I knew nothing of the patient before this illness, but since, I have taken several tracings at rest without finding any irregularity and an average of pulse of 75 to 80.

Catarrhal jaundice in young people is commonly associated with a slow pulse, the rate being often no more than 50 to 60 per minute. The slow pulse is always irregular, and in my experience the irregularity is always due to sinus arrhythmia.

Fig. 3 is a tracing from a boy, aged 13, with catarrhal jaundice; the rate of the pulse is about 52 per minute; the irregularity is of sinus origin. The pulse-rate in health was usually about 80 and irregular in the same way. A year before this record was taken he had scarlet

FIG. 3.

fever, and during convalescence his pulse slowed as much and became as irregular as it did during jaundice.

Fig. 4 is from another case, a boy aged 9; the rate is about 63 and sinus irregularity is present. This boy's pulse is usually about 80 and irregular. He had a pulse of 60 after measles two years later.

These tracings are exemplary of a number I have from similar cases. Sinus irregularity is present in about 80 per cent. of healthy children; those who show it usually have a slower rate of pulse than the average for the age, and there is a curious susceptibility in this rhythm for the pulse to become unduly infrequent under conditions which tend to lower the pulse-rate; during sleep, for example,

FIG. 4.

and after any febrile illness the pulse often becomes very slow and irregular.

In catarrhal jaundice there is usually fever with a rapid pulse before the jaundice appears; when the jaundice comes out the fever goes, and often the pulse suddenly

falls in rate—may be from 100 to 120 with regular rhythm to 50 to 60 per minute in course of a few hours—and

FIG. 5.

becomes very irregular. This naturally attracts attention, and is ascribed to the jaundice; it will generally be found, however, in such cases that sinus irregularity is present in health, and the pulse will behave in the same way in the same patient after any febrile illness; such at least has been my experience.

Poisons which slow the heart have also the power of causing heart-block or hindrance to the passage of *a-v* impulse through vagus inhibition of conductivity. As already stated, no instance of heart-

FIG. 6.

block during jaundice has been illustrated. In 1911 I had a case of catarrhal jaundice under my care, in which at first there was seemingly impaired *a-v* conduction, evidenced in the jugular pulse. The patient was a boy aged 13; Fig. 5 is the record taken on the fourth day of well-marked jaundice; the pulse-rate is 75 per minute; impaired conduction is suggested by the lengthened *a-c* interval, which measures about $\frac{2}{3}$ sec. Next day the rate of the pulse had fallen to 68; in the tracing (Fig. 6) there is an additional wave marked *b* with the slower beats; careful examination of this curve will show that the lengthening of the *a-c* interval is apparent only, being brought about by fusion of the waves *b* and *a* during the quicker pulse periods. I have illustrated this fallacy more fully in a paper published in 1912.¹

REFERENCE.

¹ *Quarterly Journal of Medicine.*

FROM THE VISIBLE TO THE GAMMA RAY SPECTRUM.

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(With Special Plate.)

In the accompanying Plate (Fig. 1) is represented a chart of the wave lengths of rays ranging from the visible part of the spectrum to x rays and the gamma rays of radium. The numbers across the top of the diagram represent the number of octaves which the rays range over; the numbers across the bottom give their respective wave lengths in tenth-metres—that is, ten thousand millionth parts of a metre.

The limit of visibility at the red end of the spectrum is 7,594 tenth-metres, and is a convenient starting-point for the purposes of this article; the visible region of the spectrum is constituted by almost exactly one octave of radiation, for the wave length of the ray corresponding to the extreme violet is very nearly one-half that of the extreme red. Passing into the ultra-violet portion of the spectrum, it will be seen that rather more than two octaves have been investigated.

A region of about six octaves, which remains at present unmapped, separates the extreme ultra-violet from the commencement of very "soft" x rays. The most easily absorbed x rays whose wave lengths have been determined are the characteristic rays from aluminium with a wave length of 8.4 tenth-metres. As we pass up through

several octaves of x rays the limit indicated by π is reached; this represents the "hardest"—that is, the most penetrating x ray which has, so far, been produced. The line π represents an x -ray beam of "medium" penetrating power.

The gamma rays from radium are represented in wave lengths as extending between the two heavily dotted lines on the diagram, and it will be seen that the most penetrating gamma rays are of appreciably smaller wave length than the "hardest" x rays so far available. On the other hand, some of the gamma rays are of longer wave length, and therefore more easily absorbed than "very hard" x rays.

The two other lines marked Ca and Ag represent the characteristic x rays emitted by calcium and silver respectively.

One of the objects of this article is to put forward a plea for a more exact specification of the different types of radiation which are used in experimental investigations and therapeutically. It is submitted that the time has passed when it sufficed to record, for example, that exposure to hard x rays caused the disappearance of a malignant growth, or that a lethal effect was observed

SIDNEY RUSS: FROM THE VISIBLE TO THE GAMMA RAY SPECTRUM.

FIG. 1.

FIG. 2.—Sources of Ultra-Violet Light. 1. Mercury arc. 2. Silver arc. 3. Copper arc. 4. Simpson arc. 5. Carbon arc.

FIG. 3.—Absorption of Ultra-Violet Light by Human Skin. 1. Unscreened radiation from the Simpson arc; exposure 5 seconds. 2. Screened by one-tenth of a millimetre of skin; exposure 2 minutes. 3. Screened by one-half of a millimetre of skin; exposure 8 minutes. 4. Screened by one and a half millimetres of skin; exposure 8 minutes.

FIG. 4.—Ultra-Violet Spectra of Simpson Arc and Pure Tungsten Arc. 1. Simpson arc. 2. Pure tungsten arc.

upon some organisms by submitting them to ultra-violet light.

THE X-RAY SPECTRUM.

The data are at hand for introducing an added degree of precision in specifying the type of radiation which is utilized. The matter may be illustrated by an example selected at random. The term "hard x rays" is understood to mean x rays which have a high penetrating power; for the production of such rays a bulb would be run with a parallel spark-gap of about 20 to 25 cm. The radiation from such a bulb is, however, heterogeneous; a screen of aluminium 2 mm. thick will cut out the "soft" constituents, but the rays are not yet homogeneous, for an additional 1, 3 and 5 mm. will cut out various other components of the beam until it becomes practically homogeneous with a wave length of almost exactly 0.2 tenth-metres. The beam of "hard x rays" in these several cases may range over an octave of wave lengths, and different reactions are exhibited by tissues according to whether they are exposed to radiation at one or the other end of the octave. It is suggested that a statement of the range of wave lengths utilized would eliminate many of the uncertainties introduced by such terms as "hard," "medium," and "soft."

Reference may be made here to one difficulty that presents itself with regard to x rays. The question arises as to what regions of wave length are to be assigned to the radiation which is commonly known as "soft," "medium," or "hard." Reference to the diagram shows that x rays have been mapped over a region of about $5\frac{1}{2}$ octaves. The rays "characteristic" of aluminium (8.4 tenth-metres) are "very soft," for they are absorbed by a few centimetres of air; in fact, over the three octaves from this starting point the radiation might be termed "very soft." The next octave—namely, from 1 to 0.5—includes the characteristic rays from platinum and a good part of the unscreened rays from a "soft" bulb (5 to 10 cm. spark gap). The next octave would then comprise "medium" rays; any radiation of smaller wave length than 0.25 could safely be considered as "hard." This subdivision is quite arbitrary, and it is hoped that the Röntgen Society will make some definite recommendations on this subject in the near future.

We may briefly consider the remaining features of the diagram. It will be seen that a portion marked "unmapped region," which comprises about six octaves, separates the extreme ultra-violet from the very "softest" x rays. There are good reasons for believing that ether vibrations in this region, that is, of wave lengths ranging from 900 to 9, are very easily absorbed by matter, and this is no doubt, in part, the reason why the other properties of these vibrations have not yet been investigated. Such radiations, however, should not be dismissed from our minds, for it is by no means unlikely that these six octaves of radiation play some part in the reactions of tissues, when they are exposed to the x rays or the rays from radium. If we may apply the information which has been gleaned from the x ray spectrum we might suggest that the amount of this "unmapped" radiation excited in tissues depends not only on the intensity of the beam of x rays, but to a very large extent upon the particular wave lengths utilized. The main chemical constituents of most tissues are essentially the light elements, and all the evidence goes to show that the secondary x rays given out by them under the influence of a primary beam would be very easily absorbed; these rays may even be so slightly penetrating as to be mainly absorbed within the cells from which they originate. Now it is safe to say that more of such radiation would be provoked by a beam of "soft" x rays than by a "hard" beam of equal intensity. Such a secondary process, initiated by the primary beam, may in fact play a dominant part in determining what is spoken of as the reaction of the tissues. The fundamental fact that the human skin when exposed to "soft" and "hard" x rays of equal intensity reacts in an entirely different manner has not, so far, received a rational explanation, and it may be appropriate in this connexion to invoke the above probability which is suggested by general considerations of the spectrum.

THE DANGERS OF X RAYS.

Let us now turn to a second aspect of this spectrum, which impresses one more and more of its potentiality for harm as well as for good.

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When the first warning was sounded of the damage which x rays did to operators who were insufficiently protected from them, additional precautions were taken to obviate the dangers as far as these were known at the time. The range of ray which may be utilized has, however, greatly widened as the result of investigation, and this is especially the case for radiation of a high penetrating power. It may well be questioned whether the precautionary measures have extended simultaneously with the wider range of radiation utilized and with the more exacting conditions under which so much of the present x -ray work is conducted.

There are two main aspects of the application of x rays which may be briefly considered. When the rays are administered therapeutically it is a desideratum to be striven after that whoever dispenses the ray should receive no fractional part of the dose given. This becomes increasingly difficult to secure when the more penetrating rays are used, and it is precisely when the step is made from one phase of x -ray therapy to another, such as from the treatment of superficial conditions to what is known as deep-therapy, that it becomes necessary to reconsider the efficiency of methods of protection which, eminently suitable for the former, are inadequate for the latter. When it is borne in mind that "hard" x rays have a penetrating power so high that the intensity of a beam is only cut down to 10 per cent. of its intensity by going through about 12 or 13 cm. of tissue, the difficulty of adequate protection from such radiation will be apparent.

When we turn to the other aspect of the utility of the rays, namely, in radiographic and screen work, the dangers are of rather a different character, though no less real.

The conditions under which the radiographic work necessitated by military affairs is conducted are often very exacting, and this is particularly the case in screen work; such procedure involves the proximity of the operator to the bulb, and however efficient the protective devices may be, it is almost impossible to arrange that the operator does not become irradiated to some small degree. The protective devices cannot be pushed to the limits which are possible under other conditions, for the gloves worn by the operator must not be so cumbersome as to hinder his manipulations, the lead glass of the screen which protects his face must not be so thick as to interfere unduly with the visibility of the picture he interprets, and so on. Again, it has to be recognized that an installation which provides reasonable protection to any one engaged upon it for short or intermittent periods may be quite inefficient when use is made of it for periods of a good many hours per day.

In the light of our present knowledge it cannot perhaps be stated what is a safe limit for an operator to be the daily recipient of in the way of x radiation, but it would appear certain that unless stringent precautions are taken, damage—perhaps irremediable damage—will be done to those who are engaged in one of the branches of medical work the importance of which can hardly be over-estimated.

ULTRA-VIOLET RADIATION.

Ultra-violet rays have been investigated over a range of rather more than two octaves. The first octave beyond the visible portion of the spectrum, with wave lengths from 3,800–1,900 A.U.,* is the region of therapeutic interest, for the radiation beyond this, and forming the second octave, is so easily aborted by air that investigation of it has to be carried out in a vacuum.

In Fig. 2 are reproduced photographs of the ultra-violet radiation from various arcs taken by means of a quartz spectrograph. They are respectively (1) mercury, (2) silver, (3) copper, (4) the Simpson arc, and (5) carbon. It will be seen that the spectrum of mercury vapour does not extend quite so far as that of silver, which, again, has not so large a range as copper. The Simpson arc consists of pole pieces of wolframite, the main constituent of which is tungsten. The radiation from this arc is very rich in ultra-violet rays, and an examination of it shows that it consists of a large number of emission lines which do not vary locally very greatly in relative intensity from one another, although the photographic intensity of the rays gradually fades off toward the region of short wave lengths. The general character of the spectrum of the Simpson arc appears, therefore, to be one rich in ultra-violet radiation, which is graded fairly uniformly throughout the region

* A.U., that is, Angstrom unit, is one-tenth metre.

under consideration; this is in marked contrast to the arc spectrum of copper, which is seen to consist of groups of very bright lines, with considerable intervals between them. The carbon arc (5) is seen to have a somewhat restricted range of ultra-violet radiation.

THE PENETRATING POWER OF ULTRA-VIOLET LIGHT.

When any of the various sources of ultra-violet light are used therapeutically the question arises as to how far the rays are able to penetrate through the tissues. It has long been known that blood pigments are strongly absorbent of such radiation, and means were accordingly taken to prevent, as far as possible, direct access of the blood to the part receiving the rays.

It seemed desirable, however, to make some measurements of the extent to which the ultra-violet rays penetrate the skin. For this purpose skin removed from the human abdomen was used; it was cut parallel to the external surface in layers $\frac{1}{10}$ mm., $\frac{1}{2}$ mm., and $1\frac{1}{2}$ mm. thick by means of a large-sized microtome; these different thicknesses of skin were then placed in front of the slit of the spectrograph, to ensure that any radiation entering the instrument and affecting the photographic plate placed in position, would first have penetrated the particular thickness of skin.

The source of ultra-violet radiation selected was the Simpson arc. When this was placed about 20 cm. distant from the slit of the spectrograph an exposure of a few seconds was sufficient for a photograph of this radiation as far as wave length 3,000. In order to bring out the very short wave lengths the plate has to be rather over-exposed in the violet region (see Fig. 3, No. 1). The exposure in this case was 5 seconds.

It was soon found that skin was very absorbent for the ultra-violet radiation, and consequently the time of exposure had to be much increased in order to obtain any record on the photographic plate. Fig. 3, No. 2, shows the result of interposing $\frac{1}{10}$ mm. of skin in front of the slit of the instrument; the exposure was increased from five seconds to two minutes. No. 3 and No. 4 show the results for a thickness of $\frac{1}{2}$ mm. and $1\frac{1}{2}$ mm. respectively; the exposures were in each case eight minutes—that is, nearly one hundred times that of the unscreened radiation. In spite of this, however, a large portion of the spectrum is cut out.

It will be seen, therefore, that ultra-violet rays of wave lengths 2,100 to 3,000 A.U., the approximate positions of which are indicated in Fig. 2, are very easily absorbed by human skin; certainly less than one part in a thousand of this radiation penetrates to a depth of half a millimetre.

As we proceed to the region of wave lengths 3,000 to 3,800 A.U., which latter marks the onset of visible radiation, the rays become rather more penetrating, but it is doubtful whether as much as 1 per cent. of the radiation penetrates as deep as 1 mm. Fig. 3, No. 4, shows, however, that a small percentage of ultra-violet radiation penetrates $1\frac{1}{2}$ mm. of human skin.

THE SPECTRUM OF THE SIMPSON ARC.

The poles of the Simpson arc are said to consist of wolframite, a prominent constituent of which is tungsten. In order to see to what extent tungsten contributes to the ultra-violet radiation from the Simpson arc, two electrodes of pure tungsten were obtained, and the arc spectrum photographed in the same way as indicated above for the Simpson arc.

In Fig. 4, No. 1 is a photograph of the spectrum of the Simpson arc, between wave-lengths 5,800 and 2,100 A.U. No. 2 is a photograph of the spectrum of a pure tungsten arc over the same region; the exposures were for five and ten seconds respectively.

Inspection shows that the two spectra are apparently identical. Whether there are differences in the relative intensities of the emission lines cannot be said without a more extensive examination.

THE last report of the librarian of the Harvard Medical School states that 3,100 volumes have been added to the collection during the past year. The library now contains 27,000 volumes and 46,067 pamphlets. The College of Physicians of Philadelphia has 105,540 volumes; the New York Academy of Medicine, 100,320; the Boston Medical Library, 83,107; and the Johns Hopkins Hospital, 17,000.

SODIUM HYPOCHLORITE IN THE TREATMENT OF SEPTIC WOUNDS.

BY

FLEET SURGEON FREDERICK J. A. DALTON, R.N.

IN September, 1915, a committee was sent to the Gallipoli peninsula in the naval hospital ship *Rewa*, by order of the Medical Director-General of the Navy, to report on the efficacy of hypochlorites in the treatment of infected wounds. The committee made two trips to the beaches in this ship—one to Anzac and one to Cape Helles. Unfortunately for their purpose, there was at this time very little attacking going on at the peninsula, and although 1,176 patients were carried in the two trips, the majority were cases of dysentery, enteric, and epidemic jaundice, and the proportion of wounded to sick was very small. The committee returned to England on October 18th.

Before leaving, Dr. H. D. Dakin, who was working in connexion with the Medical Research Committee, asked me to continue the investigation of the value of hypochlorites as opportunity offered on this ship, and this has been done.

In the past two months we have carried an additional 2,753 cases to Alexandria and Malta, but of this large number only a very small percentage have been wounded.

Every wounded patient received on board during this period, whose wound or wounds were clinically septic on arrival, has been treated with the special sodium hypochlorite solution prepared according to Dakin's formula. No other form of antiseptic was employed. Although this report is based on the small total of 57 cases, the results have been so uniformly and consistently good that I think it may be useful to publish it now, in order that the hypochlorite solution may be more generally used in the treatment of wounds than is the case at present.

Wounds that were clinically clean on arrival on board were also irrigated with the sodium hypochlorite solution and dressed with gauze soaked in the antiseptic. But these cases are not considered in connexion with this report since they would probably have remained clean and healed with any other form of customary dressing, and therefore cannot be counted as evidence in favour of hypochlorites being far superior to any other form of antiseptic that we have so far used on board this ship; that being the point I wish particularly to bring out.

Before employing the sodium hypochlorite antiseptic, my colleagues and I in this ship used various weak antiseptic lotions for the thorough irrigation of these large septic wounds, each fancying his own pet solution—be it carbolic acid, perchloride of mercury, etc.—gave the best results. My own predilection was for passing pints of ordinary sterile salt solution through the wound. Since making trials of the hypochlorite solution there has been absolute unanimity among us as to the preference for it, and we all now use it as our routine lotion.

Preparation of Hypochlorite Solution.

The antiseptic solution is made on board from dry carbonate of soda (United Alkali Co.'s best soda ash), bleaching powder of good quality, and boric acid, according to Dakin's directions given in the *BRITISH MEDICAL JOURNAL*, August 28th, 1915. The solution was made in large carboys holding about 40 litres.

Five hundred and fifty grams of the carbonate of soda were dissolved in a carboy half filled with fresh water; 800 grams of bleaching powder were then added, and the mixture thoroughly shaken for five minutes. The carboy was then filled up with fresh water, and, shaking the mixture once more, it was allowed to settle for half an hour. The clear fluid over the precipitate of calcium carbonate was siphoned off as completely as possible, and filtered into a second carboy by passing through a plug of cotton in the neck of a large funnel; 150 grams of boric acid were added to the filtrate, and the mixture was then ready for use. It was drawn off from the carboy as needed by means of a siphon.

The solution was never kept longer than a week, and any unused solution that had been made longer than a week was thrown overboard. This waste is a matter of no moment since the cost of the preparation is so extremely small.