to the coal face. The "deputies" put as much strain on the elevators as any other class of underground worker and they are not affected in any greater proportion than the others.

No case of nystagnus has been recorded as having occurred in a ceiling decorator, an occupation which entails a greater strain on the elevators than any other.

As regards the fatigue, this has never been

known to exist. And besides, in Erb's disease, (in which fatigue of the muscles can be readily and rapidly produced when excited either by the will or by the faradic current) after the ocular muscles have been fatigued, the nystagmus which can then sometimes be elicited, is of a jerky character and not like the smooth, regular oscillations met with in miners' nystagmus.

As on the one hand the position assumed by the miner at his work and the strain and consequent fatigue of the elevator muscles of the eyeballs, so on the other imperfect illumination from the safety lamps, has been advanced to account for the causation of nystagmus.

Previous to 1850, in which year the safety lamps were introduced, the illuminating agents were candles and torch lights but as all candles are not of standard power some figures are necessary to a clear conception of the value of these as illuminating agents.

Standard candle power.	1 C.P.
Tallow candles (16 to the pound).	.69 C.P.
Tallow candles (18 to the pound).	.55 C.P.
Torch lights.	2 to 3 C.P.
Primitive Davy lamp.	.28 C.P.

Marsant Safety Lamp. .66 to .75 C.P.

Muessler Safety Lamp. .44 C.P.

The Marsant and the Muessler lamps are the two now in most common use, the Marsant in England and the Muessler in Belgium. These are oil lamps but, unlike the Davy lamps which were completely enclosed in wire gauze, in them the flame is shining through clear glass.

But the candle powers given to these lamps are true only when the lamps are clean and when the coal dust has accumulated on the lamp glasses their illuminating powers fall by 25%.

Then the miner can use a candle much more freely than a safety lamp; he usually sticks it into a piece of clay and places it close to where he is working. On the other hand a safety lamp does not lend itself to such treatment; it is forbidden by law for the miner to place his safety lamp within reach of the swing of the pick. Consequently the safety lamp is usually twice as far away from the actual spot to be lighted and in this way the illuminating power of the lamp is diminished.

Court summarises his views on the causation of miners' nystagmus by insufficient illumination as follows: "Inquiry has satisfactorily convinced me that it is the want of a good light that is the only

cause of the mischief," and produces the following figures in support of his contention.

Number of men working with safety lamps.	524.
Number of cases of nystagmus.	164.
Number working with torchlight.	231.
Number with nystagmus who had always used torchlight.	0.
Number with nystagmus working with torchlight who had previously used safety lamp.	6.
Number working with candles.	342.
Number with nystagmus who had always used candles.	3.
Number with nystagmus working with candles who had previously used safety lamps.	23.

This view has been confirmed by the independent researches of Dr. Llewellyn, of Bargoed, and is also the one accepted by the miners themselves who frequently "blame them lamps."

Harrison Butler says, "There is no doubt that nystagmus is far more common in safety lamp mines than in candle mines."

Nuel states that "the frequency of nystagmus varies in inverse ratio to the illumination of the mines." On the other hand Snell regards the faulty

illumination as a very minor element in the production of the disease. He says, "It has been shown that notwithstanding a noteworthy improvement in the illuminating powers of modern protected lights, the disease is not less frequent. The importance of not accepting any instances of alleged benefit resulting from simply changing from a safety lamp pit to a candle lighted one has been shown, and cases have been mentioned in which either no improvement has taken place, or the condition has become worse. Moreover, the occurrence of nystagmus in candle lighted pits, and indeed of men so suffering who have never used a safety lamp, thoroughly disposes of such a hypothesis; and the fact of the existence of nystagmus and as it has been shown by no means infrequently in miners working with candles - - - - - is evidence of a character preventing the acceptance of 'safety lamps,' or for that matter the mode of illumination, so playing a prime part in the causation of miners' nystagmus."

Nystagmus has been found in persons working in mines where the illumination was carried on by candle light and flare light. Now these conditions as regards illumination were prevalent for a long time previous to 1850 and nystagmus was unknown.

Snell also states, "If imperfect illumination

were the cause of the disorder - - - - - all the ocular muscles should be implicated." But the oscillations are rendered evident or made worse only on looking above the horizontal line and not below it.

Byron Bramwell (Lancet 1875, Vol. II. p. 763) points out that the oscillations are not increased by dim light. If defective illumination were the cause, one would expect the condition to be worse when the causative factor is present than when it is absent.

In factories where photographic plates are made, the work in connection with the ordinary plates is done in a very feeble red light and that in connection with the isochromatic plates in total darkness. Now nystagmus is unknown amongst these workmen. The absence of asthenopia in cases of miners' nystagmus is evidence that the defective illumination does not cause strain on the intrinsic muscles of the eye.

Peters has evolved a theory to show that miners' nystagmus is of labyrinthine origin and builds it up as follows: Backward inclination of the head results in a passive movement upwards of the eye and a forward movement of the head after backward inclin-



ation is accompanied by a passive movement of the eyes downwards. In these movements a redistribution of the endolymph in the vestibule is produced by gravitation. If this marked backward inclination of the head, which results as a compensatory movement to upward movement of the eyeballs, is maintained for 8 hours a day for years, a new condition of equilibrium will be brought about to a certain degree, in which the backward bent head and the upturned eyes will have adjusted themselves with the position of the rest of the body.

If with the return from work, the position of the head and eyes is changed to upright, an irritation in the vestibule will be caused by the change in equilibrium, which may be manifested reflexly from the central apparatus to the eye muscles. At first the condition will remain latent, and additional irritation in the form of increased innervation to produce action of the elevators is necessary to make it manifest.

One cannot, however, agree with Peters because he asserts that an incipient attack may be warded off by holding the head backward, which statement is contrary to my experience.

Reid's Theory.

This theory is an extension of Gower's theory of nystagmus. He accepts the existence of an eye equilibration centre and assumes that it is affected in a functional manner which is in the direction of suspension of its functions by

(a) Poor illumination - abolishing the superior macular image.

(b) The constant tendency to disturb the equilibrium of the body entailed by the necessary swinging movements of the arms with the pick, with the jar at the end of the stroke and suggests that the rhythmical swing and sway of the body may possibly act through the medium of the semi-circular canals.

Reference will be made later to the relationship existing between the semi-circular canals and nystagmus.

Sir W. Gowers has advanced a theory of causation of nystagmus and bases it on the researches of Professor Sherrington into the action of antagonistic muscles and the spinal centres.

The latter found that in animals, if the spinal cord is divided in the cervical region, so as to cut off the voluntary impulse from the brain to the spinal centres, these centres pass into a peculiar functional state. When contraction is excited in a

group of extensor or flexor muscles, their action ceases suddenly and contraction occurs in the opposing group, to cease in its turn, when the first set again contracts. An alternate contraction of the two opposing sets of muscles is thus set up, which goes on automatically. If the nerve to the opposing group be divided and the proximal end is stimulated, the effect is at once to inhibit the centre for the acting muscles. Since the nerve is purely muscular, the inhibition must be due to an impulse from the opposing group caused by their extension, doubtless through the agency of the muscle spindles, and it also causes their own contraction. This process goes on alternately by a muscle reflex action.

These facts Gowers has applied in his theory of the mechanism of nystagmus. He assumes that the centre (this centre with first assumed by Wilbrand) which combines and co-ordinates the actions of the ocular muscles has also a muscle-reflex action. When this centre is disturbed by various influences the control of the muscle reflex diminishes or disappears and under the influence of extrinsic stimuli the muscle-reflex action tends to commence.

The only objection to this theory is that a rapidity of 360 oscillations per minute does not al-

low much time for complicated nerve reactions.

Accepting this theory as a working hypothesis, examination may be made of the influences at work in the life of the collier which may conceivably affect the centre and in doing so will begin with the miner on his way to work.

The first abnormal influence to which the miner is generally subjected in the course of his day is the descent of the mine and, after his day's work is done, the ascent. As the perfection of the steam winding engine has been more nearly approached this influence has become more and more pronounced, and it is possible to trace a distinct relationship between the rate of winding and the occurrence of nystagmus in miners.

In considering this influence some figures are necessary to a clear conception of the difference which exists with regard to this influence as present today compared with what it was 50 or 60 years ago when nystagmus was practically unknown.

Old coal mines were entered very often by an adit and in cases where there was a shaft and winding was done, the rate of winding was very slow and the depth of the mine was very shallow. Previous to the middle of last century the deepest coal mine was about

100 feet and this has gradually increased, as the old seams have become worked out, till the depth of the present day mines varies from 100 yards to 800 yards.

As will be seen from the following figures, the depth of the mine bears a distinct relationship to the rate of winding - the rate of winding, providing other things are equal as regards machinery, varies directly as the depth of the shaft of the mine.

Rates of winding.; present day figures.

Depth of shaft.	Average speed of cage.
100 fathoms.	25 feet per second.
200 fathoms.	30 feet per second.
300 fathoms.	35-40 feet per second.
400 fathoms.	45 feet per second.

In 1880 these average speeds were about  $\frac{2}{3}$  the above. In 1860 the speeds were about half the present day speeds, while in 1840 they were extremely low. From all this it will be seen that there has been a great increase not only in the depth of coal mines, but, what is more important, also in the rate of winding which is used in connection with them. This appears to be the only abnormal influence at work in the course of the miner's employment which has increased - the ventilation of the mines is much more efficient now than formerly and a very marked

improvement has been effected in the illuminating agent used by the miners - and the incidence of nystagmus has increased with it.

In the South of Wales coalfield, where the coal is found in two seams, the steam coal is always much lower down than the house coal. In the collieries with which I was connected the depths of the two seams were as follows:-

Number 1. colliery :

House coal seam. 110 yards.

Steam coal seam. 290-320 yards.

Number 2 colliery :

House coal seam. 200 yards.

Steam coal seam. 350-390 yards,

and the same method of illumination was in use in both these seams.

Now we have seen that the rate of winding varies directly as the depth at which the coal seam to be reached is found; consequently the rate of winding for the steam coal seam is greater than that for the house coal seam.

As it has been mentioned in another part of this thesis, Tatham Thompson found nystagmus with greater frequency amongst workers in the steam coal seam than amongst those working the house coal and my own observations agree with this.

In further support of the contention that nystagmus is due to the winding there is the fact that no cases have ever been reported as having developed when the miner was not wound up and down a shaft and Snell mentions a case which developed when the man was working in an engine-wound safety lamp mine, who recovered on going to work in a mine which was entered by an adit. When a coal miner arrives at the bottom of the shaft the light of his lamp appears to him to be blurred, he sees indistinctly, and has to wait for his eyes to "settle." That this is not due to the miner seeing with his rods in the dim light of the mine is evidenced by the fact that he can distinguish the red end of the spectrum in the pit and that it is not due to any marked difference in the degree of illumination at the bottom as compared with the top of the shaft is shown by the fact that men working in mines where electric light is used at the bottom of the shaft experience the same thing.

There are some marked differences with regard to this influence in the life of the coal miner when compared with the metal miner.

The average depth of metal mines is less than half that of coal mines though there are exceptions notably the Dalcoath tin mine in Cornwall which is

250 fathoms deep.

Many metal mines are entered by an adit - the Lanarkshire ones are so entered now and up till two years ago those at Laxey I.O.M. were entered in the same way.

Other metal mines are entered by climbing up and down ladders and in those where the men are wound up and down a shaft, the rate of winding is slow. The rate of winding in the case of metal mines is less than half that of coal mines. There is an engine-wound lead mine in Cumberland but the rate of winding is only 10 feet per second.

Much work has recently been done, more especially by Barany, on the functions of the labyrinth, and the most important clinical outcome of his labours has been the discovery that the labyrinthine reflex of nystagmus can, under certain conditions, be provoked.

When a patient, with head erect so that the horizontal canals are acted on, is rotated to the right - at the beginning of the rotation a horizontal nystagmus is produced which is intensified on looking towards the right side and which diminishes or ceases entirely if the patient is made to look to the left side; when the rotation is suddenly stopped the ny-



stagnus is intensified by making the patient look towards the left side and is diminished or ceases entirely on looking towards the right. The explanation is that at the beginning of rotation the endolymph will tend to lag behind and there will be relatively a flow of endolymph from the convexity of the right horizontal canal towards the ampulla. As rotation continues the endolymph gradually attains the same speed as the canal. If now rotation is stopped there will be relatively a flow from the ampulla towards the convexity.

All movements of the endolymph of the horizontal canal of the opposite side will be in the reverse direction.

If the head is inclined  $90^{\circ}$  towards the shoulder a vertical nystagmus is produced; if forwards or backwards a rotatory nystagmus, for now the posterior vertical and the anterior vertical canals are affected.

Scott forms the following rule: "The deviation of the eyes is in the same direction as the current in the endolymph, and the nystagmus is in the opposite direction."

Regarding the formation of currents throughout the whole canal Scott says, "Whether there is a flow throughout the canal or not does not affect the poss-

ibility of movement of endolymph in the ampulla alone. If normal stimulation of the ampullary nerves is due to temporary change of pressure it must be because this change of pressure has produced a movement in the endolymph. It is only a stage further to suppose that this is accompanied by a movement of the extremely delicate fibrillae of the epithelial cells of the ampulla. - - - - -In no case is it necessary to imagine the current flowing rapidly through the semicircular canals, though it is necessary to admit movement of endolymph in the ampulla itself."

To the reaction produced at the commencement of rotation Scott applies the term alpha reaction and to the reaction produced when rotation is suddenly stopped he applies the term omega reaction.

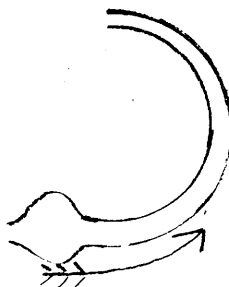
After unilateral ablation of the labyrinth and on rotation to the ipsilateral side he finds the alpha reaction much weaker than the omega reaction, which is exaggerated. When the rotation is made to the contralateral side the alpha reaction is much greater than the omega reaction.

Position of right anterior vertical canal - patient sitting up with head bent forward.



Direction of current in omega reaction.

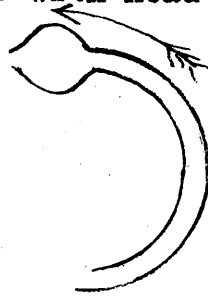
Position of right posterior vertical canal with head inclined 90° towards right shoulder.



Direction of current in omega reaction.

Position of right external canal with head erect.

Direction of current  
in omega reaction.



In ablation of the labyrinth of left side and when rotation is made to the left, i.e. the ipsilateral side, the alpha reaction is much weaker than the omega reaction, i.e. currents from the ampulla towards the convexity produce stronger reactions than those in the opposite directions in the case of the two vertical canals, and currents from the convexity towards the ampulla produce stronger reactions than currents in the reverse direction in the case of the horizontal canals.

Now consider the miner in the descent and the ascent of the shaft of the mine. At the commencement of the descent there will be a pressure, in the two vertical canals, from the ampulla towards the convexity. Then the endolymph will attain the same speed as the canals and at the end of the descent there will be a pressure from the convexity towards the ampulla. In the ascent the order of the pressures will be reversed. Thus the currents from the

ampulla to the convexity and the currents from the convexity to the ampulla would be expected to neutralise each other. But it has been shown that the currents from ampulla to convexity produce stronger reactions than the reverse currents; consequently, when the centre with the muscle reflex action becomes disturbed from these abnormal stimulations carried on for a number of years, the reaction produced by currents from ampulla to convexity in the case of the two vertical canals will predominate - thus the rotatory movements are seldom, if ever, absent and the nystagmus is worst on looking upwards and ceases on looking downwards.

In men who use the pick in the mine, the head and body is constantly swinging backwards and forwards with the pick - this tends to produce currents in the posterior canals and hence nystagmus is more common in these men than others, and the nystagmus is elicited, as Elworthy points out, on making the man bend up and down quickly.

This explains too, how it is that shouting at anyone with nystagmus, who is perfectly well able to walk about the streets, causes him to be immediately lost in a fog and to stagger about, quite unable to see what is coming or where he is going. Scott

says, "By means of the mechanism of the stapedial foot-plate and the formation of the membrana secundaria which closes the fenestra rotunda, it will be understood that any to and fro movement of the stapis, due to compression and rarefaction waves of sound, will cause synchronous movements of the membrana secundaria through the intervention of the perilymph.

Those who have studied the cochlea from the physical aspect conclude that the motion in the perilymph can be no other than mass motion. Such mass movement of perilymph must affect the pressure in the endolymph, possibly in the form of compression and rarefaction waves."

## Treatment.

### (1) Prophylactic.

Snell advocated giving up the work of "holing" but, in view of the fact that nystagmus is not confined to "holers," this would seem to be of little value though in those men whose work in the mine entails swinging movements of the head and body with the pick are more liable to be affected than the other workmen, the giving up of such work would tend to mitigate the condition.

On the other hand better conditions as regards illumination have been advocated and Elworthy has proposed having the mines whitewashed but this would seem to be quite impossible owing to the large size of many of the mines, the coal dust laden currents and the continually altering face. Not only so, but the fact of nystagmus occurring in miners working in mines lighted by flare lights and the fact that the miners have to wait for their eyes to "settle " after reaching the bottom of the shaft in mines where electric light is used (and the electric lights at the bottom of the shafts are usually 16 C.P.) tends to show that improved lighting would not obviate the occurrence of nystagmus.

As to the ventilation of the mines this is

secured by the Coal Mines Act.

The rate of winding the miners to and from their work should have the attention of the colliery managers; this rate should be approximately that used in the metal mines where winding is the rule, i.e. less than half the present day rate of winding in coal mines.

## (2) Curative.

The treatment of miners' nystagmus is very simple and, though mainly passive, is attended by very successful results.

The treatment should be instituted at as early a moment as possible after the diagnosis has been made - it may be taken for granted that the sooner treatment is instituted in a man with nystagmus the sooner will he get better.

Elworthy gives the following figures.

- 1 case of axial rotation recovered in 6 weeks.
- 18 indefinite cases recovered in an average of 3 months.
- 27 rotatory cases recovered in an average of  $4\frac{1}{2}$  months.
- 14 cases associated with nictitation recovered in an average of 5 months.
- 25 lateral cases recovered in an average of  $5\frac{1}{2}$  months.
- 11 vertical cases recovered in an average of 6 months.
- 12 mixed cases recovered in an average of 8 months.

His conclusion is "the cases with the greatest inco-ordination take the longest time to recover. The rotatory and indefinite take the least."

This should be directed first of all to the removal of the cause of the nystagmus. Hence the main indication is for the miner to leave his work and stop going down the mine altogether until the nystagmus has disappeared completely though it does not necessarily follow that the miner may not be employed above ground. It is necessary to insist on his absence from the pit till the nystagmus has disappeared completely as relapses are by no means rare and he often wishes to get back to work, when the symptoms have become less pressing though the physical signs have not disappeared, so that he can earn more money. Unsymptomatic nystagmus does not appear to interfere in any way with the miner at his work.

After the measures taken for the removal of the cause of the nystagmus the treatment should be directed to alleviating the symptoms. If there is much headache, giddiness or tremor, a course of sedatives such as the bromides may be given with advantage.

Photophobia should be relieved by the use of dark glasses. I have found no benefit from the use



of coloured glasses though Elworthy relates a case who got relief by going into a green field. Any refractive errors present should be corrected by the use of suitable glasses.

If the nystagmus has been consequent on any debilitating condition the general health should be attended to by a course of tonics such as strychnine and the hypophosphites.

On returning to work the miner should if possible obtain work which does not entail swinging movements rather than return to the "face" for a time.

Case 2, aged 30, worked underground for 10 years and had a rotatory nystagmus which was slight at the primary position and symptoms and signs cleared up in four months.

Case 3, aged 30, worked underground for 10 years in steam coal seam. Complained of headache, photophobia, and "dancing lights". The nystagmus, which was rotatory, was very rapid especially when worse on fixation upwards. His work was changed to surface work and the nystagmus cleared up in four months. His symptoms were relieved by treatment with the hypophosphites.

## Cases.

Case I. aged 22, had worked underground for eight years in the steam coal seam. Headache was the only symptom and the nystagmus was rotatory and present only on fixation upwards and to the left. He obtained work at the pit head for three months and then returned to his usual work underground with no symptoms nor signs.

Case 2, aged 41, had worked underground in the steam coal seam for 29 years, as a labourer. He had had no trouble with his eyes until he sustained a scalp wound and then he commenced to complain of "dancing lights" with headache and giddiness. He had a rotatory nystagmus which was slight at the primary position and symptoms and signs cleared up in four months.

Case 3, aged 28, worked underground for thirteen years in steam coal seam. Complained very much of headache, photophobia, and 'dancing lights.' The nystagmus, which was rotatory, was very rapid becoming much worse on fixation upwards. His work in the mine was at the 'face' with the pick. He was myopic and always wore glasses when not at his work. After seven months treatment, when I saw him last, the nystagmus was still very bad though the symptoms had

improved.

Case 4, aged 36, had worked house coal in a colliery where there was no steam coal for 24 years. Naked lights were used by him, he was a "holer" and would not leave his work though he had had symptoms for about a year.

Case 5, aged 43, for 32 years a worker at the 'face' in the steam coal seam complained of headache, giddiness and dancing lights. Had rotatory nystagmus which was slight with the eyes in the primary position but becoming very rapid and wide on fixation upwards. He was away from the pit for four months and persisted in returning to his usual work at the end of that time when the symptoms had disappeared but the physical signs not quite.

Case 6, aged 40, had been engaged underground for 26 years, for the past 6 of which he had been at the face in the house coal seam. He had never had any trouble with his eyes, till he had a cycle accident on returning from work by which he sustained slight concussion of the brain. After that he complained of dancing lights and headache and giddiness. Recovery was complete in five months.

Case 7, aged 40, engaged at face of steam coal seam for 24 years. No trouble until attack of influ-

enza which left complaint of moving lights. The nystagmus was rotatory, of medium severity, and he recovered in seven weeks.

Case 8, aged 43, worked underground in the steam coal seam for 31 years as a 'timberman.' No eye trouble till convalescent from influenza then dancing lights. Movements very fine and cure completed at end of four months.

Case 9, aged 43, worked underground for 30 years at the face in the steam coal seam. Has had trouble with his eyes for three years during 18 months of which I know he had nystagmus though he refused to leave his work. Headache was the most pressing symptom and he stated he could manage with the lights and giddiness though he often had to sit down.

Case 10, aged 47, worked in steam coal seam for 24 years as a labourer. Complained of headaches for two months and then slight rotatory nystagmus noticed. Had been under treatment for two months when seen last.

Case 11, aged 48, engaged at face of steam coal seam for 37 years, had been troubled with his eyes for two years before movements were noticed. He had been under treatment for four months when last seen.

Case 12, aged 33, for 18 years working at the face of the steam coal seam. Had had nystagmus for seven months with symptoms before giving up his work and had been under treatment for four months when symptoms disappeared. When I saw him last a month later, he still had the physical signs.

The proportion of steam coal workers to house coal workers was 8 or 9 to 1.

process in the rate of winding.

(2) That the depth of the mine is a geological factor in so far that the deeper the mine (other things being equal as regards machinery) the greater is the average rate of winding.

(3) That the majority of the men who suffer from it are men who are in the habit of swinging a pick at their work and I agree with Reid's suggestion that this also will act through the medium of the semicircular canals.

To prevent the occurrence of nystagmus in coal mines the rate of winding should be kept as low as possible and the speed of the winding should be gradually increased to a speed appropriate to the work. It is also suggested that the rate of winding should be kept as low as possible in the early stages of the work.

### Summary.

The view which I wish to put forward is that coal miners' nystagmus is due to a failure of the central nervous co-ordinating mechanism and that this failure is brought about by a long-continued series of abnormal impulses from the semicircular canals.

I maintain (1) that miners' nystagmus is closely associated with the practice of winding the miners in shafts and that the increase in the incidence of the condition amongst miners coincides with the increase in the rate of winding.

(2) That the depth of the mine is an aetiological factor in so far that the deeper the mine (other things being equal as regards machinery) the greater is the average rate of winding.

(3) That the majority of the men who suffer from it are men who are in the habit of swinging a pick at their work and I agree with Reid's suggestion that this also will act through the medium of the semicircular canals.

To prevent the occurrence of nystagmus in coal miners the rate of winding the men in coal mines should be greatly reduced and a speed approximating that used in metal mines instituted whilst coal-cutting machinery should be introduced where practica-

ble to obviate as far as possible swinging movements of the head and body when using a pick.

As things are at present, the only possible manner in which to effect a cure of the condition once it has developed is to keep the patient away from the mine altogether and improve the general health.

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