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COMMUNICATIONS

THE STUDY OF SUN GLARE IN IRAQ

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Part One.

INTRODUCTION.

Analysis of the Solar Spectrum and the Influence of its Component Parts upon the Eyes.

Variations in the Actions of Solar Light.

The influence of Local Conditions upon Sun Glare.

Sun Glare Direct and Reflected.

The Varying Exposure of General Workers in Different Trades to Sun Glare.

Consideration of Glare as it concerns those Engaged in Aviation both by Day and Night and the Dual Problem thus Exposed.

THE problem of sun glare as experienced in tropical and sub-tropical countries has ever been of sufficient prominence to merit consideration. The law that postulates the adaptation of structure to function, has by the process of evolution, largely eliminated the natural inhabitant from the issue, though not entirely. Successful conquest and colonization, has spread the dwellers in the West over the territories of the Middle East and East, to deal not only with the problems of government, but also to engage in combat the endemic and epidemic diseases of these lands, and

to struggle with a surfeit of heat and of light, completely out of all keeping with their normal environment. Swift transport by land and sea, and more particularly by air, has by its unchecked haste, cut down the gradual change in each succeeding East-bound day, and thrown therefore a greater climatic strain upon the traveller.

The Solar Spectrum.—Within the bounds of the solar spectrum are rays both visible and invisible. The visible group have a wave length varying between 8,000 A.U. and 3,800 A.U. The invisible components are represented by waves above and below this group with the chemically acting ultra-violet at the short and the infra-red heat producing rays at the long end.

We have thus three solar spectral functions with which to contend, namely, chemical activity, light and heat.

Examination of the literature devoted to the study of the ocular effects which can be induced through the agency of the invisible spectrum, shows immediately, how wide has been the field of investigation.

The Ultra-Violet Spectrum.—Widmark¹ in 1889, linked the condition, later named "photophthalmia" by Parsons,² with the shorter ultra-violet rays, and thus was the first to establish its aetiology. He demonstrated that ultra-violet rays emanating from a carbon arc of 1,200 c.p. caused conjunctivitis, desquamation of epithelium, corneal opacities and lenticular changes in rabbits' eyes. Later, Birch-Hirschfeld demonstrated retinal changes with vacuole formation in the ganglion cells.

Experimenting also with rabbits, Parsons and Martin³ showed that marked changes in the anterior capsule of the lens could be effected, and their findings were in agreement with those of Hess.

Stewart Duke-Elder⁴ considers that the longest wave lengths, "by increasing molecular movement produce mainly thermal effects, while the shorter ones, whose frequencies correspond to the intra-molecular oscillations, by increasing atomic motion, produce molecular disintegration with consequent photo-abiotic, photo-chemical and photo-molecular changes."

For the production of effect, absorption must take place.

Histologically, W. S. and P. M. Duke-Elder⁵ have given a detailed description of corneal, lenticular, and retinal changes, as a result of the influence of short wave light upon rabbits' eyes. The area of greatest corneal damage was situated centrally.

Lenticular disturbance was confined chiefly to the periphery, and a special alteration of the epithelium, described as an "epithelial wall" was emphasized. Retinal changes which included disintegration of ganglion cells and vacuole formation were met with. Nuclear changes were in excess of cytoplasmic changes; a point at variance with the findings of Verhoeff and Bell.

Cortese⁶ working with ultra-violet rays found that the absorption of these rays by the refracting media, represented the major part of their action.

The Infra-Red Spectrum.—Hoffman,^{7,8} researching upon the effects of infra-red rays upon rabbits, employed wave lengths of from 700μ to $1,700\mu$. Four minutes irradiation caused lenticular opacity and also destruction of the chromatophores in iris and ciliary body. Weak irradiation with short waves of the infra-red group, produced changes mainly in retina and choroid. Long waves of the infra-red spectrum, produced damage to the circulation and to the tissues of the lids and anterior part of the eyeball. The ultra-violet rays, in his opinion, only seldom reached the retina, owing to the extensive absorption of them by cornea and lens.

Kranz⁹ maintains that the action of the infra-red rays is founded on transmission into a thermal form of energy. He asserts that he is not in agreement with the views held at one time by Vogt who attributed to the infra-red spectrum an unknown but possibly chemical action.

The Visible Spectrum.—Sun glare as manifested by the visible ray group is responsible for photophobia, lacrymation, conjunctival irritation resulting in blepharospasm, pupil contraction, and, according to Ferree, fatigue of the extra-ocular muscles.

Permanent intra-ocular damage, according to Hoffman's experiments, does not occur from exposure to visible light, but Herzog¹⁰ in 1898, carrying out tests in Leber's laboratory, produced cataracts in three fully grown rabbits. Ultra-violet rays were excluded by numerous layers of glass and infra-red rays by a filter of alum solution. Prolonged irradiation was, however, necessary in order to produce these results.

According to Langley solar rays reach the earth in the following percentages :—

				Per cent.
(i)	Ultra-Violet	...	...	39
(ii)	Violet	...	...	40
(iii)	Blue	...	...	48
(iv)	Green-Blue	...	...	54
(v)	Yellow	...	...	63
(vi)	Red	...	...	70
(vii)	Infra-red	...	...	76

The following table sets out the several functions of sun light and the physiological and pathological conditions that it is capable of producing (Castellani).¹¹

Variations in Actions of Solar Light.

Solar Light.		Visibility.	Action.	Disease.
Heat.	i. Infra-red ii. Red	Invisible Visible	Heat	Heat Stroke
Luminous Rays	Orange Yellow Green	Visible	Illuminating	Glare Headache Night-blindness
Chemical.	Blue Indigo Violet	Visible	Stimulating and anti-rachitic. In large doses, irritant and tissue destroying	Pigmentation

The intensity of glare depends upon season, atmospheric conditions, and the composition of the landscape either immediate or remote.

Glare in Iraq.—In Iraq the soil consists chiefly of infinitely fine fawn-coloured mud, there is little true sand. Over the desert on certain days hangs “mirage.” (See photographs No. 1 and 2.)

White buildings increase glare considerably. Vegetation gives remarkable relief.

Iraq sunlight is considered low in its ultra-violet properties and relatively high in infra-red light. In this country the process of skin pigmentation is slow. (See Chart I, p. 597.)

Classification of Glare.—It is important to consider sun glare apart from its analytical make-up and to distinguish between :

- (a) Atmospheric glare.
- (b) Reflected glare. (i) Direct ground ; (ii) Lateral.

(a) Atmospheric glare if we exclude the direct rays of the sun, causes relatively little trouble. The unbroken expanse of sky, generally cloudless, evenly receives the light and reduces the general intensity to an amount within the bounds of ocular tolerance.

There is however much variation in this direction and it is unquestionably more difficult to face a general atmospherical glare on certain days. It is said by Gibbs and others that with an equally clear sky it is possible to have “actinic” and “non-actinic” days, though the reason for this difference is not understood.

(b) Far more troublesome is reflected glare. The truth of this is immediately evident if one employs the simple test of holding the hand across the face just below the eyes, and parallel with the ground. The relief afforded upon a day when strong glare is

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PHOTO No. 1. Machines of No. 55 Bombing Squadron over the hills towards Sulamania, foothills and plains in the distance.

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PHOTO No. 2. Machines of No. 55 Bombing Squadron over typical Iraq desert.

present is immediate, while the discomfort returns directly the protecting hand is removed. Lateral glare can be readily appreciated though in a more modified degree. This may be proved by wearing a pair of moderately dark anti-glare neutral-tint goggles without side pieces, and while standing in a glare area covering up the unprotected lateral spaces with the hands, once again a difference and feeling of relief from light reduction is experienced.

Classification of Workers.—It is necessary now to give consideration to the influence of the glare factor upon workers in those various occupations which, by their linking form the chain of administration overseas.

Broadly speaking a classification may be set out as follows :

1. *Indoor Workers.*—Clerks (Accountant and general duty); nursing sisters; fitters aero engine; riggers; wireless operators.

2. *Outdoor Workers.*—Pilots; aerial gunners; armoured car crews; motor transport drivers.

Now the worker in offices overseas has perforce to spend much of his time in artificial light, the architecture of the buildings in which he must pass his morning hours, is as a rule of such a character that unrestricted daylight cannot reach him. The size and position of windows, and the breadth and setting of sheltering verandahs, constructed as they are to reduce internal temperatures, demand the use of artificial light. Thus alternate stimuli by glare and by artificial light, go with him in the process of his daily duty. So also with others whose work demands confinement in closed or partially closed buildings.

A glance at the several trades classified will suggest the various ocular strains associated with each group. While including pilots, armoured car crews and drivers of motor vehicles under the heading of outdoor workers, it must be appreciated that this is but relative, and that a fair proportion of the day is always spent within buildings of the type already described, but the ration of exposure to sunlight compared with artificial light is definitely increased in these cases.

Sun Glare and Aviation.—So rapid have been the advances towards the perfection of aircraft considered from the standpoint of construction and engine power, that it is necessary always to direct attention upon the human factor, and the ability of man to master successfully, machines of many designs and sizes capable of outstanding air speeds.

There must be a fine co-ordination between eye, limb, and a rapidly analytical brain.

It has been shown in the past, that disturbance of the ocular muscle system, may readily cause defective judgment of distance where the landing of aeroplanes is concerned, especially those in which the stalling speed is relatively high. It has been found

for example, that pilots suffering from an ocular fatigue of sufficient amount to produce a palpable exophoria, tend to reduce their gliding angle too soon, and this action, if sufficiently pronounced, may bring about serious mishap.

There are many instances that can be cited which show how an unconscious alteration in ocular muscle balance may produce gross errors in visual judgment. To offer an example, the case may be quoted of the pilot stationed in Iraq, who, after long experience of the aerodrome where he was stationed, suddenly for no reason that he could give, proceeded to "flatten out" his machine several feet too high, and landed in the ditch at the far side. He was found to be suffering from a very weakened power of convergence and a marked exophoria as revealed by the standard tests. A course of eye training after a preliminary period of leave, enabled him to resume successfully his flying duties.

In view of cases such as these the problem of sun glare assumes a new aspect. Does its prolonged influence undermine the accuracy of visual judgment?

What are the fatigue factors that may be attributed indisputably to its action and made apparent when flying either by day or night?

In day flying the outstanding visual essentials are good visual acuity and sound visual judgment. Night flying demands a more delicate visual perception from many standpoints, it postulates a normal, or super-normal light sense, it calls for the accurate interpretation of coloured flares, or lamp signals, it demands the full faculty of visual adaptation. Not only then must central vision, with binocular co-ordination be of a high standard, but also the retinal periphery must be fully responsive to many and varied stimuli.

Is it possible that sun glare prolonged from summer to summer can, through its constant and unnatural intensity, produce a dulling of the retinal perception and thereby affect detrimentally the reactions and responses of the night pilot?

Alterations of vision and of the visual mechanism which influence the manoeuvres associated with aviation by day and night may be divided into:—

A. Intra-ocular.

(1) Visual Acuity (developing myopia, advancing astigmatism, etc.).

(2) Accommodation.

i. Spasm:—causing change in size of objects. (Macropsia).

ii. Fatigue:—causing also alteration in size of objects. (Micropsia.)

iii. Irregular action:—causing tendency to a transient astigmatism of low degree as a result of sectional spasm or fatigue. (This is much questioned by some authorities).

(3) Retinal.

Alteration in :—(a) Fields of vision.
 (b) Form Sense.
 (c) Light Sense.
 (d) Colour Sense.

B. *Extra-ocular.*

1. Spasm of Convergence.= Esophoria.
2. Fatigue of Convergence.= Exophoria.
3. Other disorders of the extra-ocular muscle system, *e.g.*, Cyclophoria, Hyperphoria, etc.

C. *Cerebral.*

Loss of the power to concentrate, producing ocular muscle imbalance, or weakening of the desire for binocular vision (fusion sense) either slowly progressive or of relatively sudden onset.

This classification embraces a wide area, but it has been set down in the manner shown because it covers to a very great extent the scope of the experimental work which follows.

The visual problems of day and of night flying are embraced within its range, and the manner of their experimental investigation and the nature of the results which have been compiled will now be considered.

Part Two.

EXPERIMENTAL INVESTIGATION.

Discussion on the Tests Employed and on the Technique Followed—Visual Acuity, Accommodation and Convergence—The Cover Test—The Bishop Harman Test—and the Phorometer Test.

Tests for Light Sense as Revealed by the Birch-Hirschfeld Lichtsinnprüfer and the Clement Clarke Apparatus.

Examination by the Bjerrum Screen and by the Cargill Perimeter. The Test of Pulse Response to Fatigue and the Reason for its Inclusion.

Consideration of the Diet Factor, Smoking, Colour of Eyes and Other Details.

In a maze so intricate and intersected by pathways so indefinite as to their ultimate termination, it is not possible in the first instance to assign to each its relative significance. Many directions must be pursued and at the beginning none may be considered of such minor importance in the general design, as to be wholly

neglected. Thus in the process of this investigation, the tests employed will be found to embrace a wide field, so that when interpretation is placed upon the results obtained, fallacy and misconception may not endanger the issue.

The first concern was the choice and grouping of cases selected for examination. How many should be called upon, and from what departments? How often should re-examination be carried out?

Method of Selection of Cases.—The optimum conditions seemed to be satisfied by taking (where possible), ten to twenty individuals from each of the several departments and subjecting them to a series of what may be called "routine tests" at intervals of roughly one month throughout summer and winter, thus keeping under observation over a 100 members of the local population. They differed in their employment, differed in their period of overseas service and differed in their attitude regarding the use of anti-glare glasses. In short, they were normal people, living the normal Iraq day after their own fashion. As time went on it was found impossible to hold fast to the monthly routine, owing to absence on duty, or on leave, to illness and to aerial mishap, but the process was adhered to as closely as possible.

The selection of cases fell under the following groups shown in alphabetical order :—

- (a) Aerial Gunners.
- (b) Armoured Car Crews.
- (c) Clerks (Accountant and general duty).
- (d) Fitters Aero Engine.
- (e) Motor Transport Drivers.
- (f) Nursing Sisters.
- (g) Pilots.
- (h) Riggers Aeroplane.
- (i) Wireless Operators.

If reference be made to the Tables A, B and D, the character of the tests made will be apparent. In many instances their nature is well recognized and no discussion on technique is called for, but some are less common and thus demand a passing consideration.

Accommodation.—Regarding the measurement of accommodation, it should be understood, that the readings represent *distance from the corneal surface* recorded with the unaided eyes or eye, and *not distance from the anterior focal plane*. A form of Princes's Rule was employed, and fine print was set in the moveable slide. A shield on each wing of the face piece made it simple to occlude the vision from one eye while making uni-ocular estimations.

The power of convergence was tested by the same apparatus, a vertical stick acting as the object for fixation.

The Cover Test.—The cover test is too well known to call for any description.

The Red Green Test.—Phorometer Test.—The Red Green test, always employed in the Royal Air Force when the ophthalmic problems of flying arise, is, of course, an instrument in fairly common use, and its value in the estimation and analysis of ocular muscle imbalances (heterophorias, etc.) is well known. Two strips of glass (one red and one green) half an inch wide and about four inches long are superimposed, or set end to end (depending upon the visual plane under test). Two sides of a square box are used for the setting of the glass strips, and within the box is an electric lamp the light from which is diffused through a porcelain glass plate before it comes to the coloured strips. The observer wears a pair of spectacles (reversible) containing in one chamber a red glass, and in the other a green glass. Now it is essential that the spectacles are made of the same glass as that on the box, and it must be such that red neutralizes green and *vice versa*, for this is a dissociation test, and everything hinges upon this point. Tests are made at 20 feet.

Readings may be recorded in inches, centimetres, or prism-dioptres of displacement when a phoria has been demonstrated. If the movement is only slight the result is noted as a "tendency." If the red glass is before the *right eye* and the red strip over the green strip set in the box moves towards the *left*, the condition is of course an exophoria, and one of varying degree from simply a "tendency" as noted, to several inches or even feet in the case of extreme fatigue and facile dissociation.

The Bishop Harman Test.—Bishop Harman's Diaphragm Test is an instrument requiring some explanation. A photograph is shown of the modification used in the Royal Air Force (see photographs No. 3 and 4). The instrument gauges the "desire" for binocular vision under increasing binocular strain. Variation in pupil distance is allowed for. The readings taken from the scale over which runs a pointer, are easily recorded. They represent an arbitrary calculation and the value of the results lies in the fact that any reading above "4" demonstrates a definite weakness in the power of binocular fixation. To apply the test. The pupil distance is first measured and set on the P. D. scale. The face piece is now placed against the observer's upper lip just below the nose. The diaphragm, near the other end, is fully open. The printed card at the extreme end is clear to both eyes together, and to each eye separately. The subject is asked to watch closely the printed matter (for simplicity 1, 2, 3, 4, 5, 6, 7 in a row) while the diaphragm is being closed by turning a screw at its side, and to state directly he

PHOTO No. 3. The Bishop Harman Diaphragm Test.

PHOTO 4.

notes a crowding of the middle numbers (esophoria) or a separating of them with the interposition of a black bar (exophoria). The readings are made in this fashion, "bar at 2," "crowding at 1," "uni-ocular at 10" and so on. This is an exceptionally valuable and delicate test for binocular co-ordination and early fatigue of the fusion sense.

Dark Room Experiments.—The tests in the dark room were initiated to discover whether or not sun glare influenced the ocular reactions to controlled light stimuli. The room used for the purpose was tested by exposing photographic films within it for varying periods—after the lapse of five minutes, reaction, due to light, took place in a section of film exposed.

Two types of instrument were used, namely the Birch-Hirschfeld *Lichtsinnprüfer* and the Clement Clarke threshold and light-sense test.

The Birch-Hirschfeld Apparatus.—This apparatus is illustrated in photograph 5.

A rheostat controls the primary light source. A small frosted electric lamp is fixed into a tube at the back of the instrument. It throws light through a variable diaphragm and evenly illuminates a round porcelain glass plate. Just in front of this is a pair of grooves for sliding into position certain metal stencils, (in this

Diaphragm
control lever.
"L" "G"

Rheostat

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PHOTO 5. The Birch-Hirschfeld Lichtsinnprüfer showing Goldberg Wedge in place, "G."

series of tests only the stencil containing five small circles placed as the five on a die, or domino was used) while in front of this a further pair of grooves are placed for the reception of two oblong frames. These frames, which hold glass of varied type, are capable of movement from side to side, and the amount of this movement is controlled by a ratchet. Now these slides are of two kinds. One is composed of glass giving finely graded shading from a very light neutral down to what might be described as completely black (the Goldberg Wedge), the other holds squares of glass, the first being red, the next blue, then dark, medium and light smoke.

In setting the instrument the rheostat control is brought to a higher resistance than that coming from the electric supply as otherwise the small bulb gives too great an illumination thus spoiling the delicacy of the test (voltage 220 rheostat beyond 250).

In order to make the experiments as standardized as possible, all cases were retained in the main ophthalmic room out of the glare for ten minutes, as some of them had a long way to come during the early part of the day and the protection offered by the available transport differed. The tests set down in Table A were next carried out. Then the subject was admitted to the dark room which was lighted for the purpose of explaining the nature of the experiment, by one 18 c.p. bulb. A further pause of five seconds being made the light was then snapped off.

Methods of Examination.—First "light minimum" and then "light difference" were examined, but it soon became apparent that the grading was too coarse to be of value and the readings were all discarded.

The examination with the Goldberg Wedge followed. The slide was run into position with the diaphragm (for the purpose of this test) closed. As soon as the light shaded end of the wedge covered the five illuminated holes, the observer was asked to state the number of spots of light he saw, and this was recorded by repeating to an assistant in the main room. The slide was moved across from left to right until it engaged the first ratchet, and a further reading taken and so on. A pause of five seconds came with each movement. When, owing to the steadily diminishing illumination, all the spots of light had vanished, the reading ceased. The next slide was now run into position, and a similar routine ensued. The diaphragm now came into use. It was found that only in exceptional cases was there appreciation of red or of blue when the diaphragm was closed. The method of examination therefore differed from that with the Goldberg Wedge. When the red glass was in place a pause of five seconds was made. If nothing was seen, the diaphragm was opened one ratchet, and after a further pause of the same time, another ratchet. The number of spots were revealed. (Method of recording see Tables B and C.)

In succession, readings for blue, dark, medium, and light smoke were taken.

The Clement Clarke Test.—This apparatus, at present in its first experimental stage, was designed for the author for the estimation of light minimum and of light difference. (See photographs No. 6 and 7.)

At one end of a hollow tube (the big end) is placed the source of light—this can be controlled by a double rheostat. The electric lamp light source is attached in such a way that adjustments may be made by means of three screws to permit of an even diffusion of light. Within its enveloping tube the instrument is divided through its long axis into two separate chambers, presenting thereby a dual light source to the observer.

Now it is possible by means of a stencil passed through a slot at the position noted (B) in the photograph to occlude one source called the "permanent source," and to allow light to pass only through the other, or "variable source," so called because its light value can be altered through the action of a camera diaphragm.

The observer sits opposite an opal circular glass window roughly 2.5 in. diameter. About this window a large circular wooden disc can be made to revolve (D in photograph 6) in such a fashion that three apertures containing glass of different neutral (smoke) densities may be interposed between it and the observer. A fourth aperture in the wooden disc is freely open.

Thus are there six (including the rheostat and diaphragm) methods of altering the strength of light from the original source. The diameter of the circular apertures in the wooden disc are about 4 in. in each case. A wooden screen (A) separates the observer from any diffuse light not directed down the two compartments within the tube.

Method of Examination.—The technique of using the apparatus was as follows: The stencil which was shaped so as to occlude the "permanent light source" was set in position, and the darkest tinted glass disc rotated into place before the opal glass window. The rheostat was set to half way. When the principle of the tests was grasped by the observer, the room was thrown into darkness and a minute's pause recorded. Because of the extreme heat experienced in the dark room in summer, adaptation time had of necessity to be considerably restricted.

The light source was then switched on and the diaphragm controlling the "variable source" opened one point every five seconds. If the light became visible to the observer the diaphragm reading was taken. Sometimes with so great a light reduction nothing could be seen and a "nil" record therefore made. The experiment was repeated with the other, lighter shaded glass discs, and with the empty frame, and further records made (see Table D). These

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PHOTO No. 6. The Clement Clarke Light Sense and Threshold Test, note the Stencils (Cross and Clocks). Note the protecting screen "A," the permanent source occluding stencil "B," the diaphragm control "C," and the rotating disc "D."

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PHOTO No. 7. Another view of the Clement Clarke apparatus showing more clearly the Stencils placed against the apparatus and the double Rheostat.

results demonstrated the "light minimum" reaction for the particular case under test.

To estimate the "light difference" reaction, the stencil was removed and thus gave freedom to light passing down the "permanent source chamber," so that now two separate sources of light could be seen at the observer's end of the apparatus. Into the path of the variable light source was slipped a stencil representing either a "plus" or a "multiplication" sign. (See photograph of stencils propped against the instrument.)

The movements of diaphragm and rotating disc were repeated exactly as before and recorded. The appreciation of "light difference" came of course with the accurate interpretation of the stencil figure, showing that a greater proportion of light was passing through the variable source owing to diaphragm aperture increase, than through the permanent source. Finally a stencil punctured with 12 holes placed in circular fashion to represent the hours on a clock face was used. This stencil had also a single radius composed of small holes set in a line, which did duty for an hour hand. (See photograph No. 7). The previous routine was carried out and a record taken showing in each case the moment of appreciation of the "hours" and of the "hour hand," and of the time demonstrated.

Perimetry

The Bjerrum Screen.—Readings with the Bjerrum screen were taken in order to investigate the state of the central visual field after varying periods of duty in the country. Charts were plotted from readings taken at 1,500 mm. a distance giving the optimum conditions for illumination (it will be noted on inspecting the charts that the screen itself was primarily intended for examinations at 1,000 mm. and mapped accordingly). Hence the blind spot is set rather far out. This being understood, the comparative results are unaffected.

The blind spot was mapped out with a 4 mm. white disc (Traquair's test objects). The colours blue, red, and green, were all charted from observations with 15 mm. discs. In every case the central and centro-caecal areas were tested by a 2 mm. red and green object. An assistant plotted the results as they were dictated to him. Readings both by daylight and by artificial light (two 220 volt screened lamps at 1 foot, one above and one below) were recorded.

The Perimeter.—Readings with the Cargill perimeter were made by using a 3 mm. white test object only. The periphery of the field was examined for fatigue contraction. The illumination of

this instrument is of the type called "standard" and the lamp is fixed beneath glass at one end of the arc. Charting is mechanical.

Vitamin Factors.—In order to learn something about the visual reaction of the Indian and Iraqi inhabitants, the series of "routine tests" coupled with the examination by the Birch-Hirschfeld apparatus and the Clement Clarke instrument were made. About one half of the number taken were strict vegetarians. All were employed on clerical duties. (The possibility of vitamin deficient diet was borne in mind in these cases with the consequent effects upon the reaction of the visual purple, in view of the work of Katharine Tansley¹² upon this subject.)

Tobacco.—The question of smoking was considered, and the average amount of tobacco smoked appeared to be roughly 12-15 cigarettes a day. Pipes were not commonly used.

A note was made regarding the colour of eyes in each case.

The 40 mm. Test.—The 40 mm. test in standard use in the R.A.F. was recorded in all cases with the exception of the members of the nursing staff of the hospital. This test consists in asking the examinee to blow by means of a mouth-piece and rubber tube, a column of mercury to 40 mm. and retain it there as long as possible. The reactions from general fatigue and debility, neurasthenia, etc., are well and easily demonstrated from the resulting pulse response recorded in five second intervals during the experiment. It was considered important to make this test part of the routine in a country where general bodily fatigue might exaggerate ocular symptoms attributed otherwise to the pure influence of sun glare. Also on the "routine test" forms, space was allotted for noting any special points in the history of those under observation, such as hospital treatment for "Sand-fly fever," etc. If the series of tests was broken, then the reason for this was noted.

Part Three.

Graphs, Tables, and Calculations.

Interpretations of the Results Achieved and General Conclusions.

It is now necessary to enter into the consideration of results. The period covered lies between May, 1930, and November, 1931. Examination and re-examinations proceeded throughout summer and winter, so that two hot seasons were separated by the cool period; for it was considered important to ascertain the "factor of recovery" in the winter months as demonstrated by the routine tests (see Tables A and B). The Clement Clarke Apparatus was first used in October, 1931, and at the same time a study of the visual fields was commenced.

Routine Tests

Visual Acuity.—(Average age of the 129 cases 22 years.)

Certain changes took place. Cases were re-examined from five to ten times, so that the total tests for visual acuity rose to well over 800. Altogether 14 individuals were found to have fallen below their initial visual standard. In no case did the divergence pass beyond the range of 6/18, from 6/6. The more common form of refractive error was found to be a low myopic or mixed astigmatism. The general tendency was always towards recovery during the cool weather. Only three of the fourteen cases demonstrated persisting errors.

The occupations of the 14 cases under consideration were as follows :

Armoured Car Company	...	...	3	} 6
Drivers, Petrol...	...	...	3	
Fitters, Aero Engine	...	...	3	
Riggers, Aeroplane	...	...	3	
Pilots	...	...	1	
Acetylene Welder	...	...	1	
Total	...	...	14	

Accommodation Convergence and the Bishop Harman Test

Accommodation.—Considered generally it will be noticed (Graphs No. 1 and 2) that the accommodation curves tend to rise in the spring, reach more or less a peak by August or September, and then fall with the onset of winter. The curves in detail are erratic and sharp peaked in many places. This can be explained in part by the fact that the number of cases available for examination from month to month inevitably varied. There is a very uncertain relationship between the uni-ocular accommodation values, with the exception of the Pilots group (Graph 1). Here the smoothness of the curves is striking when compared for example with that appearing in the Drivers M. T. group (Graph 2). Pilots are more careful in the use of anti-glare glasses. (Anti-glare flying goggles and ground spectacles are issued to flying personnel.)

Convergence.—The convergence curve follows broadly the sweep of the curves for accommodation. The power of convergence shows a tendency to weaken in the summer months and to return to its original state with the departure of the hot weather.

The Bishop Harman Test.—Response to this test is well shown upon the graphs which will be shortly analysed. The variations between summer and winter readings can be seen in all but the

graph for clerks (not published). An interesting general feature is the lack of symmetry between the curve for this test and the other curves upon the charts.

Analysis of the Charts.—Before examining the curves, attention should be given to the values arranged at the side of the graphs. It will be found that different space values have been given to

GRAPH NO. 1. Showing curves of Ocular Muscle Fatigues. The upper curve (Convergence) shows a peak of 9.5 cm. summer and a drop to 7 cm. winter. The three middle curves (Accommodation) show uni-ocular readings always higher than the binocular readings, with the left eye weaker than the right. Maximum binocular 12.4 min. 10.8, uni-ocular readings up to 13.8. The lowest is that for the Bishop Harman test, variations from 1 to 3.3.

GRAPH NO. 2. Note the more erratic nature of the curves as compared with graph No. 1. Convergence peak 12-13 cm., accommodation peak 13 cm., binocular and 14-16 cm. uni-ocular.

different tests. This has been done for the sake of clarity, and to prevent overlap of the curves wherever possible.

Pilots.—(Graph No. 1.) The most interesting feature here is the smooth sweep of the accommodation curve. There are no violent movements to be seen. Fatigue is present up to a point (peak 12.4 cm.) but binocular and uni-ocular reactions trace their way across the paper in close harmony.

Convergence reaches a peak of 9.5 cm.

The Bishop Harman curve tends to climb in the region of September. From November to March a drop is noticeable.

Armoured Car Company and M. T. Drivers.—(M. T. Drivers, Graph No. 2. Armoured Car graph not published.) The curves taken in these cases show points of great interest. The peaks are sharp and erratic. There is a remarkable divergence between the uni-ocular accommodation readings. The Bishop Harman response is of the climbing type.

Drivers of Motor Transport suffer more than those engaged in armoured car work. Here again the explanation may be found in the fact that anti-glare glasses are issued to members of the car crews for use on duty.

Ground Staff.—(Graph not published.) The sharp peak in the graph of these cases is not characteristic and its presence is due to the fact that only two individuals were available for examination in March. The summer and winter responses run more or less in company.

Clerks.—(Graph not published.) Here the outstanding feature is the persistent climb of the Bishop Harman curve. It never really settles in the winter, but continues its upward slope throughout. Its peculiar nature can be attributed to occupation inducing mental fatigue and loss of the desire to maintain fusion.

The Group Graph—all trades.—(not published.) This graph demonstrates very clearly the fatigue peaks rising to the maximum about November, 1930, and sinking by stages to a lower level in February followed by a marked rise again in March, 1931.

In the interpretation of these graphs it should be recalled that the summer of 1930 far exceeded in heat intensity that of any hot season in Iraq for the previous ten summers. (See p. 597.)

In July, 1930, it will be seen that there is a general tendency for most of the curves to fall.

This is considered due largely to the beneficial results of leave and change to the Rest Camp in the hills.

The Phorometer Test.—Muscle balance for distance (20 feet) remained little affected. No marked alterations appeared and very many cases commenced and finished their tests with orthophoric readings. A little hyperphoria showed itself here and there but did not exceed one prism dioptré.

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CHART 1. Temperature Chart included for Comparison with Graphic Case Fatigue Curves.
The heat wave in August, 1930, reached 120.6° F.

The Light Sense Tests

The Birch-Hirschfeld Lichtsinnprüfer.—Over 800 examinations were taken with this instrument. Variations were wide, and led to divergent results in many cases. The explanation of this hinges to a great extent upon the employment of the "five spot disc." The spots, yielding a low degree of illumination, tended to appear and disappear rapidly so that in general an accurate interpretation was difficult to attain. Those cases, which in the general darkness were by chance looking at the dial slightly off their fixation points numbered more spots, while others again seemed to retain the after images as the slides passed across the source of light. The strength of suggestion with this instrument is very great. A group of cases averaged for May, August and December, 1930, will be found in Tables F and G with a final reading taken from July, 1931, figures.

The Clement Clarke Test.—This instrument, although in little more than its experimental stage, has produced excellent and consistent results. Groups of cases representing controls (of the 1931-32 draft), pilots, ground staff, drivers of motor transport and clerks have been analysed and the results graphed (Chart No. 2, also Table D. To understand fully the significance of the chart thus displayed, it is necessary to pay particular attention to the figures framed in silhouette wherever they are shown above the blocked spaces. These squares denote the actual number of negative responses on the diaphragm set in the path of the variable light source (for description see Part 2). The diaphragm is capable of opening as far as "10" after which it is fully opened and no further readings can be made.

Therefore the figures which show a negative response demonstrate weaknesses in the light minimum and threshold reactions beyond the registering capacity of the instrument. The chart is divided into four sections vertically. The upper section is given to the representation of light sense. Readings should be made across the sheet noting the designation dark smoke, medium smoke, etc. in each connection. The diagonally shaded areas represent quantity of light perceived. In reading these, reference should be made to the left-hand marginal figures which show the average diaphragm values recorded in each instance from zero upwards in a scale of one.

Compare then the control readings with those of subjects who experienced one or more glare seasons. The control results very far exceed in the rapidity of their reactions the responses of all other groups to similar stimuli. For example take the reactions of the five groups to the four tests available in this instrument, the dark smoke glass being in place.

CHART 2. Block graph giving details of responses to the Clement Clarke Test. (See text, p. 590 and p. 598.) The black squares with numbers inset represent negative responses in spite of full diaphragm aperture; the shaded columns show the position of the diaphragm averaged for the number of cases in each group. For example take the top extreme left column, it represents 3 negative responses and an average diaphragm of "5" for the remaining cases in the group (Pilots).

DARK SCREEN

Light Sense			Threshold						
Light Sense			Neg.	Clocks	Neg.	Time	N.	Crosses	Neg.
Pilots (20)	...	5.0	3	4.5	9	1.8	18	5.4	7
Ground Staff (9)		5.0	3	4.2	5	0.0	9	3.0	6
Controls (10)	...	5.8	1	7.6	1.	2.4	7	6.0	2
Drivers (6)	...	3.2	3	3.0	4	0.0	6	4.2	3
Clerks (10)	...	4.6	3	3.7	6	0.9	9	4.3	5

It will be seen that :—

- (a) Pilots gave 37 negative readings.
- (b) Ground Staff gave 23 negative readings.
- (c) Controls gave 11 negative readings.
- (d) Drivers of M. T. gave 16 negative readings.
- (e) Clerks gave 23 negative readings.

Indian and Iraqi clerks produced results that were a little above the average for British clerks. They were inferior, however, in estimating the "time" section of the Threshold test.

The readings for pilots are exaggerated to some extent because they represent a larger group, and because two of their number had some shortening at the red end of the spectrum. Nevertheless this total must be considered high and due in some degree to their work over the desert areas in the hot weather. Pilots have described the glare as so bad on one landing ground that they found it almost impossible to make a reasonably good landing in spite of a considerable number of flying hours to their credit. From personal experience as a pupil under instruction, partly upon this particular ground, it is easy to understand that the difficulty and visual strain in endeavouring to estimate distance and speed over a flat glare area, void of all vegetation or colour variation, is very great.

The remaining comparisons may be made by referring to the blocked graph already mentioned (Chart No. 2.)

The Visual Fields

The Central Field.—(*Bjerrum Screen.*)—Over 50 examinations were made employing the Bjerrum Screen as described in Part 2 of this work. When the results of these examinations had been charted a further ten readings were made from members of the new draft arriving in November, 1931, so that a "control value" could be set upon the basis of the lighting system of this particular screen. It should be understood that tests made with the perimeters and with the Clement Clarke apparatus fell within the months of October and November, so that conditions were very similar.

The controls had of course established a short acquaintance with increasing light intensity during the voyage out to Basrah in October.

In the case of the fifty odd persons under routine observation whose fields were plotted, about half were examined by daylight illumination and half by artificial light alone (See Part 2), and all passed through the routine tests and the Clement Clarke test. One case among them was found to have a defective colour sense with shortening of the red end of the spectrum. The control group considered as a whole produced fields very definitely more full in all respects than those demonstrated in individuals who had passed through one or two hot seasons (See reproductions of Visual Fields, photos. No. 8-15.)

Results by Artificial Light.—The results of examination by artificial light gave wide variations. Three cases registered fields corresponding to the normals of the control series. Of the remainder:—

(a) Two showed fields practically full, but containing scotomata leading from the blind spot.

(b) Three had full fields for blue, and contracted fields for red and green.

(c) Nine were found to exhibit a general contraction, and three from these gave large or moderate scotomata to be described later.

(d) Two cases had "inversion for blue" with marked contraction as well for red and green (the so-called "torpor retinae").

Results by Daylight Illumination.—Examination by daylight illumination gave these results:—

(a) Two cases produced readings similar to those of the control series.

(b) Five were full in field for blue but contracted for red and green and one of these possessed an arcuate scotoma.

(c) Thirteen gave fields that showed a tendency towards general contraction with arcuate scotomata in some cases.

(d) One case showed "blue inversion" with general marked contraction for red and green; "torpor retinae" again.

To complete this analysis it should be noted that two cases from the control series demonstrated small relative scotomata associated with the blind spot. For comparative tests and sketches see Tables H and I.

Description of the Structure of these Scotomata.—It is well known that bright light and malnutrition are responsible for certain forms of ring scotomata. Traquair in his work on Clinical Perimetry says:—"These cases form a somewhat indefinite group in which the distinction between actual injury at the one extreme, and a psychical manifestation at the other is often obscure."

Speleers¹³ in examining cases affected by a solar eclipse found three signs, namely, enlargement of the blind spot, annular scotoma, and concentric diminution of the field of vision.

In studying the prints of the field defects demonstrated in his paper, there is seen to be a broad similarity between these and the fields investigated in Iraq. He showed the presence of irregular ring scotomata with an incomplete secondary ring within the main circle. They differed, however, in being situated outside the blind spot and often well towards the periphery.

Beauvois and Werdenburg, also working upon eclipse affected cases, described central scotomata.

Giannantonio¹⁴ reported upon four cases of dazzling by watching a solar eclipse. A central scotoma was present. The annular scotoma described by Jess was not a constant finding. Macular changes were present in two of the cases and absent in the other two.

Jess¹⁵ demonstrated ring scotomata in 36 out of 51 cases seen.

Ask¹⁶ described para-central scotomata as being present, more commonly than is usually supposed.

The scotomata found during this investigation differ from the general type just mentioned. The following table will show that the peripheral field, as examined with the perimeter, may or may not be affected where scotomata are found to be present.

Bjerrum Screen Charts		Perimeter Charts (Standard Illumination)	
Daylight	1. Two cases showing scotomata	1. Contraction present	2. No contraction
	2. Five cases showing scotomata		
Artificial Light	1. Four cases showing scotomata	1. Contraction present	2. No contraction
	2. Two cases showing scotomata		

Of the 13 cases demonstrating ring or arcuate scotomata, the blind spot was always in the ring, or, in those cases where the opposing scotomata did not meet, in the line of the ring.

From the total cases, three produced complete ring scotomata, and ten arcuate scotomata; peripheral contraction from the perimetric standpoint being present as well. (See charted description, Tables H and I, giving the responses of these cases to many other tests.)

A ring scotoma was found also in a case showing no peripheral contraction.

There was considerable variation in intensity. Patches giving absolute scotomata wedged themselves into areas showing relative scotomata which in some cases were only faintly present. In the full ring types, two particularly demonstrated these characteristics, while the others, once the blind spot had been mapped out, gave only a relative defect for the remainder of their course.

In position, all were para-caecal, sometimes being both supra- and infra-caecal, and at others only the one or the other.

In shape, some tended to be circular and some arcuate. Of the latter form, the two sub-types were also to be found, namely, the nerve fibre bundle type, and the zonular type, which, while facing the fixation point, varied in their course about it, and in one case even hooked round it.

The papillo-macular bundle escaped. That area, as already noted, was always tested thoroughly for white and for red and green with 2 mm. diameter objects.

Photographs from some of the charts have been reproduced in the text. (No. 8-15.)

Perimetric Readings

In Part 2 it has been stated that this instrument was used solely for examining the peripheral and intermediate zones, for white 3/380. Beyond marking roughly the blind spot no analysis of it was attempted.

From the 68 fields thus taken 29 demonstrated some degree of contraction usually of the regular concentric type. It was found that in all but one case the condition of contraction held also for colours on the Bjerrum Screen. Of the 39 fields however which were found to be full (when compared with control cases) 14 of them exhibited defects for colours on the screen and of these two gave marked inversion for blue.

Ophthalmoscopic Examinations.—Repeated examinations of the fundus oculi, revealed no changes apparent by ophthalmoscopic examination. It must therefore be concluded that indirect sun-glare (as opposed to dazzling by a solar eclipse), while of sufficient

intensity to cause the field changes already described is unlikely to damage the retina sufficiently to produce visible lesions.

The 40 mm. Test.—The table following shows the alteration in pulse response to fatigue in the months of May, 1930, and October, 1930 (See Part 2).

35 cases were taken and averaged: the first 45 seconds only being utilized in each group.

		Initial Pulse	Response to Fatigue										
		5 second intervals	5 second intervals										
May, 1930	...	7	7	7½	7	7	6½	6½	7	6½	6½	—	45 seconds
October, 1930	...	7	7½	9	8½	8½	8½	7½	7½	7½	7½	—	45 seconds

It will be seen that although a slight increase in pulse rate occurs, especially in the early part of the test, this is well within normality and does not express an undue physical fatigue.

Value of Anti-Glare Glasses against Unprotected Eyes.—It is always difficult to estimate exactly the value of anti-glare measures. Subjects vary so much in the way they use spectacles or goggles as a protection against the sun. The blocked graph (Chart No. 3)

CHART 3. Block graph illustrating the value of Anti-Glare prophylaxis. Note the July reading left hand (glare glass wearing) group and compare with July reading right hand no protection group. Note also how a tendency to stop wearing glare glasses too soon (September-October) throws the figures for fatigues up in the left hand group (Oct.)

however, goes far to prove the value of such measures. 12 cases were taken in each of two groups. Half were known definitely to avoid sun glasses and half made a habit of employing them. The contrast is most striking; a marked variation occurring in July. In October the quality of the blocks tends to approach one another. This has come about because there is a general tendency to discard anti-glare glasses in late September. The result is a burst of residual glare for a few weeks upon eyes reasonably protected up to that time.

Colour of Eyes.—When the “colour of eyes” figures were examined so little did the fatigue factors vary that a graphic or other representation was found of no value. It may be said that no appreciable variation exists between blue, brown, or grey eyes considered in numbers and in terms of ocular fatigue resulting from the glare of the sun.

These findings are interesting as they are confirmed by Elliot.¹⁷

The Diet Factor and Smoking.—Nothing worth recording came to light in considering the question of smoking or diet. Readings in the dark were made with Indian clerks and Iraqi clerks as subjects with the Clement Clarke instrument. 15 out of 22 demonstrated reduced light sense.

These men had of course spent their lives either in India or Iraq, some were vegetarians and others not. Although food values in Iraq may not be comparable to those in England yet there is not sufficient lack of Vitamin “A” in daily diets to cause reduced light sense or to exaggerate the readings where it is found to be present.

Conclusions

If we group together the results of the many and varied tests that have been used in this investigation it becomes evident that :—

(a) It is exceedingly rare for any subject to experience the full glare of a hot season without producing objective signs of fatigue of the ocular system in some form or other. There may be no subjective signs in many instances, yet the presence of abnormal weakness or fatigue can be fully demonstrated in varying degree.

(b) The 40 mm. mercury test shows that the pulse rate is greater in summer, but remains within normal limits.

(c) A condition of mental inertia is demonstrable in many instances through the use of the Bishop Harman test. Most characteristic is the Bishop Harman curve for office workers already referred to.

(d) Fatigue of accommodation and convergence is almost universal.

(e) Reduced light sense and threshold is exceedingly common.

(f) Changes in the visual fields take place in many instances and show considerable variations.

Peripheral contraction for white and for colours occurs and scotomata can be demonstrated in a number of instances.

A functional element in certain instances is present and appears, not in those cases found at random, but in the hospital admissions for sun glare where the symptoms have become acute. (See case reports below).

(g) Visible ophthalmoscopic changes do not occur through reflected desert sunlight. (In contradistinction to macular changes resulting from exposure to solar eclipse.)

(h) Colour of eyes is unimportant as a method of deducing glare susceptibility.

(i) The careful use of anti-glare spectacles offers a valuable and proved means of ocular protection.

Of the several trades which enter into the general scheme of administration, certain ones are more open to the detrimental effects of sun glare than others.

(1) Pilots appear to suffer more from deterioration of light sense than from extra- or intra-ocular muscle fatigue.

(2) Drivers of Motor Transport tend to suffer more than any other group from fatigue of accommodation and from loss of the power to converge. A certain proportion of general transport is of necessity on the move during the heat and full glare of the day. Reflected glare is thus able to exercise its influence upon the driver.

(3) Members of the clerical staff show a tendency to ocular muscle weakness and to weakening of the power to maintain binocular vision under stress.

(4) Regarding the figures obtained from the examination of eight members of the nursing staff in the routine manner, a relative proportion of ocular fatigue was found chiefly associated with the convergence and Bishop Harman readings. No characteristic feature was demonstrable.

Part Four.

Symptoms and Clinical Signs of Sun Glare (Photophobia Dolorosa Tropicalis).

Prophylaxis and Treatment.

There is no way by which we can differentiate the glare susceptible case from the glare tolerant. No structure complex exists that stands denounced as an immediate capitulator to the influence of intense sunlight. A faint clue may be considered to lie not in the

eyes, but in the individual. We find that cases freely exhibiting the symptoms and clinical signs of sun glare tend, in many instances to be "highly strung," or "nervous" or "temperamental." How much the condition is primary, and how much it is induced by intense ocular discomfort, with enforced idleness in countries and areas where men keenly seek work in order to span the days, it is not possible to estimate. But it is a very characteristic feature and one not out of tune with a nervous system keyed high and ever receptive to divers stimuli in an exaggerated degree. The presence of chronic conjunctivitis in subjects who have not been abroad tends to create a susceptibility to sun glare.

Symptoms and Clinical Signs

The onset of sun glare may be dramatically sudden or quietly progressive.

In its mildest form it produces a feeling of irritability in the eyelids which differs from that produced by dust and mild bacterial conjunctivitis, becoming suddenly and considerably worse in the presence of an increase of light intensity that would of itself have small influence upon the other forms of conjunctivitis named. Pronounced photophobia occurs early, lacrymation follows and headache appears as a rule about this stage, although it is quite common for frontal or occipital headache to exist as the sole symptom of sun glare intolerance.

Sun headaches are fairly characteristic. The frontal type makes itself felt as a dull pain situated bilaterally an inch above the supra-orbital margin.

There is sometimes a complaint of tenderness just where the supra-orbital nerve passes through its canal, or notch, as the case may be. In the occipital type of headache, the point of maximum discomfort is just inferior to the ext. occipital protuberance. Elliot¹⁷ describes a similar area of hyperaesthesia. A common time for this to appear is during or shortly after tennis, or other games, played without the protection of sun glasses. That headache should arise over this point is not surprising in view of the distribution of the visual areas in the brain.

Clinical Signs

The outstanding features are of course the extreme irritability of the conjunctivae, the vascular suffusion that ensues upon examination, and the profuse lacrymation upon exposure to almost any degree of illumination. Spasm of the orbicularis oculi and upward version of the eyeballs occur. To differentiate such a picture from cases of acute conjunctivitis, it may be said that no blepharitis forms, and no pus or muco-pus develops. Added to

these features is a definite tenderness of the globe on palpation. Pupil reactions are variable and show no characteristic points.

Later, as the acute symptoms and signs abate, and it is possible to enter into fairly full investigation, it will be found that in many instances there is a moderate general contraction of the peripheral visual fields; that reduction in the colour fields is present showing a great variation as to type (See charts and case notes), and that scotomata such as those previously described (Part 3) have appeared. Light sense and light threshold may be affected. In short we see a profound physiological upheaval set at times undoubtedly upon a functional foundation.

PROPHYLAXIS

Types of Glasses

Many forms of anti-glare glass exist but put broadly there is the type which reduces glare by its tint alone, and the type again in which the glass itself possesses special properties enabling it to absorb certain of the deleterious rays of the solar spectrum.

Regarding tint alone, a light and moderately smoked glass gives much comfort; but the glass must be of good quality and contain no flaws or hidden refractive errors. As an example of the danger of using "any glass" may be quoted the case of a child, aged five years, whose anti-glare glasses on casual inspection were found to show a spherical curvature equivalent to -1.5 D. Sph.

In selecting anti-glare glasses the psychological outlook must not be neglected. Certain colours, yellow and blues, seem to depress; so also with any glass that is unnecessarily dark.

We come now to types of glass which perform a dual function, reducing light intensity by their tint, and combating the harmful effects of certain solar rays by their power to absorb them. Better known in this connection are the Crookes' lenses. Of these, the so-called B.1 glass is generally useful. The Crookes' "ultimate" has in its time also proved valuable. It has been shown that plain glass will reduce the ultra-violet end of the spectrum to a certain degree, further reduction being attained by Crookes', Euphos, Ultrasin and others. The reduction by absorption of infra-red rays is less easily obtained. Here Crookes' glass, containing iron oxydate (No. 240) or ferric carbonate (No. 217) is useful, as also are the glasses recommended by Vogt, containing iron oxydal, but the ideal balance that will embody adequate reduction of either end of the invisible spectrum with simultaneous optimum translucency for the visible spectrum has not so far been completely realized. Tests in Iraq with a glass named Infrex are encouraging. Reduc-

tion of the infra-red end of the spectrum is very definite. An increase of the temperature of the surface of the glass is marked. Making use of reflection, it has been shown that certain metals; platinum, gold and silver in sufficiently thin layers can eliminate or reduce to a harmless percentage the injurious rays. The advantage here, is that heat from absorption does not accumulate to a troublesome degree.

Frames

No frames yet produced approach the ideal. Much remains to be perfected in the matter of design. To state the case broadly the glass diameter is almost invariably too small. Nor should the shape be round. Projection downward, oval in form to engage reflected glare, would undoubtedly prove an advantage. Well-fitting side pieces, made as dust proof as possible, yet giving access for air to minimise fogging are essential. Here fine mesh double thickness silk has proved better than any material so far put to practical test. Finally no anti-glare glasses or goggles should be constructed so that their bulk makes them unnecessarily awkward to carry. The ideal case should be flat faced and hinged so that no unnecessary strain is put upon frames and side pieces through pulling or pushing.

Treatment

Mild cases respond immediately under the protection of anti-glare glasses. For lid irritation a weak lotion such as the following used twice a day is helpful :—

R. Zinc sulph. } aa. grs. $\frac{1}{2}$.
 Zinc chlorid. }
 Liq. hamamelidis m.xxx.
 Double strength saline ad. $\bar{3}$ l.
 Sig. dilute with equal parts of warm
 water and use twice a day.

Some cases, relatively rare, are of sufficient severity to necessitate treatment in hospital.

Here the problem is two-fold—(a) Local. (b) General.

(a) Local Treatment

Atropine 0.25 per cent. b.d.s., or if that prove irritating, scopolamine hydrobromide 1/5th per cent. At the same time the lotion above mentioned is used. Excess of light is dealt with by employing dark smoked glasses.

(b) General

One must not overlook the functional element often associated with these cases. The conception of a darkened and silent room is wrong. These patients should be treated in the general wards and kept mentally employed by the daily affairs in progress around them. Solitude and consequent moping upon their visual hardships aggravates their condition and exaggerates their potential worries. In a few cases heterophoria may complicate the issue. The mydriatic should be stopped on the third day as a rule so that the pupils may regain their reactions before the patient faces the sun once more. Any refractive error should be corrected. Relapses sometimes occur and cases showing this tendency should not remain in a glare country.

Cases

For the purpose of illustrating the several features of the sun glare symptom complex the following three cases may be cited.

(i) S/M. W., aged 39 years. Trade Fitter A. E. Period in Iraq one year. Colour of eyes brown. Admitted from Basrah. Employed on technical work. Complaints of extreme ocular discomfort in sunlight. Quite unable to face any glare without dark glasses and even then experiences discomfort. Admitted for treatment. Found to be in a "highly strung" condition.

V. Rt. 6/12. correction R. $+0.25$ D. Sph.
 -1.00 D. Cyl. 105° 6/0.

V. Lt. 6/9. correction L. $+0.5$ D. Sph.
 -0.75 D. Cyl. 60° 6/6.

Visual fields showed contraction for colours. Blue field only slightly greater than that for red. Left eye even more affected with blue cutting red in places. Peripheral field for white contracted.

Annular scotomata of irregular form clearly marked.

Light sense tests showed slight reduction only.

Muscle Balance Tests

Binocular Accommodation.—19.5 cm.

Uni-ocular Accommodation.—Rt.—19.0 cm.

„ „ Lt.—21.0 cm.

Convergence.—15.5 cm.

Cover Test.—Bilateral divergence with tendency in left eye to lag before recovery.

Phorometer Test.—Slight tendency to neglect red. Slight Hyperphoria. Fundi normal.

Recovered after local and general treatment.

(ii) L. A. C., P. Age 33 years. Trade Fitter A. E. Period in Iraq eight months. Colour of eyes blue-grey.

Admitted complaining of marked glare intolerance. Headaches supra-orbital and at times occipital, also "nervous temperament."

V. Rt. 6/9. correction R. $+0.25$ D. Sph.
 -0.25 D. Cyl. 120° 6/6.

Lt. 6/9. correction L. $+0.25$ D. Sph.
 $+0.25$ D. Cyl. 110° 6/6.

Visual fields contracted for colours and for white. (Photos. 8 and 9, 12 and 13.) Slight tendency to reduction in red sense along centro-caecal area 10° out. Large erratic scotomata of annular type in continuity with the blind spot, absolute in small patches and relative over the greater portion (See photographs Nos. 10 and 11).

Light sense and threshold tests show marked reduction in every phase.

Muscle Tests

Binocular Accommodation.—17.5 cm.

Uni-ocular Accommodation.—Rt. 19.5 cm.; Lt. 24.5 cm.

Convergence.—12 cm.

Bishop Harman Test.—4 cm.

Cover Test shows tendency for neglect to be present.

Phorometer Test records a tendency to hyperphoria.

Fundi normal.

Responded to treatment.

(iii) L. A. C., D. Age 21 years. Driver Petrol. Period in Iraq eight months. Colour of eyes grey.

Definite refractive error present before coming abroad.

Refractive state November 7, 1930.

Rt. 6/18 partly, with $+0.5$ D. Sph.
 $+1.75$ D. Cyl. 150° 6/9.

Lt. 6/9 partly, with $+0.5$ D. Sph.
 $+1.25$ D. Cyl. 175° 6/9.

Had not then experienced a hot season. Refractive state when invalidated.

R. 6/60 with $+1.00$ D. Sph.
 $+1.25$ D. Cyl. 65° 6/24 partly.

L. 6/18 with $+2.00$ D. Sph.
 $+0.5$ D. Cyl. 75° 6/9.

Complained of intense reaction to glare. Admitted to hospital on two occasions. "Highly strung" temperament.

Typical clinical signs of glare susceptibility, photophobia, lacrymation, spasm of orbicularis, etc.

Fields show peripheral contraction for white. Marked colour contraction. Large annular scotomata. (Photos. 14 and 15.) Relieved from his trade and invalidated.

These cases may be considered fairly typical. As it happens all three exhibited signs of the nervous instability already referred to in general terms. It appears that once the glare symptom complex has acquired mastership over a case, the controlling forces of the mind tend to waver. It should be realized, however, that in the process of following the visual reactions of a large group of cases through the glare periods, a fair proportion will reveal conditions not far removed from those prevailing in the cases above stated without any external manifestation of neurosis. One can only assume that these cases suffering as they do excessive discomfort acquire a weakened nervous threshold, depression of which projects them across the border.

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TABLE A.

DEMONSTRATING THE SCHEME OF THE "ROUTINE TESTS" AND SHOWING AT THE SAME TIME THE RESPONSES OF A GLARE TOLERANT CASE (SEE ALSO TABLE E).

Date.	Test.	Visual Acuity.		Accommodation.		Convergence in cm.	Cover test.	Red Green test.	Bishop Harman test.	Fundus.	Ophth. App Conjva. Lids, etc.	Any Glare Complaints.
		R.	L.	Binoc.	Monoc.							
2/6/30	1	6/6	6/6	11'0	R. 11'0 L. 10'5	9'0	Slight Lat. Div. rapid	Normal eso.	1½	N.	Nil	Does not wear glare glasses. Glare does not worry him
19/7/30	2	6/6	6/6	11'5	R. 10'5 L. 10'5	11'5	N.	Normal eso.	1½	—	Nil	—
22/8/30	3	6/6	6/6	11'5	R. 11'5 L. 11'5	11'0	N.	Normal eso.	1½	—	Nil	—
13/10/30	4	6/6	6/6	10'5	R. 11'5 L. 11'5	10'0	Slight Lat. Div. rapid	Normal eso.	1½	—	Nil	—
14/11/30	5	6/6	6/6	10'5	R. 12'0 L. 11'0	12'0	N.	Normal eso.	1½	—	Nil	—

No. - 335974.

Rank - Cpl.

Name - H.

Unit - 55 (B) Squadron.

Age - 25.

Trade - Aerial Gunner.

Demonstrating a glare tolerant case. Colour of eyes, blue grey.

Period in Iraq, 4½ years.

Refraction :—

R. 1'50 sph.

L. 1'75 sph.

Medical History during periods of tests—Nil.

40 mm. Hg. test :—

1. 50 secs. 5/676, 566, 565, 5.

2. 75 secs. 7/566, 656, 666, 576, 675.

3. 50 secs. 6/686, 767, 776, 6.

4. 60 secs. 7/566, 666, 667, 756.

5. 60 secs. 7/556, 766, 767, 656.

TABLE B—BIRCH-HIRSCHFELD TEST.
SHOWING THE REACTIONS OF A GLARE TOLERANT CASE.

Date.	Test.	Light Min.	Light Diff.	Goldberg Wedge.	Colours.			Neutrals.					
					Red.		Blue.	Dark Smoke		Med. Smoke	Light Smoke		
				1 2 3 4 5 6 7 8	1 2 3 4 5 6	1 2 3 4 5 6	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	1 2 3 4 5	
15/5/30	1	Instantaneous	1	5 5 5 4 3 2 1	—	1 5 5 5 5 1	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5
21/6/30	2	Instantaneous	1	5 5 4 3 2 1	—	—	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5
7/8/30	3	Instantaneous	1	5 5 3 1	—	1 5 5 5 5 5	5 5 5 5 5	5 2 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5
17/10/30	4	Instantaneous	1	5 5 5 2	—	—	5 5 5 5 5	5 3 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5 5 5 5 5	5
15/11/30	5	Instantaneous	1	5 4 1	—	—	—	—	—	—	—	—	5

Name - Pilot Officer. W.
Unit - 70 (B.T.) Squadron.
Age - 30.

Individual case showing very good Birch-Hirschfeld response, but tending to fall away during the glare period, May, 1930 to November, 1930.

The figures for each examination represent the number of spots seen in the following manner:—(a) Goldberg readings are recorded by movement of the ever-darkening slide across the source of light.

(b) All other readings represent size of diaphragm aperture when presence of light is appreciated.

The numbers in sequence show number of 5-second pauses made until the five spots are visible.

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TABLE C—BIRCH-HIRSCHFELD TEST.

SHOWING THE REACTIONS OF A GLARE INTOLERANT CASE.

Date.	Test.	Light Min.	Light Diff.	Goldberg Wedge.						Colours.						Neutrals.									
										Red.			Blue.			Dark Smoke		Med. Smoke		Light Smoke					
										1	2	3	4	5	1							2	3	4	5
				1	2	3	4	5	6	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	6
10/6/30	1	Instantaneous.	1	5	3	-	-	-	-	-	-	5	5	5	-	-	5	5	-	-	-	5	5	5	5
25/7/30	2	Instantaneous.	1	5	2	-	-	-	-	-	-	5	5	5	-	4	5	5	-	5	5	5	5	5	5
23/8/30	3	Instantaneous.	1	3	-	-	-	-	-	-	-	5	5	5	-	5	5	5	-	5	5	5	5	5	5
13/10/30	4	Instantaneous.	1	3	-	-	-	-	-	-	-	5	5	5	-	4	5	-	5	5	5	5	5	5	5
22/11/30	5	Instantaneous.	1	3	-	-	-	-	-	-	-	5	5	5	-	5	5	-	5	5	5	5	5	5	5

No. - 363876. (Compare this with Table B).

Name - A C. BL.

Unit - 55 (B) Squadron.

Trade - F.A.E.

Age - 22

Individual case showing indifferent response to this test, with tendency further to weaken in his responses during the glare season.

The figures for each examination represent the number of spots seen in the following manner: — (a) Goldberg readings are recorded by movement of the ever-darkening slide across the source of light.

(b) All other readings represent size of diaphragm aperture when presence of light is appreciated.

The numbers in sequence show numbers of 5-second pauses made until the five spots are visible.

TABLE D—CLEMENT CLARKE LIGHT SENSE AND THRESHOLD TEST.
LIGHT SENSE. (a) THRESHOLD TEST.

Screen.	Resistance.	Diaphragm.	Clocks.	Resistance.	Diaphragm.	Crosses.	Resistance.	Diaphragm.
Dark Smoke - -	2	4	Hours -	2	—> 6	—>	2	6
			Hand -					
Medium Smoke -	2	2	Hours -	2	—> 6	—>	2	4
			Hand -					
Light Smoke - -	2	2	Hours -	2	—> 5	—>	2	4
			Hand -					
Clear - - -	2	1	Hours -	2	—> 5	—>	2	3
			Hand -					

Index No. 3. L.A.C. F. Fitter Aero Engine. (b)

Dark Smoke - -	2	Nil	Nil	2	Nil	—>	2	Nil
Medium Smoke -	2	9	Nil	2	Nil	—>	2	8
Light Smoke - -	2	4	Nil	2	Nil	—>	2	6
Clear - - -	2	3	Hours	2	7	—>	2	4

Index No. 98. A.C.1. N. Rigger Aero.

The reaction to Light Minimum and Light Difference tests by the Clement Clarke apparatus showing:—

(a) A good response. (Control Case New Draft, November, 1931.)

(b) A bad response taken from a man who has completed one glare period (April, 1931, to October, 1931). The resistance is unaltered at "2." The figures in the column labelled "diaphragm" represent size of the diaphragm aperture when the initial light, or light difference, is first appreciated.

TABLE E.

SHOWING THE RESPONSES OF A GLARE INTOLERANT CASE (SEE TABLE A).

Date.	Test.	Visual Acuity.		Accommodation.		Convergence in cm.	Cover test.	Red Green test.	Bishop Harman test.	Fundus.	Ophth. App. Conjva. Lids, etc.	Any glare complaints.
		R.	L.	Binoc.	Monoc.							
6/6/30	1	6/6	6/6	10'0	R. 11'5 L. 12'0	9'0	Slight Lat. Div. rapid	Orthophoric	1	N.	Nil	Glare does not worry him; does not wear glare glasses
24/7/30	2	6/6	6/6	14'0	R. 15'0 L. 17'0	7'5	Ditto	Ditto	Zero	N.	Nil	—
29/8/30	3	6/6	6/6	14'5	R. 14'5 L. 16'0	11'5	Slight Lat. Div. medium	Normal eso.	1½	N.	Nil	—
14/10/30	4	6/9	6/6	15'5	R. 17'5 L. 20'0	12'5	Some Lat. Div. rapid	Normal eso.	2	N.	Nil	—
14/11/30	5	6/9	6/9	18'5	R. 21'5 L. 22'5	16'5	Lat. Div. both medium	Normal eso.	Bar at 5	N.	Nil	—

No. - 275403.

Rank - Sgt.

Name - T.

Unit - 55 (B) Squadron.

Trade - Rigger Aero.

Age - 30.

Demonstrating a case of intolerance to glare. Note rapid increase in fatigue of accommodation, convergence and Bishop Harman. No stated subjective symptoms however. Period in Iraq, 5 months (previously India, 3 years). Colour of eyes, blue grey.

Refraction:—

R. + 1.00 sph.

L. + 0.75 sph.

Medical History during periods of tests—Nil.

40 mm. Hg. test:—

1. 40 secs. 6/787, 888, 98.
2. 58 secs. 8/679, 798, 989, 109.
3. 55 secs. 7/777, 777, 778, 89.
4. 55 secs. 6/787, 888, 889, 910.
5. 45 secs. 8/699, 999, 9109.

TABLE F—BIRCH-HIRSCHFELD.

May, 1930.

	COLOURS.																		NEUTRALS.																	
	GOLDBERG WEDGE.						Red.						Blue.						Dark Smoke.						Medium Smoke.						Light Smoke.					
							Red.						Blue.																							
	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6		
Averages	4'06	2'13	1'13	0'53	0'13	0'0	0'73	1'8	5'0	5'0	0'46	1'2	3'06	4'06	4'6	5'0	0'66	1'2	4'06	4'6	5'0	5'0	4'0	5'0	5'0	5'0	5'0	5'0	5'0	5'0	5'0	5'0				

August, 1930.

	COLOURS.																		NEUTRALS.																													
	GOLDBERG WEDGE.																		Red.						Blue.						Dark Smoke.						Medium Smoke.						Light Smoke.					
	1	2	3	4	5	6	1	2	3	4	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6														
Averages	4'44	1'73	0'33	0'0	0'0	0'0	0'2	1'66	5'0	5'0	0'0	0'0	0'33	3'0	4'13	4'86	5'0	0'0	1'2	4'2	4'86	5'0	5'0	2'8	4'0	5'0	5'0	4'86	5'0	5'0	5'0																	

Fifteen cases followed throughout two "hot seasons" demonstrating the Birch-Hirschfeld routine and responses averaged for comparison as shown by the corresponding figures for each stated month (compare with Tables B and C, pages 614 and 615, showing single case reactions).

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TABLE H.

COMPOSITE TABLE SHOWING RESPONSES TO MANY TESTS UPON CASES REVEALING SCOTOMATA.

Index No.	Visual Acuity.		A.G.G.	Binoc. Acc.	B.H.	Fundt Ophth.	BIRCH-HIRSCHFELD.						CLEMENT CLARKE LIGHT SENSE TEST.				Sketch of Scotoma. F. = Fixation Pt.		Illumination.	Field's Perimeter.												
	R	L.					Goldberg Wedge.	Red.			Blue.			Light Min.	Light Difference.		R.	L.		R.	L.											
																							Crosses.	Clocks.								
J 69	6/6	6/6	Nil	13.5	14	N.	3	-	-	-	-	5	10	4	3	1	-	7	6	4	-	7	6	5/9		A.	C.	C.				
J 96	6/6	6/6	Nil	14.5	5	N.	3	-	-	-	-	5	5	5	-	-	5	4	2	-	7	6	4	-	9	6	6/8		A.	C.	C.	
1 Z	6/60	6/18	-	17.5	4	-	-	-	-	-	-	1	4	5	not seen			8	4	3	2	-	-	7	-	-	8	7		A.	C.	C.
M 16	6/6	6/6	Yes	13.0	-	N.	3	1	-	-	-	3	5	5	5	-	-	4	5	5	5	NOT AVAILABLE.					A.	C.	C.			
D 123	6/6	6/6	At times	14.0	1	N.	5	-	-	-	-	5	5	5	5	-	-	5	5	5	5	NOT AVAILABLE.					D.	C.	C.			
M 33	6/6	6/6	Nil	10.5	2	N.	5	3	3	-	-	5	5	5	5	-	-	5	5	5	5	NOT AVAILABLE.					D.	C.	C.			

A. = Artificial Illumination.
D. = Daylight Illumination.
A.G.G. = Anti-glare Glasses.

The dark spaces in the sketches represent areas of absolute Scotomata, the lighter areas, relative Scotomata.

TABLE I.

SIMILAR TABLE TO H.—IT WILL BE SEEN THAT THE LIGHT SENSE REACTIONS ARE MUCH REDUCED.

Index No.	Visual Acuity.		A.G.C.	Binoc. Acc.	B.H.	Fundt Ophth.	BIRCH-HIRSCHFELD.						CLEMENT CLARKE LIGHT SENSE TEST.										Scotoma.		Illumination.	Field's Perimeter.			
	R.	L.					Goldberg Wedge.	Red.			Blue.			Light Min.	Light Difference.				R.	L.	R.	L.							
								Crosses.		Clocks.																			
N 107	6/6	6/6	Yes	11'5	4	N.	3	-	-	-	5	5	5	1	1	8	6	5	4	10	7	6/7	6/6	D.	N.	N.			
M 57	6/6	6/6	No	15'5	4	N.	5	-	-	-	5	5	5	-	-	9	7	6	-	10	9	6/10	D.	N.	N.				
M 47	6/12	6/12	Yes	14'0	2	N.	5	5	-	-	5	5	5	5	-	5	2	-	6	5	4	8	7/9	6/6	A.	N.	N.		
M 13	6/6	6/6	Yes	12'5	4	N.	5	-	-	-	5	5	5	7	3	2	1	8	6	5	4	9	6	5/10	5/7	A.	N.	N.	
M 53	6/6	6/6	No	13'0	1½	N.	5	3	-	-	5	5	5	5	-	8	3	1	8	5	5	4	10	8/10	7/10	6/7	A.	N.	N.
X 154	6/6	6/6	Yes	11'0	1	N.	-	-	-	-	5	5	5	7	3	2	1	9	7	6	5	8	6	6/10	5/8	D.	N.	N.	
M 61	6/6	6/6	No	9'5	3½	N.	5	-	-	-	1	5	5	5	-	9	4	2	-	8	6	5	-	8	8/10	D.	N.	N.	

General comparison of various tests. Note weakened Birch-Hirschfeld and Clement Clarke responses in most cases. The darkened areas in the sketches represent absolute, and the lighter areas relative Scotomata.

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PHOTO No. 8. Case showing very marked Colour Contractions. Treated in Hospital for Glare Asthenopia, recovered. (Case ii.)

PHOTO No. 9. Colour Contraction a little less marked in left eye, from same case as photo 8 above.

PHOTO No. 10. Bjerrum Screen. Right eye.
Annular Scotomata for White Glare Case ii, p. 611.

PHOTO No. 11. Bjerrum Screen.
Annular Scotomata (left eye), same case as No. 10.
Dark areas represent absolute, pale areas partial
Scotomata.

PHOTO No. 12. Case (ii) Right Eye, presenting marked peripheral contraction for white (3/380). Suffered from Glare and received Hospital treatment, cured (p. 611).

PHOTO No. 13. Case (ii) Left Eye showing even greater contraction for white.

PHOTO No. 14. Bjerrum Screen, Left Eye.
 Annular Scotoma (for white, 4/1500) - Glare, Case iii,
 p 611, eventually invalidated.

PHOTO No. 15. Glare case iii, showing Annular Scotoma
 for white, 4/1500. Right Eye (see above).