MEASURING THE HEAT OF THE STARS.

BY MARY PROCTOR.

That the heat of the stars can be measured, has been proved by Prof. E. F. Nichols, of Dartmouth College, who has invented a delicate sensitive instrument known as the radiometer and specially designed for this purpose. In 1898, Prof. Nichols was invited by Prof. George E. Hale to come to the Yerkes Observatory and experiment with the radiometer, the fine equipment of the observatory being placed at his disposal. The invitation was accepted, and Prof. Nichols spent the two summers of 1898 and 1900 in perfecting his invention and testing its capabilities.

The case of the instrument was made of a block of bronze, which was bored out to receive it, the block being about two inches square and four inches long. The case was perfectly air-tight. The radiometer suspension or torsion pendulum was built up on a thread of fine drawn glass 32 millimeters long, to the lower end of which was attached a very small plane mirror, 2.2 by 3 millimeters, made by silvering a fragment of very thin microscope cover glass.

To the upper end of the drawn glass was attached a very fine quartz fiber 32 millimeters long, the upper end of the fiber being made fast to a bit of steel wire, which passed up through a small hole in the axis of the torsion head (*a*, Fig. 1). The torsion head which carried the upper end of the suspension was in turn carried on a small square block (*b*, Fig. 1), free to slide in a slot in the bridge (*c*, Fig. 1), permitting the suspension to be brought closer to or withdrawn from a fluorite window in the front of the case.

On the axis, two-thirds of the way above the mirror, and in a plane at right angles to it, a delicate cross arm of drawn glass was fastened, having on its two extremities the two blackened radiometer vanes (*d d*, Fig. 1). The sensitive vanes were circles about 2 millimeters in diameter, which to secure lightness and uniformity, were stamped out of thin mica, with a circular steel punch made for the purpose.

The vanes were uniformly coated with lamp black, and mounted as symmetrically as possible with reference to the axis of rotation (*E F*, Fig. 1). The distance between the centers of the vanes was 4.5 millimeters, and they were placed from 2.5 to 3 millimeters behind the fluorite window. A piece of good plate glass was cemented over the opening in the side of the radiometer case, through which the deflections of the suspension could be read by the telescope and scale method.

The rays of the star projected from a condensing mirror (*F*, Fig. 2), entered the radiometer by passing through the fluorite window, and could be directed to fall on one of the blackened surfaces of the suspension vanes behind the window. Through a window in the back of the case, the star image in the radiometer and the blackened vanes of the suspension could be seen at the same time.

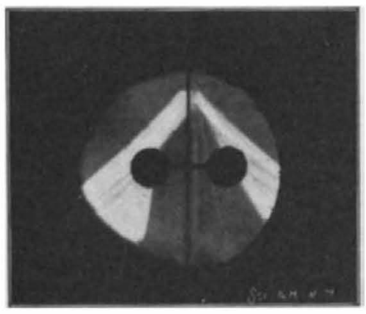
The heat rays of the star falling on one of the vanes warm it slightly, and in accordance with a principle discovered by Prof. Crookes a surface in a partial vacuum so warmed tends to back away from the source of heat. The suspension is thus slightly rotated as the fine quartz fiber offers little resistance to any force tending to twist it. It was in terms of this twist of the fiber caused by the different star images that the heat sent us by the stars was compared.

The experiments with the radiometer were made in the heliostat room of the Yerkes Observatory, which has been purposely designed for work of this kind. The gallery to the left of the double partition is provided with a movable roof and sides which slide back between the walls of the inclosed room to the right, leaving only a low parapet above the level of the floor. The only openings through the double partition are, a window large enough to admit the beam from the heliostat (at *H*, Fig. 2), and a passageway closed by double doors.

The beam of starlight from the heliostat was thrown upon a two-foot concave mirror (*M*, Fig. 2), of 7 feet 9 inches focal length, and the converging cone was caught on a small 45 deg. flat mirror (*F*, Fig. 2), four by six inches, and directed thence into the radiometer case (*R*, Fig. 2), passing through the fluorite window, the focal point lying in the plane of the vanes.

The radiometer (*R*, Fig. 2) was mounted on a wooden table, standing on an overhang built out from the long slate pier shown in the diagram. An observer at the telescope (*T*, Fig. 2) read the deflection of the radiometer suspension in millimeter divisions, on a reflected scale at *S* (Fig. 2), behind and above him at a distance of about 6 feet from the radiometer.

Cords connecting the slow motion on the heliostat were brought to a point within convenient reach of a second observer at the telescope (*T'*, Fig. 2) which was focused on the sensitive vanes as seen through the rear window. The latter observer could keep the star image constantly in sight, except when it fell upon one of the vanes, in which case a very small quantity of stray light in the image showed its position.



RADIOMETER VANES.

With an observer at each of the telescopes *T* and *T'* (Fig. 2) the observer at *T* watched the motion of the radiometer, and waited for a period of comparative quiet which would bring the image of the scale to rest, then signaled to the observer at *T'* to throw the star image on the vane or off it, as the case might be, by means of the cords running to the slow motion of the heliostat. After a suitable time the radiometer deflection was read. Thus a series of "on" and "off" observations were taken and averaged. The results were quite uniform, the radiometer vane showing about the same deflection at each observation of the same star, or object under examination. In this way, Prof. Nichols experimented again and again with the bright stars Arcturus and Vega. The averaged results were quite uniform, the radiometer vane showing nearly the same average deflection in each series of observations.

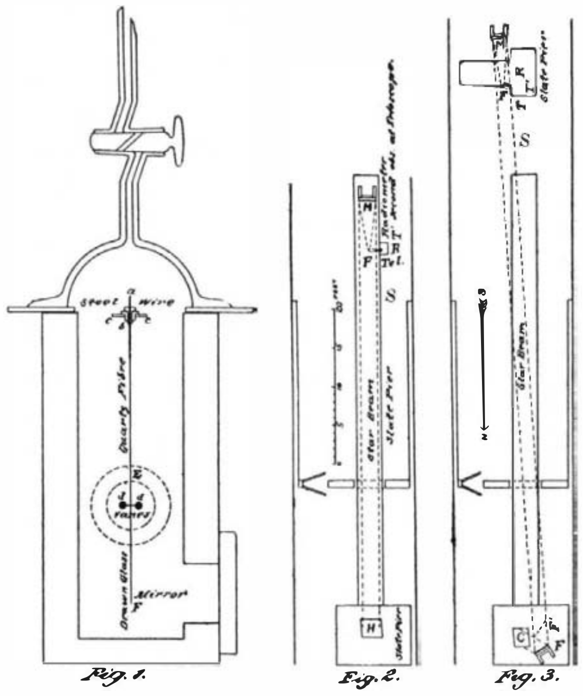


Fig. 1. Fig. 2. Fig. 3.

RADIOMETER. HELIOSTAT AND MIRRORS.

H, heliostat; *M*, mirror (concave); *F*, flat mirror; *T*, telescope; *T'*, second telescope observer; *R*, radiometer; *S*, scale; *C*, coelostat; *F'*, plane mirror.

In the second series of observations, made in 1900, the heliostat was replaced by the heavily mounted coelostat, used by the Yerkes Observatory at the total eclipse of the sun, May 28, 1900, at Wadesboro, N. C. The coelostat was driven by the clock of the 12-inch Kenwood telescope. The same plane mirror used in 1898 with the heliostat, was resilvered and mounted on the polar axis of the coelostat.

The change to the coelostat made the use of an additional plane silvered surface necessary, to direct the beam to a 24-inch concave mirror. The position of the new vertical plane mirror depended upon the declination of the stars observed. In the diagram (Fig. 3) *C* shows the position of the coelostat, *F* the position of the vertical plane mirror when used in observations of Jupiter and Saturn, and *F'* its relative position while used in observations of Arcturus.

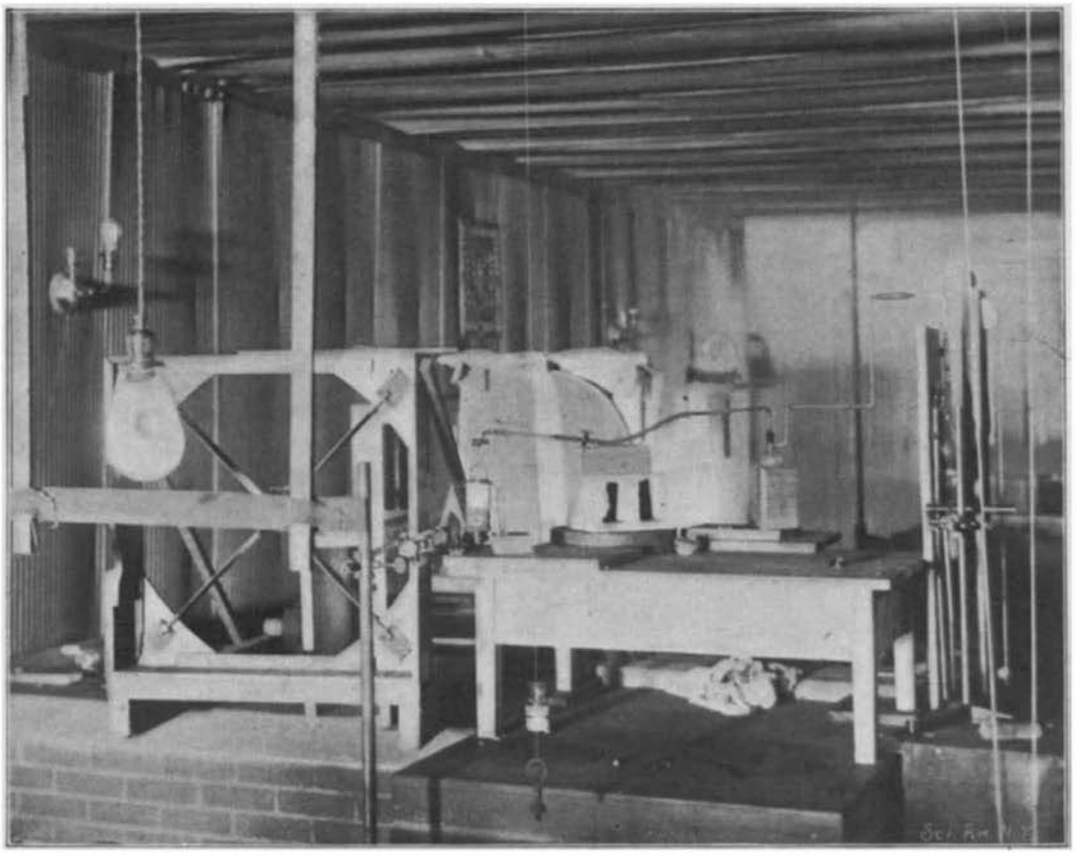
The remaining parts of the diagram (Fig. 3) correspond to that in Fig. 2, with the exception of the radiometer which was mounted farther back in the covered gallery, than in the arrangement made in 1898. Plate I. shows the radiometer in this position and the 24-inch mirror used in measuring the heat rays of the stars and planets.

To test the sensitiveness of the instrument, some convenient standard of reference was required, and Prof. Nichols used a common paraffine candle as a basis for his experiments. The radiometer having been thoroughly tested by means of these experiments, it was used to measure the heat of the stars Arcturus and Vega, and the planets Jupiter and Saturn with the following results. The quantity of heat sent from Arcturus was found to be somewhat greater than the heat which would be received at a given point from a candle six miles away, if none of the candle's heat were absorbed by the atmosphere. Observations on Vega showed that it radiated about one-half the amount of heat received from Arcturus. The planet Jupiter sends us about twice as much heat as Arcturus, while we receive from Saturn only heat enough to equal the unabsorbed radiation of a candle ten miles away.

Chinese Shipbuilders.

Mr. W. G. Winterburne, who has resided in China for many years, recently read a paper before the Institute of Marine Engineers, England, which contained some facts of interest concerning the ability of the Chinese as shipbuilders and shipwrights, which will serve to dispel previously formed impressions of many in the direction indicated. In the type of trading vessel built to-day in China there is little or no departure from the practice of thousands of years; the junk still remains in use for general trade, and is likely to for some ages to come. It answers the purpose intended and is good enough to go to sea with for considerable distances, so Chinese vessel owners do not see any good reason for discarding it. It has, however, some disadvantages in sailing qualities which detract from its value; it sails very fast with the wind on either quarter, but cannot run before the wind, or sail close to it. It has bulkheads (which the Chinese have used for years unknown) and many of them come into harbors after gales with the bows completely destroyed by heavy seas, but with their cargoes intact. They are usually handled by one man and his family, the wife steering with the aid of a small boy to help run the tiller over, and, clumsy as the junk appears, they are easily navigated by this "short-handed crew." The rudders have large diamond-shaped apertures in them which facilitate putting them over, and do not detract from their efficiency. The sails are usually of cotton, sometimes of reed matting, and are so knocked about that they are badly torn, but there is always area enough left to handle the vessel.

In building vessels the Chinese follow the rule of thumb, or the plans of procedure handed down to them from ages past; they are



RADIOMETER AND 24-INCH MIRROR USED IN MEASURING THE HEAT OF THE STARS AND PLANETS.

capable of building modern ships from wood, but do not read drawings well, still less are they able to calculate from them, and all this without assistance from Europeans. Most of the vessels are of wood, imported from the Philippine Islands, for China is a treeless country, and the native workmen understand the handling of these woods better than any other people in the world.

There are plenty of workshops in China where there is not a single European employed, and the author of the paper says they are very docile, learning readily the methods pointed out to them, with no predilections for trade unions. There are some very able draughtsmen to be found among them, and but rarely, mathematicians. The ship owners themselves are said to be very easily satisfied and pay no attention to the construction of their vessels, their supervision being wholly confined to seeing that they get the scantlings they pay for.

It is a mistake, says the author of the paper, to assume that the Chinese are so conservative they will not adopt new ideas; they are very ready to do so after the utility of them has been proved by someone else. They are not experimenters, but discover things by accident or evolution, and, so far as the laws of the country permit, will use any process or machine that has been demonstrated to be of practical value.

Red Dust Analysis.

Mr. Barac, in the Journal of the Meteorological Society, gives an analysis of a sample of the dust which he collected at Fiume (Hungary) on the 10th of March during the red dust-shower known as the "rain of blood." The dust analyzed as follows:

	Per cent.
Silica	49.49
Sesquioxide of iron	9.96
Alumina	12.10
Peroxide of manganese	1.99
Lime	11.46
Magnesia	0.40
Carbonic acid	8.96
Organic matter	5.48

Also traces of soda, sulphuric and hydrochloric acids, etc. With a microscope of 640 diameters M. Barac found that the principal mass was colorless, with colored particles of irregular form partly made up of angular fragments of crystals, also mineral particles and silicious skeletons of micro-organisms, and lastly particles of soot. A further examination showed the existence of well-formed rhombohedra of calcite and cubes of common salt. As regards size, the crystalline particles varied from a minimum of 0.00004 inch to 0.00007 inch mean and 0.002 maximum, while the yellow and structureless particles reached 0.00046 inch.

THE EVOLUTION OF THE MOTOR CYCLE.

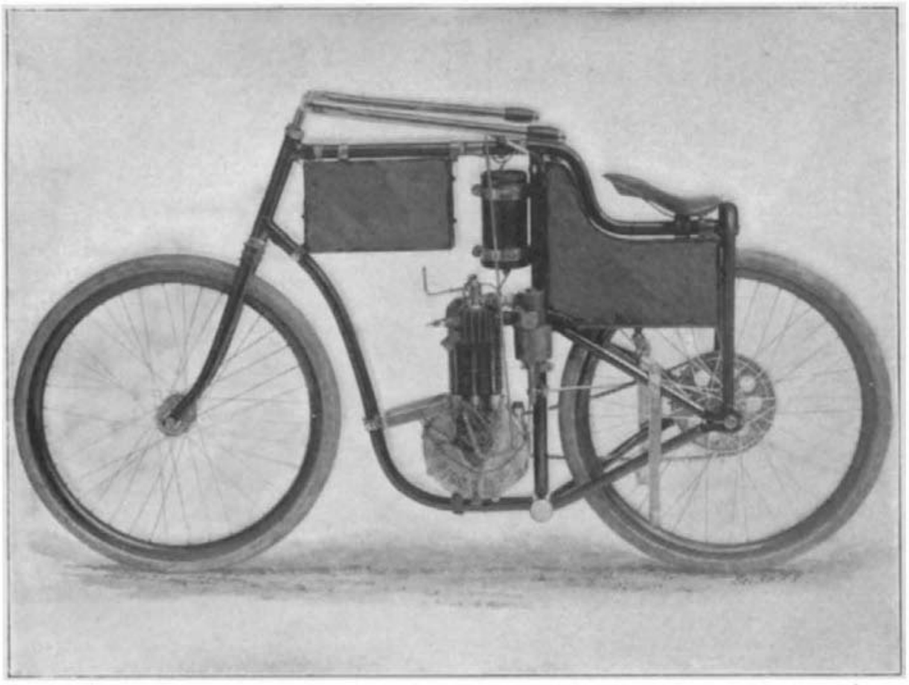
BY HROLF WISBY.

Only a few years ago it would have been impossible to secure an efficient, safe, and practical motor cycle. It is only within the last two years that this special industry has shed its experimental swaddling clothes. It is now at a stage when the standardizing of essential features, the interchangeability of parts, and the comparative unanimity of design has put it on a practical mechanical and commercial basis.

France led the way. She was the first to produce a practical motor tricycle. In England, where the three-wheeler has always been popular, the makers were quick to follow suit. In this country three notable bicycle manufacturers produced mechanically successful patterns of motor tricycles, which, however, failed to attract the public, doubtless for the reason that the three-wheeler has never been a favorite here.

The Patee Motor Bicycle (1½ H. P.)

The Mitchell Motor Bicycle (2 H. P.) with Flexible Rawhide Belt.



The Stearns Racer (3¾ H. P.)

A French Motor Tandem for Pacing. (Combination Gasoline Tank and Wind Shields.)

THE EVOLUTION OF THE MOTOR CYCLE.

The motor bicycle, however, supplies the hitherto "missing link" between the bicycle and the automobile, between the poor and the rich of the speeding sport. It makes its owner feel that he is still a wheelman in spite of the snorting motor on his wheel, and when automobiles of much larger horse power try to pass him in vain on the road he is pleasantly reminded that he is in it and able to hold his own among the swift company of the automobilists. That, too, has something to do with the popularity of the motor bicycle. It is far cheaper to operate than the smallest launch, it is much less liable to get out of order than the most reliable type of horseless vehicle, and it is the swiftest and most economic vehicle known in proportion to weight, carrying capacity and fuel consumption.

A SIMPLE COMPARISON.

A motor bicycle weighing only sixty pounds, of 1½ horse power, will easily and safely carry a man weighing 180 pounds across the average kind of country road at a maintained speed of from twenty to twenty-five miles an hour. The automobile has not been built which, weight for weight and proportionate power, could come anywhere near this performance. When it is considered that the factor of safety in steel bridges is four, or, in other words, that a bridge to be safe must be strong enough to sustain four times the sum of its own weight and the live load, the fact that the motor cycle is able to carry three times its own weight and over, in addition to propelling this load at a rate of speed prohibited on most bridges, and by virtue of a comparatively small horse power, we begin to appreciate the amount of practical science involved in the building of the motor cycle.

SOME SPECIAL DEVELOPMENTS.

When the English Singer motor tricycle was first introduced, it was ridiculed as a toy of very little practical use. Wheelmen jeered at the idea of comprising the motive power within the front steering wheel, and automobilists—don't ride motor cycles. It was soon found, however, that this unsightly but reliable machine would carry its passenger over British roads at a twenty-mile clip with no material drawback except the liability of the steering wheel to be jerked from side to side in traversing rough pieces of road.

Another quite characteristic, but not so very reliable development, is evident in the English Derby motor bicycle, which transmits power directly to the rear-wheel tire by means of a spur-gear contact arrangement.

Among other interesting foreign types may be mentioned the Werner, which has a belt-driving motor attached on the steering head and outside the frame; the Minerva, of practically the same construction, with a belt-driving motor on the bottom frame tube flush with the crank-hanger; and the Rex, chiefly remarkable for an aluminium bed fixed on the bottom frame tube, to which the motor is bolted.

SUPERIOR DEVELOPMENTS.

If we will regard these various phases of motor cycle construction as forerunners of the distinctly superior developments as evidenced in the 1902 models of the leading American makes, we shall be in a position to better appreciate the advance made by our makers.

It is difficult to say which is most popular in this country, the chain or the belt-driving motor cycle, though present indications point to the obvious desirability of the belt driver. A round rawhide belt insures a smooth and much less jerky pull than a chain. It is considerably cleaner, not quite so liable to break, and permits of almost instant adjustability. With a