ACCORDING to a brief report by J. Stěp, director of the Joachimsthal Mine, published in the *Proceedings* of the Vienna Academy of Sciences (No. 14), freshly excavated uranium ore, which has never been exposed to the light, is strongly radio-active. A comparative study of the activity of illuminated and unilluminated specimens of the ore has yet to be made.

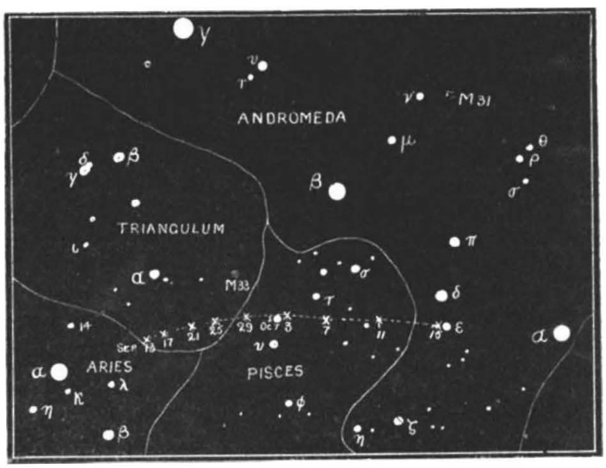
IN vol. vii. of the *Fortschritte auf dem Gebiete der Röntgenstrahlen* Dr. Josef Rosenthal discusses the relative advantages of large and small induction coils for producing X-rays. When the tube used is not too highly exhausted, and consequently has not too great a resistance, a small coil giving a comparatively short spark may be used with good results. Small coils have, moreover, the advantage of being more portable and less costly than large coils. But when a tube with a high vacuum is used a higher tension coil has to be employed, and in such cases, in order to prevent the tube from changing during a long exposure, the number of interruptions per second must be reduced as much as possible.

OUR ASTRONOMICAL COLUMN.

THE RETURN OF ENCKE'S COMET (1904 *b*).—As announced in these columns last week, Encke's comet was re-discovered at Koenigstuhl-Heidelberg on September 11.

It was found by Herr Kopff, who describes it as being, at present, a faint object. According to a note by Mr. Denning, however, mentioned in NATURE for July 21, the favourable conditions of 1805, 1838, and 1871 should be repeated during the present apparition, and it is possible that the comet may become visible to the naked eye when near to Altair, early in December.

The accompanying chart given below shows, approximately, the apparent path of the comet among the stars from now until October 15, according to the daily ephemeris published by MM. Kaminsky and Ocoulitsch in No. 3962 of the *Astronomische Nachrichten* :—



VARIATIONS IN THE LUNAR LANDSCAPE.—A communication from Harvard reports that Prof. W. H. Pickering, at present located at the Lowe Observatory, California, observed a bright hazy object 2″ in diameter upon the floor of the lunar crater Plato on July 31. Six previous observations made between July 21–28 inclusive gave no indication of this novel feature.

On August 2 a black elliptical shadow two miles in diameter was seen in the place of the previously observed bright spot, whilst to the north-east and north there extended a large white area, the existence of which was confirmed by an observation made on August 3.

A telegram dated August 22 states that real conspicuous changes have taken place in this region during the past month, and confirms the existence of the new crater, which has a diameter of about three miles. The bright area has shifted considerably since August 3.

Several other objects which have not been mapped before were observed whilst examining Plato, and it was seen that the previously conspicuous white area surrounding craterlet No. 54 (Harvard College Observatory *Annals*, vol. xxxii., plate x.) has now disappeared.

SUN-SPOT PERIODICITY AND TERRESTRIAL PHENOMENA.—In a brochure published at Rochechouart (1904), Prof. O'Reilly, of Dublin, emphasises the important part which a knowledge of the periodicity of solar activity plays in the prediction of terrestrial meteorological events, and also demonstrates that the origins of several important historical events may possibly be attributed to the meteorological effects of solar changes.

After discussing the more recent droughts, such as have caused distress in Australia and India, and showing that these occurred at definite epochs of solar cycles, he shows that the successive floods which caused the formation of the Zuyder Zee probably occurred at epochs of sun-spot maxima. Similarly he points out that each of the ten centuries in Etruscan chronology were approximately 122·2 (*i.e.* 11·11 × 11, or nearly 11^2) years in length, that is to say, they contained about eleven sun-spot periods, and he supposes that the Etruscan era probably commenced from a period of great cold, or maybe some memorable flood, which could be attributed to excessive solar activity.

From a study of Brückner's sun-spot cycles, Prof. O'Reilly believes that the year 1895 was the culminating year of a period of heat and drought, and that 1915 will be the corresponding centre-year of a period of cold and rain.

OBSERVATIONS OF THE RECENT PERSEID SHOWER.—M. Henri Perrotin, observing at Nice, saw 1184 meteors, of which 1041 were Perseids, during the nights of August 9–14 inclusive. The observations were made between the hours of 8 p.m. and 3 a.m. each night at the meteorological station of the Nice Observatory, situated at an altitude of 2740 metres on Mount Mounier.

The Perseids, as shown in his tabulated results, were very numerous, the maximum display of the shower occurring on the night of August 11–12, especially between 1 a.m. and 3 a.m. The maximum for each night occurred between midnight and 3 a.m.

A notable feature of the display was that the meteors appeared in groups of two or more, each group being followed by a break five to fifteen minutes in length.

The radiant of the shower was seen to be a fairly extensive area, not a point, having its centre near to γ Persei.

The Perseids were white and very swift, whilst the paths were comparatively short. On the other hand, the sporadic meteors observed were of a reddish-yellow colour, their paths were long, and they travelled slowly, leaving trails which lasted for some seconds.

These observations again emphasised the importance of selecting a station situated at a high altitude where the atmosphere is generally exceptionally clear (*Comptes rendus*, No. 9, 1904).

RADIATION IN THE SOLAR SYSTEM.[1]

I PROPOSE to discuss this afternoon certain effects of the energy which is continuously pouring out from the sun on all sides with the speed of light, the energy which we call sunlight when we enjoy the brilliance of a cloudless sky, which we call heat when we bask in its warmth, the stream of radiation which supports all life on our globe and is the source of all our energy.

As we all know, this ceaseless stream of energy is a form of wave motion. If we pass a beam of sunlight, or its equivalent, the beam from an electric arc, through a prism, the disturbance is analysed into a spectrum of colours, each colour of a different wave-length, the length of wave changing as we go down the spectrum from, say, 1/30,000 inch in the red to 1/80,000 of an inch in the blue or violet.

But this visible spectrum is merely the part of the stream of radiation which affects the eye. Beyond the violet are

[1] Afternoon address delivered at the Cambridge meeting of the British Association, August 23, by Prof. J. H. Poynting, F.R.S.

the still shorter waves which affect a photographic plate or a fluorescent screen, and will pass through certain substances opaque to ordinary light. Here, for instance, is a filter devised by Prof. Wood which stops visible rays, but allows the shorter invisible waves to pass and excite the fluorescence of a platinocyanide screen.

Again, beyond the red end are still longer waves, which are present in very considerable amount, and can be rendered evident by their heating effect. We can easily filter out the visible rays and still leave these long waves in the beam by passing it through a thin sheet of vulcanite. A piece of phosphorus placed at the focus of these invisible rays is at once fired, or a thermometer quickly rises in temperature. The waves which have been observed and studied up to the present time range over some nine octaves, from the long waves described to the section yesterday by Prof. Rubens, waves of which there are only 400 in an inch, down to the short waves found by Schumann in the radiation given off by hydrogen under the influence of the electric discharge, waves of which there are a quarter of a million in an inch. No doubt the range will be extended.

Radiant energy consists of a mixture of any or all of these wave-lengths, but the eye is only sensitive at the most to a little more than one octave in the nine or more.

This radiation is emitted not only by incandescent bodies such as the sun, the electric arc, or flames. All bodies are pouring out radiant energy, however hot or cold they may be. In this room we see things by the radiation which they reflect from the daylight. But besides this borrowed radiation, every surface in the room is sending out radiation of its own. Energy is pouring forth from walls, ceiling, floor, rushing about with the speed of light, striking against the opposite surfaces, and being reflected, scattered, and absorbed. And though this radiation does not affect our eyes, it is of the utmost importance in keeping us warm. Could it be stopped, we should soon be driven out by the intense cold, or remain to be frozen to death.

As the temperature of a body is raised, the stream of radiation it pours out increases in quantity. But it also changes in quality. Probably the surface always sends out waves of all lengths from the longest to the shortest, but at first when it is cold the long waves alone are appreciable. As it gets hotter, though all the waves become more intense, the shorter ones increase most in intensity, and ultimately they become so prominent that they affect our sense of sight, and then we say that the body is red or white hot.

The quality of the stream depends on the nature of the surface, some surfaces sending out more than others at the same temperature. But the stream is the greatest from a surface which is, when cold, quite black. Its blackness means that it entirely absorbs whatever radiation falls upon it, and such a surface, when heated, sends out radiation of every kind, and for a given temperature each kind of radiation is present to the full extent, that is, no surface sends out more of a given wave-length than a black surface at a given temperature.

A very simple experiment shows that a black surface is a better radiator, or pours out more energy when hot, than a surface which does not absorb fully, but reflects much of the radiation which falls upon it. If a platinum foil with some black marks on it be heated to redness, the marks, black when cold, are much brighter than the surrounding metal when hot; they are, in fact, pouring out much more visible radiation than the metal.

It is with these black surfaces that I am concerned to-day. But, inasmuch as it seems absurd to call them black when they are white hot, I prefer to call them full radiators, since they radiate more fully than any others.

For a long time past experiments have been made to seek a law connecting the radiation or energy flow from a black or fully radiating surface with its temperature. But it was only twenty-five years ago that a law was suggested by Stefan which agrees at all satisfactorily with experiment. This law is that the stream of energy is proportional to the fourth power of the temperature, reckoned from the absolute zero 273° below freezing point on the centigrade scale. This suggestion of Stefan served as the starting point of new and most fertile researches, both theoretical and practical, and we are glad to welcome to this meeting Profs. Wien, Lummer, and Rubens, who have all done most brilliant work on the subject.

Among the researches on radiation recently carried out is one by Kurlbaum in which he determined the actual amount of energy issuing from the black or fully radiating surface per second at 100° C., and therefore at any temperature.

Here is a table which gives the amount at various temperatures, as determined by Kurlbaum:—

Rate of Flow of Energy from 1 sq. cm. of Fully Radiating or "Black" Surface.

Absolute Temperature	Calories Grams of water heated 1° per sec.
0°	0·0
100° Air boils	0·000127
300° Earth's surface	0·0103
1000° Red heat	1·27
3000° Arc carbon	103
6000°	1650
6250°	1930

As an illustration of the "fourth power law," let us see what value it will give us for the temperature of the sun, assuming that he is a full radiator, or that his surface, if cooled down, would be quite black.

We can measure approximately the stream of energy which the sun is pouring out by intercepting the beam falling on a surface exposed to full sunlight, measuring the heat given to that surface per second, and then calculating what fraction the beam is of the whole stream issuing from the sun.

This was first done by Pouillet, and his method will serve to illustrate the principle of all other methods.

In his apparatus the sunlight fell full on a box containing water, and the rate at which the water rose in temperature gave the energy in the stream of solar radiation falling on the box.

Simple as the experiment appears, the determination is beset with difficulties, the chief being the estimation of the fraction of the energy intercepted by the atmosphere, and we are still unable to give a very definite value. Indeed, we cannot yet say whether the outflow of energy is constant or whether it varies. In all probability, however, it does vary, and Prof. Langley, who has devoted years of work to the subject, has recently obtained evidence indicating quite considerable variation.

We may, however, assume that we are not very far from the true value if we say that the stream of radiation from the sun falling perpendicularly on 1 sq. cm. outside the earth's atmosphere will heat 1 gm. of water 1/24° C. every second, or will give 1/24 calory per sec.

Now the area of a sphere round the sun at the distance of the earth is 46,000 times the area of the sun's surface. The energy from 1 sq. cm. of the sun thus passes through 46,000 sq. cm. at the surface of the earth. It is therefore $46,000 \times 1/24$ calories, or 1920 cal./sec. But from the table already given, a black surface at 6250° absolute, say 6000° C., gives 1930 calories per second, or the temperature of the sun's radiating surface is 6000°—if he is a full radiator, and there is good reason to suppose that no great error is made in taking him to be one.

Let us now take another illustration of the fourth power law.

Imagine a little black body which is a good conductor of heat placed in full sunlight at the distance of the earth. Let it be 1 sq. cm. in cross section, so that it is receiving 1/24 calory per second.

It will soon warm up to such a temperature that it gives out just as much as it receives, and since it is so small, heat will rapidly flow through it from side to side, so that it will all be very nearly at the same temperature. A sphere 1 sq. cm. in cross section has area 4 sq. cm., so that it must be giving out from each sq. cm. of its surface $1/96 = 0·0104$ calory each second. From the table above it will be seen that this corresponds very nearly indeed to a temperature of 300° absolute or 27° C., say 70° F.

It is to be noted that this only applies to a little round body. A flat plate facing the sun would be about 60° C.

hotter, while if it were edgewise to the sun it might be very much colder.

Let us now see what would be the temperature of the small black sphere at other distances from the sun. It is easily seen that, inasmuch as the heat received, and therefore that given out, varies inversely as the square of the distance, the temperature, by the fourth power law, will vary inversely as the square root of the distance.

Here is a table of temperatures of small black spheres due to solar radiation :—

Distance from Sun's centre	Temperature Centigrade
$3\frac{3}{4}$ million miles	1200° C. Cast iron melts.
23 million miles	327° Lead nearly melts.
At Mercury's distance	210° Tin nearly melts.
At Venus's distance	85° Alcohol boils freely.
At Earth's distance	27° Warm summer day.
At Mars's distance	– 30° Arctic cold.
At Neptune's distance	– 219° Nitrogen frozen.

We see from this table that the temperature at the earth's distance is remarkably near the average temperature of the earth's surface, which is usually estimated as about 16° C. or 60° F. This can hardly be regarded as a mere coincidence. The surface of the earth receives, we know, an amount of heat from the inside almost infinitesimal compared with that which it receives from the sun, and on the sun, therefore, we depend for our temperature. The earth acquires such a temperature, in fact, that it radiates out what it receives from the sun. The earth is far too great for the distribution of heat by conduction to play any serious part in equalising the temperature of different regions. But the rotation about its axis secures nearly uniform temperature in a given latitude, and the movements of the atmosphere tend to equalise temperatures in different latitudes. Hence we should expect the earth to have, on the average, nearly the temperature of the small black body at the same distance, slightly less because it reflects some of the solar radiation, and we find that it is, in fact, some 10° less.

Prof. Wien was the first to point out that the temperature of the earth has nearly the value which we should expect from the fourth power law.

Here is a table showing the average temperatures of the surfaces of the first four planets on the supposition that they are earth-like in all their conditions :—

Table of Temperatures of Earth-like Planets.

Mercury	196° C.
Venus	79° ,,
Earth	17° ,,
Mars	–38° ,,

The most interesting case is that of Mars. He has, we know, a day nearly the same in length as ours; his axis is inclined to the ecliptic only a little more than ours, and he has some kind of atmosphere. It is exceedingly difficult to suppose, then, that his average temperature can differ much from –38° C. His atmosphere may be less protective, so that his day temperature may be higher, but then to compensate, his night temperature will be lower. Even his highest equatorial temperature cannot be much higher than the average. On certain suppositions I find that it is still 20° below the freezing point, and until some new conditions can be pointed out which enable him to establish far higher temperatures than the earth would have at the same distance, it is hard to believe that he can have polar caps of frozen water melting to liquid in his summer and filling rivers or canals. Unless he is very different from the earth, his whole surface is below the freezing point.

Let us now turn from these temperature effects of radiation to another class of effects, those due to pressure.

More than thirty years ago Clerk Maxwell showed that on his electromagnetic theory of light, light and all radiation like light should press against any surface on which it falls. There should also be a pressure back against any surface from which radiation is reflected or from which it is issuing as a source, the value in every case being equal to the energy in a cubic centimetre of the stream. The existence of this pressure was fully demonstrated independently by Lebedew and by Nichols and Hull some years ago in brilliant experiments in which they allowed a beam of light to fall on a suspended disc in a vacuum. The disc was repelled, and they measured the repulsion and found it to be about that required by Maxwell's theory. Nichols and Hull have since repeated the experiment with greater exactness, and there is now no doubt that the pressure exists and that it has Maxwell's value.

The radiation, then, poured out by the sun is not only a stream of energy. It is also, as it were, a stream of pressure pressing out the heavenly bodies on which it falls. Since the stream thins out as it diverges, according to the inverse square of the distance, the pressure on a given surface falls off according to the same law. We know the energy in a cubic centimetre of sunlight at the distance of the earth, since, moving with the velocity of light, it will supply 1/24 calory per second. It is easy to calculate that it will press with a force of 6×10^{-5} degree on a square centimetre, an amount so small that on the whole earth it is but 70,000 tons, a mere trifle compared with the three million billion tons with which the sun pulls the earth by his gravitation.

But now notice the remarkable effect of size on the relation between the radiation pressure and the gravitative pull. One is on the surface and proportional to the surface, while the other penetrates the surface and pulls every grain of matter throughout the whole volume.

Suppose we could divide the earth up into eight equal globes. Each would have half the diameter of the earth and a quarter the surface. The eight would expose twice the surface which the earth exposes, and the total radiation pressure would be doubled, while the total gravitative pull would be the same as before. Now divide up each of the eight into eight more equal globes. Again the radiation pressure would be doubled, while gravitation would be the same.

Continue the process, and it is evident that by successive division we should at last arrive at globes so small and with total surfaces so great that the pressure of the radiation would balance the pull of gravitation. Mere arithmetic shows that this balance would occur when the earth was divided up into little spheres each 1/40,000 cm. in diameter.

In other words, a little speck 1/40,000 cm., say 1/100,000 of an inch in diameter, and of density equal to that of the earth, would be neither attracted nor repelled by the sun.

This balance would hold at all distances, since both would vary in the same way with the distance. Our arithmetic comes to this: that if the earth were spread out in a thin spherical shell with radius about four times the distance of Neptune, the repulsion of sunlight falling on it would balance the inward pull by the sun, and it would have no tendency to contract.

With further division repulsion would exceed attraction, and the particles would be driven away. But I must here say that the law of repulsion does not hold down to such fine division. The repulsion is somewhat less than we have calculated owing to the diffraction of the light.

Some very suggestive speculations with regard to comets' tails have arisen from these considerations, and to these Prof. Boys directed the attention of Section A last year. We may imagine that the nucleus of a comet consists of small meteorites. When these come near the sun they are heated and explosions occur, and fine dust is produced not previously present. If the dust is sufficiently fine, radiation may overpower gravitation and drive it away from the sun, and we may have a manifestation of this expelled dust in the tail of the comet.

I do not, however, want to dwell on this to-day, but to look at the subject in another way.

Let us again introduce our small black sphere, and let us make it 1 sq. cm. in cross section, 1·13 cm. in diameter, and of the density of the earth. The gravitation pull on it is 42,000 times the radiation pressure.

Now let us see the effect of size on the radiating body. Let us halve the diameter of the sun. He would then have one-eighth the mass and one-quarter the surface. Or, while his pull was reduced to one-eighth, his radiation push would only be reduced to one-quarter. The pull would now be only 21,000 times the push. Halve the diameter again, and the pull would be only 10,500 times the push. Reduce the diameter to 1/42,000 of its original value, that is, to about 20 miles, and the pull would equal the push.

In other words, a sun as hot as ours and 20 miles in diameter would repel bodies less than 1 cm. in diameter, and could only hold in those which were larger.

But it is, of course, absurd to think of such a small sun as this having so high a temperature as 6000°. Let us then reduce the temperature to 1/20, say 300° absolute, or the temperature of the earth. Then the radiation would be reduced to the fourth power of 1/20, or 1/160,000, and the diameter would have to be reduced to 1/160,000 of 20 miles, or about 20 cm., say 8 inches, when again radiation would balance gravitation.

It is not very difficult to show that if we had two equal spheres each of the density and temperature of the earth they would neither attract nor repel each other—their radiation pressure would balance the gravitative pull—when their diameters were about 6·8 cm., when, in fact, they were about the size of cricket balls.

It must be remembered that this is only true for spheres out in space receiving no appreciable radiation from the surrounding region.

It would appear that we have arrived at a result of some importance in considering the aggregation of small meteorites. Imagine a thinly scattered stream of small meteorites at the distance of the earth from the sun. Then, even if they be as large as cricket balls, they may have no tendency to move together. If they are smaller they may even tend to move apart and scatter.

In conclusion, let me mention one more effect of this radiation pressure. You will remember that radiation presses back against any surface from which it issues. If, then, a sphere at rest in space is radiating equally on all sides it is pressed equally on all sides, and the net result is a balance between the pressures. But suppose that it is moving. It is following up the energy which it pours forth in front, crowding it into a smaller space than if it were at rest, making it more dense. Hence the pressure is slightly greater, and it can be shown that it is greater the greater the velocity and the higher the temperature. On the other hand, it is drawing away from the energy which it pours out behind, thinning it out, as it were, and the pressure at the back is slightly less than if the sphere were at rest.

The net result is a force opposing the motion, a force like viscous friction, always tending to reduce the speed.

Thus calculation shows that there is a retarding force on the earth as it moves along its orbit amounting in all to about 20 kgm., say 50 lb. Not very serious, for in billions of years it will only reduce the velocity by 1 in a million, and it will only have serious effects if the life of the earth is prolonged at its present temperature to hundreds of billions of years.

But here again size is everything. Reduce the diameter of the moving body, and the retarding effect increases in proportion to the reduction. If the earth were reduced to the size of a marble, the effect would be appreciable in a hundred thousand years. If it were reduced to a speck of dust a thousandth of a centimetre in diameter, the effect would be appreciable in a hundred years.

Note what the effect would be. Imagine a dust particle shot out from the earth and left behind to circulate on its own account round the sun. It would be heated by the sun and would be radiating out on all sides. As it journeyed forward there would be a resisting force tending to stop it. But instead of acting in this way the resistance would enable the sun to pull the particle inwards, and the fall inwards would actually increase the velocity. This increase in the velocity would increase the resistance, and at the same time the approach to the sun would raise its temperature, increase the radiation, and so increase the resistance still further. The particle would therefore move in a more and more rapid spiral orbit, and ultimately it would fall into the sun. Small marble-sized meteorites would fall in from the distance of the earth probably in a few million years. Small particles of dust would be swept in in a few thousand years.

Thus the sun is ever at work keeping the space round him free from dust. If the particles are very minute he drives them forth into outer space. If they are larger he draws them in. It is just possible that we have evidence of this drawing in in the zodiacal light, that vast dust-like ring which stretches from the sun outwards far beyond the orbit of the earth, and is at once the largest and the most mysterious member of the solar system.

PHYSICS AT THE BRITISH ASSOCIATION.

THE number of communications made to Section A this year was again so large as to necessitate duplicate sittings on several days, an arrangement which appears to bring home to members in a forcible manner the impossibility of being in two places at once. For some undiscovered reason the subcommittee which arranges the order of the papers is generally held responsible for this limitation, and gets a considerable amount of abuse. The disadvantage of the division was particularly evident at the discussion on the units used in meteorological measurements opened by Dr. W. N. Shaw. A subcommittee of the council of the association appointed to consider the question, recommends the use of the absolute zero of temperature with either the centigrade or Fahrenheit degree as the unit, but preferably the former, and the introduction of a new "degree of pressure" which is equal to 2000 C.G.S. units, and involves a graduation of the barometer in nearly 1/16th of an inch (0·06 in.), and the use of a vernier down to 1/160 inch. The meeting before which the matter was discussed was disposed to dwell mainly on the cost of effecting the changes proposed, and owing to the scant attendance of physicists, rather lost sight of the advantages of adopting what is practically equivalent to the C.G.S. system.

Attwood's machine as an aid to the teaching of dynamics was much discredited during the discussion of a paper by Mr. Eggar on an apparatus for verifying Newton's second law. Mr. Eggar finds that the movement of a truck down an inclined plane the angle of tilt of which can be altered, is much more convenient and effective than the fall of a weight.

The coefficient of expansion of hydrogen at various pressures down to low temperatures was the subject of a communication from Prof. Witkowski. He finds that the coefficient increases with decrease of temperature, and decreases with increase of pressure, a result which must have an important bearing on our standards of temperature.

Dr. Glazebrook's account of the recent work of the National Physical Laboratory made one hope that the efforts to cope with the demands made on it by our manufacturers for tests of materials and for scientific help of other kinds, will not be hampered by the insufficiency of the financial support the institution receives from the Government. In order to establish a scale of temperature, Dr. Harker has compared up to 1000° C. the constant volume nitrogen thermometer with a thermojunction previously standardised at the Reichsanstalt, and a platinum thermometer. Mr. Smith has constructed and compared a number of mercury standards of resistance, Dr. Stanton has been engaged in determining the amount and distribution of the pressure on structures due to wind, Dr. Carpenter has investigated the solidification of iron-carbon alloys, and a number of other important investigations have been carried out for manufacturers and for the Government.

Problems connected with radiation played a prominent part in the proceedings of the section. Prof. Poynting's interesting afternoon address, which appears in another part of the present issue, dealt with the applications of the laws of radiation to the solar system. Taking Stefan's law as a basis, the temperature of the sun works out as 6250° C., and that of a black body at the distance of the earth from the sun at 27° C., which agrees well with the average temperature of the earth. A description of an apparatus by means of which he had measured the tangential stress on a surface due to the oblique impact of light, was also given to the ordinary sectional meeting by Prof. Poynting. If E is the stream of momentum per sq. cm. per second due to the light incident at an angle θ, and μ is the fraction of the incident light reflected, the tangential pressure on the surface is $(1-\mu)/2.E \sin 2\theta$, and although in general it is smaller than the normal pressure,