by the new diet is permissible even for the most unstable diabetic patients.

The calorie control diet has proved to be as satisfactory in every way as the older type of diet in use in these clinics. It is more simple to use, and it allows patients to replace foods that are scarce with foods that are plentiful. This has also meant that the diet is cheaper, since the carbohydrate foods in general are cheaper than the protein and fat foods which they have replaced. Finally, a group of patients, including some severe cases, have agreed to forgo the extra rations allowed to them by the Government, and they have remained just as stable and well without them. We believe, therefore, that even if the food rations have to be still further reduced and the diet of diabetic patients is affected they could be maintained in good health on the new diet.

Summary

A diabetic diet is described in which the total calorie value is kept constant but an unlimited variation in the proportion of carbohydrate, protein, and fat is permitted.

The effect of this diet has been examined after one year's trial on a large series of cases and found to be satisfactory.

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THE ACTION OF RADIANT-HEAT CRADLES

BY

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The Physical Action of Cradles

The cradles used were those issued by the Ministry of Home Security, consisting of a sheet of polished metal bent in the shape of a horseshoe, and fitted with 12 carbon filament bulbs of 230 volts and 16 c.p. (about 65 watts) controlled by two switches. Each switch controls 6 bulbs and is so arranged that 2, 4, or 6 bulbs can be switched on. The object of the cradle is to supply heat to patients, and our primary aim was to investigate how this end was achieved by this type of cradle. It was also hoped that an analysis of the factors involved might suggest improvements in the apparatus.

The usual method of employing such cradles is to place the patient inside, covered with a blanket, and to drape another blanket over the whole cradle so as to retain the heat. The radiation emitted by the bulbs consists almost exclusively of infra-red rays of long wave-length, the remaining small percentage being emitted as visible light and short-wave infra-red rays. This radiation either falls directly on the blanket-covered patient or is reflected without change of constitution from the polished surface of the metal background. A certain amount is absorbed by the background, and the latter is gradually raised in temperature until it forms a source of long-wave infra-red radiation on its own.

Before reaching the patient, however, the radiation encounters the blanket, which becomes warmed on its upper surface and radiates heat as long infra-red rays on its own account. A certain amount passes through the blanket to the patient; but since the blanket is a good insulator, this is a very inefficient method of transferring heat. The energy which reaches the patient is thus much reduced in amount, but has been converted by the action of the blanket into very long infra-red rays. Some such convertor mechanism appears to be necessary; for, as we shall see, when a patient is placed in the unshielded cradle without the protection of a blanket he soon begins to suffer from burns. A mode of conversion was therefore adopted which involved a negligible loss of energy.

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The metal background of the cradle was blackened† and the bulbs were covered with strips of thin metal which cut off the direct radiation completely, but which rapidly became hot and acted as a source of long infra-red radiation like the cradle background (Fig. 1). The blackening of the background ensured 100% absorp-

FIG. 1.—Modified cradle.

FIG. 2.—Skin thermometer.

tion of the direct radiation incident upon it from the bulbs, so that in this "shielded" cradle the heat transmitted to the patient is furnished only by the thermal radiation of the cradle background and the shielding strips.

In order to measure the radiation a small blackened square of copper was used, the temperature of which was measured by means of a thermo-junction fixed to its back. As this is heated by the incident radiation, which it absorbs completely, the radiation emitted from its surface is also increased, until after a few seconds the receiver is in equilibrium with its surroundings and emits as much as it absorbs. The temperature of the receiver is then the same as the effective temperature of the radiation field, provided that no heat conduction takes place.

For the physiological part of the investigation a suitable skin-temperature thermometer had to be devised. The form adopted (Fig. 2) consisted of a small grid about 4 cm. by 2 cm. of fine copper mesh carrying a thermo-junction on the side in contact with the skin, the whole being protected by a thin coat of shellac varnish. The junction thus gave a mean value of the skin temperature over the whole area covered by the mesh because of the good heat conductivity of the latter. The skin was exposed to the air and was free to sweat, while the area obstructed by the wires of the mesh was sufficiently small not to interfere with the full access of the radiation to the skin. Three such instruments, of mesh sizes from 1 mm. to 2 mm., were found to give consistent readings over a wide range of radiation temperatures and air temperatures.

Experiments were carried out with a blanket over the cradle and all 12 bulbs switched on. The radiation meter was placed a few centimetres above bed level in the centre of the area covered by the cradle. Fig. 3 shows graphs of the observed temperatures of the receiver plotted against time. The receiver is affected by radiation from the bulbs and from the metal background, as well as by con-

FIG. 3.—Radiation from shielded and unshielded cradle. For details see text.

duction through the air. The room temperature is represented by OA and the cradle is switched on at A. In the unshielded cradle the curve ABC is followed. At C the bulbs are switched off and the temperature immediately falls to F and dies away along FG as the cradle begins to cool.

In the shielded cradle, in which direct radiation from the bulbs is absent, the curve AFG is followed. Thus the contribution AB must be due to the direct radiation from the bulbs. This component of the radiation remains constant in time, as is evident from the fact that when the bulbs are switched off at C the drop in radiation recorded, CF, equals the initial rise, AB. The curves AF and BC are almost identical,‡ and this implies that the amount of heat supplied by the bulbs to the cradle background is the same whether

† A thin coat of any flat black-out paint, not water-soluble, is suitable.

‡ This is strictly true in an energy-time diagram, and is almost exact in our temperature-time diagram because of the very small range of temperature involved.

the bulbs are shielded or not. This is also corroborated by the fact that a few minutes after the bulbs have been switched off the radiation recorded in the shielded and that in the unshielded cradle are identical. This means that the direct radiation from the bulbs plays only a very small part in the total energy supply to the patient. The radiation from the background, however, which is represented by AF, increases steadily. Thus we have been able to separate the two components of the radiation from one another.

We have so far omitted from our discussion the question of heat conduction by the air in the cradle. In fact, such conduction does take place, and even plays a considerable part in the heat transfer between cradle background and patient. The existence of this conduction, however, does not affect our conclusions, since there exists no direct heat conduction between the filaments of the bulbs and the patient, and heat conduction through air, as well as convection, takes place only between the cradle background and the patient. These effects are thus the same in the shielded and unshielded cradles.

Thus it appears that during the first few minutes the shielded cradle delivers rather less energy than the unshielded, but the amount of energy which can be delivered to the patient is very much greater in the former, since the conversion to long-wave radiation has already been carried out, whereas in the unshielded cradle the patient will only get what can eventually filter through a blanket.

The Physiological Action

The skin temperature of volunteers was measured in the two cradles. In each case a blanket was draped over the whole cradle and the volunteer placed naked inside. As was to be expected, the skin temperature rose in the first few minutes more rapidly in the unshielded cradle, but in both cases the same temperature (about 45° C.) was reached after about 15 minutes. While, however, this was very unpleasant under the unshielded cradle, no discomfort was felt in the shielded cradle. In the subsequent few minutes in the unshielded cradle first-degree burns developed, but no ill effects were suffered in the shielded cradle.

It is therefore clear that burning must be due to the direct radiation from the bulbs, which is present only in the unshielded cradle. As we have seen, this direct radiation forms a comparatively small fraction of the total heat output of the cradle, and it is evident that the burns are caused rather by the particular constitution of the direct radiation, which contains a certain amount of short-wave infra-red rays (0.4 to 4 μ), than by the amount of energy supplied. The shielded cradle emits thermal radiation with a maximum at 7 μ . It is not the total amount of thermal energy supplied by the unshielded cradle which limits its application, but the fact that the direct radiation from the bulbs can be tolerated by the skin for a comparatively short time only. This is, in fact, the reason why it has been found necessary to insert a blanket between the patient and the cradle. Though this acts as a convertor from short-wave to long-wave radiation, it cannot fulfil this purpose as efficiently as the blackened cradle background.

It was clear that the new shielded cradle could safely be used without protecting the patient with a blanket, while the old unshielded cradle could not. In order to test the efficiency of the two cradles as heaters a comparison was made between the unshielded cradle with a single blanket over the patient and the shielded cradle with the patient naked. In both cases blankets were draped over the whole cradle. Volunteers were placed in each of the cradles in turn on different days and heated with 12 bulbs until the oral temperature reached 100° F. or until the oral temperature remained constant for so long that it was clear that no further rise would take place. It was found that the best position was when the upper edge of the cradle was level with the lower end of the sternum. Observations of oral temperature and of skin temperature on the abdomen and thigh were made. Altogether 6 volunteers were heated, giving a total of 12 experiments. Two of the 6 cases were not conclusive. In one an oral temperature of 100° F. was reached in both cradles, and in the other this temperature could not be reached in either cradle. In the latter instance the cradle was placed considerably lower than the height which we have since found to be the optimum.

A typical result is shown in Fig. 4. In the shielded cradle the skin temperature rose to a roughly constant value of just under 45° C., although the temperature of the radiation field was almost double this. The oral temperature rose rapidly after about 30 minutes. In the unshielded cradle the skin temperature follows the same trend, but remains at a slightly lower level. The oral temperature could

not be increased above 99° F. even by heating for 90 minutes. In this particular case the oral temperature reached 100° F. in the shielded cradle after 47 minutes' heating. This was almost the

FIG. 4.—Oral and skin temperature of a patient heated in the two cradles. The shielded cradle is a more efficient heater owing to absence of necessity for skin protection.

shortest time taken to attain this level with the shielded cradle, the shortest being 42 minutes.

It will be seen that there was a drop in the oral temperature after the cradle was switched on. This phenomenon occurred in both the shielded and the unshielded cradles. In 9 out of the 12 cases observed there was a decrease of oral temperature of 0.3 to 0.5° F., which took place in from 5 to 20 minutes after the heat was turned on, and thereafter the temperature rose steadily. The blood pressure, both systolic and diastolic, also fell slightly during the first 20 minutes. After that the systolic pressure and the pulse rate usually rose above the initial values; the diastolic pressure tended to remain low.

Comparing the two types, we find that the shielded cradle is definitely more efficient as a means of raising the body temperature than the unshielded. There is a very considerable scatter in the results, but we have plotted for each experiment a point representing the rise in body temperature during the experiment against the time for which the heat was applied (Fig. 5). The mean of all the shielded results falls well above the mean of the unshielded results, the slope of the dotted line in the former

FIG. 5.—Rise of body temperature plotted against time of exposure for 12 experiments.

case being over twice the slope of the latter. All the inconclusive cases are included in this diagram—a representation which does less than justice to the shielded cradle, since an unshielded case in which the temperature refused to rise above a certain level would have been represented by a still lower mean rate of rise if the experiment had been continued longer.

Even with the shielded cradle it was found that if the heating was continued at full strength for a considerable time a burning sensation was experienced and erythema developed. This is due to the fact that the cradle background gets steadily hotter and delivers a steadily increasing amount of energy; in fact,

the system shows no sign of reaching equilibrium after more than two hours' heating. This means that under these conditions the patient is subjected to an ever-increasing flow of heat and that sooner or later the threshold for tolerance must be reached. The ideal situation would be one in which the patient received a constant flow of heat of tolerable strength. This can be achieved by switching off a number of the bulbs after an initial boost with 12 bulbs.

Investigations with a radiation meter were carried out in order to determine how many bulbs are needed to maintain a constant heat flow at various levels. Experiments were made by switching on 12 bulbs for a standard time (20 minutes) and then changing to the required number of bulbs. After falling for a short time the heat flow then became constant. For instance, when two bulbs only were left on after the boost, the temperature eventually fell and remained at 37° C. During the boost with 12 bulbs this level had been reached after about 8 minutes, and it was found that using 12 bulbs for 8 minutes and then switching to 2 produced the final equilibrium conditions in a few minutes, without at any time exposing the patient to more radiation than was needed.

Instructions for Use of the Shielded Cradle

It is suggested that the shielded cradle should be used by boosting for a certain time with 12 bulbs and then turning down the heating so as to maintain a heat flow of the desired strength. The accompanying table shows the times recommended for this procedure as suggested by these experiments (Fig. 6).

Boost Time with 12 Bulbs in Minutes	Final Radiation Temperature (° C.)	Number of Bulbs for Final State
8	37.0	2
12	47.5	4
32	63.5	6
60	73.0	8

It should be added that boosting with 12 bulbs for more than 40 minutes sometimes caused the patient's skin to become irritated. The kinder way is to apply 12 bulbs for 25 to 30 minutes, then 10 for about 20 minutes, and 8 thereafter. This

FIG. 6.—Chart showing boosting-times for the shielded cradle.

is very little slower, and it causes far less discomfort. Irritation and erythema develop in the region of the groin at much lower rates of heating than anywhere else on the skin, and we have made it a standard practice to cover this region with a folded towel. To protect a restless patient from contact with the hot cradle we have used a guard of strong wire, similar to those ordinarily employed to lift the weight of blankets off the legs and feet. The wires of the guard were covered with two layers of white bandage, which kept it sufficiently cool, and distance pieces were fitted to hold the guard in the correct position.

Some Further Investigations

A female patient suffering from arthritis was treated at various heating rates. Four experiments were made with 4, 6, 8, and 8 bulbs respectively, the boosting-times being regulated as above. Using 4 bulbs, the body temperature rose from 98.4° F. to 100° F. in 1 hour 55 minutes, including the boosting period. With 6 the rise was from 98.0° F. to 100.1° F. in two hours; with 8, rises from 99.5° F. to 101.8° F. in 1 hour 15 minutes and from

97.8° F. to 100.8° F. in 1 hour 35 minutes were secured. Thus the temperature can be raised quite comfortably at a fairly considerable rate. It immediately suggested itself that there might be a relation between the rate of rise of temperature and the heat input. The observational material was analysed by taking each

FIG. 7.—Diagram showing correlation between heat input and rise of body temperature.

period over which the heat input was constant and noting the rise of temperature in that time. The mean rate of rise was thus obtained for each heating rate, and from the observational records of this patient 8 points were obtained. A scatter diagram was plotted (Fig. 7), and it was found that all the points lay on a narrow band passing through the origin.

While the results are certainly too scanty for a definite opinion to be formed, it is possible that such a correlation may exist for each individual case. If this is true a single determination of the rate of rise of body temperature at a given heating rate would form a valuable guide to the heat response and further treatment of the patient, since it would thus be possible to predict the rise in body temperature for any other heating rate. It should be noted, however, that the observed correlation relates only to the region between normal temperature and 102° F. and may not be continued to higher temperatures.

Discussion

This investigation was undertaken after two serious burns had occurred with the use of the Ministry of Home Security heat cradle. Questioning of senior sisters revealed no standard procedure in the heat-cradling of cold or shocked patients, and none was found in the literature. Aside from this lack of knowledge concerning the proper use of a powerful instrument, it was obvious that the cradle was needlessly dangerous, and that the customary procedure which made it tolerable—the protection of the patient by a blanket—greatly reduced its efficiency. Heat administration should be as carefully controlled as the administration of drugs or oxygen.

By simple modifications which a handy-man can carry out in an hour or so, a heat cradle has been devised which gives complete protection from early burns and which heats the patient much more quickly. The near infra-red component of the radiation has been converted with negligible energy loss to far infra-red, a type of radiation for which the skin has evidently a greater tolerance. This permits the withdrawal of the protection afforded by the blanket. The ability to control the dosage of heat accurately has resulted in the elimination of late burns, and is of obvious value in careful treatment. With the shielded cradle it is possible to expose the patient in a heat bath at any desired temperature without ever exceeding that temperature.

There remain certain dangers. With the unshielded cradle the risk of burning the skin, or actual burns, must often have prevented the introduction into the body of a dangerous amount of heat. When that costly safeguard is removed, more careful supervision of heat treatment is demanded. Under some conditions we have found that the patient's temperature rose at the rate of 2° F. in 20 minutes. This is a state which demands skilled observation, and we are firmly convinced that medical officers should supervise the use of the heat cradle more closely and not regard it as an instrument which can be left without instruction to the nursing staff.

The question of the place of heat in the treatment of shock is made more urgent by the more efficient cradle. There is

little doubt that it can be overdone. Blalock and Mason (*Arch. Surg.*, 1941, **42**, 1054) have found that exsanguinated and traumatized animals survive longer if they are cooled rather than warmed, and our own observations show that soon after the application of heat the blood pressure falls. Vasodilatation of the skin and enlargement of the vascular bed may well be harmful in shock. Some experimental work is being carried out to elucidate this point, but there is need for more observations on shocked patients.

Summarized Instructions for Use of the Shielded Cradle.—

(1) Place the upper end of the cradle at the level of the lower end of the sternum. (2) Cover the cradle and its open ends with two blankets, and do not disturb these unless absolutely necessary. (3) Leave the patient naked except for a small hand towel to protect the groins, and if the patient is restless insert the guard (see above). (4) At first turn on all 12 bulbs. (5) After not more than 30 minutes reduce the bulbs to the number required to maintain the air temperature at the desired level (see Fig. 6). (6) Determine the oral temperature at least every 15 minutes.

Summary

The heat cradle issued by the Ministry of Home Security has been modified by shielding the bulbs and blackening the reflector.

As a result of the conversion of the short-wave infra-red radiation into long-wave infra-red the risk of burns is almost eliminated and the patient can be heated at least twice as rapidly.

The danger of overheating the patient is emphasized.

Instructions are provided for using the new cradle.

We should like to thank Prof. Witts for his interest and suggestions. Our thanks are also due to the volunteers who were used in the experiments, and to Mrs. V. Launchbury, who gave technical assistance.

SYPHILIS TREATED WITH DAILY MULTIPLE INJECTIONS OF MAPHARSIDE

BY

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When Norway was invaded by Germany in April, 1940, a large part of the Norwegian Merchant Navy was isolated from its bases and eventually made its way to this country. In spite of dangers and hardships these ships continue their hazardous work, and it is not difficult to understand why, under prevailing conditions, the crews become easy victims to venereal disease when they are in port. There has been a serious increase in syphilis and other venereal diseases amongst the crews of these vessels; this constitutes a grave problem for the authorities at the present time and points to future difficulties in our social welfare. Before the war fresh cases of syphilis in Norway were very rare, and in 1938 there were only about 200 new cases amongst the whole population.

Routine treatment of syphilis is possible only if a sailor stays ashore for any length of time; but in most cases this cannot easily be arranged; and, furthermore, life ashore often has a demoralizing effect upon the men. Many who contract venereal disease come to the clinics only at irregular intervals, and treatment is necessarily unsatisfactory. These conditions obtain not only in the Merchant Navy but also in the smaller vessels of the Navy proper, and the smaller Army groups, none of which has a doctor on the staff.

At the beginning of 1942, following a review of syphilitic cases treated in the clinic, it was found that less than 30% of the patients were being adequately treated, and it was decided to start intensive arsenical treatment at the Norwegian Naval Hospital. Continuous intravenous drip therapy, using neoarsphenamine, has been tried in America (Chargin *et al.*, 1935), but the drug proved to be too toxic, peripheral neuritis being one of the most frequent complications. Later it was found that "arsenoxide" (mapharside), given in massive doses by the intravenous drip method, caused appreciably fewer toxic effects than neoarsphenamine (Chargin, 1940). Even so, the

method presented difficulties, and massive arsenotherapy, using multiple-divided doses, eventually came into use. Gordon (1941), and later O'Malley (1941), in South Africa, employed a course of treatment consisting of five doses, each of 0.02 g., of mapharside at two-hourly intervals daily for a period of five days. At the same time 25 oz. of a 10% solution of glucose by mouth, spread over the day, were given during the period of treatment. Similarly, other workers in America have administered the drug by multiple doses, but, for the most part, have given two injections daily for a period of five days.

Method of Treatment

It was decided to follow the South African method, but to give larger doses of mapharside. On Feb. 2, 1942, treatment was begun, and by June 25 one hundred patients had completed the course. In this preliminary report consideration will be given to five groups of patients, all of whom have received the intensive course, special reference being made to the complications and reactions noted during treatment.

At the outset only untreated cases of syphilis in the first and second stages were given massive arsenotherapy. As the earlier patients tolerated the treatment so well it was decided to use the intensive method in cases in which either neoarsphenamine had been given previously and had not been well tolerated or the conditions were such that the patient was unable to follow routine treatment with weekly injections. Before starting the course the patients were carefully examined clinically and the urine investigated. On the day preceding the beginning of treatment each patient had an enema, and 300 to 500 c.cm. of glucose (6%) was given orally.

TABLE I.—Scheme of Dosage

Mapharside				
	8 a.m.	12 noon	4 p.m.	8 p.m.
1st day	0.04 g.	0.04 g.	—	0.04 g.
2nd	0.04 g.	0.04 g.	0.04 g.	0.04 g.
3rd	0.04 g.	0.04 g.	0.04 g.	0.04 g.
4th	0.04 g.	0.04 g.	0.04 g.	0.04 g.
5th	0.04 g.	0.04 g.	0.04 g.	0.04 g.

Glucose Solution 6%				
Daily for 5 days (total per day, 1,500 c.cm.):				
7 a.m.	250 c.cm.	2.30–3.30 p.m.	..	300 c.cm.
8 a.m.	250 c.cm.	6–7 p.m.	..	200 c.cm.
10.30–11.30 a.m.	300 c.cm.	7–8 p.m.	..	200 c.cm.

The total amount of mapharside administered over a period of five days was 0.76 g., but in the 83rd and subsequent cases each dose was increased to 0.06 g. on the third, fourth, and fifth days, making a total of 1 g. of the drug given during the five-day period. In the earlier cases the patients received 1,500 c.cm. daily of a 6% solution of glucose orally, and they were instructed to sip the solution over a period of one hour. When the dosage of mapharside was increased the amount of glucose was also increased to 1,800 c.cm. daily, in 6 doses of 300 c.cm. On the first day of treatment the 4 p.m. dose of mapharside was not given because this period of the day usually coincided with the time at which a Herxheimer reaction might occur. During treatment the patients were kept in bed and the urine was tested every morning and evening.

TABLE II.—Complications and Reactions occurring in Five Groups of Patients

Group	No. of Patients	Pyrexia	Nausea	Vomiting	Headache	Dizziness	Dermatitis	Cerebral Symptoms	Jaundice after Hospitalization	Albuminuria	Serological and Clinical Relapse
I ..	70	36	17	8	20	2	—	—	—	1	1
II ..	10	—	—	—	—	—	1	1	—	—	—
III ..	14	—	2	—	4	—	—	—	1	—	—
IV ..	1	—	—	—	—	—	1	—	—	—	—
V ..	5	—	—	—	—	1	—	—	—	—	—
Total ..	100	36	19	8	24	3	2	1	1	1	1

Results

Group I: Primary and Secondary Cases not Previously Treated.—In 36 of the 70 cases pyrexia occurred on the first day of treatment only. Occasionally the temperature rose to 103.4° F., but in the majority of cases it lasted only from three