

us this afternoon. It certainly has raised an interesting question and has elicited interesting opinions. I am only expressing the feelings of the whole meeting when I venture to offer him, on your behalf, our most sincere thanks for the trouble which he has taken in drawing up his paper and coming and addressing us this afternoon.

EQUIPMENT FOR HIGH ALTITUDE MOUNTAINEERING, WITH SPECIAL REFERENCE TO CLIMBING MOUNT EVEREST

Captain G. Ingle Finch

Read at the Afternoon Meeting of the Society, 20 November 1922.

IN climbing Mount Everest, high altitude may be said to begin at 22,000 feet when the North Col is approached from the east. Although there is no sharp line of demarcation between what constitutes low and high altitudes, I select the above figure for the following reasons: Firstly, all the strongest and most physically fit members of the Expedition are of the opinion that at 21,000 feet (Camp No. 3) one's physical functions are practically unimpaired, and good sleep and recuperation from fatigue are possible; but at 23,000 feet (North Col), owing to the altitude, one's physical functions are impaired; sleep becomes fitful, in some individuals the appetite falls off, and there is a general loss of physical fitness. The conclusion may therefore be drawn that in the case of the most favoured individuals acclimatization to altitude ceases between 21,000 and 23,000 feet. Secondly, up to a height of 22,000 feet, snow and ice conditions approximate very closely to summer conditions in the Alps; above 22,000 feet, however, the state of the snow resembles that met with in mid-winter in the Alps. This high-altitude zone may be further divided into two sub-zones—the first from 22,000 feet (foot of the steep snow and ice slopes leading up to the North Col) to 23,000 feet, and the second from 23,000 feet onwards. The first zone is protected by the North Col from the prevailing westerly wind, whereas the second is fully exposed.

Equipment for First Zone.—Oxygen should be used from the foot of the North Col slopes onwards. No useful purpose is served by tiring oneself through not using oxygen, when, as we have seen, full recovery from fatigue is no longer possible at 23,000 feet.

Clothing somewhat warmer than that used in the Alps in summer is quite sufficient. A solar topee is advisable as protection against the sun, and Crookes' glasses of smoke-blue colour afford complete protection from glare without causing eyestrain and subsequent headache. It is also advisable to wear a veil or similar protection, and not to expose the hands to the rays of the sun. Sunburn is invariably followed by a condition of feverishness which cannot but impair one's fitness.

Equipment for Second Zone.—Above 23,000 feet conditions change radically. The wind is almost invariably blowing and the cold is intense. The degree of intensity of the latter is comparable with that met with at the Poles and, indeed, probably often exceeds it. Also, owing to the rarefied state of the atmosphere, cold is much more severe in its effects than would be the case at sea-level. A far greater volume of air is expelled from the lungs, and this air is saturated with moisture at blood heat and under a low pressure. A proportionately more rapid loss of animal heat is the result. The partial pressure of oxygen is so low that, unless the climber has recourse to a supply of oxygen carried by himself, his climbing efficiency is enormously lessened. It follows that the climbing equipment of the mountaineer in this second high altitude zone should include (1) a supply of oxygen; and (2) warm and windproof clothing and foot gear. (3) The use of oxygen increases the appetite, and due provision must be made for a sufficiency of suitable food and drink.

Oxygen Equipment.—The oxygen equipment should consist of an improved form of the apparatus, using cylinders of compressed oxygen, described by Mr. P. J. H. Unna in the *Alpine Journal*. Numerous other methods of supplying oxygen have been suggested, but these all fail in one or more respects.

In the Leonard Hill Bag oxygen is generated from sodium peroxide and water. Already at an altitude as low as 16,500 feet there is thrown up into the oxygen developed a fine spray (probably caustic soda solution) which settles so slowly that, even after standing for two hours, the oxygen is still unfit to be breathed. In addition, water is required for developing the oxygen, and at high altitudes water is almost too precious a commodity to be used for this purpose.

Mr. Harkness advocates the use of oil of garlic. He found from practical experience in the Andes (at an altitude of 16,000 feet) that the smelling of oil of garlic dispelled his symptoms of mountain sickness. He offered as explanation that oil of garlic contains much oxygen and emits this oxygen freely. Oil of garlic certainly does not do this, but it may possibly act in another way by stimulating normal involuntary breathing.

The Administration of Oxygen by Subcutaneous Injections.—I shall refrain from discussing the possible value of oxygen administered in this manner, but will content myself with merely pointing out what seem to me to be weaknesses in the proposed method of administration. Presumably such subcutaneous injections would be employed only at high altitudes, say, 25,000 feet or more, in the hope of thus dispensing with the heavy and bulky oxygen apparatus. At such altitudes, however, the climber must concentrate all his powers of resolution upon one object, namely, the getting to the top of Mount Everest. I think that the pushing of a needle into his skin and injecting a large volume of oxygen—it must be large to be of any use—would irritate him to such an extent as

to divert his mind from this main object. Furthermore, unless the man who operates upon himself is possessed of a certain amount of skill and is mentally still sufficiently alert in spite of the high altitude, he will run the risk of doing himself an injury. The method of administration also leads one to suppose that the needle should be left in position. Owing to the intensity of the cold, this would result in the formation of a considerable area of frost-bite all round the heat-conducting needle. Again, I believe it is suggested that the injection be made in the thigh; with the needle in position and passing through or covered by clothes, laceration of the muscles while climbing would be almost inevitable. I do not know whether it would be possible for an extremely clumsy man to push the needle into a major vein. Should this occur, the results of injecting oxygen would be disastrous. There is one other point. I am not sure that we ought to ask even a climber to insert a needle into his skin when, in order to do so, he must, owing to the cold, push the needle through clothes that are bound to be septic and dirty, and so run the grave danger of infection.

With reference to the injection of oxygen under the skin, however, I would like to suggest that physiologists consider the advantage of occasionally flushing out the stale air surrounding the body by allowing a few litres of oxygen to flow from the apparatus into rubber tubes leading down inside the clothing, say, to as far as the knees.

Another suggestion was to take potassium chlorate. The oxygen of potassium chlorate is chemically very stable, and it is not absorbed by the blood, and for all the oxygen you would obtain by this means, you might just as well take sodium chloride.

Recently the proposal was made to me very earnestly indeed that hydrogen peroxide could be used. The method has this in its favour at first glance: the ratio of the oxygen to the total weight of the hydrogen peroxide is a very favourable one (about 16 to 34)—far more favourable than in our oxygen apparatus, which weighs about 35 lbs. to about 3·3 lbs. of oxygen actually available. The unfortunate thing about hydrogen peroxide however is that, although I believe it has been prepared pure, it is with reference to its products of decomposition a highly endothermic compound, and as such extremely dangerous and liable to explode. Further, the rate at which the oxygen would be given off by a commercial hydrogen peroxide, although controllable in the laboratory, would not be so on the slopes of Mount Everest.

The Effects of Tobacco.—Captain Geoffrey Bruce, Lance-Corporal Tejbir, and I arrived at an altitude of 25,500 feet and pitched camp about half-past two in the afternoon. From half-past two until seven o'clock the following evening (that is, for more than twenty-eight hours) we used no oxygen at all. Very fortunately, I had brought with me three packets containing in all thirty cigarettes. About half an hour after arriving in camp, I do not mind confessing that we felt a little bit miserable. We

had been exposed to a considerable degree of cold and wind, and warmth once lost does not, at that height, return very quickly to one's members. I also noticed in a very marked fashion that unless I kept my mind on the question of breathing, that is, made of breathing a voluntary process instead of the involuntary process which it ordinarily is, I suffered from lack of air and a consequent feeling of suffocation. By forcing my lungs to work faster than they would have done of their own accord, I would recover and again become normal. There is a physiological explanation of this phenomenon. The partial pressure of carbon dioxide in the blood falls below normal because it is washed out of the system owing to the enormous volume of air which one inhales in order to obtain a sufficient supply of oxygen. Carbon dioxide stimulates that nerve centre which controls one's involuntary breathing.

About 4 o'clock that afternoon I smoked a first cigarette, remembering how often in quite different situations the mere act of smoking had distracted the attention from unpleasant things. I was joined by Geoffrey Bruce and Tejbir, both of whom had been experiencing the annoying necessity of having to concentrate on breathing the whole time. After the first few deep inhalations of the smoke, this was no longer necessary, although at first we had to pant a little on account of the time during which the lighting of the cigarettes had interfered with our breathing. Evidently something in the cigarette smoke acted as a nerve stimulant in the place of the carbon dioxide in which the blood was deficient, and, making breathing once more an involuntary process, relieved us of the need for constantly keeping our minds fixed on the controlling of the lungs. The effect of a cigarette lasted for about three hours, so that by 5 o'clock the next afternoon our supply was consumed. At 7 o'clock, rather sorely craving a substitute, we had recourse to the oxygen apparatus. Instead of breathing the normal two litres per minute each, we contented ourselves with about half a litre between us. This amount not only sufficed to make us feel much more comfortable and less cold, but it also enabled us to obtain the first sleep which we had had at this great altitude.

It is not yet known what the stimulant contained in cigarette-smoke is. It is not likely to be carbon monoxide. I have carried out laboratory experiments, in which an intermittent current of air at a pressure of 380 mm. was drawn through a cigarette, lighted at the beginning of the experiment by means of an electrically heated platinum wire. The gases after washing through glass-wool moistened with dilute sulphuric acid were colorimetrically tested for presence of carbon monoxide on absorption through iodine pentoxide. The results were negative. Perhaps the stimulant is pyridine, which is present in comparatively large quantities in tobacco-smoke. Pyridine is frequently used in the laboratory for the extraction of certain constituents from coal, and it has been independently observed by several research workers that the slight traces of the pyridine in the air of the

laboratory have, for the first few days, a distinct stimulating effect upon respiration.

Morphia is another stimulant which has been suggested. I cannot speak with authority about morphia, but I should be very glad to have medical opinion as to the exact nature of its effect at high altitudes. It must always be borne in mind, however, that a man has no business to be at 23,000 feet on the slopes of Mount Everest unless he is feeling fit and practically immune at that height from the evil effects of high altitude.

Clothing.—I would recommend clothing on the following lines: One suit of thin silk underwear, followed by a suit of (1) light woollen underwear, (2) medium-weight woollen underwear, (3) heavy-weight woollen underwear, and a loosely fitting woollen sweater with trousers of the same material. In order to keep the abdomen completely unrestricted, nether garments should be supported by braces. Two-piece under garments are preferable to one piece, as they provide a double protecting layer round the abdomen. Over all should be worn a suit of warm and windproof clothing consisting of (beginning from the inside) a layer of thin flannel followed by a layer of duopreened light canvas, green in colour, another layer of light flannel, and a layer of transparent oiled silk of yellow colour. The coat should be made in blouse form with a hood, fur collar round neck to act as a brake upon the efflux of air from between the clothing and the body, a narrow fur band round the abdomen for the same reason, and likewise fur bands round the inside of the cuffs. Suitable tapes should be provided at the neck, round the waist and round the wrists, by means of which these openings can be comfortably closed. The trousers, fashioned on the same lines, should reach to the ankles and be provided with tapes for binding at the ankles and just below the knees (to prevent dragging on and hence impeding the action of the knees). Trousers should be supported by braces.

Gloves.—I wore one pair of thin woollen finger gloves, one pair of lambskin gloves, and one pair of duopreened canvas gauntlets with a lining of flannel. My hands kept warm, and I was able comfortably to manipulate the oxygen apparatus.

Headgear.—The R.N.A.S. pattern helmet is the most suitable form of headgear, with a chin piece covering the whole of the face up to the nose. Crookes' glasses, let into a mask lined with soft fur and large enough to cover the remaining exposed portion of the face, complete the headgear.

Footgear.—Leather is too good a heat-conductor, and reliance should not be placed upon it for warmth. The uppers of the boots should be of felt, strengthened where necessary to prevent stretching by sewn-on leather straps. The felt should be covered by duopreened canvas. Toe and heel caps must be hard and strong; the former should be high.

The sole should consist of thin leather, a layer of three-ply wood hinged in two sections at the instep, and a thin layer of felt. The boot should be large enough to accommodate in comfort two pairs of thick socks. As regards nailing, ten tricouni nails per boot would be sufficient. These should be fastened by screws passing through the leather sole and entering into, but not penetrating, the three-ply wood.

Short-length ankle putties will prevent ingress of snow into the boots. Climbing irons are unnecessary.

Food.—Altitude does not impair the appetite, at all events when oxygen is used. Food, together with the necessary fuel (Meta) for cooking, should be made up in 10-lb. parcels contained in three-ply wood cases and clearly marked "for high altitudes only." A light tin-opener, a box of matches (Swan wax vestas or equally reliable "strike everywhere" brand), and a supply of cigarettes should be included in each parcel. The greatest care must be taken in the selection and making up of the contents of these parcels in this country; the best organizer is likely to be somewhat below par when at the North Col.

Cameras should be of the roll-film type.

Aneroids.—I would suggest considering the advantages of the Pallin barometer. It is a zero instrument and light and robust.

Thermometer.—This should be graduated below zero only, and should be lighter, smaller, and better protected against rough handling than those with which we were supplied in 1922.

Rope.—There are no crevasses above the North Col. A light sash line, say 6 mm. or at the most 8 mm. diameter, is sufficient. Fifty feet should be allowed for two men.

Axes.—Light axes with long picks and short hafts are best. The axes should be soaked for a day or two at the base camp and then well rubbed with linseed or similar drying oil.

Before the paper the PRESIDENT said: This afternoon Captain Finch is to give us a paper on the use of oxygen and the apparatus required. He will also refer to the equipment necessary in high climbing.

Captain Finch then read the paper printed above, and a discussion followed.

Professor J. B. HALDANE: I unfortunately missed my way here and did not hear the first part of Captain Finch's paper on the oxygen apparatus, so I do not think I can say anything as to that beyond giving my own impressions as to the use of oxygen. I have for many years held that, although an unacclimatized person breathing only air would perish rapidly at the height of Mount Everest, there was on the existing evidence every reason to hope that, apart from the physical difficulties, men could with the help of acclimatization get to the top without oxygen, and that was the opinion I expressed last year. It is also expressed in the report we made on the Pike's Peak Expedition of 1911. I think that the most interesting scientific question in connection with any future expedition is whether you can get to the top without oxygen. If you can it throws much important light on the physiology of respiration. As to going to the top with oxygen, it would be easy with a sufficient supply.

Paul Bert's experiments of forty-five years ago indicated that one might go to over 40,000 feet with pure oxygen, even without acclimatization. The difficulty is to carry an oxygen supply which is sufficient, and until liquid oxygen can by hook or crook be supplied we are up against a proposition which presents some difficulties. I think it is very important to economize the use of oxygen as much as possible. In the experiments which Kellas and I made in steel chambers we used an apparatus which did not waste the oxygen, and we found that with one litre a minute at about 25,000 feet, even when we were not acclimatized, it made an extraordinary difference to the subject of the experiment during work. As to the effects of it, I can confirm Captain Finch in every respect. But my calculation was that a man who was thoroughly acclimatized at, say, 23,000 feet would want very little more oxygen to carry him to the top. Possibly one litre a minute would be sufficient. Dr. Kellas and I did not contemplate anything more than the weight of one cylinder. Kellas knew very well what a handicap weight is. The cylinder we used then was the same as was used by the Air Force and the Army Medical Department during the war, and I calculated we could make it last about six hours. We had little doubt you could get to the height contemplated by Kellas (25,500 feet) without oxygen, but we thought it was very desirable to have it in case anything went wrong with any one. I do not think I need say anything more as to oxygen. The whole question has been perfectly clear from the physiological point of view ever since Paul Bert investigated it.

As to other means of what may be called doping the person, I was very much interested in the account of the effects of garlic. If I were feeling mountain sick I think the least whiff of garlic would make me sick on the spot. You did not try it, I think ?

Captain FINCH : No, sir.

Professor HALDANE : But there may be people who like garlic so much as to feel no ill effects. I think the same may be said about cigarette-smoking. It may be that the large amount of carbon monoxide in the smoke has a favourable effect. Lorrain Smith and I found about twenty years ago that an animal exposed to very low barometric pressures was affected favourably by carbon monoxide. It had just the opposite effect to what we expected. Later on we discovered the theoretical explanation. On Pike's Peak, where we often administered carbon monoxide for experimental purposes, we never got headaches from the administration of it, whereas we suffered from headaches at sea-level. Dr. Douglas was very much struck with that. He nearly always used to get headaches lower down, but he got none on Pike's Peak. As to chlorate of potash, it was a ridiculous idea. It dates from the time when physiology was merely qualitative and not quantitative, and the same applies to injections of oxygen. It is very little you would get in by means of injections.

There is another thing which is likely to be most important at very high altitudes, and that is the administration of something which will produce what is called acidosis in the living body. In the experiments that Dr. Kellas, Dr. Kennaway, and I made, it was shown that until acclimatization occurs the body suffers from alkalosis, owing to the increase of breathing and excessive washing out of carbon dioxide from the blood ; and this is associated with mountain sickness. Acclimatization consists partly of the process by which the excess of alkali in the body is got rid of by the kidneys. Mountain sickness can probably be avoided to a great extent by hastening that process up. One way to hasten it is by administering ammonium chloride, which when taken in considerable quantities has a very peculiar effect, discovered by my son eighteen

months ago. The ammonia disappears in the body and hydrochloric acid is left and produces marked symptoms of acidosis, so that at ordinary atmospheric pressure the subject of the experiment begins to breathe far more deeply than usual. It seems probable that in the last push from a camp of 21,000 feet or higher, a little ammonium chloride would hasten the acclimatization at greater heights by getting rid of the alkalosis and so increasing the breathing. It was formerly supposed that there was a condition of acidosis at high altitudes and in cases of want of oxygen. That put people on the wrong track altogether.

It seems to me that the prospects of getting to the top now with all the experience and all the new facts that have been gathered in the last expedition are extraordinarily bright. I cannot judge of the tremendous physical difficulties that there are, but as far as the physiological difficulties are concerned the prospects seem very good. All the evidence and the new facts ascertained by this expedition are extraordinarily important and they are of the utmost physiological interest, particularly the fact that men could get to 27,000 feet with no oxygen at all.

Captain FINCH: The next point, and I do not seem to have made it clear, was the question of our mask. Instead of using the mask as originally described and figured by Mr. Unna, we inserted in the business end of the apparatus a T-piece, and on that T-piece we put a rubber bladder. The mouth of the T-piece went into the climber's mouth. Before exhaling he bit the tube. On re-inhaling he merely released the pressure of his teeth and the oxygen flowed into his mouth. It was a perfectly economical mask and after ten minutes' practice it could be used quite easily, not only waking but when in a state of semi-unconsciousness, on the dividing line between wakefulness and sleeping. I watched Captain Geoffrey Bruce. He would stop working his jaw and then simply content himself with breathing the oxygen as it flowed. The tube would sometimes slip out of his mouth, and he would grope round for the tube without properly waking up and put it back in his mouth almost unconsciously.

Mr. DOUGLAS W. FRESHFIELD: We have heard objection raised to the use of oxygen, but I think in this room we may dismiss that. Oxygen, after all, is only another form of stimulant. Its use can only be argued against logically by a Pussyfoot! Beyond this special point it appears to me that we ought to consider the general question of food or nourishment in ascending Mount Everest. I should like to ask Mr. Finch whether he thinks they were this year in all ways suitably provided. I was, twenty years ago, at a height of 20,000 feet near Mount Everest, on Kangchenjunga, and at camps at that height we found it possible to use self-cooking soup-tins. I have been told they would be useless at 23,000 feet, but I have no evidence that they were tested at that height. What makes me more doubtful about their not being serviceable is that when my friends Donkin and Fox were lost in 1888 in the Caucasus, we found their soup-tins after they had been for a whole year buried under snow and ice at a height of 14,000 feet, in perfectly good condition. We lit the spirit and cooked the food inside. Those soup-tins would be invaluable if available at 25,000 or 27,000 feet. Next we have heard a good deal about starvation. Did the climbers carry chocolates? In the mountains a long day can be done on a supply of chocolates and biscuits, and there is no food, *experto crede*, that is so digestible at great heights.

Then with regard to clothing. I am glad to hear what Mr. Finch has told us—that he believes the members of any future party may be effectually protected from frost-bite. It will be invaluable if you can provide footwear suitable

for climbing that will avoid this danger. Prevention is better than cure! But in case of need I can supply an interesting prescription for use in cases of frost-bite, one which proved effectual in the case of an Italian guide who had been dismissed uncured from the great Hospital at Milan. It is printed in an article by Mgr. Achille Ratti, who was a very eminent mountaineer thirty years ago, and who is now Pope Pius XI.

Captain FINCH: As to the question of shortness of food, I cannot speak with regard to Geoffrey Bruce, but I can speak for myself. Before going on to Mount Everest, and indeed many years ago, I had read a great deal about it and also about the travels of numerous explorers in the Himalayas, including Mr. Freshfield. And one thing that had been more or less firmly impressed upon me by these books was the impossibility of prolonged camping out at an altitude, I might almost say, in the neighbourhood of 23,000 feet; and certainly the idea of camping out for more than one night in succession at an altitude of 25,000 feet appeared impossible. When we went up to our highest camp it was with the fixed determination of getting to the top of Mount Everest, and then returning at once to the North Col without passing a second night up at 25,500 feet, because we thought that would be courting disaster. It was later experience that taught me that one can hold out for two, and possibly three or four, nights at that altitude. Because we had no idea of staying a second night we only took with us sufficient food for one day, and even then we took rather short rations because we had also had it impressed upon us that we could eat very little at that altitude. We had a fair quantity of sugary food in the shape of mint cake, and devoured every vestige of it. We also enjoyed ration biscuits. One of the effects of oxygen was to increase our appetite, so that all our food was disposed of in the course of the first night and the first half of the next day.

As to the question of cooking, I like the small flat tin in which those preparations are made up, but I do not like the little cooker underneath. We dispensed with that and took blocks of Meta which are wrapped up in silver foil, and thus saved carrying the heavier weight. That is the only way in which I can criticize those cookers; if you take off the small cooking stove and keep the tin without it, it is an improvement.

As to the footgear, there is absolutely no doubt about that question. I had with me footgear that was absolutely frost-proof, but unfortunately it was so large that I could almost turn round in it. It was really rather too large for climbing. It is, however, only a question of making that same kind of gear rather smaller and better fitting.

Dr. LONGSTAFF: I do not think there is really much for me to say. I had written some notes for the *Alpine Journal*, but I find that Captain Finch has said most of what I was going to say, and he has said nothing with which I do not generally agree. With reference to oxygen, Professor Haldane is the greatest authority in the world about it, and after what he has said there is very little for me to add. Therefore I think I had better speak simply as the doctor of the Expedition and put on record the evidence as it appeared to me. Of course I was a spectator, but a spectator often sees more of the game than any single player. Also it is much easier for a spectator to speak than for an actor to speak, because actors are so modest. I have come back finding that it is not universally realized that if those two attempts on Everest had not been made when they were, the Expedition would have returned to England having accomplished precisely nothing. I take great credit to myself for having urged from the earliest moment that I met any member of the climbing party that they should take the first possible opportunity of having a smack at the

mountain. But I also observed that the climbers were even cleverer than I, because they all very soon perceived that my remarks were merely the repetition of a platitude! I wish very strongly to take the opportunity of emphasizing the fact, because there has been a certain amount of criticism: Why didn't they wait until their arrangements were a little more advanced? Was not it rather precipitate? Was not it a pity to use up four men on the first attempt? No; it was exceedingly wise of General Bruce and Colonel Strutt to send four men on that first attempt.

There is one remark I should like to make as a spectator having no bias either for or against oxygen. With the twelve apparatus we took up, it took Captain Finch a couple of days' work on the Rongbuk Glacier to assemble sufficient parts to make up four complete apparatus. So that when you are sending oxygen apparatus you want to send a competent man along with it. There is no question about oxygen, no mystery; with oxygen there is nothing in the altitude to stop you getting up. The only difficulty is in carrying sufficient oxygen. Without oxygen we do not know whether it will be possible to get to 29,000 feet; but, on the other hand, we know no reason why it should not be possible.

I noticed that the frost-bites did very badly even at the base camp, that is 16,500 feet—more than half an atmosphere. They did very badly; they all went downhill. And then I noticed that the second party who had taken oxygen were not nearly so badly frost-bitten as the first party. That distinctly shows two things. It shows what a vicious circle is set up by frost-bite plus want of oxygen. It is obvious it is made worse by a lack of oxygen, and it showed that the latter was a protection against frost-bite. There is no doubt about that. What I am coming to is, from a medical point of view, what I should like to see done. I should like the climbers to use oxygen, but as little as possible; to go as high as possible without it. It will enable them to face, say, forty-eight hours in a blizzard. If a man can get a little oxygen during that time he can face those forty-eight hours at 26,000 feet or 27,000 feet with equanimity. If he has not oxygen he is extremely likely to get very badly frost-bitten. But against oxygen I should record that the general physical condition of the second party (using oxygen) was distinctly worse than that of the first party (no oxygen) on their arrival at the base camp and afterwards. The physiological explanation of the apparent paradox is simple. Unfortunately there is no actual proof that the second party would have been no more exhausted than the first party if neither had used oxygen.

Again, in presenting the evidence I must recall that the only member of the whole party who was fit to make a second attempt on the mountain was Somervell, and he was in the first party. He was only very superficially frost-bitten on the hands, but his general condition was extraordinarily good. Otherwise the first party were more frost-bitten than the second, although Captain Finch's feet did not escape, and Geoffrey Bruce had to be brought from Camp III. to halfway to Camp II. on a sledge because of superficial frost-bites on his feet.

There is one other point I should like to make. I would like to say this as a climber, pure and simple: that the first attempt on Mount Everest was absolutely ruined; its chances were absolutely destroyed on the second day of the climb. Our dispositions envisaged a three days' climb; one day up to the North Col, where afterwards the avalanche fell; the second day from the North Col to over 26,000 feet; then on the third day the final climb. The first attempt was absolutely destroyed by bad weather on the second day's climb, so that they had to camp about noon at 25,000 feet, and lost their chance

of getting up. It was the same with Finch's attempt. Although he got to 25,500 feet, he intended to have got higher on the second day, and his chance was ruined by the fact that he was kept there a night and a day in very bad weather. They stayed up the second night, but of course that sort of experience is not the best preparation for your third day's climb. I venture to point out that the Committee of the Mount Everest Expedition were extremely fortunate in selecting climbers who, although they had lost all real chance of success on the second day, still in both cases went on and tried to the last. Both parties made marvellous records on the third day, and we are very lucky indeed that we had such men with us.

Major C. J. STEWART (Air Ministry): I am afraid, speaking from personal experience, I am only a baby in regard to altitude. My height record is 20,000 to 21,000 feet. I hope I am not misinterpreting the remarks that have been made, but from such experience as that I should not like to feel that anything was being put forward as to the ease of climbing with oxygen. The fact that oxygen was taken, to my mind, certainly does not in any way minimize the astonishing performance that has been put up and the tremendous size of the achievement. I have been at 21,000 feet without oxygen, and I will frankly confess, the idea of staying through a night at 25,000 feet with half a litre of oxygen is somewhat appalling.

There are one or two points which might be borne in mind in discussing the apparatus. One has to remember that the Air Ministry—and Mr. Eagar is here with me to-day—had a very short time (I think only three weeks from the beginning) to settle the design of the apparatus, and no little credit is due to the firm, Messrs. Siebe, Gorman & Co., who made the apparatus in that short time. I think their work, both in the willing way in which they threw themselves into it and the speed with which they got all the apparatus out, was a very great credit to them.

As to soldered joints, trouble has been experienced in that way. We have lately had some difficulty with soldered joints when they have been subjected to cold, although nothing like the cold we subject a 50–50 composition of solder to in liquid oxygen vessels. There, instead of having a temperature of something like -50° C. we go to something like -182° C., and vibration is not absent, when the containers are being used. In discussing the question of solder I may say the troubles we have experienced with certain solder joints were with those from the same source. I think the subject may be dismissed with Captain Finch's decision to use silver solder, which no doubt will be thoroughly well tested. It will be well to subject it to very low temperatures and vibration.

Professor Haldane made some reference to the use of liquid oxygen. While I think it would to a great extent minimize the bulk and weight of the apparatus I see little or no chance of such apparatus being used in an Everest climb. Owing to the time it takes to climb to the uppermost camp it would be quite impossible to carry stores of liquid up there; so it means a plant, and however small the plant is it is bound to give a good deal of trouble on account of temperature conditions, besides the trouble of taking up liquid fuel for the prime mover. So I can see no prospect of liquid oxygen being used in climbing Mount Everest. It is a difficult problem. In the Air Force where we climb to an altitude like that in a matter of minutes, getting to 20,000 or 21,000 feet is a comparatively rapid process, and there is no chance of acclimatization. Consequently at 20,000 feet if one has no oxygen one is panting very vigorously, and that, I may say, is the least troublesome of the symptoms.

There is one point I would like to make as to the cylinders. I do not know what arrangements are being made with regard to them, but this type of Air Force cylinder is getting on in years now. As they are only about $\frac{1}{16}$ inch thick, with the presence of rather damp oxygen inside—in the opinion of the makers there is, of course, no such thing as that, but the substance is not unknown—and weather conditions outside, that $\frac{1}{16}$ inch thick may be dangerously reduced. Steps are being taken by the Gas Cylinders Committee to produce rather better cylinders. I think the question ought to be gone into as to whether, if these new cylinders are not forthcoming in time for a future expedition, entirely new light cylinders of the kind used in the last expedition should not be made. If not, those that are used should be very seriously overhauled, because they are not suitable for indefinite use.

Another point I should like to make is this: that if the apparatus is going to be sent, as it must be of course, by sea and by rail to Mount Everest, then if it is going to be a long time on its way to the tropics and through the high temperature belt, some attention should be paid to the question of the rubber perishing. There may be trouble over that. It is not rare for us to get considerable trouble with the rubber tubing after its journey through India. If there is any information we can give on that when the time comes we shall be ready to do so.

There is some talk, as you know, by the Gas Cylinders Committee—Professor Haldane will smile at this—of producing cylinders which should be much more satisfactory and perhaps a shade lighter. I think it is not unwise to forecast that a cylinder considerably stronger than that at present in use, if properly selected, may be produced of a weight of about 5 lbs. 12 ozs. for containing something like 20 cubic feet of gas at 150 atmospheres. It could contain rather more if the pressure could be raised. The strength of the cylinders, if successful, will be considerably in excess of the strength of those now used. The Department of Scientific and Industrial Research, Gas Cylinders Committee, of which I am a member, will no doubt help as much as they can. The Committee has been in touch with the Mount Everest Committee. That, I think, is all I have to say on the matter so far, except to add that anything we can do to help you may feel quite sure we shall be only too pleased to do.

Captain FINCH: With reference to a suggestion by Dr. Longstaff, who said we should go as high as possible without oxygen and then use it in the smallest possible quantities: I say not. Both Mallory and myself—and I see that Mr. Mallory has put it in print—think that the limiting height for acclimatization is somewhere about 21,000 feet. I found it somewhere above 21,000 feet, but certainly below 23,000 feet. At 21,000 feet I can sleep my sixteen hours a day and enjoy my sleep. I also have a very healthy appetite indeed. At 23,000 feet there is a distinct falling-off in appetite, although it still remains good. I found, however, that instead of sleeping twelve hours or more out of the sixteen hours spent on my back, I only slept four, and Mr. Mallory and his party noticed much the same thing. So I think at somewhere between the 21,000 and 23,000 feet line is the limit at which we can hope to acclimatize. Climbing or doing anything at any altitude above that acclimatization limit will only mean that you will be gradually going downhill, becoming weaker and weaker, and if you persist in living long enough in that way, you will eventually die.

Dr. LONGSTAFF: I quite agree.

Captain FINCH: If you go on without oxygen as high as you can you will get higher and higher above your acclimatization level, but you will also get weaker and weaker. I think the point where oxygen should be used is the

point where acclimatization no longer occurs. Begin to use oxygen there in small doses. We used quantities of oxygen varying from $2\frac{1}{2}$ litres a minute down to one litre while actually climbing. Going straight up and one of us carrying 60 lbs. and the other 50 lbs., and covering the ground at a pace equivalent to 1000 feet per hour and a half—that is approximately 1000 feet in elevation being gained for every one and a half hours' climbing—we used oxygen at the rate of $2\frac{1}{2}$ litres per minute. But when we actually ceased climbing speedily upwards and began to traverse out across the mountain-side we economized our oxygen because we were not putting forth anything like the same effort as if we were climbing straight up. Then we used approximately only about a litre of oxygen per minute.

We had climbed to a point of 26,000 feet when Tejbir broke down. Then Geoffrey Bruce and I climbed on until we were driven off an easy ridge by the high wind, and in order to avoid it we traversed out across the face. It was on that almost level traverse where we hardly gained any height that we only used about one litre of oxygen per minute. I think one could carry on, for instance, on a future expedition approximately as follows: The best camping-ground, as we discovered later, is on the north ridge where there is room to pitch a tent and some protection from the wind. At a height of nearly 26,500 feet and thence onwards I should recommend a full dose of oxygen, $2\frac{1}{2}$ litres up to the shoulder, which can be reached within an hour's climbing. From the shoulder I should recommend slower going with one litre of oxygen per hour, until we get to a difficult pitch and the final difficult slope up towards the summit. Over the difficult places where one is actually putting forth a big effort I should recommend taking the oxygen as fast as you can usefully cope with it.

Mr. DOUGLAS W. FRESHFIELD: What sort of ground was it on the other side of the ridge?

Captain FINCH: Bad ground; it resembles the Macugnaga slopes of Monte Rosa.

With reference to the points mentioned by Major Stewart, I am extremely glad he referred to the makers of the apparatus. It was quite an oversight on my part that I have not done so hitherto. Messrs. Siebe, Gorman's work was done under most difficult circumstances, and it was wonderfully well done. They are not to blame for the 50-50 solder failing. It is really remarkable that the apparatus, which was purely experimental and which had been designed and made in such a short space of time, worked as well as it did. I am very glad to hear about the new cylinders. I think with those new cylinders Everest will only have another clear year of freedom. There is no doubt about it now at all. The co-operation of Major Stewart and his staff was indispensable, and when I have said that there is nothing more to be said. We could not have got on without Major Stewart and Mr. Eagar's help, and we hope that their help will be available in the future—in fact, we shall be quite dependent upon them.

Lord EDWARD GLEICHEN reminded the lecturer that he had made some mention of ultra-violet rays, but nothing more had been said with regard to them.

Captain FINCH: We had so many layers of clothing that there was no risk of the skin being burned. The only portions of the skin that might have been exposed to the sun's rays were actually covered up. Thanks to Major Stewart, we were put in the way of getting good goggles. They were of the Flying Corps type, and covered up the whole of one's forehead; they also had flaps

of fur or leather which came down almost to the level of the tip of the nose. The glasses were Crookes' ultra-violet glass, which completely absorbed the ultra-violet rays. The design was criticized at first on the ground that there was not enough room for ventilation, but I stuck up for them on that point, saying that we should need no ventilation whatever at heights above 20,000. That was found to be the case. At heights below 17,000 feet the glasses fogged up because there is no possibility of air escaping freely from over the eyes behind them outwards; but at an altitude of 19,000 feet such a thing as the glasses fogging up was unknown, and the less moisture lost, the less your eyes will be irritated. One of the effects of doing experiments in a low-pressure chamber is the evaporation of moisture from the eyes, which produces a dry burning sensation on the cornea. The rest of the head and face was completely covered by a Flying Corps helmet. Under that was another light woollen helmet, and Geoffrey Bruce, in addition, wore a sun-proof cloth helmet over all his other head-gear.

Major STEWART asked whether Captain Finch had suffered any psychological effect from the wearing of Crookes' ultra-violet glasses. Did the blue light have a depressing effect?

Captain FINCH: We were not depressed in the least. In fact, the highest praise I can bestow upon the glasses is that we really hardly knew we were looking through glass at all.

The PRESIDENT: I am sure Captain Finch's address and the speeches which have followed it have added very much to our knowledge of the equipment which is necessary to make mountaineering at these great altitudes possible. We are all deeply indebted to Captain Finch, who has managed to find the time, in spite of a very heavy programme of other engagements, to come and give us this discourse. You will desire to express your appreciation of his having done so.

A NOTE ON BAFFIN LAND

From a letter of the Rev. J. Bilby, of the Missions to Seamen.

BETWEEN lat. 62° and 69° are three large lakes or inland seas, that to the north being the largest; they are connected with one another, and with the coasts by rivers which are in part tidal. These lakes and rivers are used annually by Eskimo hunters on their summer deer-hunting expeditions.

Of these lakes two only have been shown hitherto, that to the north called "Netselik" = place of seals, and that to the south called "Angmekjuak" = the great water. The central lake known to the natives as "Tesseyoakjuak" = the great lake, approximately 70 miles by 50 miles, is not known and not charted in the latest maps.

These lakes abound in fish and seals, and are the highways for the Eskimo entering the deer-hunting country.

The southern lake "Angmakjuak" contains a large island, seen for several miles, in shape like an iceberg, hence its native name "Pilka-looyoyarktok" = that which is like an iceberg.

The country surrounding these lakes is reported by the hunters to be