apparatus. A marking arrangement permits of making such regulations once for all.

The stereoscopic spyglass may be employed in two different positions of the telescopes, one nearly horizontal and the other nearly vertical.

The first position, as in Fig. 1, increases the spacing of the eyes through an optical illusion. In this position of the telescopes remote objects situated in different planes can be seen. The second position (Fig. 2) increases (artificially likewise) the stature of the observer. In both cases, the observation may be made from a place of concealment. For the horizontal position of the telescopes, the observer merely takes shelter behind a tree and allows the ends of the instrument to project behind the sides of the tree. Fig. 2 needs no comment. The observer can calmly make his observations while concealed behind a wall, with the two extremities of the apparatus carrying the objectives projecting above the obstacle.

It is hardly necessary to dwell upon the utility of the instrument from a military point of view. From a very interesting report made by Lieut.-Col. Becker, of the Swiss army, we select the following passage: "With a common ordnance fieldglass we observed, at a distance of about two miles, a trigonometric signal situated at the same height as ourselves and on the verge of a forest. It was impossible to recognize whether this signal was upon the very outskirts of the forest or remote therefrom. Upon making the same observation with the stereoscopic spyglass, the signal appeared remote from the edge of the forest, and it was possible, besides, to estimate the distance that separated it therefrom at 40 or 50 feet. The artilleryman will at once recognize the advantages that may be derived from so precise an observation."

The instrument under consideration magnifies ten times and embraces a linear field of 65 yards. Its weight is about a pound and a half, and it may be easily carried in a case.

THE BOLOMETER OR ACTINIC BALANCE.

BY MARCUS BENJAMIN, PH.D.

In the domain of astronomical physics American scientists hold a foremost place, and among those who have devoted their attention to that branch of science, Samuel P. Langley has been accorded the highest honors.

In 1867 Dr. Langley was called to the charge of the Allegheny Observatory in Pittsburg. The obscured condition of the atmosphere, due to the smoke from the many large metallurgical and other industrial establishments in the vicinity of that city, made it practically impossible to study the smaller heavenly bodies, and he naturally turned his attention to the sun, beginning almost at once that brilliant series of investigations with which his name has been so honorably connected.

As has been indicated, it was doubtless the atmospheric conditions that surrounded Pittsburg that led Dr. Langley to devote his attention to the sun, and it seems equally probable that it was these conditions that influenced him to investigate the phycieal conditions of that great orb. But even physical conditions may be differentiated, for to be exact, it was chiefly with the amount of light and heat radiated from the sun that he occupied himself.

In February, 1874, he published his first paper on the sun, and in it he described in minute detail the general solar surface and the extraordinary sun spots. Four years later, in discussing the temperature of the sun, he compared the heat and light of the sun to that of molten steel in a Bessemer converter, and at the same time showed that the temperature of the sun was very much greater than 1500° C., which was the temperature usually accepted by men of science. These results were obtained by means of a thermopile, which was the most delicate instrument then known for measuring radiant energy. It became manifest to Dr. Langley that an apparatus more sensitive than the thermopile, and which at the same time should be more accurate, would be of the utmost value in such investigations. What was needed, he said, was "a measurer of radiant energy, and not a mere indicator of the presence of feeble radiation." Aided by a grant from the Rumford Fund of the American Academy of Arts and Sciences, he set to work in December, 1879, to invent an instrument that would yield the desired results.

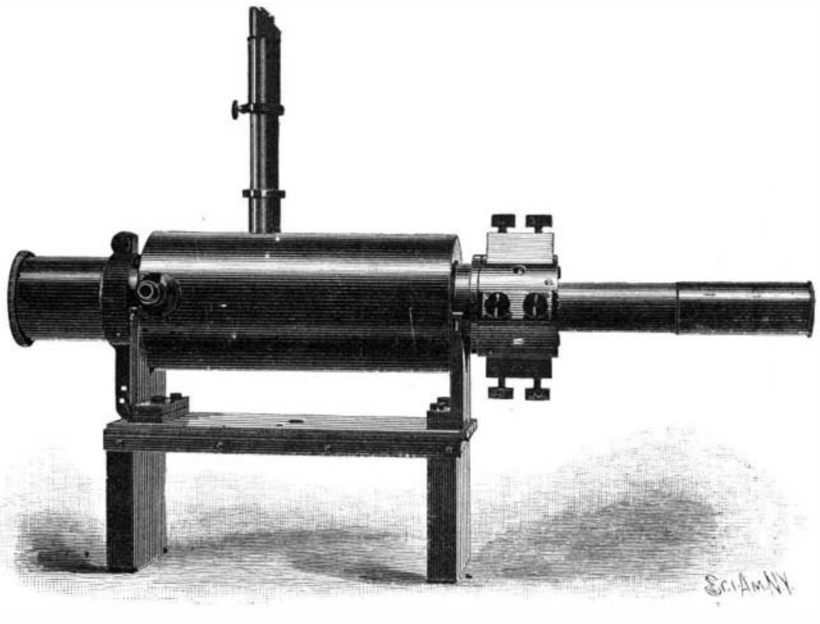
His earliest design consisted of two strips of thin metal placed side by side in conditions of environment as nearly identical as possible and in such a manner that one strip could be exposed at pleasure to the source of radiation. When warmed by the radiation, the electrical resistance of the strip exposed increased proportionately over that of the other, and this increased resistance to the flow of the current from a battery could be measured by a galvanometer.

Having thus determined the nature of the instrument to be used, the next step was to study the best method for its manufacture, and in this much time was consumed in experimenting. To secure a radiating body that would not vary from one experiment to another, or from day to day, was the first problem to be considered, and it was not an easy one. He decided to employ the flame of a petroleum lamp within a glass chimney, the radiation being limited by a circular opening of one centimeter diameter in a triple cardboard screen.

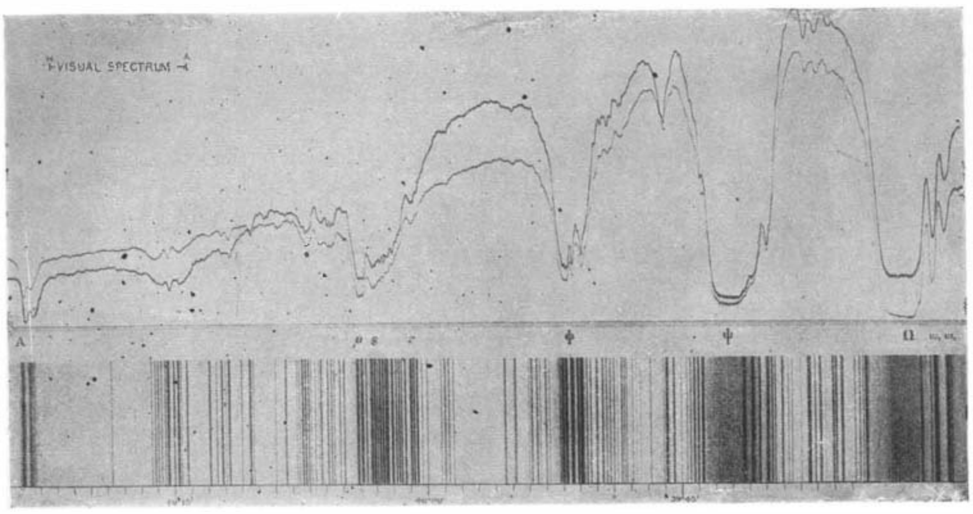
With this lamp he tested various metals, such as gold foil, platinum foil, and various grades of platinum wire, gold leaf gummed on glass, extremely thin sheet iron, and the same metal blackened with camphor smoke. The size of the strips was also carefully studied, and he found after much painstaking work that the best results were obtained with an instrument which he described somewhat as follows:

Metallic steel, platinum or palladium are rolled into sheets of from $\frac{1}{100}$ to $\frac{1}{1000}$ of a millimeter in thickness, and from these sheets strips one millimeter wide and one centimeter long, or less, are cut. These strips are then united so that the current from a battery of one or more Daniell's cells shall pass through them. The strips are in two systems, arranged somewhat like a grating; and the current divides, one-half passing through each. When the two currents are equal, the needle of a delicate galvanometer will not be deflected; but when radiant energy in the form of heat falls on one of the systems of strips and not on the other, the current passing through the first is diminished by the increased resistance; and, the other current remaining unaltered, the needle is deflected by a force due to the battery directly, and immediately to the feeble radiant heat, which by warming the strips so little as $\frac{1}{10000}$ of a degree Centigrade, is found to produce a measurable deflection.

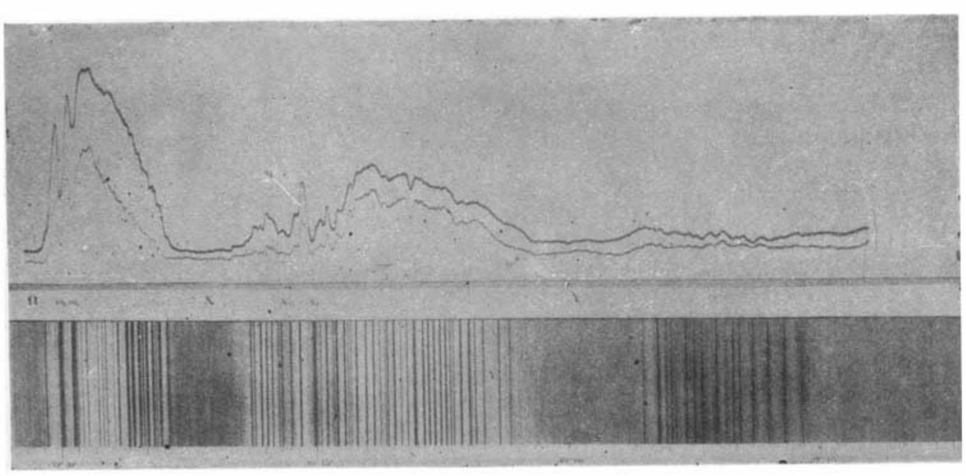
So delicate was the instrument thus added to the tools of science that it was said by Dr. Langley that "a change in the temperature of the metallic strips of one hundred-thousandth of a degree can, I believe, be thus noted;" and it is evident from



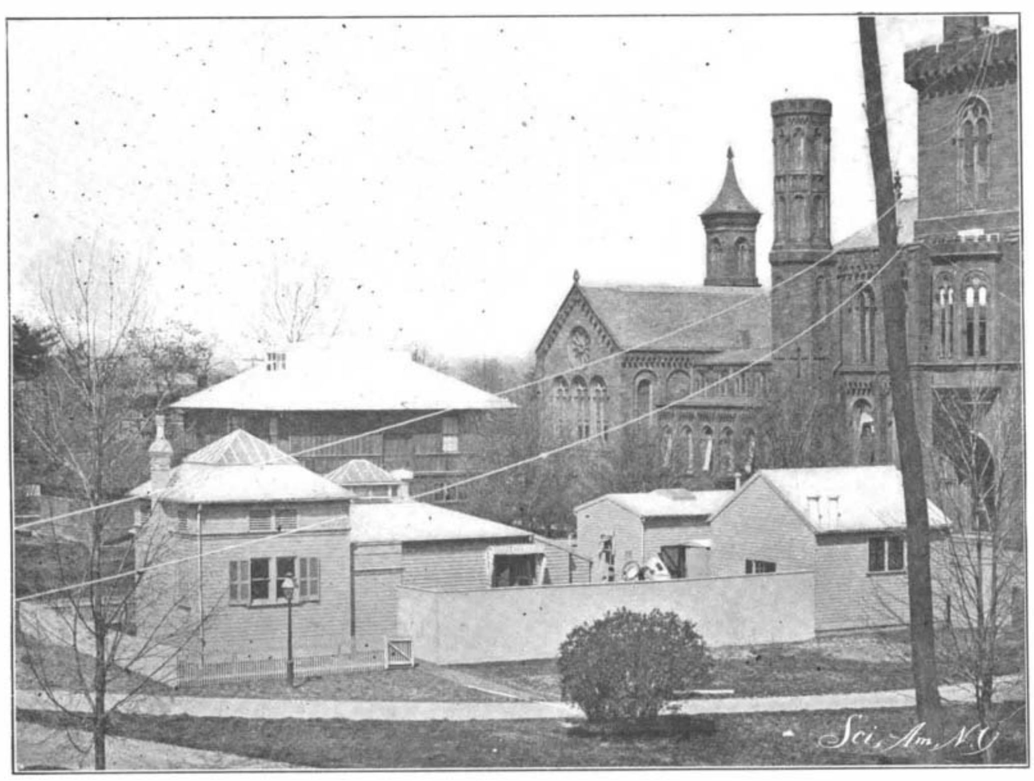
DR. LANGLEY'S BOLOMETER.



INFRA-RED SPECTRUM OF ROCK SALT PRISM.
Wave Lengths, 0·75μ to 2·29μ.



INFRA-RED SPECTRUM OF A ROCK SALT PRISM.
Wave Lengths, 2·09μ to 5·69μ.



THE ASTRO-PHYSICAL OBSERVATORY OF THE SMITHSONIAN INSTITUTION, WASHINGTON, D. C.

the excessive thinness of the strips that they take up and part with the heat almost instantly.

The sensitiveness of the instrument depends naturally upon the amount of current used. With the current which experience recommended as leaving a very steady galvanometer needle, it was found that the bolometer showed a sensitiveness of from ten to thirty times that of the most delicate thermopile, area for area.

At first, when the instrument was used, two observers were required, one of whom was occupied in recording the reading of the circle which fixed the place of the bolometer in the spectrum, while the other sat at the galvanometer and noted through how many divisions of the scale the needle swung, owing to the electric disturbances. This process was exceedingly tedious, and involved going over the work again and again with almost interminable repetition ; indeed, the galvanometer had to be read over a thousand times to obtain with sufficient accuracy the position and amount of a deflection of the energy curve in any single part of the invisible region.

As an illustration of the slowness of the process, Dr. Langley said that "it took nearly two years to fix the position of twenty lines" in the spectrum.

Some years afterward Dr. Langley was called to the Smithsonian Institution, and there organized the Astrophysical Observatory, in which the work of examining the infra-red portion of the spectrum by means of the bolometer was continued. He then introduced a method by means of which the work could be carried on not only with far greater rapidity, but with greater certainty, and by an automatic process. Briefly, it was as follows :

Originally, as has been said, the deflection of a spot of light upon a scale was read by one observer, while another simultaneously read the position in the spectrum of the line that caused the thermo electric disturbance. In the automatic form a photographically sensitive plate was substituted for the scale on which the light was deflected, and both observers were dispensed with. As the needle swung to the right or left, the spot of light would trace upon the plate a black horizontal line, whose length would show how far the needle moved and how great the heat was which originated the impulse. If no other conditions intervened, an impulse originated by the movement of the spectrum over the bolometer thread when the needle swings a second time, it will go over the same place ; but if the plate be provided with clockwork so as to produce a uniform vertical movement of the spectrum, the combination of the two motions of the needle and the plate will trace upon the latter a sinuous curve which will be, in theory at least, the same as the curve formerly deduced from thousands of galvanometer readings.

If we assume that the movements of the invisible spectrum as well as of the plate are controlled by the same clockwork, so that the spectrum is caused to move uniformly over the bolometer thread, and that these movements are by accurate mechanism rendered absolutely synchronous with those of the moving plate, it is evident that not only the amount of heat, but also each particular position in the spectrum of the thread of the bolometer which can alone correspond with any given inflection of the curve, can be deduced from the photographic curve traced on the moving plate.

To this automatic form of bolometer the name of "spectro-bolometer" has been given, and as the principle on which the apparatus was constructed may not clearly indicate its method of manipulation, the following description, taken from Dr. Langley's own account, is added. It may be said that the installation has reference to the Smithsonian Astrophysical Observatory, where for some years it has been in active use.

He says : "A beam from the mirror of the siderostat is conveyed through the slit of a telescope having a rock salt objective of about ten meters focal length to the prism, which is mounted on the massive spectro-bolometer, the novel feature lying in the mechanical connection of the large circle carrying the prism with a distant photographic plate susceptible of vertical motion and taking the place of the scale formerly in front of the remote galvanometer, both circle and plate being now moved by the same clockwork through a continuous train of shafting, which works with such steadiness and precision as to make the two movements entirely synchronous."

To understand this better, let us suppose that the very slowly moving circle carrying the prism moves the spectrum through one minute of arc in one minute of time, across the vertical bolometer thread. To the observer watching the spectrum the motion is as slow as that of the hour hand on the dial, but it is continuous and uniform, and the same mechanism which causes this motion of the spectrum of one minute of arc in one minute of time causes the photographic plate to move vertically before the galvanometer mirror at any given rate ; for instance, at the rate of one centimeter of space in one minute of time. It follows that during every second of this minute a portion of the spectrum represented by one second of arc will have glided before the bolometer thread, and that during this same second the photographic plate will have been lifted automatically through one-sixtieth of a centimeter in space ; the essential thing being that the plate shall show, on simple inspection, not only the inflection of the energy curve there written down, but the exact relative position in the distant spectrum which the bolometer thread occupied at the moment it caused the disturbance. By suitably changing the wheels on the clockwork we may cause the spectrum to move fast or slow, in the former case giving only its principal inflections, in the latter case giving a great deal more of detail, but with liabilities to error.

It is with this instrument that for nearly ten years persistent work in the examination of the infra-red solar spectrum has been carried on. This extended research is now fast drawing to a close, and in the last annual report submitted by Mr. Abbot, who, under Dr. Langley, has charge of this work, may be found the following summary of the results obtained. He says : "While our knowledge of the infra-red still remains less complete than that of the visible spectrum, both in the number of absorption lines mapped and in the accuracy of determination of their wave lengths, yet the difference in the methods of observation must be recalled. On the one hand are the most powerful gratings with all the advantages of direct photography, while on the other is only a simple prism, in whose dark spectrum we grope for cold lines and measure their wave lengths indirectly. The results of the latter process are 750 lines determined in wave lengths to an accuracy of three parts in ten thousand, and besides—what photography does not give—an exact knowledge of the distribution of the sun's energy."

At the recent eclipse of the sun the bolometer was used in connection with the observations made, and the heat of the corona was, for the first time, successfully observed. The apparatus used by Mr. Abbot was so sensitive that the observer's hand, at distance of five feet, gave a deflection of the galvanometer of sixty scale divisions.

In conclusion, I am very glad of this opportunity to express my appreciation of Secretary Langley's courtesy in allowing me to use the prints from which the illustrations that accompany this article were made.

The Current Supplement.

In the current issue of the SCIENTIFIC AMERICAN SUPPLEMENT will be found, among other articles, a well illustrated description of some Roman amphitheaters and an account of trade in ancient Assyria, both of which should prove of interest to those of our readers who have an archæological bent. "The Aquarium at the Paris Exposition" is the title of an article which describes the remarkable work of MM. Albert and Henri Guillaume. The well-known chemist Berthelot tells of the experiments which he has conducted for the purpose of determining when and why potassium chlorate explodes. In an illustrated article on the "Metallurgical Uses of Aluminium," the Goldschmidt process of industrially utilizing the chemical reaction of aluminium on metallic oxides is described at length. The process has attracted no little attention both here as well as abroad. The Thomson-Houston underground trolley, recently opened for service between Place Pereire and Montmartre, in Paris, is illustrated and described. "Clockwork at the Exposition of 1900" is the title of an illustrated account of some horological curiosities. The address delivered by Mr. H. W. Jane on the "Present Condition of the Coal-Tar Industry," before the Philadelphia Section of the American Chemical Society, is published in full. Mr. H. C. Weeks exhaustively discusses the "Extermination of Malaria-Breeding Mosquitoes by Petroleum and Drainage." The new rattler for testing paving-brick and the improved impact testing-machine which have been installed at Purdue University are described and pictured in a paper contributed by Prof. William K. Hatt and W. P. Turner. The turbines exhibited at the Exposition are discussed and illustrated in a well-written article. How structural iron is cut by the electrical arc is told by J. R. Cravath. The consular and trade notes will be found in their usual places.

Contents.

(Illustrated articles are marked with an asterisk.)

RECENTLY PATENTED INVENTIONS.

Engineering Improvements.

ROTARY ENGINES.—ABRAM L. SCUDDER, Deposit, N. Y. In the annular casing of the engine is a steam-chamber. The casing is provided with inlet and exhaust ports and with a slot for the piston-disk, having a head filling the steam-chamber. An abutment slides in guides in the casing. A cam-disk is mounted to turn with the piston-disk and is engaged at its free-end by a pivoted lever. A rock-shaft has arms connected with the upper end of the lever and with the abutment. The valve for the admission of steam is opened for approximately one-half the rotation of the piston-disk and is then closed for the other half of the rotation, whereby the steam which has been admitted is expansively used. The amount of the steam in each chamber may be varied by altering the shape of the cam so as to hold the valve open for a longer or shorter time.

CHECK-VALVE. — THOMAS J. HACKETT, Wardner, Idaho. The check-valve comprises a valve body having an inlet and an outlet, between which is a conical valve-seat. Caps screwed in the body have elongated, inwardly projected tubular bearings or guideways. In one of these guideways a stem is received ; and the other guideway receives a second stem, which has a flange and a threaded end, screwing in the conical core of a valve provided with an integral flange. A conical ring of flexible material fits on the valve-core, between the flanges. The valve is made preferably in sections to permit the convenient removal of the ring.

VALVE FOR PUMPING-ENGINES.—JAMES S. ATKINSON, 601 Twenty-sixth St., Louisville, Ky. The inventor has devised a valve and a steam-chest having a flat base provided with central and end ports and with a curved exhaust passage formed as a groove in the base. A piston and cylinder have a flat top provided with steam-passages, some of which are formed as grooves extending in the flat top. The passages are arranged to coincide and communicate with those of the steam-chest base. The piston-valve acts automatically to allow alternate induction and exhaust of steam to and from the piston cylinder through the proper passages, and is itself acted on by live steam and thereby shifted at each half reciprocation, so as to cut off steam at the right moment. The formation of the passages as grooves effects a considerable economy in the construction of the engine, as compared with cored castings.

Electrical Apparatus.

ELECTRICAL CONNECTION. — WILLIAM GERHARDT, Hazleton, Penn. It is the purpose of this invention to provide a convenient device for facilitating the connection or disconnection of electrical wires. The electrical connection has two insulating sections, one being provided with a projection and the other with a cavity in which the projection is received. Oppositely-disposed dogs are carried by the section having the cavity, and work through the walls to engage with the projection of the other section so as to hold the two sections together. Electrical conductors are carried in the sections and are in contact with each other when the sections are engaged.

ELECTRIC SWEEPER AND DUST GATHERER.—CORINNE DUFOUR, Savannah, Ga. In the casing of the sweeper rotating brushes are arranged which are driven by an electric motor. Above the brushes is a suction-fan also driven by the motor and serving the purpose of throwing the sweepings and dust upwardly against a screen containing a sponge or moistened cloth. The arrangement is such that the motor can be readily moved when the machine is not to be used as a sweeper. If the device is to be used for street cleaning, a scraper is added which serves the purpose of loosening the dirt on the street surface. If the device is to be used in hospitals or hotels for cleaning hard wood or tile floors, a rotating mop is employed on the outside of the casing.

INSULATOR.—EMIL RISLER, Freiberg, Baden, Germany. The insulator consists of a pin ; a lower insulating piece designed to fit over the reduced and screw-threaded end of the pin ; and an upper insulating piece comprising a part having a central bore and a screw-threaded metal lining inserted in the bore. A cap is cemented both to the upper insulating piece and to the lining. The upper insulating piece is adapted to screw on the threaded end of the pin and to clamp an electric wire between itself and the lower insulated piece.

Mechanical Devices.

WINCH.— ROBERT A. MCLEOD, Kaihu, Auckland, New Zealand. This improved winch is a direct fair-lead winch, which, when swung around at the required angle, hauls, lifts or lowers loads directly without the use of lead-locks. The invention comprises a winch-barrel driven by vertical gear-wheels from a main horizontal gear-wheel, which is movable on a circular guideway bolted into a frame, so that the winch can be turned through a portion of a circle. A pull-back drum operated by gearing, and a horizontal capstan or gipsy, are provided. A vertical shaft carries a capstan or gipsy on its upper end and is secured to the main horizontal gear-wheel. By means of clutches the vertical gear-wheels can be thrown out and the winch held in horizontal adjustment.

LUBRICATING APPARATUS.—LEON SERPOLLET, Paris, France. The invention is a mechanically operated lubricator of the kind in which oil is drawn from a reservoir by a piston and delivered to the parts to be lubricated through distributing-pipes. In the present invention a piston is provided, which is designed to be simultaneously rotated and reciprocated in a cylinder attached to the reservoir, so as to lubricate without the intervention of suction or pressure valves. A device is also provided whereby overpressure is avoided if the apparatus be used for lubricating under pressure.

Designs.

SMOKE-PIPE REGISTER.—GEORGE KESSLER, Brooklyn, New York city. The leading feature of the design consists of a rim joined by openwork with a solid ring and a center-piece set in the ring.

COLLAR-PROTECTOR.—LOUISE R. SEWWARD, New Brighton, Richmond, N. Y. The shape of the collar-protector is that of an elongated oval, both sides being convex and one somewhat flatter than the other. The side which is least flat has in its middle a V-shaped notch resolving the two portions of the collar-protector into halves in which all the marginal lines are convexed or inwardly curved lines, terminating at the ends in sharply rounded corners.

TROUSERS HANGER. TIMOTHY B. SHUMAN, Tyrone, Pa. This device consists of a semi-circular portion formed with a stout spring wire having a bend or loop at one side of the middle for attachment to a nail or hook. Two pairs of jaws are provided, one pair being attached to each end of the wire and having teeth designed to grip the trousers legs at opposite points.

PRINTING-FILM.—BENJAMIN DAY, Hoboken, N. J. This printing-film for printing skies on photographs has a series of dots arranged irregularly. Novel and valuable results are claimed for this film.

NOTE.—Copies of any of these patents will be furnished by Munn & Co. for ten cents each. Please state the name of the patentee, title of the invention, and date of this paper.