

THE HEAT OF THE SUN.

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The additions which the sun has received during these times must have caused a great change in the periods of planetary revolution and it is hardly possible to avoid the conclusion that if such is taking place, that some evidence of it would have been found ere this. Considerations somewhat of this nature induced the great German philosopher Helmholtz to discard the theory and to propose in its stead one founded on the heat given out by the contracting of the body of the sun and hence called the contraction theory. Speaking of this theory in a recent lecture at New York, Prof. Young of Vermont, says: "It is the one held by most scientific men and is one which I think will be found more than half true." Without entirely endorsing Prof. Young's words, there can be no doubt that we have in it a thoroughly competent cause to produce the effects.

Starting at the beginning, Helmholtz assumes the truth of Laplace's great conception known as the Nebular Hypothesis. This theory supposes, as is well known, that at one time millions of years ago, the whole of the matter composing the various members of the solar system together with any interplanetary substance which may exist was diffused in space in the form of highly rarefied gas. The only known cause capable of keeping such materials in such a condition is heat and it is thus further assumed that the whole of the heat in our system together with a large quantity which has been wasted in space (i.e. space beyond the confines of the orbit of Neptune) was stored up in the nebulous matter in the form of latent heat. This highly rarefied matter gradually radiated its heat into space, and in consequence began to diminish in bulk, and at the same time to increase in specific gravity. Planets and satellites began to form out of it, and the process of cooling and contraction continued until the system assumed its present condition. In this process, assuming the specific heat of the condensing matter to be equal to that of water, Helmholtz calculates that the heat given out would raise the temperature 28,000,000° centigrade. What then has become of this immense amount of heat? All of it, except a very small fraction has been radiated into stellar space, and practically lost amid the vast recesses which exist between suns or between the satellites of suns. The small fraction has been intercepted by the matter of some of the planetary bodies and its energy, or some portion of it used up in rearranging the materials of the planet. In this way perhaps the vast store of energy which the deposits of carbonaceous matter in the earth possess, may have been derived from the condensation of the nebulous matter, and was employed at one time in keeping the molecules of that substance in a state of vibration. But the process of condensation having gone on from the remotest times up to the present does not stop here. Helmholtz supposes it to be still going on, and in this way he accounts for the heat which we and our fellow worlds derive from the sun. According to this theory the central orb is radiating heat into space at the enormous rate indicated at the commencement of this paper and is being cooled by the loss thus experienced. In con-

sequence of the cooling the materials composing the sun must occupy less space and consequently its diameter becomes less.

Moreover the more rapid the shrinkage the greater the amount of heat radiated. Or, in other words; knowing the amount of radiation taking place, the weight and volume of the radiating body and its specific heat, it is possible to calculate the rate of shrinkage necessary to keep up the energy expended. Without going farther the superficial reader would at once discard the theory as untenable. "Here, he would say, you have the sun emitting radiant energy at this enormous rate which has been demonstrably, not diminished during historic times and has probably continued for 20,000,000 years; and all produced by the shrinkage of his substance. Why long ere this he would have shrank into a cold dead mass."

But let no one imagine the celebrated German guilty of want of care in examining the subject. He has made the calculation indicated above, and he proves that a shrinking of the sun's diameter by $\frac{1}{170,000}$ th of its present length (i.e. 88 miles) would produce an amount of energy capable of keeping up the solar emission at the present rate for 2,000 years. But if the sun be supposed to go on contracting, and its specific gravity to go on increasing until it equals that of our earth, then Helmholtz shows that the heat evolved would supply the sun with energy for no less than 17,000,000 years! In brief outline this is the celebrated theory of contraction. Simple in its assumptions, and quite competent to fulfil the demands made upon it, it is not a matter of surprise that it is held by many of the first thinkers of our time. Yet we cannot help thinking that two considerations weigh heavily against it. First, the researches of modern spectroscopy seem to indicate that we have in the sun an intensely hot nucleus surrounded by an atmosphere or shell of less intensely heated matter. Now if the heat is produced by condensation the whole body would be equally heated, and consequently no such partial separation would take place. Also the formation of a nucleus is difficult of explanation on such a theory for although the temperature of the nucleus may be greater, the actual heat in the solar atmosphere must be greater. Secondly as Siemens has pointed out, the heat being produced throughout the mass must reach the surface by conduction and convection. But we know of no substance capable of conducting the immense amount of heat which we find being radiated.

THE REGENERATIVE THEORY.

This theory, which I have so named because of its most characteristic feature, is at present literally and absolutely in its infancy. It first saw the light in March, 1882, having been proposed in a paper entitled the "Conservation of Solar Energy," read before the Royal Society of London, by Dr. C.W. Siemens, F.R.S., the great electrician, and president for the British Association for 1882-83.

It essentially differs from all the other theories, in that it supposes the action of the sun in sending out light and heat to be eternal. The preceding causes which we have considered, yield the sun energy enough to last him for millions of years. This one affords a cause which its author considers will last for ever. But if it is to last for ever, then it is a physical impossibility that anything should be used up or