me she could see to count her fingers. She was making rapid progress when seen last.

DR. EDWARD C. ELLERT, Memphis, Tenn.: I have used thyroid extract in six cases of uveitis and I am impressed with the fact that in addition to the treatment of accompanying and apparently casual constitutional conditions, the relief of focal infections, etc., thyroid extract seems to have a beneficial effect in uveitis, but more extended experience is needed to enable us to say what we may expect from its use.

DR. CLARK W. HAWLEY, Chicago: Four years ago I had a very severe case of erysipelas which left me with several troubles that I could not account for. One of them was swelling of the feet and legs, and it was difficult for me to walk on account of pain. I supposed it was heart and kidney trouble, but both were eliminated. I went to a laboratory and they told me I was suffering from autointoxication at this time. I had had chronic uveitis for some time, so that it was difficult to read newspaper print without shaking my head, when the bodies would float back again. I saw two large yellow circles composed of small opacities. They were increasing in size. Fortunately I discovered the source of it. I commenced treating the autointoxication for the swollen feet, and within thirty days more than half the opacities had disappeared. In two months I could read newspaper print comfortably. This was in September. I used a restricted diet mainly. In February or March I believed I might increase the diet a little and I made an attempt to eat meat. In a week the opacities began to return. I stopped using meat and the effect could be seen in a few days. I have quite a number of patients with chronic uveitis who have, from that discovery, been very much benefited, so that, perhaps, my personal experience may be of as much value to others, to help clear up some indefinite cases.

EFFECTS OF HEAT ON THE EYE*

WILLIAM E. SHAHAN, M.D.
ST. LOUIS

Since ophthalmic thermotherapy is in an indefinite state, and the beneficial or harmful effects of heat on the eye are moot questions among ophthalmologists, it is desirable to make an exact study of the effects of heat when applied to the eye in various conditions of health and disease.

In order that the study may be exact, the following preliminaries must be satisfied:

1. The devising of some simple, convenient means of applying constant, measured quantities of heat directly to the corneal or scleral surfaces for measured lengths of time.

2. The determining by experiment on animals of the physiologic limit of heat tolerance for stated lengths of time. The physiologic limit of heat tolerance will be defined as the maximum temperature at which tissues may be held for stated lengths of time without permanently harmful effects.

3. The application of physiologic limits to various pathologic conditions (infections, etc.), and tabulation of results. This is the aim and end of the study.

The first of these preliminaries was solved in a satisfactory way by the construction of an instrument which may be conveniently designated as a thermophor.

DESCRIPTION OF THE THERMOPHOR

This consists of a central brass tube one-half inch in diameter and 6 inches long with a walled off slot 4 inches long and five-sixteenths inch wide, cut into its side. This

walled off rectangular space communicates directly with the interior of the tube and serves to contain a zinc-iron sensitive strip. One end of this sensitive strip is fixed to insulating material in one end of the slot; the other end is tipped with platinum plate and swings free. Around the brass tube and the rectangular space containing the sensitive strip, a sheet of insulating material is placed, and around this is wound about 6 feet of No. 26 nichrome resistance wire. One end of the resistance wire is fastened to the fixed end of the sensitive strip while the other serves as one of the terminals of the electric heating circuit. Over the end of the rectangular space in which the platinum tipped end of the sensitive strip swings is a small brass casing tapped for an 8-32 machine screw and fastened by means of insulating material to the central brass tube. The machine screw carries on its head a nonconducting disk of fiber. Its tip carries a platinum point. The screw is connected directly with the other terminal of the heating circuit. By revolving this screw, its platinum tip can be brought into contact with the platinum plate of the sensitive strip and current be made to flow through the resistance wire, generating heat. Almost immediately the zinc element of the sensitive strip will expand more than the iron, and carry the platinum plate away from the platinum tip of the regulating screw, breaking the circuit and stopping the heat. Shortly the strip will cool and the plate again come into contact with the screw point, reestablishing the circuit and heat flow for a few seconds. After oscillating for a short time, the temperature of the interior of the central brass tube will settle down to a nearly constant quantity.

When it is desired to use the instrument, a nickel plated brass heat conducting head or applicator of the size and shape desired is placed within the central brass tube and allowed to project about one-half inch beyond its end. This projecting end is shaped to a definite size, and is intended to be placed in direct contact with the part of the eye to be heated. The center of this applicator is drilled out as nearly as possible to its tip so as to contain a thermometer. In the end of the central brass tube opposite the end containing the applicator is a small brass collar with an aperture of a size just sufficient to admit the thermometer. When the thermophor is in use, therefore, the thermometer extends through its center and has its bulb in the exposed head of the applicator.

Around the above described resistance wire is placed suitable insulating material and the whole inserted into a tube of ordinary red fiber so as to make a neat looking instrument. The amount of resistance wire used in the instrument is just enough to get the desired heat when connected up in a series on a 110 volt current with a 32 candle carbon lamp. If connected directly with a 110 volt current, the amount of heat generated would shortly destroy the instrument. Up to 130 F. this instrument can readily be kept constant within 1 degree. Up to 150 F., variations of 1½ degrees may occur. The platinum terminals must of course be kept clean.

The apparatus for determining the thermal behavior of the interior of the eye, when the applicator of the thermophor is in contact with all or a part of its accessible surface, consists of a dead-beat low resistance galvanometer supplied by the Leeds & Northrup Company, a vacuum bottle and several German silver-iron thermocouples and all-iron switch with several poles. The galvanometer was kindly lent me by Prof. Lindly Pyle from the Department of Physics in Washington University. German silver and iron wires (of small caliber) were selected for these investigations by advice of Professor Pyle. The special advantage of these two metals for thermocouple junctions is that for the required range of temperature (from 80 to 150 F.) that part of the hyperbolic curve used is practically a straight line.

In constructing the thermocouples for these investigations, two German silver wires were soldered at one end to an iron wire, which was connected to one pole of the galvanometer. The two German silver wires were then soldered at their other ends to two iron wires which were connected to two separate poles of the iron switch. Another iron wire

* From the Laboratory of Ophthalmological Pathology, in the Department of Surgery, Washington University Medical School.

* Read before the Section on Ophthalmology at the Sixty-Seventh Annual Session of the American Medical Association, Detroit, June, 1916.

ran from the switch to the other pole of the galvanometer. By means of this arrangement either of the junctions could be almost immediately connected with the galvanometer, and the temperature of its surroundings indicated. For calibrating these thermocouples an especially large thermophor with a sensitive strip 8 inches long and about 15 feet No. 26 nichrome resistance wire was constructed so that temperatures could be held constant within very narrow limits for long periods of time. Previous attempts at calibration in water heated by a Bunsen burner had ended in failure, owing to "lag" of the mercury in the thermometer. In this calibration a large bulb thermometer with a long stem was used, and no reading was taken until after the mercury had been stationary for some time and all motion of the galvanometer mirror had ceased. All thermometric readings were made with the aid of a hand lens and from a position such that the scratch on the thermometer stem was exactly in line with its image as reflected from the column of mercury. The junctions to be calibrated were bound to the bulb of the thermometer. The cross piece on the arm of the galvanometer is graduated in millimeters and it was found that 1 F. corresponded to exactly 4 mm. of the arm throughout the whole range from 90 to 150 F. The readings obtained from a smaller thermometer used in the thermophor proper would differ from those obtained from the larger (and slower) thermometer by from 0.1 to 0.4 F. The probable limit of accuracy of all readings may be stated with reasonable certainty to be 0.25 degree F. as shown by variations in several graphs drawn.

When this apparatus is set up for use, the common joint, where two German silver wires are soldered to one iron wire, the whole being insulated, is placed in the vacuum bottle which has been filled with cracked ice and water drained from it (the ice having been made from distilled water). It takes about three days for the ice placed in a vacuum bottle like this to melt; consequently a junction placed in such a bottle can be kept at constant temperature for that length of time, and the apparatus be constantly ready for use. The other junctions can then be arranged (say) so that one is in a groove in the tip of the applicator of the thermophor, and in direct contact with the corneal surface, while the second is in the large calibration thermophor so that if the galvanometer should be accidentally jarred, it can be properly readjusted. With the apparatus thus set up, we are in a position to read off the average temperature of the applicator (from the thermometer in it), and the exact temperature in the transition plane between the tip of the applicator and the corneal (or other) surface, in quick rotation, and study any relation between them.

In these experiments it is necessary for the wires of the thermocouples to be insulated by some convenient material that takes up very little space. The best material found for this purpose was a celluloid varnish made by dissolving 15 gm. of sheet celluloid in 85 c.c. of acetone and 15 c.c. of amylacetate. This makes a firm, flexible, waterproof insulation entirely stable for the temperatures employed, and easily painted on with a camel's hair brush.

EXPERIMENTS

In rough preliminary experiments in which parts of dog's or pig's eyes were placed in a test tube with a thermometer and 0.7 per cent. sodium chlorid solution and the whole slowly heated in a water bath over a Bunsen burner, the following results were noted:

1. Corneal epithelium began to cloud faintly at 122 F. and became unmistakably clouded after remaining at that temperature for one minute. At 123 F. there was slight opalescence of corneal substance, at 130 F. dense opalescence. At 138 F. the epithelium was white, and at 140 F. the corneal substance was shrinking and the epithelium shriveled.

2. The lens began clouding slightly at 135 F.; began to get opalescent at 142 F.; became opal white at 157 F., and pearl white above that, and became of a firm rubberlike consistency.

3. Vitreous remained perfectly unchanged until the temperature approached 212 F., when the whole gelatinous mass became perfectly fluid, and remained so on cooling, even to low temperatures (approaching 32 F.).

These experiments would suggest beginning on living eyes with a temperature of about 120 F. and varying that according to findings.

It is realized that when the temperature of the applicator is raised considerably above the normal temperature of the eye, the surface applied to the eye, in consequence of rapid withdrawal of heat, may have a lower temperature than that indicated by the thermometer within it. Accordingly, a small hole was drilled through the end of an applicator parallel to the surface to be applied to the eye and as near to it as possible. Within this hole was placed a thermo-

Fig. 1.—Complete thermophor with connections.

junction, and the temperature indicated by it compared with that indicated by the thermometer. By means of this arrangement it was found that up to 125 F. the thermometer accurately indicated the temperature applied to the corneal surface (our limit of accuracy is 0.25 F.). At 128 F. the thermometer was 1 degree ahead of the thermocouple, at 131 F. the thermometer was 2 degrees ahead, and at 135 the thermometer was 3.6 degrees ahead.

Corrections for these differences are made in the readings noted below. It was soon found in searching for physiologic limits that the different tissues of the eye have different limits.

The first to succumb to heat is the corneal epithelium. The limit of tolerance of this tissue was determined by means of an applicator with an end surface 14 mm. in diameter, consequently covering the entire cornea. It was found that application of 120 F. (48.9 C.) for ten minutes removed the epithelium completely over the whole of the area heated; 119 F. (48.3 C.) did likewise; 118 F. (47.8 C.) left an irregular border of incomplete desquamation. By the next day this had desquamated, leaving a sharply defined border. A temperature of 117 F. (47.2 C.)

applied for ten minutes caused an extremely faint opalescence, but not the slightest immediate desquamation, as shown by total absence of staining with fluorescein. Twenty-four hours later, however, an area 5 by 3.5 mm. had desquamated. Forty-eight hours later this was completely replaced, but clouded. The clouding disappeared in three or four days. A temperature of 116 F. (46.6 C.) did not cause any desquamation, immediate or remote, nor was there any clouding or other pathologic results. This may be stated, therefore, as the limit of physiologic tolerance of the corneal epithelium for a ten minute application.

When temperatures higher than 117 F. were used with an applicator covering all or most of the cornea, it was observed that the epithelium replaced itself rapidly to within 1.5 or 2 mm. of the center, or even replaced itself entirely, but subsequently broke down and entered into a state of dystrophy during which the substantia propria gradually wasted away with much discharge of leukocytes, perforation occurring after about three weeks. When the area denuded of epithelium was no greater than 11 mm. in diameter (where the cornea was 14 mm. in diameter), no such effects were noted, the epithelium replacing itself completely and permanently.

The anesthetic used in these experiments was cocain 5 per cent. in epinephrin 1:2,000. The "drying effect" of cocain must be guarded against. The drying is not due to the cocain but to the fact that when a rabbit's cornea is anesthetized, the animal will not blink its lids. In this regard a rabbit's eyes appear to be independent of one another. The untreated eye will blink, while the anesthetized one will remain constantly open and its surface dry.

In applying heat for effects on the substantia propria, an applicator with a 7 mm. point was used. The following data were obtained:

A temperature of 124 F. (51.1 C.) applied for ten minutes did not cloud the substantia propria. Twenty-four hours later an area 7 by 8 mm. was denuded of epithelium; forty-eight hours later the denuded area was 2.5 by 3 mm.; seventy-two hours later, the epithelium was entirely replaced. The cornea was clouded over the treated area. Two weeks later, the cornea was entirely clear. A temperature of 128.4 F. (53.5 C.) applied for ten minutes to the upper part of the cornea caused slight clouding of the substantia propria (Bowman's membrane being included with this structure). One day later, the whole upper part of the cornea was opal white, and the iris was indistinctly visible through it. There was no discharge. A sharply defined area 9 by 9 mm. was denuded of epithelium. Three days later, the epithelium was completely replaced; the cornea continued opalescent. Seventeen days later, the cornea was entirely clear except for slight pigmentation which streamed in from the periphery during the process of repair.

A temperature of 131.6 F. (55.3 C.) applied for ten minutes caused some clouding over the area treated. Next day an area 10 by 11 mm. was denuded of epithelium. The cornea was more clouded. Six days later there was a very faint clouding of the cornea with faint irregularity of the surface. Twenty-four days later it was almost entirely clear.

A temperature of 135.3 F. (57.4 C.) was applied for ten minutes under a general anesthetic (ether). The cornea was markedly clouded over the area treated. The epithelium was denuded over an area 11 mm. in diameter (the diameter of

the cornea was 14 mm.). That part of the cornea not in contact with the applicator was not changed. Next day the cornea was more clouded. The pupil was somewhat irregular at the lower side. The epithelium was denuded over an area 9 mm. in diameter. Two days later, the epithelium was denuded over an area 4 by 6 mm. Three days later the epithelium was entirely replaced, but the clouding unchanged. Seven days later, the cornea still was gray and bulging over the site of the application in the form of a keratoconus. Vessels were growing markedly into the cornea from above; there was no discharge. Ten days later, keratoconus was more marked. Twelve days later keratoconus was very marked. Fifteen days later, the keratoconus was receding, and the cornea was much clearer. Twenty days later, the keratoconus was about gone, and the cornea was clouded only over the center of the heated area. Twenty-eight days later, the keratoconus was gone, and the site of apex was occupied by a slightly pigmented and vascular scar. Most of the cornea was clear.

It is evident from these experiments that the substantia propria has no sharply defined limit of physiologic tolerance to heat, but that the effects on it vary increasingly with increase in the intensity of the heat applied. It would appear, however, that about 130 F. (54.4 C.) is as high as it is safe to go without producing gross permanent changes.

There are some changes in the interior of the eye worthy of note:

Shortly after one cornea had been anesthetized, the pupil was 11 mm. in diameter. After the application of a 14 mm.

Fig. 2.—Longitudinal section of thermophor: A, applicator; B, B, thermocouple within applicator; C, resistance wires for generating heat; D, zinc-iron sensitive strip; E, regulating screw; F, F, wires for electric current.

applicator ten minutes at 116 F. (46.6 C.) the pupil was 3 mm. in diameter, although the anesthetic effect on the cornea was still in full force. This miotic effect of heat was a constant and striking feature in all these experiments. In cases in which the pupil was fully dilated and the heat centrally applied so that the point of application was rather distant from the iris, the effect was less noticeable. When the experiment was done under ether, the effect was much more marked. The miosis was always transient. When the heat reached 128 F. (53.3 C.) and was applied opposite a part of the iris, either above or below, that part of the iris subsequently (in about two weeks) became gray, somewhat shrunken and drawn toward the filtration angle, and evidently atrophied, without apparent injury to the rest of the iris or the eye. Physostigmin (eserin) applied in such a case did not affect the discolored part, while causing marked miosis in all the rest of the iris.

By means of the thermocouple set up as described above, the rate at which heat passed through the cornea was studied. First, general data as to the rabbit's temperature were obtained. The rectal temperature (thermometer) was 104.2 F. (40.1 C.). The rectal temperature (thermocouple) was 104.2 F. The temperature of the upper culdesac varied from 102 F. (38.9 C.) to 103 F. (39.4 C.), increasing as the eye was handled. The temperature of the lower culdesac varied from 102.2 F. (39 C.) to 103.7 F. (39.8 C.), increasing as the eye was handled. The temperature under the third lid was constantly 103 F. (39.4 C.).

The junction was then introduced into the center of the anterior chamber just behind the cornea. The temperature there ranged from 101.2 to 101.7 F. (38.4 to 38.7 C.). A 7 mm. applicator was then applied at 123 F. (50.5 C.). The temperature just behind the cornea rapidly rose to 116.5 F. (46.9 C.), where it became stationary. The applicator was then removed, and the temperature dropped to 102.5 F. (39.2 C.) in fifty seconds. The applicator was then raised to 132.5 F. (55.8 C.), and applied to the cornea. The tem-

perature just behind the cornea then rose rapidly to 124 F. (51.1 C.), where it became stationary. The applicator was then removed, and in one and a half minutes the temperature just behind the cornea fell to 103.2 F. (39.5 C.) and subsequently fell slowly to 100.2 F. (37.9 C.). The applicator at 133 F. (56.1 C.) was now applied to the cornea, and the temperature just behind the cornea rose from 100.2 F. (37.9 C.) to 122.7 F. (50.4 C.) in one and a half minutes.

The vitreous was apparently unaffected by changes in the anterior chamber, remaining constantly at a temperature very near that of the body temperature of the animal. This shows that heat passes rapidly through the cornea in either direction. Any degree of heat, therefore, that will affect organisms or pathologic conditions on the surface of the cornea ought to affect them anywhere in its interior.

Most of the eyes on which the foregoing experiments were performed have been removed, and are being prepared for histologic investigation by Dr. Harvey D. Lamb, to whom I am indebted for earnest cooperation throughout this investigation. The results of this will be reported in a separate paper.

There are some organisms, such as the pneumococcus of *ulcus serpens*, that have a relatively low thermal death point. The destructive effects of this organism on some corneas are well known. There appeared to be excellent theoretical reasons for believing that the cornea would stand more heat than such invading organisms. It was now very desirable to obtain some virulent pneumococci for the production of experimental hypopyon ulcers. After considerable difficulty this was finally accomplished by Dr. Lamb, who procured material from the lung of a patient who had died of bronchopneumonia with pulmonary infarction and thrombosis of a lateral sinus.

This was injected into mice. These died of general septicemia, and cultures were taken from the blood of one of them on serum agar. A profuse growth of pneumococci (identified in the laboratory of bacteriology) took place on this. Material from this tube was then inoculated into the center of the cornea of several rabbits. Ulceration took place in every case. Some of them proceeded to spontaneous cure with or without hypopyon. Others ran a destructive course with hypopyon.

To these ulcers various degrees of heat were applied with variously sized applicators according to the size of the ulcer. In one case 125 F. (51.7 C.) was applied for eight minutes with a 4 mm. applicator. Next day the ulcer was larger and progressing steadily. Then 129 F. (53.9 C.) was applied for ten minutes under ether. The ulcer was now about 5 mm. in diameter. An area 8 mm. in diameter was denuded of epithelium. From day to day the ulcer steadily grew larger. The epithelium, however, completely replaced itself, converting the ulcer into an abscess by the third day. This was punctured and thick pus expressed from the *substantia propria*. Microscopic examination showed this to be chiefly mucoid material with a few bacteria. A serum agar culture gave a profuse growth of pneumococci in twenty-four hours.

In another case, 130 F. (54.4 C.) was applied for ten minutes under ether. This ulcer recovered beautifully, as also did the opposite entirely untreated control.

In another case, 130 F. was applied for ten minutes under ether. The heated cornea at the present writing is in worse condition than the opposite untreated control.

In short, any temperature up to 130 F. applied directly to an *ulcus serpens* for ten minutes appears to have no beneficial effect whatever. It is probably even harmful. This is the only condition so far investigated.

Before heat is discarded as useless in these conditions, however, it is necessary to investigate another

method of applying it, namely, that of applying higher degrees for shorter lengths of time. As shown above, the full temperature applied to the anterior surface of the cornea reaches the posterior surface within two minutes, possibly within one minute. If now beginning at 135 F. or about 57 C. successively higher temperatures are employed, there will certainly come a time when infecting organisms will be destroyed. The effect of this temperature on the cornea for the given length of time can then be studied, and its usefulness or uselessness be established. An investigation of this sort is now under way.

ABSTRACT OF DISCUSSION

DR. T. B. HOLLOWAY, Philadelphia: While the various properties or physiologic actions attributed to heat are well known, the most suitable method and duration for its application and the benefits to be derived from it in certain conditions are still matters for discussion. In eye affections heat, as it can now be employed, is in the majority of instances an adjuvant to other lines of treatment, if we exclude the direct effect on certain conditions or structures that have been attributed to diathermy. It must also be considered as to whether it is to be used for what might be described as its stimulating effects, styptic influences, or its destructive and cauterizing action. Numerous instruments or appliances have been devised for the application of either dry or moist heat, but none has been more ingenious in its construction than the one described by Dr. Shahan, which has also the distinct advantage of accurately measuring the degree of heat applied. As he has stated, it remains for his future experiments to prove whether it has certain clinical advantages over other methods or appliances already described. It is probable that the use of Dr. Shahan's instrument would be attended by greater risk and it seems to approach more in its action the hot air douche or the method of Weekers, although both of these methods cause distinct, if only temporary, changes in the cornea. Further, are these methods superior to the application of moist heat by means of hot irrigations, hot compresses, the dropping of hot water on the eye, the steam spray, or the mixture of steam and hot air? Finally, how do these measures compare in their efficiency to the development of heat by high frequency currents, so-called diathermy? In regard to the albumin content of the aqueous and the predominance of antibodies, Sattler found that hot air was no more efficient than other types of heat; that the agglutinins and hemolysins were increased by temperatures that produced inflammatory irritations, but that the highest temperature tolerable had no effect on the antibodies. In this respect subconjunctival injections and tapping the anterior chamber were more efficient. After later experiments he stated that diathermy afforded greater effects on the ciliary body than subconjunctival injections. Zahn found that the temperature of the conjunctival sac could be raised on an average of 4.2 by diathermy, against 1.6 C. with hot applications. The results of various researches show that with diathermy the temperature tolerance is quite uniformly placed at 44 to 45 C. (109.4 to 113 F.) at which point chemosis of the conjunctiva and corneal changes develop; 42 C. (107.6 F.) is about the height that can be reached with comfort and safety. The highest obtained by Waldmann on the human eye was 42 with diathermy and 37.5 (99.5 F.) with hot application.

If these various temperatures be compared with the temperatures obtained by Dr. Shahan, whose experiments were made under cocaine or ether, it will be found that he attained considerably higher temperatures, that is, 46.6 C. (116 F.) as the physiologic tolerance of the corneal epithelium for a ten minute exposure, while 53.3 C. (128 F.) caused permanent changes in the iris; a higher temperature than 54.4 C. (130 F.) was apt to be followed by definite changes in the corneal stroma.

Weekers and Angus MacNab have stated that a temperature of 42 C. (107.6 F.) for twenty-four hours will kill

the pneumococcus and Morax-Axenfeld bacillus, while the former will succumb to a ten minute exposure at 56 C. (132.8 F.), the latter to a five minute exposure at 55 C. (131 F.). In his experiments on rabbits the essayist was still capable of obtaining a positive culture from a pneumococcus corneal lesion after a ten minute exposure to a temperature of 53.9 C. (120 F.) and states that a temperature of 54.4 C. (130 F.) was of no value. We will watch with interest the future experiments of Dr. Shahan when he uses a high temperature and shorter exposure, conditions that would seem to bring his heat effects in closer relation to that obtained by Weekers, Bourgeois and others. In the presence of severe cornea ulceration after the failure of such cauterizing agents as phenol and iodine thoroughly applied, I rely on the actual cautery, but we must not lose sight of other adjuvants such as the vaccines.

DR. JOHN GREEN, St. Louis: Dr. Shahan's experience with this method in experimentally produced pneumococcus ulcer in rabbits was not encouraging. Recently an opportunity presented itself to try the thermophor on a patient with hypopyon keratitis. The applications were made under the supervision of Dr. Shahan so that the conditions were favorable for a fair test. A worker in a chemical factory presented himself May 28 with a 4 mm., nearly round ulcer near the center of the cornea. There was hypopyon rising to a little less than one-quarter the height of the anterior chamber. Smear and culture showed pneumococci in abundance. The thermophor was brought to a constant temperature of 115 F. and gently but firmly held in contact with the ulcer for ten minutes. The contact was practically continuous, except for momentary withdrawals, due to sudden shifts in the position of the eye. At the end of the seance it was found that the epithelium had been denuded to a total diameter of 5 mm., the ulcer proper measuring 4 mm. Atropin, 1 per cent. three times a day, and boric acid irrigations were ordered. May 29 there was only slight change in the ulcer; the hypopyon was either stationary or had increased a trifle. Thermophor applied for ten minutes at 121 F. May 30, the hypopyon was appreciably higher and the ulcer measured 5.5 mm. in diameter. Thermophor applied at 122 F. for ten minutes. May 31, hypopyon increased, ulcer spreading superficially as indicated by nasal and temporal subepithelial yellowish exudates. Thermophor applied at 124 F. for five minutes to the nasal side of the ulcer and for five minutes to the temporal side. June 1, there was positive increase in the size of the ulcer but no tendency to penetrate deeply. It was deemed inadvisable to pursue this line of treatment further. The edges of the ulcer were touched with 20 per cent. zinc sulphate solution and the ulcer itself buried in a mass of methylene blue powder. The following day the inflammatory signs were less marked and the hypopyon had diminished. A continuance of the methylene blue treatment was effective in checking the further spread of the ulcer and the hypopyon gradually diminished. The patient is now making satisfactory progress.

DR. L. HOWE, Buffalo: We are very much indebted to the author for the way in which he has presented the negative phases of the effects of heat on the eye. We must keep clearly in mind the factors involved; that is, the resistance of the eye and the resistance of the bacteria if we expect to kill them. We now know definitely what the lethal point of the eye is. Bacteriologists are not so well agreed as to the lethal point of bacteria. When I prepared the paper three years ago which described for the first time this method of measuring the temperature of the eye by means of thermal junctions, I was rather surprised to find such a difference of opinion on this point among bacteriologists. At that time I asked Professor Ernst of the Harvard Laboratory concerning the lethal point of the gonococcus. He gave figures which made it quite sure that that form of bacteria could stand heat better than the eye. It is true we use heat when we cauterize, but over only a very small surface. The value of the measurement of heat does not relate to the higher temperatures. But as we find moderate heat of advantage clinically the practical point is to deter-

mine with delicate tests, like the galvanometer, what the exact temperature is of the applications we make. When that is done we can decide what class of cases are affected by increased temperature and in what way.

DR. WILLIAM E. SHAHAN, St. Louis: This method should not be confused with any electric method where the electric current heats the tissues by passing through them. In this method all unknown factors, except heat, have been eliminated, and the effects of this agent alone studied. Neither should it be confused with any application of heat approaching cauterization. Dr. Howe's remarks on the practical impossibility of getting accurate results with the use of the mercury thermometer alone are fully concurred in and indebtedness to him for his paper on the thermocouple at Minneapolis in 1913 ought to be fully acknowledged.

ORTHOPEDIC SURGERY IN WAR TIME *

ROBERT B. OSGOOD, M.D.

BOSTON

We are of the opinion that efficiency as it is generally understood should not be the goal of life. But we are also of the opinion that once a goal is set, it should be attained by the least expenditure of any energy which is worth saving, and we believe that this is what efficiency ought to mean.

In a physical conflict such as war, the goal of both sides is set. To attain it each must conserve the physical energy of its soldiers in order to increase their strength in battle. Each must strive for the complete recovery of its wounded in order that the ranks may be kept as full as possible. Finally, but perhaps most important of all in any long conflict, each must see to it that those large numbers who do not lose their lives, but who by reason of their mutilating wounds lose their fighting power, do not become a burden on the industrial community already depleted and vastly overburdened by the necessity of support of the armies in the field. The few left at home are doing intensive work, and the wounded heroes, if the national strength is to be conserved, must have a still further test of their heroism and be made to contribute their remaining energy to help maintain their still efficient comrades.

Our thesis is to be that orthopedic surgery has a very large part to play in (1) assuring physical efficiency in the ranks; (2) in conserving and restoring the function of the locomotive apparatus of the wounded; (3) in providing the physical possibility and perhaps reorganizing the means by which the war cripples may become happy, productive, wage earning citizens, instead of boastful, consuming, idle derelicts.

ORTHOPEDIC EXAMINATION OF RECRUITS AND SOLDIERS IN TRAINING

Posture.—It has not been, we believe, solely because of the better appearance presented by erect, full chested men, that all recruits are compelled to go through "setting up" exercises, and that good carriage is so strongly emphasized. Life insurance figures suggest that the number of inches of chest expansion up to certain limits is in direct ratio to the quality of the risk.

This important part of preventive work, namely, the acquisition and maintenance of a good posture, is surely essentially an orthopedic concern. It is well

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