as ten billion. We can write the figures which represent the total energy radiated into space by all these millions of stars continuously through a thousand or ten thousand million years, but who can comprehend their significence?

What is the source of all this energy? One statement about it, at least, may be made with confidence; it must lie deep within the sun (or star) itself; for, as Eddington remarks, supplies of energy from without, from whatever source, would simply affect the surface temperature and increase for the time being the intensity of the radiation emitted. They would not prolong the life of the sun at all. That is why the Helmholtz-Kelvin contraction hypothesis was at first received so favorably. This theory assumes that the gravitational energy released by the sun's gradual contraction suffices to balance the heat radiation, and it can, in fact, be shown that the sun's present radiation would be accounted for by a shrinkage in diameter too small to be measurable in a period of less than five thousand years. There is no question but that gravitational contraction does operate to generate heat in the sun, but, on the most favorable assumption, if this were the only source of solar energy, the sun's past life would be limited to about forty-six million years. The hypothesis is thus hopelessly inadequate. Nor does the suggestion of radioactive forces, though they too must contribute, give much help, for at best they can add but a few million years to the sun's life.

The one adequate source seems to be found in the very constitution of matter itself under the conditions of temperature and pressure prevailing in the deep interior of the sun or of a star. Under modern theories, which have been discussed in detail in the symposium this afternoon,[2] a rapidly moving electron has greater mass than one at rest, "since more force is required to deflect it from its path or to produce a specified acceleration." It follows that any body which receives energy increases its mass and one which radiates energy loses mass. The sun, on this basis, by its radiation is losing mass at the enormous rate of four million tons a second or more than one hundred and twenty million million tons a year. Even at this prodigious rate it would lose but one tenth of one per cent. of its mass in fifteen thousand million years. The theory thus solves, as Jeans says, "with a comfortable margin to spare the age-long problem of the source of the energy of stellar radiation."

But it does not by any means relieve us of our difficulties, for we have still to account for the mechanism of the release of energy, or the conversion of matter, in our usual definition of the term, into energy, and for its release at just the rate required to maintain the constant radiation from sun and stars. So far all attempts to solve this problem have raised more difficulties than they have cleared away, and Eddington, whose name is intimately associated with such progress as has been made in its investigation, is forced to conclude his most recent series of lectures on "the source of stellar energy" with the paragraph:

> I should have liked to close this course by leading up to some great climax. But perhaps it is more in accordance with the conditions of scientific progress that it should fizzle out, ending with a glimpse of the obscurity which marks the frontiers of present knowledge. I do not apologize for the lameness of my conclusion, for it is not a conclusion. I wish I could feel confident that it is even a beginning.

Eddington's words are not words of discouragement. Rather, they are a stimulus to more strenuous efforts. There is so much still to be learned, there are so many problems still to be solved. We need more data, data secured by the execution of carefully planned programs of observation and experiment. Data relating to stars and nebulae, but also data relating to the moon, the planets, the asteroids and the comets of our own solar system. They all hold secrets, secrets which can be unveiled, and in Professor Whitehead's words, "it is this instinctive conviction vividly poised before the imagination, which is the motive power of research."

ROBERT G. AITKEN

LICK OBSERVATORY

[2] June 16, 1926.

SCIENTIFIC EVENTS

RECENT RESEARCHES AT THE NATIONAL PHYSICAL LABORATORY OF GREAT BRITAIN

A LARGE number of visitors were given an opportunity of seeing something of the work of the National Physical Laboratory at Teddington on the occasion of the annual inspection by the general board. According to the London *Times*, the exhibits—nearly 200 were enumerated in the program—were for the most part selected to illustrate the more recent researches undertaken by the laboratory and the methods and apparatus employed in carrying them out.

Perhaps from the point of view of mere size the equipment of the aerodynamics department and of the ship-model experiment tank is the most imposing of all. In the former the whirling arm, one of the older pieces of apparatus, has been reconstructed and is to be used for experiments on aeroplane and airship models to determine the effect of a steady rotation in yaw upon the aerodynamic forces and moments. The shed in which it is housed has been made

octagonal instead of square by placing screens across the corners. A new one-foot wind tunnel, which provides wind speeds up to 140 feet per minute, is primarily intended for the development and calibration of instruments for measuring the speed and direction of the wind. In the duplex wind tunnel experiments are being made on a model of the Cierva autogyro, and in one of the seven-foot tunnels the conditions of the spinning of aeroplanes are being studied.

Other investigations in progress relate to high-lift wings of the Handley-Page slotted type, and to the dissipation of heat from the surfaces of wings in a wind current, the latter inquiry being in connection with the plan of enclosing the radiators of water-cooled engines in the wings with the object of reducing head resistance in high-speed aeroplanes. In the Froude tank visitors saw experiments with a self-propelled single-screw steamer, the apparatus used for measuring its speed, screw thrust, revolutions of propeller and power required for propulsion being demonstrated.

In the metallurgy department exhibits were on view illustrating the work done on light alloys, particularly of magnesium, of aluminium and silicon, and of aluminium, silicon and copper, and also on alloys for use at high temperatures. The melting of the latter is now effected in electrical high-frequency induction furnaces, gas-fired crucible furnaces having been found unsatisfactory owing to contamination of the product by oxide. For these and other investigations metals free from impurity are necessary, and there were exhibits showing what has been done in the production of chromium, manganese, iron, beryllium and silicon as nearly pure as possible, as well as in the preparation of special refractory materials for making the pots and crucibles employed in melting them. Another research which is of interest in connection with the amalgams used by dentists for stopping teeth consists in the microscopic examination of metals and alloys that are liquid, or partially liquid, at atmospheric temperatures, by polishing and etching them while they are frozen solid.

In some of these metallurgical investigations the engineering department is taking a share. It is concerned, for instance, in determining the mechanical properties of alloys intended for use at high temperatures, and another example of joint action is the research on the embrittlement of iron chains, such as are used for cranes, and the effect of heat treatment. But it has much work of its own on hand, and among other things it showed testing machines of various kinds, as for gear-boxes, spur gears, laminated springs and big-end bearings; apparatus for recording the vibrations of the ground caused by traffic; shadowgraphs of air jets from nozzles of different forms and hardness tests made with diamond cones.

Besides exhibiting mercury vapor vacuum pumps made entirely of metal, the physics department illustrated the determination of the heat conductivity of metals and other substances; the photography of sound waves and the measurement of the intensity of sound and of its transmission and reflection by partitions; and the X-ray examinations of metals and X-ray spectrometry. The new vector colorimeter was on view in the Optics Building, and methods of measuring daylight in the open and daylight illumination in various types of rooms were shown in the Illumination Building. In the main wireless hut in the meadow there was a sensitive direction finder for long waves up to 20,000 meters, and experimental transmitting and receiving apparatus for short waves down to 20 meters. Extensive displays of apparatus were also made by the electrotechnics and metrology departments.

INDIAN MOUNDS IN LOUISIANA

DEFINITE addition to knowledge of the prehistoric Indian life of this continent has been made by Mr. Henry B. Collins, Jr., of the Smithsonian Institution, in the discovery of large mounds on the marshy coast of Louisiana, west and south of New Orleans. Hitherto, it had been supposed that the Attacopa Tribe of cannibals had been the only inhabitants of the western part of the area.

Mounds found by Mr. Collins, one of which rises 45 feet above the level of the surrounding country, indicate the presence of a highly developed people. Mr. Collins believes it possible that the builders of the newly discovered mounds were the ancestors of the Chitimacha Indians, a cultured people who are known to have occupied an adjoining territory.

In his excavations Mr. Collins discovered several fireplaces six feet below the surface of one mound, indicating that the mound had had two stages of development. The majority of the mounds were probably used for temple sites and the residences of priests and chiefs. Sometimes burials took place in them. Mr. Collins brought back a series of skulls of these mound builders which will be studied to determine their racial affinities. The pottery relics which he found reveal the same type of ornamentation as that common to the Gulf region eastward to Florida.

MUSEUM OF THE PEACEFUL ARTS

DR. GEORGE F. KUNZ has announced that the projected Museum of the Peaceful Arts in New York City will soon be realized. A site on city-owned ground in upper Manhattan is under consideration by the trustees and exhibits are being collected.