Some User Objections to Fluorescent Lighting*

By

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It is about 10 years since 5-foot tubular fluorescent lamps were first used in this country for factory lighting. At first, and throughout the years of war, only one type of lamp, designated as "white," was made available, and the use of this was controlled and limited to vital factories and other war establishments where there was special need, not only of good artificial lighting, but also of light similar in colour quality to daylight. I had some association with what I believe was the first factory installation, this being arranged in consequence of my recommendation to a Government committee—then concerned as to the probable effect of the daylight black-out upon industrial morale—that it would be expedient to "naturalise." As far as practicable, the artificial lighting of the most important war factories. This "beat the black-out" installation was made in the foundry of a Midlands factory, and it took the form of artificial windows inside the real but blackened windows of the saw-tooth roof. Each of these artificial windows contained six of the new fluorescent tubular lamps. The effect produced was almost startlingly realistic. The original natural lighting appeared to have been restored and no longer was there any sense of deprivation of an habitual amenity, nor any dissatisfaction in working continuously under artificial lighting. Moreover, there was an incidental advantage which was not foreseen; owing to the diffusion and spectral quality of the light, the atmosphere in the foundry appeared to be clearer than when tungsten lighting was used. In fact, the workers remarked that the ventilation had been improved, so similar was the appearance of the foundry haze to that familiar to them when there had been natural lighting and open windows. The acceptability of fluorescent lighting as a substitute for daylight was so successfully demonstrated by this installation that it was thought that, even without the device of artificial windows, it would prevent the dissatisfaction which might otherwise be expected to develop with the protraction of work under more unnatural conditions of lighting. From then onwards during the period of hostilities fluorescent lighting was installed in parts of many vital factories, and that it was a significant factor in preventing the deterioration of morale, and in raising it where it had already deteriorated, is not, I think, doubted by most of those who were in a position to observe its effects. It may be mentioned that within the past two years a large windowless factory has been equipped with fluorescent artificial-window lighting, giving complete satisfaction to the workers.

A great extension of the use of fluorescent lighting in factories has occurred since the termination of the war, besides its application in many offices, shops, and buildings of other kinds. Probably something like a million fluorescent tubes are now in use in this country and at least a similar number of persons have actual experience of fluorescent lighting. It is well at the outset to appreciate this fact so that complaints shall be set in correct perspective. It is true that there are no means of enumerating complaints with any precision, but all the available indications suggest that the number is exceedingly small by comparison with the number of apparently contented users. Apart from enquiries for information concerning rumoured ill-effects of fluorescent lighting which have been addressed to the Medical Research Council and to me personally, and from communications referring to ill-defined effects reported by an unspecified number of persons, not more than 30 definite cases of ill-effects alleged to be due to fluorescent lighting have been brought to our notice since the advent of lighting of this kind. These cases have been considered carefully and, as the effects complained of include all those with which one is familiar by hearsay, an analysis of them will I believe be instructive and useful.

From some of these enquiries and complaints one gets the impression that the fluorescent lamp is suspected of magic second only to the fabulous Aladdin's lamp—only it is "black magic!." For instance, an M.O.H. wished to know if there was any truth in the statement that it causes sterility; and a popular illustrated weekly journal sought confirmation or denial of the claim that it causes baldness! It has been accused of producing vitamin deficiency; of making vision more distinctly outside than inside the foveal area—contrary to the normal conditions; of having an injurious hammering effect on the retina by bombarding it with unperceived pulses of light; and of giving light that is too hot! As to the last of these, one of the undeniable characteristics of fluorescent lamps is that they produce considerably less heat per unit of luminous flux than do ordinary filament electric lamps.

Leaving aside bizarre accusations let us consider some of the more usual objections raised against fluorescent lighting. It is, however, impossible to judge what substance there may be in these without knowing the properties of the fluorescent lamp; it is to ignorance of these that

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reports of the most unlikely effects of fluorescent lighting have gained credence. So I must begin with a brief explanation of the operation of fluorescent lamps and of the radiation they emit.

Light is not produced in fluorescent lamps as it is in ordinary tungsten lamps by heating a metal filament to incandescence. Instead, a stream of electrons from a heated cathode is caused to pass through a column of mercury vapour at low pressure within the tubular lamp. The collision of these electrons with those of the mercury atoms causes ultra-violet radiation to be emitted, mostly of the wavelength 2537 angstroms, though there is also some visible radiation of low luminosity value. If this were all, the lamp would be useless as a practical light source but, in fact, it is only the first step in the production of fluorescent light. The ultra-violet radiation thus generated is received by the fluorescent material coated on the inside of the glass tube and is converted by this material into radiation of longer wavelength and high luminosity value; that is to say, the short ultra-violet radiation within the tube is used up in the process of producing ordinary light and this is the fact upon which the utility of the lamp depends.

It would be harmful and also wasteful to allow the short wavelength ultra-violet radiation to escape from the tube; but this cannot happen, not only because of the "frequency changer" lining of the tube but also because the glass itself is completely opaque to radiation of 2537 angstroms. The spectrum of the fluorescent tube has often been photographed and the spectrogram shows no trace of emitted radiation of shorter wavelength than about 2900 angstroms. The so-called erythemal region of the spectrum extends from 2900 angstroms upwards to about 3250 angstroms. According to Ruff (1949), measurements of the radiated power in this waveband from fluorescent lamps amounts to one-twenty-fifth of a milliwatt per unit of luminous flux radiated. Luckiesh has published figures showing that a similar relation holds for noon summer sunlight measured at the latitude 42° N. Since the values of illumination commonly provided when fluorescent lighting is used are very much lower than those given by summer sunlight it follows that the dose of erythemal radiation received in fluorescent lighted buildings is also very much less than that normally received out-of-doors in summer time.

Radiation within the waveband 3250 angstroms to 4000 angstroms is usually termed near ultra-violet. The authors quoted above give the radiated power in this spectral region as one-fifth of a milliwatt per lumen for the fluorescent lamp, and half a milliwatt per lumen for sunlight. So the dose of near ultra-violet radiation will also be much smaller by fluorescent lighting than by sunlight. But, according to Duke-Elder and others, for all practical purposes radiation within this waveband may be considered harmless, although it is capable of causing fluorescence of the crystalline lens. I shall refer to this later.

Radiant energy of wavelength 4000 angstroms to about 7500 angstroms is visible light, and this is provided almost entirely by the u.v.-excited fluorescent material. By varying the composition of this material the distribution of luminous flux within the visible spectrum can be arranged so as to obtain light of almost any desired colour. Here I may mention that the phosphors now used in most British fluorescent lamps are calcium halophosphates. The use of zinc beryllium silicate was discontinued about two years ago, but although recently there has been "a beryllium scare," I know persons who have worked for years with this material with no untoward effects. So far as the user of fluorescent lighting is concerned there is no beryllium hazard. In the infra-red region the radiation per lumen from fluorescent lamps is considerably less than is the case with ordinary electric lamps, and there can be no question of ocular injury on this account.

Nearly all the fluorescent lamps in use are operated by alternating current supplies having the usual 50 cycle frequency. With such a supply the discharge in the fluorescent tube occurs 100 times every second, so the lamp gives 100 flashes of light per second, although it gives some light in the interval between successive flashes because the fluorescent material has an afterglow. In the ordinary filament electric lamp the current through the filament also falls to zero a hundred times per second, but, owing to thermal inertia, the filament continues to glow quite brightly during the no-current periods. Thus the radiation both from filament and from fluorescent lamps fluctuates in a periodic manner, but the fluctuation is widest in the fluorescent lamp. Nevertheless, no fluctuation is apparent because its frequency is well above that of the flicker threshold for the visual system. So, if we look directly at a fluorescent lamp which is operating normally, the frequency is well above that of the flicker threshold for the visual system. So, if we look directly at a fluorescent lamp which is operating normally, the visible parts of the tube are imaged on the peripheral retina. Any lamp giving a regularly fluctuating though apparently steady light output can give rise to stroboscopic effects. This is true of ordinary filament electric lamps on A.C. circuits, and advantage may be taken of this fact to check the speed of one's gramophone turntable by...
They experienced a mild cutaneous irritation. There was some redness and dryness of the skin in the room of a pharmaceutical chemicals factory. The women were employed in the penicillin filling-room. The other five cases were reported last year. All received makes it difficult to believe that this was the cause of their condition and the more so as, with the blonde, an exposure of only 10 to 30 minutes a day was said to maintain the dermatitis.

The first had a 40 watt daylight fluorescent tube placed three feet above her desk and a minute amount was in the erythemal wavebands. Careful investigation appeared to eliminate all possible causative agents except ultraviolet or in the erythemal wavebands. However, U.V. germicidal lamps were also installed in the room, and although these were said to be properly screened and never to be used when the room was actually occupied there is an element of doubt about this. The radiation emitted by the fluorescent lamps was ascertained and only a minute amount was in the erythemal waveband. Nevertheless Dr. Bresler (1949), who reports these cases, suggests that an exposure to it for a period of six to eight hours might produce the typical sunburn. Observing a sensitive subject and exposing him for several hours on several successive days to the radiation from a similar 20 watt fluorescent tube, placed only four to six inches from the skin, I failed to produce the slightest trace of erythema.

Cutaneous Reactions.

Cutaneous irritation and erythema affecting seven female factory workers exposed to fluorescent lighting has been reported in the American medical literature since 1941. In two of these cases dermatitis of the face and eyelids was noticed soon after the installation of fluorescent lighting. One of the women was a brunet who tolerated sunlight well, and the other a blonde who did not. The first had a 40 watt daylight fluorescent tube three feet above her desk and the second was exposed to four such lamps at a distance of about eight feet. The minute amount of erythema radiation which these persons could tolerate is always possible to minimise the occurrence of stroboscopic effects by using a circuit arrangement which puts alternate lamps out of phase. Where a three-phase supply is available, as it often is in factories, there need be no troublesome stroboscopic effects.

One other phenomenon associated with fluorescent lamps may be mentioned. It sometimes happens with new lamps that slow spiralling of the arc within the tube occurs. Although this may be disturbing it is, as a rule, of short duration.

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The other five cases were reported last year. All the women were employed in the penicillin filling-room of a pharmaceutical chemicals factory. They experienced a mild cutaneous irritation. There was some redness and dryness of the skin of the forearms and exposed areas of the neck and upper sternal region. They sought no treatment, lost their symptoms during the week-end or when working in parts of the factory not equipped with fluorescent lighting, and were at no time seriously disturbed or incapacitated by the erythema. Careful investigation appeared to eliminate all possible causative agents except local lighting at a distance of 10 to 14 inches. However, U.V. germicidal lamps were also installed in the room, and although these were said to be properly screened and never to be used when the room was actually occupied there is an element of doubt about this. The radiation emitted by the fluorescent lamps was ascertained and only a minute amount was in the erythemal waveband. Nevertheless Dr. Bresler (1949), who reports these cases, suggests that an exposure to it for a period of six to eight hours might produce the typical sunburn. Observing a sensitive subject and exposing him for several hours on several successive days to the radiation from a similar 20 watt fluorescent tube, placed only four to six inches from the skin, I failed to produce the slightest trace of erythema.

Only one case of cutaneous reaction in this country has been reported to me. Early in 1948 the manual training rooms of a provincial school were re-lighted with fluorescent lamps. Within a few days, one of the masters, aged 30, complained of irritation of the skin of the face, especially around the eyes. Two days later there was erythema of the face and swelling of the eyelids. The lamps were of the 80 watt warm white type and they were about 12 feet away from the subject. The atmosphere of the room was warm and dusty and the possible significance of this should not be overlooked. The man was examined by a skin specialist who reported that the appearance of the skin suggested an external irritant as the cause and that, from questioning the patient, he could trace no other agent but the new lighting. He suggested a test exposure of the forearm to see whether the patient was hypersensitive to some constituent of the fluorescent radiation. This was not made, and the patient said he was not sensitive to the light in summer. The fluorescent lighting was removed and the skin condition apparently improved during the following week. The spectrum of the actual lamps used was photographed and the spectral transmission of the glass tubing was measured; it was found that there was no excess of radiation in the near ultra-violet or in the erythemal wavebands.

Of this extremely small number of cases of cutaneous reactions alleged to be due to fluorescent lighting, only three are claimed to be at all serious, the other five being described as cases of ordinary sunburn—a condition often sought after and popularly regarded as healthful. But in none of these cases was it shown convincingly that fluorescent lighting was the real causal agent. I have observed very many persons who habitually work with the hands and forearms exposed to the radiation from fluorescent lamps at close range but have never seen the slightest reddening of the skin.
Headache.

It is not surprising that persons who object to fluorescent lighting often do so on account of headaches, for there is hardly a more common ailment, nor one that may be due to so many different causes and is so readily attributed by the sufferer to the action of any novel factor which is not so pleasurable as to put it beyond suspicion. In my experience women complain of headaches in fluorescent lighting much more frequently than men. Late in 1946 I was invited to investigate a variety of objections put forward by a number of members of the staff employed in different departments of a large business organisation. Among those who complained of a headache all but one were women. The man, aged 41, was subject to catarrhal colds for which he had had a course of vaccine therapy. He was also subject to attacks of vertigo, before and during the war, for which he received medical treatment. The vertigo had recurred since he was allocated a room without daylight but lighted by fluorescent lamps giving a working plane illumination of only seven lumens per square foot. All four occupants of this room made some complaint about the lighting. There was no doubt that they resented the deprivation of daylight and that, as one of them realised, the real fault of the artificial lighting was not fluorescence but inadequacy, as well as glare due to the dim background against which the lamps were seen.

Five of the women were typists. One of them worked in the room just described and was said by the firm's medical officer to be of "rather a nervous disposition, amounting to mild anxiety state," and to worry about little things and pains. The other four typists were in different departments, in one of which all the other staff liked the fluorescent lighting. The medical officer's report on two of these four women is significant. One of them, aged 39, was hysterical, had suffered a nervous collapse after her house was bombed during the war, and was still very nervous. The other, aged 42, was married with two young children, and was of an emotional type. She was in London during the war and, at the time of complaining, said she was feeling the reaction of the worry during the raids by tending to get irritable and generally nervous. She was taking nerve tonics. Her office was a partitioned one plane illumination of only seven lumens per square foot. All four occupants of this room made some complaint about the lighting. There was no doubt that they resented the deprivation of daylight and that, as one of them realised, the real fault of the artificial lighting was not fluorescence but inadequacy, as well as glare due to the dim background against which the lamps were seen.

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Glare and Insufficient Illumination.

As in the previous case, complaints of headache are often made on account of glare. Glare and insufficient illumination are to be found too frequently in artificial lighting, and they have always been the chief grounds of complaint about ordinary electric lighting by means of filament lamps. I have generally found these complaints to be justified, but there is no difficulty in designing either fluorescent or tungsten lighting installations to give adequate illumination without glare. The advent of fluorescent lamps has, indeed, simplified the problem of satisfying these two essential requirements because these lamps are light sources of high luminous efficiency and yet of relatively low surface brightness. Thus, the light output of a 5-foot 80 watt fluorescent tube is rather more than that of a 200 watt gas-filled tungsten filament lamp, while the brightness of the fluorescent tube is from three to five candles per square inch, as against 50 c/in.² for the central bright patch of a pearl tungsten lamp, and several thousand candles per square inch for the filament seen in an ordinary clear glass tungsten lamp. Nevertheless, if an unscreened fluorescent lamp is close to an observer and well within his field of view, it will occupy a fairly large part of this field, and it will directly illuminate the eyes to a degree that may prove uncomfortable.

It is impossible here to enter into a technical discussion of glare; I want merely to emphasise that it is not something peculiar to fluorescent lighting or that this kind of lighting has made it either more prevalent or more acute; rather the contrary. Similarly, insufficiency of illumination is not a characteristic of fluorescent lighting. Unfortunately, early enthusiasm for fluorescent lighting led to a scramble for the new lamps while they were still in short supply, and a number of ill-planned under-lamped installations were made. It is not to be expected that non-technical users will always discriminate between defects of their lighting which arise from unskilful design and those, if any, which can only be referred to the kind of light sources used. So it is that not few complaints are made about fluorescent lighting, and in particular those referring to glare and low illumination, amount only to complaints of bad lighting.

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Conjunctivitis.

It is scarcely surprising that the induction of conjunctivitis has been attributed to fluorescent lighting, for this unpleasant condition is of such frequent occurrence that it would be remarkable if, during a period of progressive application of this new lighting, a certain number of cases did not happen soon after the patient's first exposure to it. For the layman, it is easy and tempting to connect these events as cause and effect and, as it is often most difficult for the doctor to account for the attack, and he usually knows too little about fluorescent lighting to put it out of account, there have been cases in which he has too readily supported the patient's opinion.

From what I have said about the characteristics of fluorescent lamps I think you may share my scepticism in their capacity to initiate conjunctivitis. If I had no special knowledge of conjunctivitis and its causes I might defend this scepticism on the basis of personal experience; for, over a period of more than 10 years I suffered recurrent attacks of acute conjunctivitis, but have had none during the three years that my work light has been fluorescent. There is, however, no significance in this sequence and it might well have been otherwise, as in the following case.

A clerk in a printing office developed acute conjunctivitis soon after his placement in the printing manager's office, where there was one 80 watt fluorescent tube mounted between the manager's desk and his own. As his doctor accepted the view that the ocular condition was due to fluorescent lighting, his employers were prepared, subject to further advice, to revert to tungsten lighting, although all the compositors were very pleased with their fluorescent lighting. When I saw the complainant, in March, 1945, the right eye was more severely affected than the left, and I suspected nasal or oral sepsis. I could elicit no information in support of this view, though 14 days later the man was suffering from acute nasal catarrh and I suspect that there had been other recent attacks. The man wore glasses and had recently obtained bifocals. These would absorb a considerable fraction of the small amount of erythemal radiation to be expected from the fluorescent lamp if its emission were normal. The lamp was an old one and had exceeded its rated life, so that it was no longer efficient. The illumination it provided on the patient's desk was only 4 lumens per square foot, and it was evident that he was having to strain his eyes by bringing them too close to his work in order to see it.

The man agreed to my proposal that he should give the fluorescent lighting a further trial under more reasonable conditions. The old lamp was replaced and another new one fitted above the complainant's desk so as to raise his working illumination from 4 lm/ft.² to 20 lm/ft.². After running a typical course the conjunctivitis cleared up, in spite of the four-fold increment of fluorescent radiations. Spectrograms taken from the original lamp showed that it was emitting less short-wave radiation than a typical new lamp.

Although I have been told of other cases of conjunctivitis attributed to fluorescent lighting, I have had the opportunity of seeing only one of these, and in this case also I found the illumination to be too low for the work in hand.

Eyestrain and Fogging.

Artificial lighting has always given rise to numerous complaints of eyestrain. Many of these have been fully justified on account of inadequate working illumination and other unfavourable conditions of lighting, which lead to excessive activity of the intrinsic and extrinsic ocular muscles. There is, however, evidence that the frequency of occurrence of this kind of complaint is no greater among users of fluorescent lighting than it is among those who use ordinary electric lighting.

As we should expect, it is usually those who have to work continuously by artificial light who complain of eyestrain, but although, as I have said, many of these complaints are genuine, some are made by persons who resent deprivation of natural light and seek to obtain transference to a daylighted workroom no matter how good are the conditions of artificial lighting provided for them. There are not always manifest ocular signs of eyestrain, and in every case there should be (a) proper inquiry into the nature of the complainant's work and, if possible, he or she should be observed while working; (b) measurement of the available working illumination and appraisal of the general conditions of lighting; and (c) thorough ophthalmological examination (not mere "sight testing") of the complainant. Errors of refraction and the phorias are the usual causes of persistent eyestrain and, of course, they will make the more readily cause it if the eyes are much used in bad lighting, no matter what the illuminant may be.

In three complaints brought to me of eyestrain under fluorescent lighting, difficulty in getting clear vision owing to the nature of the light has been reported. Two of the complainants were women aged 27 and 30 respectively, and both were employed as assistants to an older woman who complained of continual eyestrain, bloodshot eyes and oedema of the lids. She was "too busy" to see the firm's medical officer, but said her eyes were in such a bad condition that it would be necessary for her to see a specialist.

There were four women in the department. Each of them complained about the lighting, which was in continuous use and provided an average illumination of only about 6 lm/ft.². The two women who mentioned fogging were advised to see an oculist. Their actual com-
ments on the lighting were: "This type of lighting is indefinite and woolly, causing severe eye-strain," and "it is a very depressing light, as it gives a hazy effect rather than a clear light, causing eye-strain." The medical officer's report on the first of these women included the following: "She has a fair degree of anaemia; had had attacks of 'swimming' feeling in the head recently and a feeling of inability to focus properly, similar to symptoms she had during influenza; very nervy as a child and had had several attacks of 'nervous dyspnoea' lately, the last five weeks ago; two years ago had a nervous breakdown." Of the second woman he reported: "Attacks of indigestion for the last 6—8 months; during last few months has complained of irritation in the eyes, making her want to rub them."

It seems just possible that uncorrected errors of refraction which do not fog vision noticeably in daylight or ordinary artificial lighting may do so when fluorescent tubes are used. But I do not think this is likely, except perhaps with tubes having light output peaks at widely separated regions of the spectrum and if, also, the illumination available is low so that the effect of spherical aberrations of the eye is not minimised by constriction of the pupil.

Another explanation of complaints that fluorescent light is "woolly" might suggest itself, although this also is not a very likely one. Fluorescence of the crystalline lens is excited by near ultra-violet radiation, especially by wavelengths between 3500 and 3900 angstroms. If this occurs the lens itself becomes a source of faint light which would produce slight haziness of vision, the effect probably being more noticeable to young than to elderly persons. Radiation in this waveband is present in sunlight also, and there is much more of it than in any room having fluorescent lighting. But, in the energy spectrum of the fluorescent tube, as compared with that of sunlight, the energy in this waveband is chiefly concentrated at the wavelength 3650 angstroms, that is to say, there is a relative excess of radiation at this wavelength which is about the most effective for the production of fluorescence in the eye. Nevertheless, since the eye receives a smaller amount of energy of this wavelength in rooms illuminated by fluorescent tubes to modern recommended intensities than it does out-of-doors in daylight, when no fogging of vision is noticeable, this explanation is not, as I have said, a plausible one. It is known to be unpleasant to be subjected to near ultra-violet or so-called "black light" alone, as the fogging effect due to fluorescence of the lens is then quite apparent, while a sense of eye-strain is experienced owing to ineffective attempts to focus the eye so as to obtain sharp images of objects at distances for which the eye can accommodate quite easily in ordinary light. But when there is plenty of ordinary light the effect of the near ultra-violet is overwhelmed and, as I have said, average daylight is never judged to be hazy or woolly and indefinite.

It is much more likely that the soft shadows produced by fluorescent lighting give some people impression that fluorescent light is hazy and indefinite when they first experience it, for they have been thoroughly accustomed to ordinary electric lighting in which the light is generally not so well diffused and often creates strong brightness contrasts.

Nervous Strain and Irritability.

Almost at the end of the war there were reports that a number of people in factories and Government establishments said they suffered from nervous strain after prolonged periods of work in fluorescent lighting. Alternatively, the term "irritability" was used to describe the state produced. It is not necessary to say much concerning these complaints. At the time in question "nervous strain" was widespread, and there is no evidence that it was more prevalent among persons working with fluorescent than with ordinary artificial lighting. In any case, fluorescent lighting was then confined to a selected population; that is to say, it was installed preferentially in those places where the most vital and "trying" work was done, and so where there was the greatest risk of "nervous strain," irrespective of the type of lighting used. For example, in one factory general irritability (and increased absenteeism) was noticed among girls working on fuse mechanisms after fluorescent lighting had been in use for some time. The medical officer considered that this was partly due to stroboscopic effects. Though this may well be so, in view of the nature of the work, it must be remembered that, in any circumstances, this work was very exacting and responsible—men's lives might be the penalty for mistakes. Moreover, towards the end of the war the cumulative effect of sustained critical work would be expected to show itself by an increase in the incidence of irritability, and without records for a "control" group operating under other conditions of lighting it remains uncertain whether fluorescent lighting played any part in producing the observed effect.

My own observations in war factories led me to the conclusion that the introduction of fluorescent lighting often alleviated "nervous strain." I well remember its effect in one blacked out engineering shop. Before its installation everyone's nerves had become "frayed," and the shop manager told me that towards the end of each day he himself was in such a state that he could not trust himself to deal with any personnel problems calmly and with the necessary tact. The facilitation of the work and the greatly enhanced appearance of the workshop where fluorescent lighting was installed raised the morale remarkably.
Flicker and Stroboscopic Effects.

With a properly designed fluorescent lighting installation no regular flicker should be apparent. On the other hand stroboscopic effects may be noticeable in certain circumstances, though these do not appear to be troublesome to most people.

I have already mentioned the means by which they can generally be effectively abolished. If in special cases these steps do not suffice to render stroboscopic effects unobjectionable, then there appears to be no other course but to abandon fluorescent lighting for the purpose in hand, or to operate these lamps on a D.C. supply. A small number of persons appear to be unduly disconcerted or actually distressed by stroboscopic effects. In every such case the cause of the individual susceptibility should be sought, and is likely to be found in a nervous temperament or psychopathic disposition, or in some anomaly of the oculo-motor or vestibular functions.

Cosmetic Effects.

The most frequently expressed, though least serious, objection to fluorescent light is on the score of its colour rendering of the persons, and of certain foodstuffs, illuminated by it. These objections do not invariably come from the fair sex. It is safe to say that the development of new fluorescent lamps will eliminate objections on cosmetic grounds, and, indeed, there is already a choice of lamps to meet most tastes. Personally I hope we shall not see a medley of differently coloured lamps, at any rate in the same room or workshop, and it seems to me that the present so-called "natural" lamp ought to be acceptable to a large majority of people. In my experience objections to fluorescent lighting on the score of personal appearance are short-lived. Even the uncolour-corrected mercury discharge lighting which found its way into a number of factories before the war evoked no sustained violent objections, despite the cadaverous appearance it produced. Modern fluorescent lighting at its worst is vastly better than this.

Conclusion.

From the foregoing analysis of objections to fluorescent lighting I hope it is apparent that a critical approach to the issues involved is essential before we accept or reject the charges preferred. When such an approach is made we find that on the evidence available the most serious charges against fluorescent lighting are not proven. Much more, and at present weighty and unequivocal, evidence must be forthcoming before medical opinion should incline to the view that any kind of organic injury to the eyes or other parts of the body is likely to result from the ordinary use of fluorescent lighting. Really thorough investigation to determine, and weigh the factors involved in every case, will yield no complaints of ill-effects of a clinical trial of fluorescent lighting on a full scale in the M.R.C. headquarters establishment, over the past four years, has yielded no complaints of ill-effects.

That psychological factors are involved in most of the complaints that have arisen is indubitable. As to this, some remarks of a distinguished ophthalmologist are very pertinent: "The popularity or otherwise of the new form of lighting will be determinable within wide limits by the method of introduction and the propaganda employed. Experiments on this could easily be devised in factories and should be of great interest. A simple one would be to introduce a similar (physiologically satisfactory) new lighting system into two separate workshops with anti- and pro-propaganda respectively. Almost certainly headache and strain could be produced by suggestion in one and not in the other."

Finally, it can be said that a "clinical trial" of fluorescent lighting on a full scale in the M.R.C. headquarters establishment, over the past four years, has yielded no complaints of ill-effects.

Changes in Human Performance with Age*

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The beginning of the scientific measurement of human performance in relation to age should, perhaps, be taken as 1884, when Sir Francis Galton, at an International Health Exhibition in London, set out to measure various kinds of human capacity, such as strength of grip and swiftness of blow. People willing to try their strength paid threepence and then went down a line of instruments, having a go at each while an attendant recorded their scores. Many other studies have been made since that time mostly in America. Some, such as that of Walter Miles and his co-workers, have been sustained efforts to gather knowledge about ageing, but more often ageing has been incidental to some other problem. The aims of the major studies

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