

made for the purpose, the oil will begin to ooze out, and it should be received in another tub placed below. After the oil has ceased to drip and the camphor has perfectly crystallized, the camphor should be put into a barrel or tub about 1'7 feet wide at the top and 1'5 feet wide at the bottom and about 1'9 feet high. The camphor put into the barrel should be made solid by pounding with a wooden mallet or pounder, and a double lid should be used to prevent the evaporation of the camphor. One barrel contains about 160 pounds. If to be exported, the lid should be pasted down with paper.

#### THE SENSITIVENESS OF THE EYE TO LIGHT AND COLOR.\*

By Capt. W. DE W. ABNEY.

THERE may be some here who have had the pleasure—or the pain—of rising very much betimes in a Swiss center of mountaineering in order to gain some mountain peak before the sun has had power enough to render the intervening snow-fields soft, or perhaps dangerous. Those who have will recollect what were the sensations they experienced as they sallied out of the comfortable hotel, after endeavoring to swallow down breakfast at 2 A. M., into the darkness outside. Perhaps the night may have been moonless, or the sky slightly overcast, and the sole light which greeted them have been the nervous glimmer of the guides' lanterns. By this feeble light they may have picked their way over the stony path, and between the frequent stumbles over some half hidden piece of rock lying in the short grass they may have had time to look around and above them, and notice that the darkness of the night was alone broken by stars which gave a twinkle through a gap in the clouds, or if the sky were cloudless, every star would be seen to lie on a very slightly illuminated sky of transparent blackness. Although giant mountains may have been immediately in front of them, their outlines would be almost if not quite invisible. As time went on the sky would become a little brighter, and what is termed the *petit jour* would be known to be approaching. The outlines of the mountains beyond would become fairly visible, the tufts of grass and the flowers along the path would still be indistinguishable, and most things would be of a cold gray, absolutely without color. The guide's red woolen scarf which he bound round his neck and mouth would be black as coal. But a little more light, and then some flowers among the grass would appear as a brighter gray, though the grass itself would still appear dark; but that red scarf would still be as black as a funeral garment. The mountains would have no color. The sky would look leaden, and were it not for the stars above it might be a matter of guesswork whether it were not covered over with cloud.

More light still, and the sky would begin to blush in the part where the sun was going to rise, and the rest would appear as a blue gray; the blue flowers will now be blue, and the white ones white; the violet or lavender colored ones will still appear of no particular color, and the grass will look a green gray, while the guide's neckgear will appear a dull brown.

The sun will be near rising, the white peaks beyond will appear tipped with rose; every color will now be distinguished, though they would still be dull; and, finally, the daylight will come of its usual character, and the cold gray will give place to warmth of hue.

But there may be others who have never experienced this early rising, and prefer the comfort of an ordinary English tramp to that just described; but even then they may have felt something of the kind. In the soft autumn evening, when the sun has set, they may have wandered into the garden and noticed that flowers which in the daytime appear of gorgeous colorings—perhaps a mixture of red and blue—in the gloaming will be very different in aspect. The red flowers will appear dull and black; a red geranium, for instance, in very dull light, being a sable black, while the blue flowers will appear whitish gray, and the brightest pale yellow flowers of the same tint; the grass will be gray, and the green of the trees the same nondescript color. A similar kind of coloring will also be visible in moonlight when daylight has entirely disappeared, though the sky will have a transparent dark blue look about it, approaching to green. These sensations, or rather

We are often told that the different stages of heat to which a body can be raised are black, red, yellow and white heat, but I wish to show you that there is an intermediate stage between black and red heat, viz., a gray heat. An incandescent lamp surrounded by a tissue paper shade has a current flowing through it, and in this absolutely dark room nothing is seen, for it is black hot. An increase of the current, however, shows the shade of a dim gray, while a further increase shows it as illuminated by a red, and then a yellow light. A bunch of flowers placed in the beam of the electric light shows every color in perfection; the light is gradually dimmed down, and the reds disappear, while the blue colors remain and the green leaves become dark. These two experiments show that there

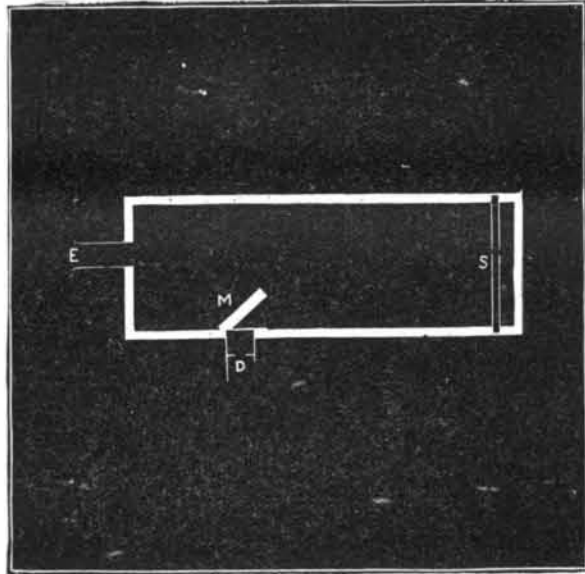


FIG. 2.—EXTINCTION BOX.

is a color, if gray may be called a color, with which we have to reckon.

Now the question arises whether we can by any means ascertain at what stage a color becomes of this gray hue, and at what stage of illumination the impression of mere light also disappears, and whether in any case the two disappear simultaneously.

As all colors in nature are mixed colors, it is at the outset useless to experiment with them in order to arrive at any definite conclusion, hence we are forced—and the forcing in this direction to the experimentalist is a very agreeable process—we are forced to come to the spectrum for information.

The apparatus on this table is one which I have before described in this theater, and it is needless for me to describe it again. I can only say that it has in all color investigations been of such service that any attempt on my part to do without it would have been most disadvantageous. The apparatus enables a patch of what is practically pure monochromatic light of any spectrum color to be placed upon the screen at once, and an equally large patch of white light alongside it, by means of the beam reflected from the first surface of the first prism.

It should be pointed out that this beam of white light reflected from the first prism of the apparatus, having first passed through the collimator, must of necessity diminish with the intensity of the spectrum, when the collimator slit is closed.

Having got these patches, the next step is to so enfeeble the light that their color and then their visible illumination disappear.

An experiment which well demonstrates loss of color is made by throwing a feeble white light on one part of the screen, and then in succession patches of red, green, and violet alongside it. The luminosity of the colored light gradually diminishes till all the color disappears, the white patch being a comparison for the loss of color.

If red, green and violet patches be placed alongside each other, and they are bedimmed in brightness together, it will be noticed that the red disappears first, then the green, and then the violet; or I may take a red and green patch overlapping, which when mixed form orange, and extinguish the color: the slit allowing red light to fall on the screen may be absolutely closed, and no alteration in the appearance of the patch is found to occur. This shows, I think, that when all color is gone from a once brilliant color, a sort of steel gray remains behind, and that red fails to show any luminosity when the green still retains its color.

The measurement of the extinction of color from the different parts of the spectrum was made on these principles. A box, similar to Fig. 2, was prepared, but having two apertures, one at each side. Through one the colored ray was reflected and through the other a white beam of light to a white screen. Both beams were diminished, and when the white and colored patches appeared the same hue, the amount of illumination was calculated. Fig. 1 shows graphically the reduction of illumination, when the D light of the spectrum is the same intensity as one amyl-acetate lamp at one foot from the screen. To measure the extinction of light, a box was made as in the diagram, closed at each end, but having two apertures as shown, Fig. 2. E is a tube through which the eye looks at S, which is a black screen with a white spot upon it, and which can be illuminated by light coming through the diaphragm, D, first falling on a ground glass which closes the aperture, and reflected on to it by M, a mirror.

The patch of light of any color being thrown on D, rotating sectors, the apertures of which could be opened and closed at pleasure, were placed in the path of the beam, thus enabling the intensity of the patch to be diminished. D could be made of any desired aperture, and thus the illumination of the ground glass would be diminished at pleasure. After keeping the eye in darkness for some time, the eye was placed at E, when the white spot illuminated by the color

thrown on D was visible, and the sectors closed till the last scintilla of light was extinguished. This was repeated for rays at different parts of the spectrum, and the results are shown in Fig. 3 by the continuous curved lines. The diagram would have been too large had the same scale been adopted throughout for the ordinates; each curve is therefore made on a scale ten times that of its neighbor, counting from the center.

In the diagram the sodium light of the spectrum before extinction was made of the luminosity of the amyl-acetate lamp (hereafter called A L), which is about 0'8 of a standard candle, at 1 foot distance from the source. Before it ceased to cause an impression on the eye, the illumination had to be reduced to

	350	A L.
	10,000,000	
E light to	65	
	10,000,000	
F light "	150	15
	10,000,000	1,000,000
G light "	3,000	3
	10,000,000	10,000
C light "	11,000	11
	10,000,000	10,000
B light "	70,000	7
	10,000,000	1,000

Of its spectrum luminosity.

There was one objection which might have been offered to this method, and that was to the use of the rotating sectors, and perhaps to the ground glass. This objection was met by first of all reducing the light by means of a double reflection of the beam forming the patch from one or two plain glass mirrors, and also by using a plain glass mirror in the box instead of a silvered glass. By this plan the light falling on the first plain glass mirror was reduced, before it reached the end of the box, 1,000 times; and again by narrowing the slit of the collimator, and also the slit placed in the spectrum, another similar reduction would be effected. All rays thus enfeebled were within the range of extinction. It was found that neither ground glass nor rotating sectors had any prejudicial effect, and therefore this extinction curve may be taken as correct.

In the curves there are two branches at the violet side, and this requires explanation. One shows the extinction when viewed by the most sensitive part of the eye, wherever that may be, and the other when the central portion of the eye was employed. The explanation of this difference in perception is chiefly as follows:

In the eye we have a defect—at least we are apt to call it a defect, though no doubt Providence has made it for a purpose—in that there is a yellow spot which occupies some 6° to 8° of the very center of the retina, and as it is on this central part that we receive any small image, it has a very important bearing on all color experiments. The yellow spot absorbs the blue, green, blue, and violet rays, and exercises its strongest absorption toward the center, though probably absent in the very center, that is, in the "fovea centralis," and is less at the outer edges. That absorption of color by the yellow spot takes place can be shown you in this way. Any color in nature can be imitated by mixing a red, a green, and violet together, and with these I will make a match with white and then with brown, two very representative colors, if we may call them colors. Now if I, standing at this lecture table, match a white by mixing these three colors together, using a large patch, the image will fall on a part of the retina of considerably large area than the yellow spot, and it will appear too green for those at a distance; but it is correct for myself. If I place a mirror at a distance, and make a match again by the reflected image, the match is complete for us all, as we all see it through the yellow absorbing medium. If I look at it direct from where I stand, the match is much too pink. It may be asked why the comparison patches

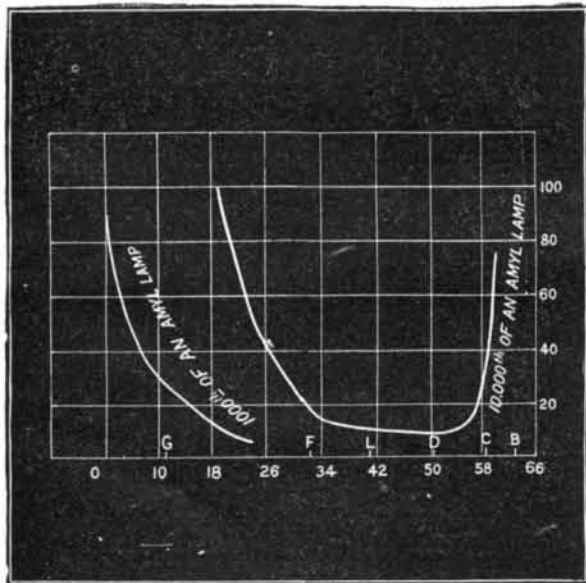


FIG. 1.—EXTINCTION OF SPECTRUM COLORS.

lack of sensations, of light and color, which as a rule attract very little attention, as they are common ones, are the subjects of my discourse to-night.

Experiments which can be shown to a large audience on this subject are naturally rather few in number, but I will try and show you one or two.

\* A lecture delivered at the Royal Institution of Great Britain by Captain W. De W. Abney, C.E., R.E., D.C.L., F.R.S.

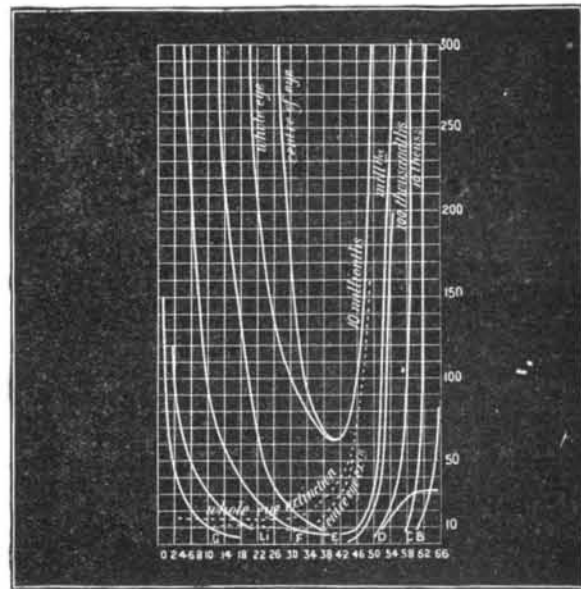


FIG. 3.—EXTINCTION OF THE SPECTRUM.

and the mixed colors do not always match, since both images are received on the same part of the retina. The reason is that the green I have selected for mixture is in the part of the spectrum where great absorption takes place, while the comparison white contains the green of the whole spectrum, some parts of which are less absorbed than others. I may remark that just outside the yellow spot the eye is less sensitive to



the red than is the center, and this is one additional cause of the difference. (See Fig. 5.)

More on this subject I have not time to say on this occasion, but it will be seen that the extinction of light for the center and the outside of the eye differs on account of this.

I must take you to a theory of color vision which, though it may not be explanatory of everything, at all events explains most phenomena—that is, the Young-Helmholtz theory. The idea embodied in it is that we have three sensations stimulated in the eye, and that these three sensations give an impression of a red, a green and a violet. These three colors I have said can be mixed to match any other color, or in other words, the three sensations are excited in different degrees, in order to produce the sensation of the intermediate spectrum colors, and those of nature as well.

The diagram, Fig. 4, shows the three sensations as derived from color equations made by Koenig. It will be seen that there are three complete color sensations, all of which are present in the normal eye. I would ask you to note that at each end of the spectrum only one sensation is present, viz., at the red end of the spectrum, the red sensation, and at the violet end of the spectrum, the violet sensation.

This is a matter of some importance, as we shall now see.

It will be recollected that in making the extinctions, the D light of the spectrum was made equal to one amyl-acetate lamp, and the other rays had the relative luminosity to it which they had in the spectrum before they were extinguished. The luminosity curve of the spectrum is shown in Fig. 5.

Suppose we make all the luminosities of the different rays equal to one, A L, we should not get the same extinction value, as shown in the continuous lines in Fig. 3. The violet would have to be much more reduced, but by multiplying the extinction by the luminosity we should get the curve of reduction for equal luminosities, and we get the dotted curves in Fig. 3.

It will be seen that it is the violet under such circumstances that would be the last to be extinguished, and that all the rays at the violet end of the spectrum would be extinguished simultaneously, as would also those at the extreme red. This looks a confirmation of the Young-Helmholtz theory which I have briefly explained, for we cannot imagine that it can be anything but a single sensation which fails to be excited.

The violet is extinguished when it is  $\frac{15}{10,000,000}$  A L,

that is, a screen placed 817 feet away and illuminated by an A L violet lamp would be invisible. The blue-

green (F) light when it is  $\frac{17}{10 \text{ millionths}}$  or 770 feet away.

The green (E) light  $\frac{35}{10 \text{ millionths}}$  or 550 feet away.

The orange (D) light is extinguished as before at  $\frac{350}{10 \text{ millionths}}$

or 180 feet away, while the red (C) light has only to be reduced to  $\frac{2,220}{10 \text{ millionths}}$  or an A L

lamp radiating C light would have to be placed only 67 feet away, while the radiation for an A L of the color of the B light of the spectrum would have to be  $\frac{2,600}{10 \text{ millionths}}$

diminished to but  $\frac{10 \text{ millionths}}$  or the screen would have to be placed 60 feet away.

It is therefore apparent that with equal luminosities the violet requires about 175 times more reduction to extinguish it than does the red, and probably about 25 times more than the green.

This being so, I think it will be pretty apparent that, at all events from the extreme violet to the Fraunhofer line, D, of the spectrum, the extinction is really the extinction of the violet sensation, a varying amount of which is excited by the different colors. If then we take the reciprocals of the numbers which give extinction of the spectrum, we ought to get the curve of the violet sensation on the Young-Helmholtz theory. For if one violet sensation has to be reduced to a certain degree before it is unperceived, and another has to be reduced to half that amount, it is evident that the violet sensation must be double in one case to what it is in the other; that is, the degrees of stimulation are expressed by the reciprocal of the reduction.

Such a curve is shown in Fig. 5 (in which also are drawn the curves of luminosity of the spectrum when viewed with the center of the retina and outside the yellow spot). And it will be noticed that it is a mountain which reaches its maximum about E. Remember that the height of the curve signifies the amount of stimulation given to the violet sensory apparatus by the particular ray indicated in the scale beneath.

Turning once more to Fig. 3, it will be noticed that if any one or two of the three sensations are absent, the persons so affected are what is called color blind. Thus if the red sensation is absent, they are red-blind; if the green, then green-blind; if the violet, then violet-blind. If both red and green sensations are absent, then the person would see every color, including white, as violet. The results of the measurement of the luminosity of the spectrum by persons who have this last kind of monochromatic vision should be that they give a curve exactly or at all events very approximately of the same form as the curve given by the reciprocals of the extinction curve obtained by the normal eye, as the violet sensation is that which is last stimulated.

It has been my good fortune to examine two such persons, and I find that this reasoning is correct, the two coinciding when the curves for the center of the retina are employed.

Further, I examined a case of violet blindness, and measured the luminosity of the spectrum as apparent to him. Now if the Young-Helmholtz theory be correct, then in his case the violet sensation ought to be absent, and the difference between his luminosity and that of the normal eye ought to give the same

curve as that of the violet sensation. This was found to be the case.

Again, the reciprocal of the extinction curves of the red-blind and green-blind ought to be the same as those of the normal eye, for the violet sensation must be present with them also. This was found to be so. We have still one more proof that the last sensation to disappear is the violet.

If we reduce the intensity of the spectrum till the green and red disappear to a normal eye, and measure the luminosity of the spectrum in this condition, we shall find that it also coincides with the persistency curve. On the screen we have a brilliant spectrum, but by closing the slit admitting the light and placing the rotating sectors in the spectrum and nearly closing the apertures, we can reduce it in intensity to any de-

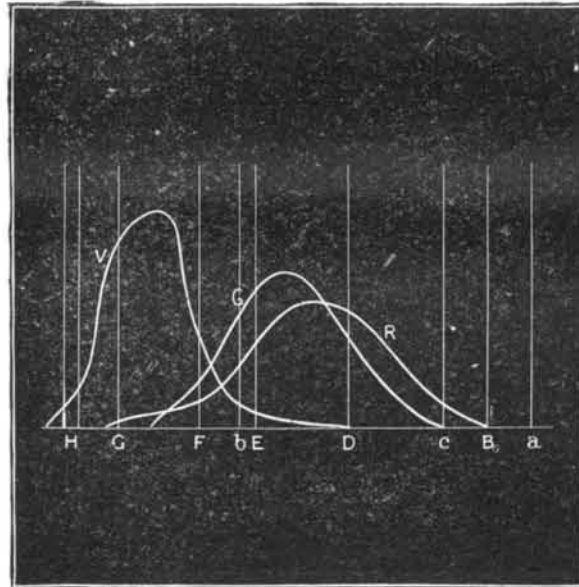


FIG. 4.—COLOR SENSATIONS.

gree we like. The whole spectrum is now of one color and indistinguishable in hue from a faint white patch thrown above it. If the luminosity of this colorless spectrum be measured, we shall get the result stated. The curve obtained in this way is in reality identical with the other curves. By these four methods then we arrive at the conclusion that the last color to be extinguished is the sensation which when strong gives the sensation of violet, but which when feeble gives a blue gray sensation.

One final experiment I may show you. It has been remarked that moonlight passing through painted glass windows is colorless on the gray stone floor of a cathedral or church.

We can imitate the painted glass and moonlight. Here is a diaper pattern of different colored glasses, and by means of the electric light lantern we throw its colored pattern on the screen. The strength of moonlight being known, we can reduce the intensity of the light of the lamp till it is of the same value. When this is done it will be seen that the pattern remains, but is now colorless, showing that the recorded observations are correct, and I think you are now in a position to account for the disappearance of the color.

I have now carried you through a series of experiments which are difficult to carry out perfectly before an audience, but at any rate I think you will have seen enough to show you that the first sensation of light is what answers to the violet sensation when it is strong enough to give the sensation of color. The other sensations seem to be engrafted on this one sensation, but in what manner it is somewhat difficult to imagine. Whether the primitive sensation of light was this and the others evolved, of course we cannot know. It ap-

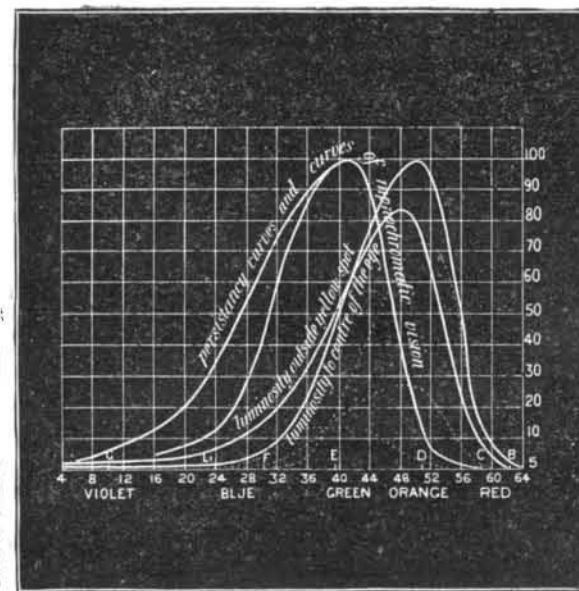


FIG. 5.

pears probable that even in insect life this violet sensation is predominant, but at all events existent. Insects whose food is to be found in flowers seek it in the gloaming, when they are comparatively safe from attack. Prof. Huxley states that the greater number of wild flowers are certainly not red, but more or less of a blue color. This means that the insect eye has to distinguish these flowers at dusk from the surrounding leaves, which are then of a dismal gray; a blue flower would be visible to us while a red flower would be as black as night. That the insects single out these flowers seems to show that they participate in the same order of visual sensations. I venture to think, without

adopting it in its entirety, that these results at all events give an additional probability as to the general correctness of the Young-Helmholtz theory of color vision. Where the seat of color sensation may be is not the point, it is only the question as to what the color sensations make us feel which the physicist has to deal with. The simpler the theory, the more likely is it to be the true one, and certainly the Young-Helmholtz theory has the advantage over others of simplicity.

#### THE ORIGIN OF THE SIGMOID FLEXURE AND THE APPENDICULA VERMIFORMIS OF THE HUMAN COLON.

THE sigmoid flexure of the human colon is the necessary result of the change from quadruped to biped, from the horizontal to the vertical position.

The colon having formerly occupied the position of an easy curve, its greatest weight rather tending from the anus downward toward the umbilicus, thus rather straightening that part of the colon which now contains the sigmoid flexure. The gradual change from the horizontal to the vertical position changed all this radically, formed of the colon an arch, whose columns bent and kinked from sheer force of the weight they were compelled to support.

The appendicula vermiformis, or worm-like appendage, resulted likewise from the same cause, namely, the upright position. Through means of the weight of the feces or excreta causing the extension of the colon beyond and below the ileo-cæcal valve, from the difficulty of expelling the accumulations in the same, it finally became constipated, peristaltic action becoming more and more difficult, expansion and contraction of the muscles ceased partly, and finally altogether, with it also a diminishing of the circulation of blood must have taken place. What other result could there be than that this part of the colon became useless and consequently doomed to gradual reduction and final disappearance?

Lady Lake, Fla.

CHAS. F. SCHNEIDER.

#### WATER CURES FROM CLINICAL AND EXPERIMENTAL POINTS OF VIEW.\*

By Prof. WILHELM WINTERNITZ.

IT is now thirty years since I began to investigate the action of water in its various temperatures and aggregate forms, and to observe how the thermic and mechanical influences manifest themselves in the healthy and in the sick. The first results aroused in me a lively desire to do away with hydrotherapy as a specialty and to make it the common property of society in so far as it merited general adoption. But after hydrotherapy had received an apparent impetus during the sixties, and especially after the question of the regulation of warmth had come to stand in the zenith of physiological interest, my hopes began to sink, and to-day, in common with other distinguished clinicians, I must declare that the proselytizing power of my own convictions has not proved equal to the achievement of this ideal. Nevertheless, the dissemination of theoretical knowledge has been greatly promoted; hundreds of my direct and indirect pupils are to-day conducting hydropathic institutes, and hundreds of thousands receive treatment for their maladies in accordance with my principles.

A few years ago I believed that the principles of my method were firmly established, and I shall endeavor briefly to sketch its main features, and to show that it is possible to speak in a rational manner of thermic and mechanical effects upon the organs and their functions. I cannot, of course, go into details here, but will simply assert that we are thus enabled to elevate, depress or modify the supply of nerve force. I merely remind you that we are in position to recall to normal perception anæsthetic portions of the body, and of again producing anæsthesia through the application of cold. We are able to exert an action not alone on the peripheral nerves, but also through the latter, by reflex action, on the central organ, and even on the gray cortex of the brain.

I have not hesitated to learn from laymen. In Grunenberg, for example, I saw a young, robust patient suffering from severe circular insanity, characterized by great depression, with feelings of anxiety, notions of persecution, self-reproaches, abstinence, impurity, etc., which alternated with symptoms of most pronounced excitation. Patient had just experienced a violent attack of mania, during which four attendants placed him gently upon a couch prepared with moist padding (water bed). The first shock of the cold sheet resulted in giving the patient a few moments' rest, and the interval was utilized by the attendants in wrapping up the patient tightly, closing the moist ends over his head, and thus forming a kind of therapeutic strait jacket. After five minutes the patient began struggling to remove the sheet, whereupon he was placed on another couch similarly prepared, and the interval of rest produced reflexively proved of longer duration. Thus from morning until evening sixteen "wrappings" were performed, the attack of mania then vanishing completely. We physicians would perhaps have hesitated to subject to such a thermic process a subject suffering from accelerated circulation and violent congestions to the head. The result was an extraordinary surprise to me, and subsequently I succeeded by following this method in treating satisfactorily very severe circular forms, with the severest stages of excitation and koprolalia. This case proves that through the periphery we can exert reflex action upon the central organ in this manner. The nervous condition depends on the impulses which are conducted to the center from the periphery. When this stimulus gradually fades away, and the peripheral vessels, through repeated stimulation, are brought into a state, not of parietic, but rather of tonic enlargement (which, under the co-operation of the inhibitory nerves, may become active), the modified distribution of the blood will have a powerful influence. It goes without saying that, aside from the influence upon the nervous forces, that exerted upon the circulation must also be taken into account, and we hope that psychiatric specialists will make experiments in this very form of nervous excitement, on a greater scale than hitherto. It is an

\* From the *Internat. Klin. Rundschau*.