course, contain a good deal of lead, sulphur, etc., and if selenium is present are generally red. They should be digested with the cyanide solution at a temperature below boiling, until the residue has lost its red color. If no red substance separates on adding an excess of hydrochloric acid, it may be assumed that selenium is absent, or present in too small quantities to pay for working it. If a deposit forms it may be tested as below described.

Another method of making selenium consists in dissolving the slime or sediment in caustic potash, and then exposing the solution to the air at a temperature of 44° Fahr. Hyposulphite of potash is formed, and selenium separates. Mansfeld soot is levigated, washed with water acidified with hydrochloric acid, then with pure water, dried, and fused with crude carbonate of soda, or potash. The selenates are extracted with water, and exposed to the air as before. The fusion, even on a very small scale, *must not be performed in a platinum vessel*, as it always contains more or less lead, which would destroy the crucible.

PURIFICATION.

Selenium prepared by any of the above methods forms red scales. If washed on a filter and then boiled in water, it agglomerates together to a hard, reddish black mass, with a metallic luster and ring. To purify selenium, Bunsen dissolves it in hot nitric acid, which oxidizes it and converts it into selenious acid. By evaporating this *slowly* on a water bath to dryness, he obtains anhydrous selenious acid as a white powder. By too rapid evaporation some of the seleniumi s carried off with the nitrous vapors. The selenious acid is next purified by subliming it in a current of air at, or below a red heat. A piece of combustion tubing is drawn out narrower in the middle, and loosely stopped with a tuft of asbestos; the dry acid is placed in one end, which is heated quite strongly, and other end cooled, while a current of air is drawn through it. Selenious acid sublimed in this way forms beautiful long white crystals. It is next dissolved in water, and a current of sulphurous acid (SO_2) passed through it, whereby the selenium is precipitated as a red powder, which may be melted and cast in moulds if desired.

TESTS FOR SELENIUM.

The characteric odor of burning selenium, resembling, as some say, decayed horseradish, is generally a sufficient test. Its soluble salts give a red precipitate when sulphurous acid is passed through their solutions; if there is but little selenium present, the solution has a *green* appearance by transmitted light. (SCIENTIFIC AMERICAN, Oct. 26, 1872.) Selenium colors the flame a bright blue, which does not serve to distinguish it from sulphur. If a small bit of any selenious compound be brought on an asbestos thread into a small reducing flame, and a glazed porcelain dish of *cold* water be held one-half inch above it, a brick-red film will be deposited on the cold porcelain; heated with strong sulphuric acid, it gives an olive green solution, which yields a red precipitate when poured into water (Bunsen). Selenium does not dissolve in sulphuric acid unless this is very strong, but if boiled in the acid for a very long time, it becomes oxidized to selenious acid, sulphurous fumes are evolved, and no precipitate of red selenium can then be obtained on dilution (Hilger).

MELTING POINT.

We have already seen that selenium can assume various forms or states, some of them soluble and others not; some conduct electricity while others do not. In regard to the melting point of selenium statements are at variance, for it sometimes becomes soft long before it is really fluid. When melted and allowed to cool very slowly, selenium becomes granular, or crystalline, with a leaden gray to reddish violet color. In this form it melts at 217° C (423° Fahr.) without previously softening. According to Bettendorff and Wüllner, the amorphous selenium begins to soften between 40° and 50° C. (104° to 122° Fahr.) Berzelius says it softens when warmed, at 100° C. (212° Fahr.) it is semi-fluid, and perfectly liquid at a slightly higher temperature, but on cooling remains soft, like sealing wax, so that it may be drawn out in long, elastic, transparent threads. Sacc says that selenium has no definite melting point, for it softens and hardens gradually; that it probably melts at 200° C. (392° Fahr.), for at that temperature it ceases to adhere to the bulb of the thermometer. It is completely melted at 250° C. (482° Fahr.), and when cooled to 150° C. (302° Fahr.) it is entirely solid.

ACTION OF LIGHT ON SELENIUM.

This seems to have been first observed by Willoughby Smith and his assistant, Mr. May, in 1874. At first the effect was attributed to heat, but the experiments of Lord Rosse, Werner Siemens, and others, soon demonstrated the fact that it was light, and not heat, that effected this change. Selenium, like most non-metals, is a very poor conductor of electricity; in the amorphous form it does not conduct the current at all, in the crystalline form it conducts the current feebly, but the resistance is less when the selenium is exposed to light than when kept in the dark. Even the cold light of the moon has the same effect as found by Adams. So sensitive can it be made by suitably "annealing," or rather crystallizing it, that Siemens constructed an artificial eye that would wink, while Tainer and Bell have produced sound by the agency of light in their photophone. The latter claims to have made sensitive selenium cells, having a resistance of only 155 ohms in the light, and 300 ohms in the dark. The cells used are made by taking a plate of brass and heating it, then rubbing it over with a stick of selenium. It is annealed by heating it over a gas burner until the reflecting surface becomes dimmed. The cloudiness resembles somewhat the film of moisture produced by breathing on a mirror. Bell says that his best results have been obtained by heating the selenium until it crystallizes, then continuing the heating until it shows signs of melting, when the gas is immediately put out. The portions that had melted instantly crystallize, and the selenium is found, on cooling, to be a conductor, and to be sensitive to light. The appearance of the crystals, seen under the microscope, differs according as the heat is removed, as soon as cloudiness begins, or not until fusion begins, or when complete fusion is followed by slow cooling.

CHEMICAL AND OTHER PROPERTIES.

We have seen that selenium does not dissolve readily except in chloride of selenium. Sulphuric acid, free from water (H_2SO_4), dissolves it, nitric acid oxidizes it, and the alkalies combine with and dissolve it. It unites directly with bromine and chlorine, and on heating, will unite with iodine, sulphur, phosphorus, and the metals. It unites with iron to form a selenide, and when this is decomposed by acid, a hydrogen compound, H_2Se, is formed, which resembles sulphureted hydrogen in its power of precipitating the heavy metals from solution, but is distinguished for its unpleasant odor. Selenium forms nearly all the compounds that sulphur does. Owing to the ease with which it may be liberated from its compounds by reducing agents, it is generally estimated in the free state, by precipitating with sulphurous acid as a red powder, boiling to cause it to adhere together, and collecting it on a tared filter, drying and weighing as such.

ELECTROLYTIC DEPOSITS.

Selenium is easily reduced from its solutions, whether acid or alkaline, by the galvanic current. According to Schucht the deposit is at first light-red, but as it grows thicker becomes darker. The precipitation is so complete that it could be employed for quantitative estimations. Only a feeble current of two elements can be employed, or the selenium would become pulverulent. When deposited on a platinum electrode, it rubs off easily; probably on brass or copper it would adhere better. From its combination with potassium, selenium precipitates nicely with a feeble current; in acid solutions some selenieureted hydrogen is given out at the negative pole. If the solution contains a metal, like copper, the selenium and copper are precipitated together, and the color of the deposit is darker than that of pure copper.

For covering metals with selenium, the method of melting on seems preferable to electrolytic deposition.

NOVELTIES AT THE NEW ENGLAND INSTITUTE FAIR.

The engravings on our front page illustrate the special features of several devices which attracted our artist's attention at the Boston fair, as combining novelty with a promise of considerable economic and industrial value.

Fig. 1 represents the general plan and pulley connections of the Harris Revolving Ring Spinning Frame. The purpose of the improvements which it embodies is to avoid the uneven draught of the yarn in spinning and winding incident to the use of a fixed ring. With the non-revolving ring the strain upon the yarn varies greatly owing to the difference in diameter of the full and empty bobbin. At the base of the cone, especially in spinning weft, or filling, the diameter of the cop is five or six times that of the quill at the tip. As the yarn is wound upon the cone the line of draught upon the traveler varies continually, the pull being almost direct where the bobbin is full, and nearly at right angles where it is empty. With the increasing angle the drag upon the traveler increases, not only causing frequent breakages of the yarn, but also an unequal stretching of the yarn, so that the yarn perceptibly varies in fineness. The unequal strain further causes the yarn to be more tightly wound upon the outside than upon the inside of the bobbin, giving rise to snarls and wastage.

These difficulties have hitherto prevented the application of ring spinning to the finer grades of yarn. They are overcome in the new spinning frame by an ingenious device by which a revolving motion is given to the ring in the same direction as the motion of the traveler, thereby reducing its friction upon the ring, the speed of the ring being variable and so controlled as to secure a uniform tension upon the yarn at all stages of the winding.

The construction of the revolving ring is shown in Fig. 2. C is the revolving ring; D, the hollow axis support; H, a section of the ring frame; E, the traveler.

To give the required variable speed to the revolving ring there is placed directly over the drum, Fig. 1, A, for driving the spindle a smaller drum, B, from which bands drive each ring separately. The shaft, which is attached by cross girts to the ring rail, and moves up and down with it, is driven by a pair of conical drums from the main cylinder shaft; and is so arranged with a loose pulley on the large end of the receiving cone as to remain stationary while the wind is on or near the base of the bobbin. When the cone of the bobbin diminishes so as to materially increase the pull on the traveler the conical drums are started by a belt shipper attached to the lift motion. By the movement of the belt on these drums a continually accelerated motion is given to the rings, their maximum speed being about one-twentieth the number of revolutions per minute as the spindle has at the same moment. This action is reversed when the lift falls. The tension of the wind upon the bobbin is thus kept uniform, the desired hardness of the wind being secured by the use of a heavier or lighter traveler according to the compactness of cop required.

The model frame shown at the fair did its work admirably well, spinning yarns as high as No. 400, a fineness hitherto unattainable on ring frames. It is claimed that this invention can do whatever can be done with the mule, and without the skilled labor which mule spinning demands.

This invention is exhibited by E. & A. W. Harris, Providence, R. I.

Figs. 3, 4, and 5 illustrate some of the applications of the electric stop motion in connection with cotton machinery. The merit of this invention lies in simplifying the means by which machinery may be stopped automatically the instant its work, from accident or otherwise, begins to be improperly done. The use of electricity for this purpose is made possible by the fact that comparatively dry cotton is a non-conductor of electricity. In the process of carding, drawing, or spinning, the cotton is made to pass between rollers or other pieces forming parts of an electric circuit. So long as the machine is properly fed and in proper working condition the stopping apparatus rests; the moment the continuity of the cotton is broken or any irregularity occurs, electric contact results, completing the circuit and causing an electro-magnet to act upon a lever or other device, and the machine is stopped. The current is supplied by a small magneto-electric machine driven by a band from the main driving shaft, and is always available while the engine is running.

Fig. 3 shows the general arrangement of the apparatus as applied to a drawing frame. In the process of drawing down the roll of cotton—the sliver—four things may happen making it necessary to stop the machine. A sliver may break on the way from the can to the drawing rollers, or the supply of cotton may become exhausted; the cotton may lap or accumulate on the drawing rollers; the sliver may break between the drawing rollers and the calender rollers; or the front can may overflow. In each and all of these cases the electric circuit is instantly completed; the parts between which the cotton flows either come together, as when breakage occurs, or, if there is lapping, they are separated so as to make contact above. In any case the current causes the electro-magnet, S, against the side of the machine to move its armature and set the stop motion in play.

Figs. 4 and 5 represent in detail the manner in which electric connection is made in two cases requiring the intervention of the stop motion. In Fig. 4 the upper part of a receiving can is shown. When the can is full the cotton lifts the tube wheel, J, until it makes an electrical connection, and the stop motion is brought into instant action. In Fig. 5, the traction upon the yarn holds the hook borne by the spring, F, away from G, and the electric circuit is interrupted. A breakage of the yarn allows this spring to act ; contact is made, and the stop motion operates as before.

This simple and efficient device is exhibited by Howard & Bullough & Riley, of Boston.

Fig. 6 shows the essential features of a positive motion loom, intended for weaving narrow fabrics, exhibited by Knowles, of Worcester, Mass. The engraving shows so clearly how, by a right and left movement of the rack, the shuttle is thrown by the action of the intermediate cog-wheels, that further description is unnecessary.

THE NATIONAL ACADEMY OF SCIENCES.

The annual meeting of the National Academy of Sciences began in this city November 14, Professor O. C. Marsh, of Yale, vice-president of the Academy, in the chair.

In the first paper Professor Loomis, of New Haven, discussed the mean annual rainfall of the several geographical divisions, and pointed out that on our Atlantic coast an annual rainfall of at least fifty inches extends from latitude 35° north to latitude 33° south. In the principal part of South America a rainfall of fifty inches extends nearly to the Andes, and there are extensive districts which have a rainfall of seventy-five inches. In Africa there is a rain belt of fifty inches, whose average breadth is 1,000 miles, and which is apparently continuous from ocean to ocean. There are also extensive districts where the annual rainfall exceeds seventy-five inches. In nearly all the islands of the East Indian Archipelago the mean rainfall exceeds seventy-five inches. We have thus an equatorial rain-belt amounting to at least fifty inches annually, having an average breadth of nearly 1,500 miles, and which appears to be continuous across all the islands and continents. With regard to the ocean our knowledge is very limited. As we recede from the great equatorial rain-belt, the amount of the rainfall diminishes rapidly, with the exception of certain districts of limited extent, where local causes give rise to a large rainfall.

Very large portions of the globe have an annual rainfall of less than ten inches. In North America such a region is found in Southern California and Arizona, and there is a large district about Slave Lake where the annual precipitation is only about ten inches of water, and is apparently less than that amount. In South America such a region is found on the west side of the Andes. In Europe there is no district having so small a rainfall as ten inches, except in Spain. In Asia there is such a region, 3,000 miles long and 1,000 broad. In the northeastern part of Asia there is also an extensive region where the precipitation scarcely exceeds ten inches. There are also large stretches of country nearly rainless in Africa and Australia. Thus we find that about one-fifth part of the entire land surface of the globe has a rainfall less than ten inches, and a still larger portion has a rainfall so small as to render it valueless for agricultural purposes, except in those limited districts which allow irrigation.

Professor Ira Remsen, of Baltimore, next reported the accidental discovery of a new form of phosphorus. To obtain some pure phosphorus he tried an improved method of distilling, using pure hydrogen and condensing the phosphorus vapor in a glass retort.

He obtained a soft, plastic, pure white form of phosphorus lighter than water. He thinks the new form is due to mechanical rather than chemical changes.

Professor C. A. Young, of Princeton, showed how he had preserved his prisms from undue heating when making observations with the telescope of 23-inch aperture, by straining out the heat-rays by means of a stream of water between the lenses of the eye piece.

Professor S. H. Scudder, of Boston, described an interesting conflict of animal and vegetable evidence found in geological formations, near Fairplay, Colorado. He said:

The plants have been pronounced permian by Leo Lesquereux. The animal remains consist almost exclusively of insects which belong to types of a far more modern character than any the palæozoic series has yet disclosed. All but one or two belong to a group which, of all palæozoic insects, has received the most attention, namely: the cockroaches. While this fact of the great preponderance of cockroaches, and the further fact that the few known genera found in this collection have hitherto been discovered only in carboniferous and permian rocks, would lead us at first to refer the beds in which they occur to one of the palæozoic series, the presence of the other forms, and even the characteristics of those which are referable to carboniferous and permian genera, unmistakably point to a later origin.

The palæozoic cockroaches are distinguished from living species by having five veins in the wing instead of four. For these ancient forms the name of palæoblattariæ has been proposed. Eleven out of the seventeen species found at Fairplay belong to this class. Only four of the eleven belong to known species, and one of these is doubtful. The average size of the Fairplay palæoblattariæ is much less than that of the palæozoic members of the group. The six species which do not belong to the palæoblattariæ show strong resemblances to the mesozoic cockroaches. They all have a decided mesozoic aspect, and would be at once considered Triassic, or at least Jurassic, by any one familiar with the forms already known from these deposits. Only one of these species resembles any one of the palæoblattariæ. This resemblance is of especial interest because it points out the methods in which the change from palæozoic to mesozoic forms is made.

The facts that have now been brought forward, show that in this locality at Fairplay we have an assemblage of forms altogether different from anything hitherto found in the palæozoic series on the one hand, or the Jurassic beds on the other. They indicate that the beds in which they belong are Triassic. If this is true, the discovery will have an added interest from the fact that little is now known of the plants or insects of this period.

Professor Guyot, in a paper presented by Professor Marsh, offered an explanation of the causes of the dry zones in both hemispheres which Professor Loomis had described. These zones were found in the sub-tropical regions, where the rainfall is usually greatest.

The first of these zones appears very generally around the globe between the twenty-eighth and thirtieth degrees of north latitude, beginning in Southern California and continuing in Sahara, Arabia, Afghanistan, and across a portion of the Malay peninsula. The second zone he marked on the southern hemisphere, beginning in Peru, appearing again in the Argentine Republic, and again noticeable in South Africa to the north of the Hottentot country, and then in the northern section of Australia.

The cause of these dry zones Professor Guyot finds in the fact that on the regions in question during the continued dry seasons there is a "descending wind." The counter currents from southwest and northeast cause an ascension of the air at the Equator, and these waves, as they may be called, descending, again take up the heat lost in altitude, and are subjected to such a pressure that they give up none of the moisture they contain. This accounts for the fact that although these waves are frequently cloud laden there is no precipitation.

A discussion of the paper followed, in which Professor Hunt, of Montreal, Professor Brown, and Professor Newberry gave isolated facts within their personal experience, which tended to strengthen the views advanced by Professor Guyot.

Of the papers presented the second day only two were of general interest. Mr. G. F. Becker, of the U. S. Geological Survey, discussed the current theories of the source of the heat of the Comstock Lode; recited observations and experiments tending to disprove the theories that the heat is caused by chemical action in the decomposition of pyrites and in the kaolization of feldspar; and gave his reasons for believing that the heat is of volcanic origin.

The longest and most interesting paper of the day was by Professor A. E. Verrill, of Yale, discussing the physical and geological character of the sea bottom off our coasts, especially beneath the Gulf Stream.

The paper embodied the general results of observations covering a period of eleven years, including dredgings by the United States Fish Commission, taken from over 2,000 stations between Chesapeake Bay and Labrador, and out as far as 150 to 200 miles off shore. Professor Verrill and his associates of the Commission found in these observations that from the shore to a point about 60 miles out the water is inhabited by animals representing arctic life, similar to those found off the coast of Greenland, Spitzbergen, and Siberia. Beyond this lies a warm belt of water which is inhabited by tropical or sub-tropical animals. This warm belt varies with the shore-line of the coast, and while its eastern edge is within 60 miles of Nantucket and Martha's Vineyard, it is much further off from the coast of Massachusetts and Maine, as what is known as the Gulf of Maine is a cold body of water, outside of which lies the warm belt. This warm belt is about 25 miles in width. In this the temperature from a depth of 65 fathoms out to the limits, where the soundings show a depth of 1,000 fathoms, is from 46° to 52° Fahrenheit near the surface, decreasing in temperature in the lower soundings, until at 700 fathoms it is 39°. In the cold belt the temperature of the water ranges from 35° to 45° in August below the surface water, which is in the autumn warmer than that underneath. The temperature at 40 fathoms in the cold belt averages from 35° to 37°. In the warm belt the temperature at 65 fathoms is 46°; at 100 fathoms 50° to 52°; at 200 fathoms 48°; at 300, 40°; and at 700, 39°. As a result of the soundings, measurement of temperatures, etc., it was discovered that an error exists in our maps and charts in placing the warm belt, or Gulf Stream, too far from the shore by 30 or 40 miles. It was also found that the soundings even on the coast survey charts were inaccurate by hundreds of fathoms in many instances, which are now, however, corrected by the coast survey soundings made during the past summer. The generally accepted theory has been that the 100-fathom line marked the line of the Gulf Stream, but this was found to be incorrect, as the line would be more nearly correct if placed at 65 or 70 fathoms line. The charts are also incorrect in that they make out a difference in the line of the Gulf Stream in summer and in winter. The Professor held that there was no variation in the body of the stream, though there is in the surface water an apparent variation, due to the sweeping in of the warm surface water in the summer and the diffusion of the cold surface water over the stream from the shore during the cold months. The proof of his theory is the fact that the sub-tropical life exists in the Gulf Stream in winter as well as in summer, while the character of the inhabitants of the cold belt remains unchanged the year through, and the line of separation between the two kinds of life is well and distinctly marked on the bottom. If there was a variation in the bottom of the stream there would be death to the sub-tropical life of the warm belt.

In the portion of the warm belt south of the New England coast, from 70 to 120 miles from the coast, there was discovered, in 1880, the most valuable ground for the sub-tropical animal life, as prolific in fauna of that class of life as any in the world. From this ground the dredges have taken and brought to the surface 800 species of fauna, over one-third of which were entirely new and unknown to science, including 17 kinds of fishes, 270 of mollusks, and 90 of crustacea. The recent observations of the Fish Commission have been made in a warm belt extending about 160 miles from the northeast to the southwest, and about 20 miles in width. Over 130 dredgings were made in this belt at a depth of 100 fathoms. At about the 100 fathom point the formation of the sea bottom is peculiar in many respects. To this point there is a gradual descent from the shore. Then there is a precipitous descent to soundings of 1,000 fathoms or more, the sudden precipitous descent corresponding to about the height of Mount Washington along the territory that has been explored. The warm belt seems to extend down this precipice only to a depth of about 125 fathoms, judging from the evidences of life brought up in the dredges as well as the thermometrical records. A trawl had brought to the surface in several instances a ton of animal life, which included crabs, shrimps, starfish, and shells of various kinds, among them shells which had hitherto been found only on the shores of the West Indies, but which are now known to be inhabitants of the warm belt of water running along the Atlantic coast. The surface inhabitants are also tropical in their nature, as is shown by the capture of argonautas, Portuguese men-of-war, varieties of the jelly-fish, and pteropods in large quantities. A peculiarity in the weather was noticed by the people engaged in dredging, for while it was pleasant out on the warm belt, they had found on their return to the shore that a storm had been raging, which had caused their associates on shore anxiety as to the safety of their steamer, the Fish Hawk, and the people on board.

The quality and quantity of the light in the depths had not yet been ascertained, but some marked peculiarities have been noticed. Many of the crabs and other animals caught have been found to have the eyes very largely developed. Other animals, which live at greater depths, have been found to be without eyes, presumably a useless organ in the great depths. Another peculiarity observed about the animals found at great depths is that their color is either red or an orange yellow, this being the case with the corals, anemones, fish, and such animals as are exposed to attack from voracious enemies. It is therefore inferred that the color is a mode of defense, in that it renders the animal invisible in the greenish-blue water, and the similarly colored rays of light which can only reach to those depths, and so render a red coat a means for its wearer to keep out of sight of its enemies. The bottom of the Gulf Stream is very peculiar. That of the Arctic belt is a coarse gravel or sand. That of the great depths a sticky mud. Under the Gulf Stream the bottom is of sand of so fine a grain that the grains can only be distinguished from one another under the microscope. This packs together so compactly that the sailors who find it clinging to the sounding leads call it mud. Yet it is the finest grade of sand, very cohesive in its nature. Mixed with it in great quantity are masses of the most minute shells. The two seem to form a bed as level and hard as any floor, and judging from the results of dredging this floor is carpeted thickly and densely with masses of vegetable and animal life. Bowlders are occasionally found on this bottom, and these, the Professor thought, had dropped from cakes of ice that had floated out from the shore. There are also brought out by the dredges occasionally a different form of rock, which seems to be indigenous to the bottom and filled with fossil shells, many of which are exactly like the shells now found on the bottoms. These rocks, he thought, might possibly date back to the pliocene age, but possibly only to the post-pliocene. Their appearance in the dredges he presumed to be due to the fact that they had been loosened from their beds by the burrowing fishes and animals and then caught up by the dredges.

In connection with the character of these fossil rocks he had noticed the absence of all vertebrate fossils. The dredges too, had never brought up any evidence of the existence of dead vertebrates, though the water swarmed with myriads of sharks, dolphins, and other vertebrates, nor had any evidences of the existence of man been brought up in these dredges, and nothing of consequence of man's work except an India-rubber doll, that had been dropped overboard from some vessel. Yet the territory dredged was in the track of the European vessels and where ships have gone down and lives been lost, but everything of this character is destroyed by the voracious animal life of the tract. These facts led him to doubt the negative evidence in geology, and the absence of vertebrates in the early fossil remains found does not lead him to conclude that the mammals did not exist at that time, as their remains might have been destroyed by the animals that have been found in the rocks, as are all evidences of vertebrates in the tract they had been dredging, although it is well known that such animals exist in myriads in the waters above. The presence of broken shells in large quantities on the bottom, he said, was due to the fact that carnivorous crabs and other animals eat the bivalves and univalves alike, cracking up and throwing away the shells. He also stated that the bivalves were food for the cod, which digests out the meat and then spits out the shells.

The third day was devoted mainly to geology and astronomy. Professor Pickering of Yale presented a plan for co-operation in the observation of variable stars. Professor Young made an address on the importance of the solar eclipse of May 8, 1883, and Mr. Chas. H. Rockwell, of Tarrytown, presented the advantages of the position of Caroline Island, in the South Pacific, as a station for observing the eclipse, and the cost of an expedition thither. Professors Langley and Newton urged the importance of such an expedition. The important questions which this eclipse may be the means of solving, Professor Young said, are those of the lunar atmosphere, the spectrum of the chromosphere, the nature of the outer violet portion of the spectrum, the polarization of the corona, the relation between the zodiacal light and the corona, the question of the existence of an intra-Mercurial planet. The path of the coming eclipse makes it exceedingly difficult to get at. The time of the eclipse is very important, because it comes at a time when there will be a great deal of solar spot activity. The duration of this eclipse will be unusually great, being about six minutes. Since 1868 we have had none which lasted over four and one-half minutes. Six minutes is nearly the maximum possible duration.

Professor Peters, of Hamilton College, discussed the structure of the present comet, and the conditions which have led to the belief that the nucleus is divided. He had failed to find evidence of such division. He did not believe the comet to be identical with the comets of 1843 and 1880. The present comet appears to have a spiral orbit, and the probability is that it has never been seen before.

Among the geographical papers, the one of widest general interest was that of Professor Newberry, on the physical conditions under which coal was formed. The recent theory that coal is the product of marine vegetation, was shown to be inconsistent with the record shown in the coal beds of Ohio, particularly the lowest coal in the series. This coal lies in a series of narrow troughs or basins, which were evidently once marshes occupying local depressions, and the valleys of streams upon the then existing surface. Many of these deposits have been worked into and expose the following phenomena to view:

(1.) A fire-clay below each seam, penetrated in every direction with roots and rootlets of stigmaria.

(2.) A coal seam having a maximum thickness of six feet in the bottom of the basins, thinning out to feather edges.

(3.) The coal on the margins of the basins is sometimes thirty or forty feet above its place on the bottom.

(4.) An average of 2½ per cent. of ash.

(5.) A roof composed of argillaceous shale, of which the lower layers are crowded with impressions of plants.

Facts like these point wholly to the origin of coal in swamps and peat bogs.

Professor E. D. Cope, of Columbia College, described the fauna of a remarkable Eocene deposit in New Mexico, in which fifty-six species of animals were found, forty-five of them land mammals. It proves to be the most ancient Eocene fauna yet discovered. Professor T. Sterry Hunt, of Montreal, read a paper on the so-called Eruptive Serpentines; and Mr. Becker described some of the topographical results of geological faults and landslides.

Cause of the Relation of the Coefficient of Adhesion to the Length of Belt in Contact with the Pulley.

BY WM. B. COOPER.

I submit the following as a simple explanation of a mechanical phenomenon the cause of which is not at first apparent. All the explanations in the text books are technical, and consequently not popular.

The law governing friction between surfaces is that it is directly related to the pressure with which they are brought together regardless of the *extent of surface in contact.*

If a belt is passed over a fixed pulley and attached to a weight, it is well known that the power necessary to raise the weight by drawing upon the other end will increase if the portion of the belt in contact with the pulley is increased, and to such a degree that if several turns are made around the pulley, the power required bears no comparison to the weight raised, so great has the friction become.

To explain this, let us imagine the portion in contact with the pulley to be divided into a number of sections; now, when sufficient power is applied to raise the weight, it is clear that, commencing at the weight end, the first section requires to move it a power equal to the weight, plus the friction between itself and the pulley; the second section will have a larger coefficient of friction on account of its being brought into closer contact with the pulley; this results from the fact that the resistance to be overcome is the weight, plus the resistance of the first section. Thus it is manifest that the last section has to overcome, the weight, plus the sum of all these increasing coefficients of all the other sections.

This explains the cause of the ability to transmit so much power by a belt coming in contact with only half of the periphery of a pulley.

This phenomenon is made possible by the convexity of one of the surfaces and the flexibility of the other. A number of shoes attached together would operate in the same way as the belt.

Where the surfaces are of such a character that the friction is at a maximum between certain pressures, it is clear that, where those pressures are exceeded, the width becomes an important factor, as it alters the pressure per inch between the surfaces; in other cases it is immaterial. The same would, of course, be true regarding the area of contact of inflexible surfaces.

SELF-REGISTERING SHIP'S COMPASS.

Among the exhibits at the recent Northeast Coast Exhibition which attracted a very large share of attention, perhaps none was of more universal interest than the self-registering ship's compass invented by Mr. Robert Pickwell, civil engineer, Hull, and which we now illustrate from diagrams and description given in the *Engineer*. This instrument has been subjected to a series of practical tests on passages between Hull and London, Hull and Newcastle, and Hull and Hamburg, with a view to ascertain its accuracy and usefulness, and in each case it has proved a remarkable success in keeping an accurate record of the working of the ship. So sensitive, indeed, is the apparatus that the act of heaving the lead twice and of stopping to take the pilot on board are distinctly shown on the diagram.

The engraving, Fig. 1, represents an elevation of a compass binnacle and stand, of the pattern used by the inventor, and Fig. 2 a cross section showing the inside compass and lamp, and the adaptation of the patent self-registering apparatus under the compass card. The wooden stand is lashed and screwed to the deck, which carries the ordinary bowl, covered by the binnacle top, with glass windows, the stand being of any convenient height. Inside the outer bowl the compass bowl is hung on gimbal rings in the usual way, and the compass card is seen below the glass cover or lid of the inner bowl, light being supplied at night by a top lamp, as shown in Fig. 2. The registering apparatus is fitted in the bowl below the card, and is indicated in Fig. 1 of the engraving. It consists of a barrel, Figs. 1 and 2, containing clockwork, which causes a second barrel within the first to continuously revolve at a given speed, the outer barrel being fixed and having two slots cut through on its upper surface parallel to the axis. The compass card has also a slot, shown by the dark line, curved in such a manner that some one part of it is always across one or other of the straight slots in the drum, and as the inner barrel is when in use covered with sensitized paper, it will be at once understood that in whatever course the ship is being steered a ray

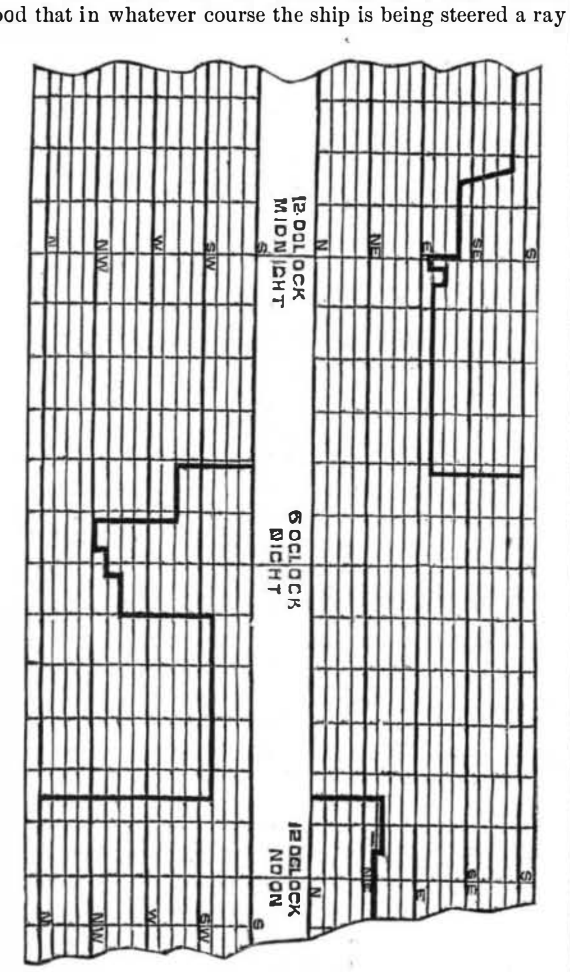

Fig. 3.—RECORD OF PICKWELL'S SELF-REGISTERING SHIP'S COMPASS.

of light either from the sun or from the lamp will pass through the small opening made at the intersection of the curved slot in the card with one or other of the straight slots in the drum envelope, which will produce a black mark upon the prepared paper, more or less distant from the center of the card, and which from its position will give an exact indication of the course of the vessel at the time. The revolving motion of the drum gives the duration of time the ship's head is on each course, as well as the time such courses are changed.

An actual diagram unwrapped from the barrel is shown in Fig. 3, vertical spaces representing directions, as indicated by the letters of the compass, and horizontal distances denoting time. To remove the paper the revolving barrel is drawn off like the drum of an ordinary Richard's indicator, through an opening in the side of the bowl, and all that is necessary to permanently fix the lines is to immerse the diagrams in a liquid solution for a short time. The papers are made for a day of twenty-four hours, or may be continuous so as to give the course for a period of three months, in which case it is proposed to inclose the apparatus in a locked case, which can only be opened by the owner of the vessel. The arrangement most in favor, however, is that for daily diagrams under the control of the captain, who can file them when fixed and produce them at the end of the voyage if required. He can also see the course made by his ship day by day in spite of thick weather, and without observation with the sextant, and can lay it down on his chart every twenty-four hours

The advantage of having an accurate record of the working of a vessel will be at once recognized by every shipowner, and as with Mr. Pickwell's invention this can be obtained without interfering with the free action of the needles, or without even altering the ordinary visible portion of the compass as at present in use, we shall hope soon to hear of its general adoption. The apparatus as at present supplied can be fitted to any ordinary compass, provided the bowl is not less than 10 inches diameter: but, if necessary, a smaller size could be made suitable for a bowl of 8 inches diameter. Mr. Pickwell received the highest award, viz., silver medal and special mention, at the Northeast Coast Exhibition.

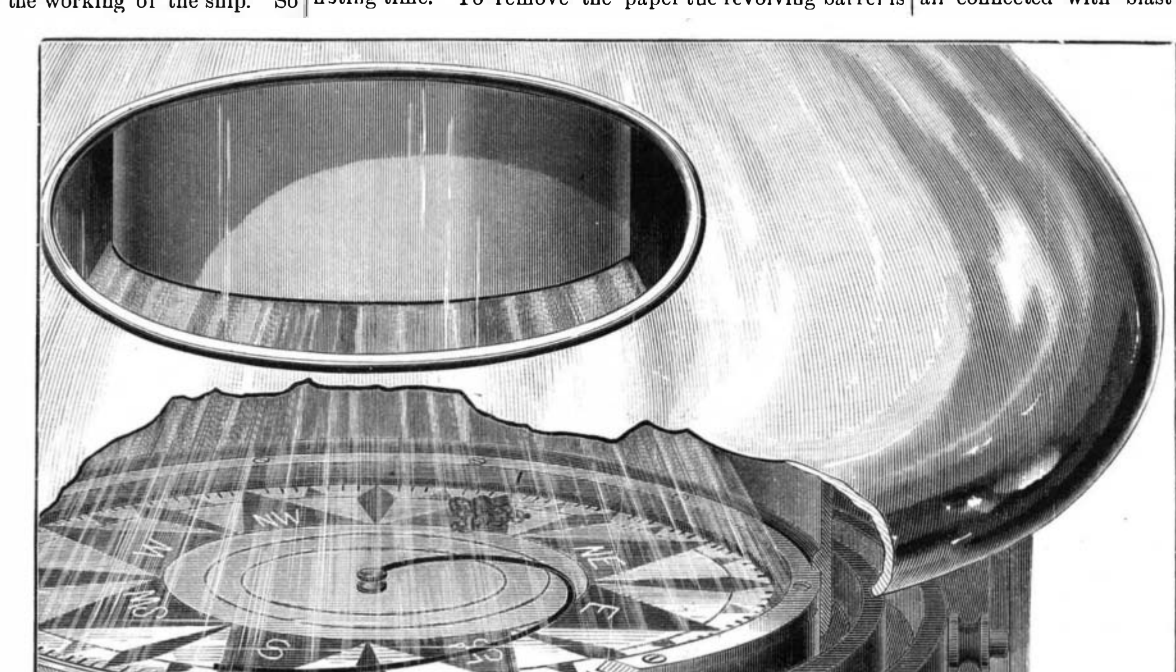

Fig. 1. PICKWELL'S SELF-REGISTERING SHIP'S COMPASS. Fig. 2.

Acid in Certain Kinds of Paper.

Papers sized with rosin size were found to have a more or less acid reaction due to free sulphuric acid, which has never been observed in samples sized with animal glue. The acid is probably derived from the alum or aluminum sulphate used in sizing, which is decomposed by contact with the vegetable fiber, as takes place in dyeing, a basic salt being deposited upon the fiber, and a portion of acid liberated.—*Prof. Feichtinger, in Chemiker Zeitung.*

Science in the Workshop.

The *Commercial Bulletin* truthfully says that when mechanics as a general body become more thoroughly impressed with the conviction that the way to advancement both as to personal position and monetary returns lies through the mastery of science in the application of principles to their daily work, we may anticipate some joint movement on their own part to establish means for acquiring technical knowledge. For instance, the laws of expansion and contraction, as applied to many castings, and even to the wrought iron and steel industries, would prevent much waste in the foundry and at the forge from the effect of unequal expansion and contraction, and also occasion fewer inequalities in the quality of that supposed treacherous material, steel. It would also prevent many mishaps to boilers, engines, and their accessories in cold weather.

A knowledge among workmen of the principles of inertia, as affecting bodies in motion, would frequently prevent a breakdown in starting or stopping machinery suddenly. For all connected with blast furnaces, the value of chemical knowledge is apparent, as enabling them to trace the cause of faulty results. There is scarcely a workshop of any importance in which an acquaintance with geometry will not be of value. In short, the value of science asserts itself every hour in the workshop. The scientific mechanic never falls into ruts either of thought or habit. Working more intelligently than others, he finds more pleasure in his labor; his suggestive faculties are ever at work, and he is ever alive to the possibility of mechanical improvements, from which he may reap a handsome reward. The manufacturers who have risen from the bench without acquaintance with technical science constantly feel themselves at a disadvantage. As all branches of science hold some relation to each other, the acquisition of any one portion of these will prove of value to the workman whatever his vocation.

THE author employs the following mixture for dyeing sole leather: 750 grammes Paris yellow, 150 grammes chrome yellow, 1250 grammes pipe clay, 1,000 grammes quercitron, 1,000 grammes alum, 750 grammes sulphuric acid, and 4 liters tragacanth solution. These are boiled together with 16 liters water, and the mixture, when cold, suitably applied.—*C. Larrabrec.*