groups of six each, shown in Fig. 3, and with sixteen coils as in Fig. 4, the arrangement for each coil being as in Fig. 5. On the glass stem carrying the 48 magnets there is a small mirror. The whole system is very light and weighs no more than 10 milligrammes. With atmospheric pressure in the bolometer case, a deflection of 1 millimeter on a scale at a distance of 1 meter is produced by a current of 5×10^{-9} ampere. With the air exhausted to 0.2 millimeter pressure, a current of $2 \times 10^{-12} \left(\frac{2}{1,000,000,000,000} \right)$ ampere can be recognized with certainty. Such a galvanometer was used by Prof. Abbot and the writer in a recent attempt to measure the heat of stars.

To measure the heat of the solar corona at the total eclipse of 1908, a bolometer was mounted at the focus of a concave mirror 20 inches in diameter and only 40 inches in focal length. A glass plate three millimeters thick was fixed close to the bolometer between it and the mirror so as to limit the radiator to waves less than 3μ in length. About 4 inches in front of the bolometer was a self-closing blackened metal shelter so that the bolometer was exposed to radiation only when this shelter was open, and between this shelter and close to the glass plate was a special screen of thin asphaltum varnish which, when interposed in the beam of light, cut off nearly all the visible part of the radiation, while transmitting nearly all of the infra-red rays that can pass through glass. The bolometric apparatus was carefully set up on Flint Island in the Southern Pacific by Prof. Abbot and was in perfect adjustment on the day of the eclipse. Many improvements were made over the apparatus used in 1900 at the eclipse at Wadesboro, N. C., chief among which were that one mirror replaced seven, that radiations were limited to those transmissible by glass, and that a direct means was at hand for comparing the radiations from the sun, sky, and corona.

In the SCIENTIFIC AMERICAN July 25, 1908, was shown how nearly the observers came to adding another disappointment to the already long list of eclipse failures through clouds coming at an inopportune moment. For fifteen seconds before totality it was raining. In spite of the nerve-racking moments of preparation, Prof. Abbot's measures with the bolometer were beautifully carried out, with the following interesting results, where the radiations are compared with that of the noon-day sun. On the same scale where the strength of the solar heat is the large number 10,000,000, that of the moon (i. e., reflected solar radiation) is only 12; or in other words, the sun shines with an intensity 800,000 times that of the moon. Again, on the same scale, the intensity of the corona at 1.5 millimeter from the sun's limb is represented by 13, at 4 millimeters from the limb by 4, and at 12 millimeters no deflection whatever was recorded by the galvanometer, i. e., the corona has no measurable intensity. (Zero intensity was likewise observed from the middle of the moon during the eclipse.) From these figures it appears that the corona of 1908 equaled only the moon in brightness—the most brilliant part of the inner corona, and that this brightness decreased very rapidly.

These measures are most exceedingly interesting to the astronomer, and taken with other observations of the corona lead us a step nearer to solving the mystery of the beautiful crown of glory about the sun which can be seen only in the few fleeting moments of a total eclipse. What have we already found out concerning the corona? First, the spectroscope shows the bright "coronium" lines which indicate that the corona in part consists of an incandescent gas; second, the spectrum also shows the dark Fraunhofer lines, and accordingly the corona consists in part of matter in a finely divided solid or liquid state which can reflect ordinary sunlight. The corona, for some reason or other, assumes different shapes which depend on the number of spots on the sun, being square when spots are at a maximum, but with a long fish tail on either side of the sun's diameter when spots are at a minimum. What is the meaning of this connection between spots and corona? At the eclipse of 1901, Perrine found a big disturbance in the corona immediately above a large sun-spot, and a long thread-like prominence emanating from the same region. What is the explanation? The Swedish scientist Arrhenius explains these matters by assuming that the corona is an electro-magnetic manifestation, and that the sun's rays exert a pressure on the finely divided matter of which the corona is composed, with the result that the small electrified particles are driven away from the sun, forming the corona. (This same theory explains the formation of comets' tails, and the aurora borealis.) It is a most beautiful theory, and one which we are ready to accept as soon as it is based on the solid truth of observational facts. But such a time has not as yet come. With our present knowledge, how are we best to explain the action of the corona of the sun so as not to take too much for granted? The observed facts discovered by the spectroscope together with the newer measures of the corona obtained by Prof. Abbot lead him to believe that the brightness of the corona is due mainly to the reflection of ordinary sun rays by matter close to the sun modified to some extent, however, by radiation of incandescence and perhaps also luminescence.

Correspondence.

MR. LARSEN'S PHOTOGRAPHS OF LIGHTNING.

To the Editor of the SCIENTIFIC AMERICAN:

In your issue of December 12 there appeared an article by Mr. James Cooke Mills, describing certain experiments made under the auspices of the Smithsonian Institution by Mr. Axel Larsen. As the impression is given in this article that many new facts have been ascertained from these experiments, I cannot let it pass without a word of protest. In the first place, lightning has been photographed with a moving camera, and the multiple nature of the discharge shown many times in past years; the dark flashes have been photographed almost from time immemorial, and the spectrum of lightning was secured by Prof. Pickering several years ago.

The cause of the dark flash has been known for the past ten years. Mr. Clayden showed that feeble flashes always came out dark on the plate if the plate was subsequently fogged by a feeble light of any sort. This light usually comes from the clouds illuminated by other flashes, or in some cases from a faint twilight sky. Mr. Clayden obtained the effect in the laboratory with electric sparks. If the fog is produced before the spark is impressed, no reversal takes place. The theory advanced in Mr. Mill's article, that the dark flash emits very short wave lengths, which decrease the sensibility of the plate, is absolutely false. There is nothing peculiar about the light from lightning except the brevity of its duration. A very brief flash of sunlight impressed upon a photographic plate, which is subsequently fogged by feeble candle light, will come out dark, as I showed nine years ago. I made at the time a rather extensive investigation of the Clayden effect, and found that it was due to the fact that an intense light of very brief duration, a light shock I called it, decreases the sensibility of the photographic plate. Reversals were obtained with shocks of as long duration as 1/1000 of a second, though in this case the intensity of the fogging light and the time of development had to be very carefully regulated. With shocks of a duration of 1/10,000 of a second, reversals could be obtained without difficulty. A full description of the experiments can be found in the Astro-physical Journal for June, 1903; still earlier experiments in the Journal of the Philadelphia Photography Society, November 8, 1899. R. W. WOOD.

Johns Hopkins University, Baltimore, Md.

THAT AEROLITE AGAIN.

To the Editor of the SCIENTIFIC AMERICAN:

In your issue of November 7 last appeared a letter from myself giving an account of the supposed flight of a great meteor over the section of Tennessee lying between Tullahoma and Altamont or Beersheba in the eastern part of the middle section of the State—which occurrence happened at 10 o'clock A. M., September 8. The noise and vibration caused by the flight of the meteor were so great, and were noted over such a wide territory, that the matter was deemed by me and others to be worthy of being noticed in the press, especially as such notice might lead to the discovery of fragments of the meteor, in case any of them reached the earth.

In your issue of November 28, E. B. Hoyte, in a letter dated November 14, Nashville, says among other things: "He" (myself) "declares that from his position the crash of the impact was as a great explosion of dynamite accompanied by a slight vibration of the earth." And again, "I find that on September 8, at about 10 A. M., a shipment of dynamite was exploded at Wartrace, Tenn., on the N. C. & St. L. Railway"—which was near Estill Springs, where I was at the time.

A reference to my communication will show that I did not say that the sound was that of an explosion of dynamite. I did not express that opinion, but only said that, among the many causes (indicated) by different persons, some thought at the time that there had been an explosion of a shipment of dynamite. I did not myself think anything of the kind, and did not say that I did. Persons came to and fro from Wartrace to Estill, and no one spoke of such an explosion. I think I can safely say that no explosion of a shipment of dynamite took place at Wartrace, or at any other point within at least fifty miles, or indeed in the State.

I took the trouble last week to make sure on this point, and, among other things, wrote to the postmaster at Wartrace. I inclose to you his reply, in which he says that no such explosion has taken place.

In your issue of December 12, a letter signed A. M. Button, dated Waterford, N. Y., says that he, Mr. Button, was at Winchester, Tenn. (near Estill Springs and Tullahoma) on September 8, and at 10 A. M. that day saw what appeared to be a large pyramid of yellowish white flame passing with great speed high up in the sky, followed by a sound such as I described.

I will add that soon after I wrote my original letter to you, I learned that at least a dozen reliable men in that vicinity, whose names I heard, reported that they saw the object very much as Mr. Button describes it.

PARK MARSHALL.

Nashville, Tenn., December 25, 1908.

ARE FILTERING BEDS CORRECTLY CONSTRUCTED?

To the Editor of the SCIENTIFIC AMERICAN:

I do not believe that you can expect very much from a person who says: "I have never studied engineering in any of its branches, but I believe that our engineers are entirely wrong upon a subject which has been studied for years and years, and upon which millions of dollars have been expended." For this person to be right and the engineers wrong is certainly against the rule. I therefore expect to be corrected, and ask you and those of your readers qualified to give an opinion on the subject to kindly point out wherein I am mistaken in my ideas, and I thank them in advance for the same.

The question is: Are our filtering beds constructed correctly or on correct principles? I believe they are not, and these are my reasons, and also a possible remedy:

The object for which filtering beds are constructed is to furnish pure water, and not to obtain all the foreign matter held in suspension by the water, and then when you have obtained the same, to know that you have something that you absolutely do not want and some pure water. As far as I know, and in a general way, filtering beds are constructed by placing conducting pipe having broken joints on the bottom of a reservoir, or by covering them with some suitable material having perforations, and upon this layers of broken stone of large size, broken stone of smaller size, gravel, coarse sand, and lastly a bed of fine sharp sand. These several layers to be about one foot in depth, but the last one from three to five feet. Water having foreign matter in suspension is pumped upon this bed and allowed to pass through, and the water then used for final distribution through the city's mains. When one portion of water has passed through another is pumped on, and so on until the surface of the bed becomes clogged or choked up from the foreign matter held in suspension, and which has accumulated from day to day for a variable time, according to the condition of the water. The surface of the bed is then scraped off, and either washed and replaced or is replaced with entirely new sand. This bed certainly catches all the foreign matter held in suspension, and if this was the object for which it was constructed, it would work to perfection; but as the object is to furnish pure water, it does not furnish all the pure water, but only a portion. The object is to furnish all the pure water, and no foreign matter or dirt. The water placed upon the filtering bed must pass through the same; there is no other outlet. Now, if the water could pass through the filtering bed, and at the same time have an outlet for the foreign matter held in suspension, then there would be no accumulation of foreign matter.

Therefore, as a remedy I would suggest that instead of building a reservoir and placing conducting pipe on the bottom thereof, the conducting pipe be placed directly on the bottom of the source of supply, be it lake, river, or whatever, and then cover them in the same manner as described above. Then the water would pass through the filtering bed just the same, and the foreign matter held in suspension would follow the lines of least resistance, and flow over the filtering bed. In this way there would be no accumulation of foreign matter held in suspension, and it would not have to be removed from time to time. You would obtain all the pure water and none of the foreign matter held in suspension, for which you have no earthly use any way unless it was as a fertilizer, and then it would be a mighty expensive article. There would be no trouble caused by the ice in winter, and would therefore not require covering or housing. Nor would there be as much wear and tear on the valves of the pumps caused by the sand and other matter. In the cost of construction there would be no expense for the land on which the filtering bed is located, in itself a large item in many cases. Neither would it cost anything for paving the bottom and the sides and the retaining walls. Nor would it cost as much to place the several layers of stone, etc., in place in the lake or river as it would if placed in a reservoir on the land. The size of the filtering bed I would suggest to be proportioned for every million gallons of water to be used every twenty-four hours, to be one acre of surface. This would cause a flow through the filtering bed at the rate of about one yard a day. When the current in the lake or river is only one mile a day, the proportion in the flow would be one to seventeen hundred, that is, the water would flow one thousand seven hundred times faster over the filter than through the filter, and where this was the case, there would surely be no depositing of foreign matter on the filter, at least I so do think it. Now, if I am right in my ideas, there is no reason whatever why all the cities in the United States, and all over the world for that matter, located on the shores of our many lakes and on the banks of our rivers, could not have all the pure water they wanted at a cost no greater than that of the mere pumping of the same, and in some cases not even as much; that is, filtered water could be had for less money than it would cost to pump unfiltered water, of course not considering the first cost of installation.

It is only upon the ground that exceptions prove the rule that I venture to make the foregoing statement, and I hope that in rendering judgment, my judges be not unmindful of leniency and mercy.

PAUL F. BUSSMAN, M.D.

Buffalo, N. Y., December 24, 1908.

[You suggest that by placing filter beds (underlaid by the usual outlets) "directly on the bottom of the source of supply, be it lake, river, or whatever," the clear water would pass out just the same, and the foreign matter would be held in suspension and "*flow over*" the filter beds. Now, the foreign matter eliminated by filter beds is largely so light and impalpable that it would be little affected by flow; and if there were enough current for water to pass through the beds, *some* foreign matter would be retained in them. Your speaking of "flow," however, presupposes a current, and does not mention what would happen in the case of a lake with *no* current. In this case surely the action of the filter beds would be exactly the same as in reservoirs, with the exception that after the cost of draining a lake in order to lay conduits and filters in its bed, the same expensive process would have to be gone through to change the filtering material. In the case of a river, supposing the flow to retard the deposition of foreign matter, the filters must necessarily be placed in a deep and consequently fairly still part, exactly where detritus from the banks brought down by every flood would accumulate, rapidly choking the filter. The whole point, however, is that your principal object seems to be to prevent the accumulation of foreign matter in the filter beds; and if the filtering material does *not* catch and accumulate foreign matter, what is the object of having it at all?—ED.]

The Great Drydock at Pearl Harbor, Hawaii.

BY ELMER MURPHY.

The drydock at the naval station, Pearl Harbor, Hawaii, is to be the largest ever constructed by the Navy Department. Its over-all length is 1,195 feet, whereas the longest dock previously constructed, which is at Philadelphia, is 799 feet over all, and the Puget Sound drydock, recently contracted for, is 863 feet over all.

The width between coping will be 130 feet, and the depth over flue blocks at mean high water, 32½ feet. An innovation, so far as American docks are concerned, is that there will be four caisson seats, two, as usual, at the entrance to the drydock and two others near the middle of the dock, dividing the main structure into an inner and outer dock. There will be two steel caisson gates, and the arrangements will be such that, with a ship in the inner dock, the outer dock may be filled and emptied independently, thus allowing the ship upon which the most extensive repairs are to be made to remain in the inner dock, while ships with minor repairs are being docked in rapid succession in the outer dock. By floating the inner caisson from the drydock, ships of greater length than any now in existence or planned could be docked. A trapezoidal form of head has been designed for this dock, different from any hitherto considered. It is arranged so that three destroyers may be docked side by side, extending to the very head end of the dock, and leaving room for three other small craft in the inner dock.

The draft over sills at mean high water will be 35 feet, which is more than any other dock excepting the one at Puget Sound, where the great variation in tides required a draft of 38 feet. The conditions of depth at Pearl Harbor are such that the largest battleship may enter the dock at any stage of the tide. Concrete will be used throughout in the walls and floor. Granite lining will be used only at the caisson seats, at the coping at entrance and at the material slides. The conditions for the use of concrete are believed to be more favorable at Pearl Harbor than at any point in the United States, on account of the equable climate and absence of frost.

A marked improvement over all previous docks has been developed in connection with the dock for Pearl Harbor, in that the working floor will be absolutely level from end to end, giving a level working surface, free from the usual obstructions, such as bilge block slides, docking keel-block bearers, bilge-block chains, temporary electric wires, temporary compressed-air lines, etc. The attempt has been made many times previously to accomplish this object, but never with success. It has been accomplished in this case by an entirely new design for bilge-block bearers and docking keel-block bearers. The bearers are made in the shape of cast-iron boxes imbedded in the dock floor, with top flush with the concrete. The wide flanges on the top form the bearers for the keel blocks and bilge blocks, and a slot is provided through the top of the box to take the anchor bolts for the keel blocks and the holding-down device for the bilge blocks. The cast-iron box is large enough also to take the chains for the hauling of bilge blocks across the floor of the dock while a ship is being placed. Another most important function of the cast-iron boxes is to drain the floor. The water passes through the slots, and flows along the sloping bottom of the boxes, and is discharged into four large longitudinal sub-floor drains. These, in turn, carry the water into the drainage chambers near the middle of the dock. The inner dock and outer dock each have an independent system of longitudinal drains and a drainage chamber. Three 54-inch pipes with gate valve pass from each drainage chamber into a common wet chamber outside of the drydock structure. The four 54-inch suction pipes from the pump well, which is close by, open into the wet chamber, thus removing water which flows in from either one or both of the drydocks. The slots, cast-iron boxes, and drains have been so designed that the velocity of water while being pumped will be sufficient to remove any silt which may have collected.

The system of cast-iron boxes with slots and longitudinal floor drains will also be used for filling the dock. Four filling culverts, two on each side of the drydock, having inlets in the quay wall at the entrance of the dock, are connected with the longitudinal drains in the inner and outer docks in such a manner that either dock may be filled independently of the other. The water will be discharged into the dock body through the slots, having thus an upward velocity on entering and being uniformly distributed over the entire floor. This is much superior to having the water enter at the ends or sides with a velocity sufficient to cause harmful movements of the ship. Sixteen flights of stairs extend from the coping to the floor. This number is liberal, in order that the workmen may enter and leave the drydock with expedition. There will be 539 keel blocks, extending from the entrance to the head of the drydock. These are for the purpose of carrying the weight of the ship when the dock is pumped. Two lines of docking keel blocks will extend on either side of these to take the weight of turrets, etc., of battleships. The pump well will be located near the middle of the dock and about 30 feet away. It will be of octagonal shape, and will contain four 54-inch pumps.

A track for a 40-ton crane will be built around the drydock structure, with the inner rail close to the edge of the coping. The total length of the rails in this track will be within a few feet of one mile. The construction of the dock will necessitate the disposal of 350,000 cubic yards of material. This will be utilized in filling some of the low areas on the station property. The depth of the excavation will be 58.5 feet. This is more than the height of an ordinary four-story building. The total amount of concrete to be used in the dock is approximately 120,000 cubic yards.

THE PHYSICAL ENERGY OF THE HOUSE-FLY.

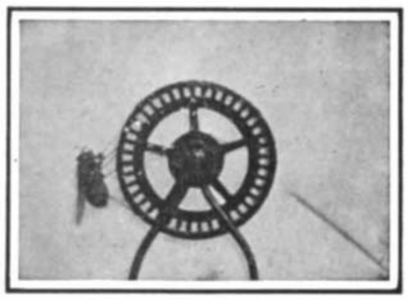
BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

Mr. Frank P. Smith, a member of the Quekett Microscopical Club, has added to our knowledge of the fly by a series of highly interesting moving-picture films,

Bluebottle fly balancing a cork ball upon which another fly is simultaneously preserving its balance.

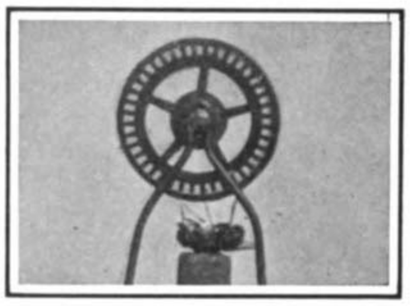
which pictorially give some idea of the highly-developed organism and the physical energy of the common house-fly.

Although Mr. Smith makes no claim to being able to train the domestic fly, yet at the same time he has



A fly walking up a revolving wheel.

succeeded, as the accompanying illustrations testify, in causing it to accomplish some curious evolutions—a result due not so much to any development of intelligence as to the deception of the insect. The flies used for the purpose of chronophotographic investigation were especially bred and reared to secure large, clean, newly-merged insects.



Bluebottle fly turning a revolving wheel.

Flies and kindred insects are equipped with a highly-developed breathing apparatus. Instead of depending upon a single tracheal tube, as do human beings and

Eating honey from a pin held in the hand.

THE PHYSICAL ENERGY OF THE HOUSE-FLY.

animals, for the inhalation of air, these insects are provided with a complex network of passages extending to all parts of the body. The outcome of this arrangement is a very rapid oxygenation of the blood fluid, with an attendant enormous development of physical energy.

To demonstrate the extent of this development, a series of popular photographs were secured, some of which are of a humorous character. The species illustrated is the familiar domestic bluebottle, which, because of its size, is more particularly suited to the purpose. In one case the fly is seen lying on its back or seated in a diminutive chair, supported or held in position by a thin band of silk passed round its waist. In this position it held and played, or juggled, with a number of articles of relatively large size, such as small dumb-bells and weights, or nursed a smaller fly without any apparent effort. A certain degree of restraint was imposed, but in the case of revolving the small wheel, the insect was allowed complete freedom. In order to revolve the wheel, the fly was made to try to walk along its periphery. An ingenious device was prepared, the object being to cause it to desist from its natural inclination to fly, and to induce it to walk up the side of the wheel. A dark box was fitted with a small door of very thin glass attached to an escapement similar to that of a pendulum clock. When the fly was first imprisoned in the box, it instantly attempted to effect an escape through the glass door with a frantic buzz. Every time it struck the glass it received a slight tap on the head from the escapement. At first such results only increased its fury, but in a short while, owing to the continued tappings upon its head, it would become more tractable. Finally, instead of attempting to escape by flying, it would make an effort to achieve its object by walking up the wheel. While in this tractable condition the photographs were secured. The entomologist, however, found it quite impossible to depend upon the results of the incarceration in the box, since very often a fly that had been under instruction for several days, upon removal to the wheel outside immediately took advantage of its liberty and flew away.

In another instance the fly is shown lying on its back supporting and turning or juggling a ball three or four times its bulk, upon the upper side of which is another fly, which also maintains its balance upon the moving spherical surface. This action, as well as that of turning the wheel, Mr. Smith attributes to the insect's illusion that it is really walking upon a fixed surface. In another instance the fly is shown merely balancing a cork ball. It is noticeable in these various accomplishments that the fly brings its wonderful proboscis into play for the purpose of guiding and partially of preserving the balances of the various moving substances. This is strikingly shown in the case where one bluebottle prone on its back is supporting another balanced acrobatically upon its upturned legs.

The Current Supplement.

Erichsen's tragic Greenland expedition is made the subject of a handsomely illustrated article which opens the current Supplement, No. 1727. Major George O. Squier contributes an article on ships in air and water, and shows the general relations between the two. Franklin Van Winkle in an article entitled "Pressure of the Atmosphere on Liquids" writes on the conditions of equilibrium in liquids of the same and different densities. The psychogalvanic reflex is a peculiar physical manifestation of mental processes in the form of a change in the electrical properties of the skin. This change occurs whenever the subject feels emotion, and it can be detected and measured with a sensitive galvanometer. By this method the irritability of the human mind may be electrically measured. James H. Baker contributes a good article on chain and chain making. The ultimate internal combustion motor and its probable fuel is discussed by Thomas White. An interesting process of color photography has been brought about by Chéron in Paris. The process is described and illustrated by our Paris correspondent. In a review of the eleventh Paris Automobile Salon, the general tendencies of the construction for 1909 are summarized, and particulars are given of some of the most notable models exhibited. H. B. Macpherson writes instructively on protective mimicry in bird life.

Fuel gas analyzers have been investigated by the committee on power generation of the American Street and Inter-urban Railway Engineeering Association, which recently reported that they were of unquestionable value where continuous records are kept. In order to get the best indication of furnace conditions, the committee recommends putting the gas collector as close as possible to the point where combustion ceases in the line of circulation. The collector should be a ¾-inch or 1-inch pipe, with the end capped and provided with ⅛-inch holes at frequent intervals along the side, but not so many that their combined area equals that of the pipe. Experience indicates the best results are secured with a recording analyzer in the main flue, supplemented by an indicating instrument connected into the breeching of each boiler, and so placed that the fireman can read it. The most common error in the operation of furnaces, which a CO_2 recorder shows, is stated to be the admission of too much air.