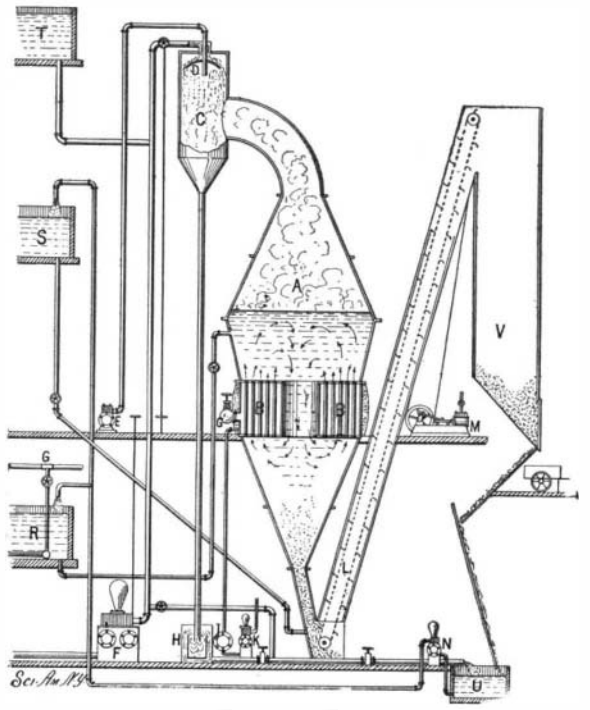
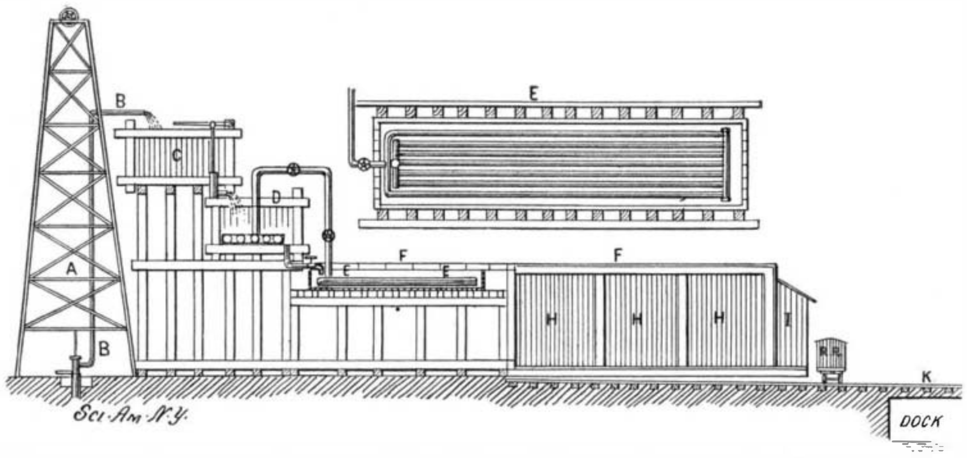
they are emptied, boiled out with fresh water, and cleaned. One of the pans is run during the day and the other during the night, each pan making in a twelve hour run from 600 to 700 barrels of salt, the combined production being from 1,200 to 1,400 barrels a day.

In the manufacture of salt it is a recognized necessity that a large quantity must be kept in storage, and for this purpose the salt is dumped into vast storerooms which measure from 200 to 300 feet in length, and the same in width; the amount in store frequently aggregated 400,000 barrels. As these rooms are from 16 to 20 feet deep the salt becomes tightly packed, and has to be worked loose by packers with picks, shovels, grubhoes, etc., who proceed to quarry, break up and pack the salt into barrels. With the coarser grades of salt made in the grainers this is not a difficult matter, but the finer grained, vacuum-pan salt becomes compact and very hard, and the packer soon finds himself confronted by a wall of salt 20 feet in height and as white, if not as hard, as marble. To undermine and bring down this mass of salt is a dangerous operation, and involves long delays; and to overcome these difficulties, the companies have used a compressed-air driven spiral auger, which is 10 inches in diameter and provided with a double spoon point. The auger is mounted on a truck and the back end of the shaft is attached to a 3 horse power Boyer rotary air drill machine. A row of holes is driven into the salt wall at a height of 10 inches from the floor for a distance of 6 feet into the mass, the holes being drilled as closely together as possible. After an interval of one to three hours, a fall of salt takes place, a mass equal to 400 or 500 barrels of salt being brought down in each section. The saving of labor by the use of the compressed-air drill is shown by the fact that sufficient salt can be undermined and caved in this manner in one-half day to keep the packers at work for two or three days following.



A, vacuum pan; *B*, steam belt; *C*, condenser; *D*, spray plate; *E*, air pump; *F*, cold water pump; *G*, steam pipe; *H*, sealing tank; *K*, hot water pump; *L*, elevator; *N*, brine pump; *R*, brine settler; *S*, brine tank; *T*, water tank; *U*, brine vat; *V*, drainage bin.

VACUUM PAN PLANT.



A, well derrick; *B*, brine pipe; *C*, cistern; *D*, settler; *E*, grainer; *F*, runway; *H*, store bins; *I*, packing shed; *K*, salt car tracks; *E*, grainer.

A SALT BLOCK GRAINER.

MANUFACTURE OF GUNS AND ARMOR AT THE BETHLEHEM STEEL WORKS.

II. FLUID COMPRESSION AND FORGING.

Our first article of the present series on the manufacture of guns and armor was devoted to the Open Hearth process, which, it will be remembered, is used exclusively in the manufacture of steel at the Bethlehem Works. We have seen that steel which is to be worked up into armor plate is cast in huge ingots, the largest of which will weigh as much as 135 tons apiece; while the steel which is to be forged into guns (technically known as "gun steel") is subjected to what is known as the Whitworth fluid compression treatment, which is designed to secure in the ingot that density and freedom from internal cavities, flaws, and impurities which is indispensable to the production of the highest class of forgings. The same results are obtained in the armor plate ingot (though in a lesser degree) by casting them with a considerable excess of metal known as the "sinking head," which serves to compress the cooling ingot and collect the impurities at the surface.

Fluid compression, then, is designed to remove certain defects which are common to all steel ingots not so treated. Chief among these are "blow holes," "piping" and "segregation." When the metal is being poured into the mould, air is apt to be drawn in with it, producing cavities in the metal, a defect which is also liable to be caused at certain stages of the cooling of the ingot by the generation of gas within the body of the metal. The most efficient way of getting rid of this trouble is to subject the molten metal in the mould to heavy compression during the process of cooling. One of our illustrations shows the massive 7,000-ton press in which all the gun steel is treated immediately upon being drawn off from the furnace. The mould is built up of massive cylindrical segments to the desired height upon a movable platen, which is located at the bottom of the casting-pit. After being filled with fluid steel the mould is run under the hydraulic press and the steel is subjected to an increasing pressure. As a result, the formation of blow holes is completely prevented.

"Piping" is the formation of a hollow cavity through the center of the ingot. It is due to the fact that the metal solidifies first at the surface of the mould and, as it cools, shrinks away from the center and from the top, leaving a long, axial cavity through the ingot. In the big armor-plate castings, the extra metal in the sinking head is added to allow it to flow down and compensate for this shrinkage; while in the fluid compression process the hydraulic pressure forces the fluid metal of the upper part of the mould down through the center, thus securing the same result, but with a greatly improved density, due to the enormous pressure applied.

"Segregation" is a mechanical and chemical separation of the component parts of the solidifying steel due to the fact that each of them has its own temperature of cooling. Unfortunately, as the mass cools, each of the ingredients (sulphur, phosphorus, silicon, manganese, etc.) tends to flow toward the central and upper portions of the ingot, thus forming a central core of less purity than the body. Fluid compression greatly mitigates this tendency, and causes the segregation to take place toward the center and toward the upper extra length of ingot. Blow holes being absolutely prevented, the result is an ingot that is perfectly solid throughout its whole mass, while the segregation is removed by cutting away the head and boring out the central core before forging.

The fluid press, like much of the plant at this establishment, is of truly monumental proportions. It consists of an upper head weighing 120 tons, in which is carried the plunger, a 135-ton base containing the hydraulic cylinder, and four vertical connecting screws, each 50 feet long and 19 inches in diameter. The base is located entirely below the floor of the pit, and in our engraving only the head of the piston is visible. Above the piston is placed the platen upon which the mould is built up. The moulds vary in diameter and height, according to the size of the ingots. A plunger, to match the internal diameter of the mould, is attached to the head, and as the mould is raised the plunger bears down upon the fluid metal, preventing its escape.

As soon as the ingot has cooled it is taken from the mould and placed upon the lathe, and the extra length cut off and returned to the scrap heap. It is then placed in a boring mill and an axial hole bored through it. After this, it is reheated in a large gas-fired furnace, a process which must be carried out slowly, great care being taken to let the heat penetrate the metal uniformly; for sudden heating of the exterior while the interior was yet relatively cold would further increase the heavy strains which are set up in the ingot during the process of cooling. The ingot, it must be remembered, cools from the outside and shrinks away from the interior, and when it is cold the interior is in a condition of strain. If the reheating were done too rapidly, the surface metal would be pulled away still further from the center and the strains increased.

In the manufacture of gun steel, with which we are now dealing, the risks of overstrain during the heating are greatly reduced by what is known as hollow forging. Before reheating, as above stated, the ingot is put in the lathe and bored throughout its whole length, an operation which not only allows the heat to act more evenly on the mass of metal, but also serves to get rid of the impurities due to segregation, which, as we have already seen, gather in the center of the ingot. The boring out of the center permits the heat to act from the center outward as well as from the exterior inward, with the result that the metal expands evenly throughout its whole mass, and the danger of cracking is entirely removed. After the ingot has been raised to a temperature from 1,800 to 2,000 degrees, a steel mandrel is placed through its center, and it is picked up by a powerful overhead crane and taken to the hydraulic forging press. The mandrel serves in some sense as an internal anvil, and the work is concentrated upon half of the amount of metal that it would act upon if the piece were solid throughout. The consequence is that the metal receives more of that "working" which is the very essence of first-class forging.

There has been a radical change in the last few years in the methods of producing heavy forgings. The blow of the steam hammer has given place to the steady pressure of the hydraulic press. The pressure applied in forging a piece of steel should be of such a character as to penetrate to the heart of the metal, causing a flow of the metal to occur throughout its whole mass. Naturally the flowing of the metal requires that the proper amount of pressure shall be maintained for a sufficient period. The sharp, heavy blows of the hammer, it has been found, do not penetrate the mass of forging, nor do they produce the desired flow. In the earlier forgings, particularly those that were made for the shafts of steamships, the interior was found to have been but little affected by the forging and to be practically in the condition which it held in the ingot state. On the other hand, the slow-

Length, 1,375 feet; width, 116½ feet.

BETHLEHEM STEEL WORKS—THE GUN-FINISHING MACHINE SHOP.

SCIENTIFIC AMERICAN

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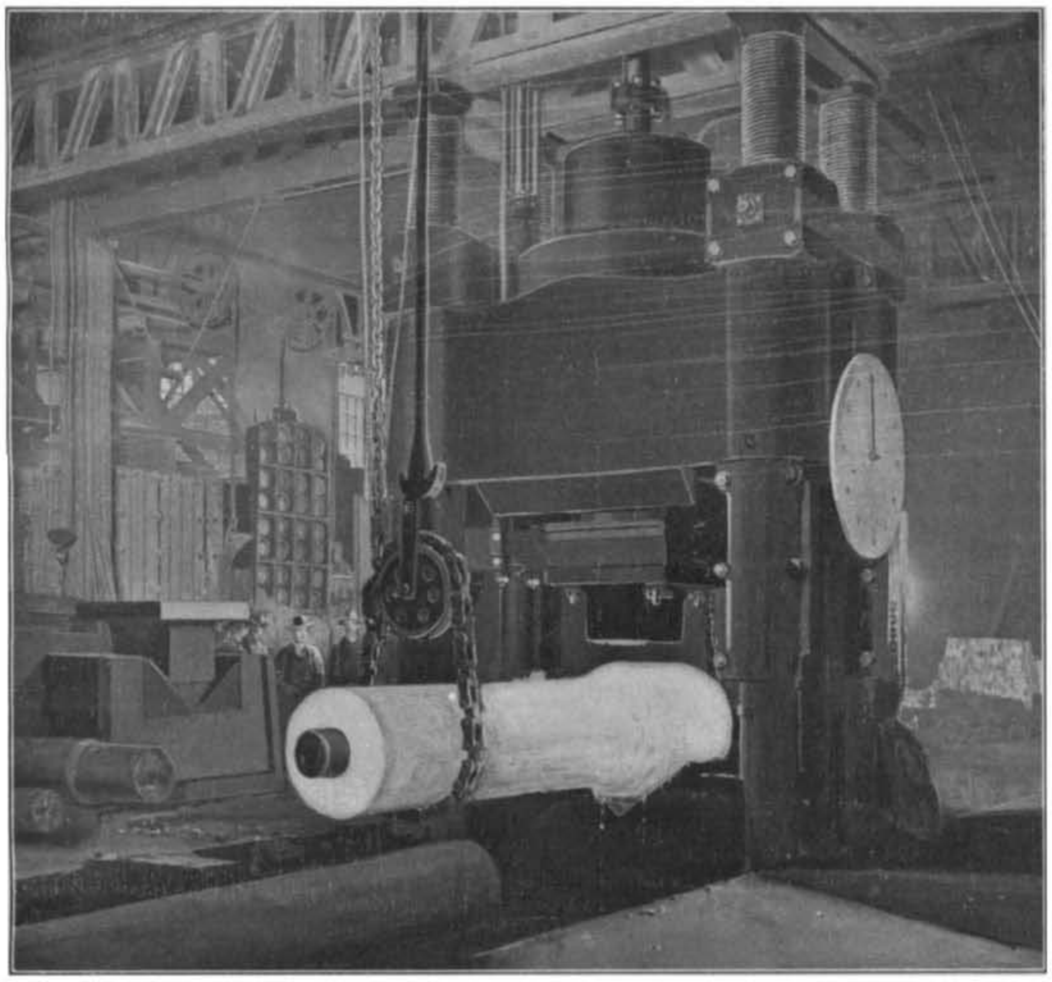
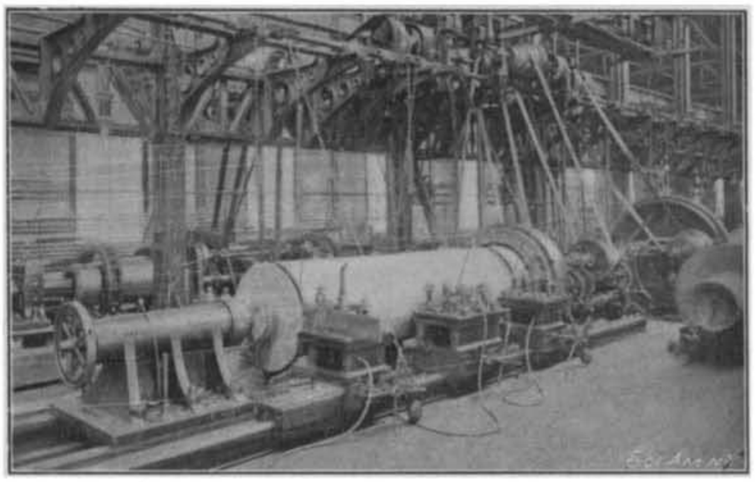
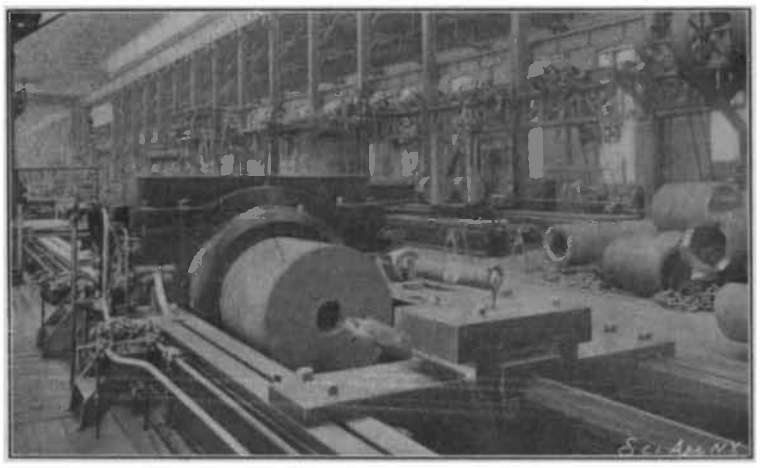


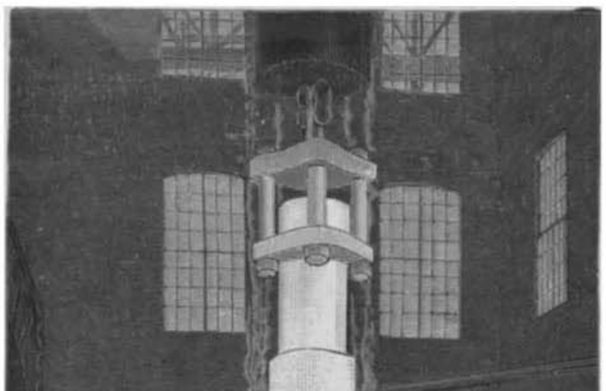
Hollow-Forging a Gun-Tube in the 5,000-Ton Press.



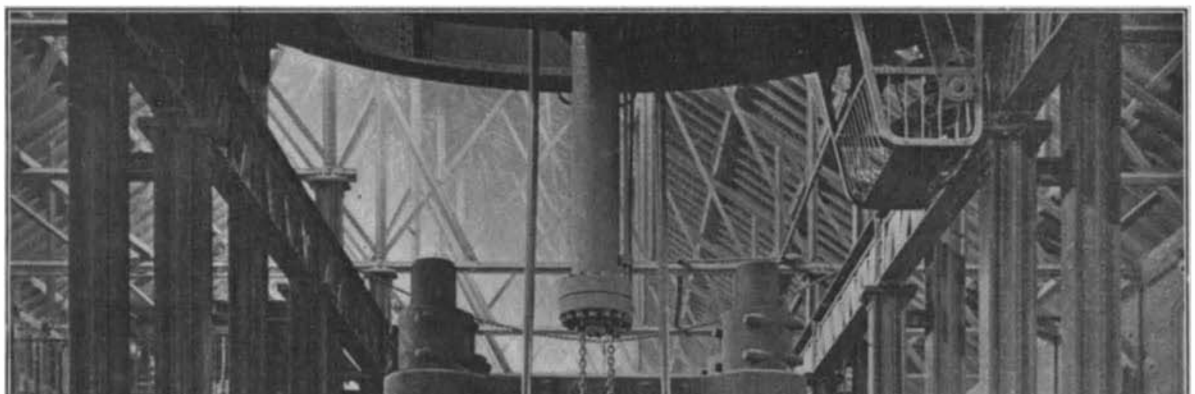
Cutting Fluid-Compressed Ingot into Blocks.



Boring a Fluid-Compressed Ingot Preparatory to Forging.



Oil Tempering a Gun Tube.



End View of the Casting Pit, Showing the Fluid-Compression Plant.

MANUFACTURE OF GUNS AND ARMOR AT THE BETHLEHEM STEEL WORKS—II. FLUID COMPRESSION AND FORGING.—[See page 358.]

protracted pressure of the hydraulic press gives ample time for the molecules of metal to flow over and around one another, and the effects are felt throughout the whole mass of forging. The center metal being the hottest is squeezed out, and the finished forgings have on their ends the convex shape which will be noticed in some of the accompanying engravings, showing that the flow of the metal has been satisfactory.

There are three large hydraulic presses at the Bethlehem forge. One of 2,000 tons, shown in our illustration, another of 5,000 tons, and a third of 14,000 tons. The first two are usually employed upon the gun forgings, while the biggest press, a truly monumental affair, is kept busy upon the huge masses of armor plate. The hydraulic press is constructed upon the same general lines as the fluid compressor. The hydraulic cylinder is carried in the upper head, and the travel of the piston is controlled by a hydraulic lever in the hands of an attendant. The disk and pointer carried at the side of the press indicate the number of inches of stroke of the piston, and as the same length of stroke is maintained throughout a complete revolution of the forging in the press, the piece is roughed out with an accuracy as to diameter and line that is remarkable, and greatly reduces the subsequent labor in the machine shop.

As it is impossible to complete the process of forging such large masses of metal in one heat, and the result of reheating, cooling and working at so many different temperatures is that the forging, as completed, is full of forging strains; to relieve these it has to be subjected to a final heat treatment which is known as "annealing." In annealing the forging is very carefully and slowly heated to a temperature which is slightly above the recalescent point (the point at which all crystallization is destroyed, and the molecules are thrown into an amorphous condition), and it is then allowed to cool very slowly. As it cools, the molecules rearrange themselves, according to natural law, leaving the metal in a state of complete rest. After the annealing, the gun-steel forgings, which consist chiefly of tubes and cylindrical jackets, are oil-tempered to give the necessary toughness to the steel. The forging is lowered into a large cylindrical furnace, where it is heated to a predetermined temperature, and it is then lifted out and lowered suddenly into a large cylindrical bath of cold oil, adjoining the furnace. This temperature being slightly above the recalescent point, there is not time during the cooling process for the formation of crystals, and the amorphous condition which the metal holds at that temperature is retained. The steel cools gradually, owing to the fact that oil is a poor conductor of heat, and the effect of the readjustment of the molecules is that the elastic limit and the ultimate tensile strength of the steel are greatly increased. The forgings are again annealed, in order to relieve the metal of any hardening effect due to the cooling process, and they are now ready to be taken to the machine shop, where they will be bored, turned and assembled into the finished gun.

The government specifications call for an elastic limit of from 46,000 to 53,000 pounds to the square inch, and an ultimate tensile strength of 86,000 to 93,000 pounds to the square inch. Moreover, the steel must show an elongation or stretch at the time of rupture in the testing machine of 15 to 17 per cent in a length of three inches.

We present an interior view of the gun-finishing machine shop, which is 116½ feet in width and has an extreme length of 1,375 feet, or over a quarter of a mile. A graphic impression of what these dimensions are may be gathered when we mention that our illustration is taken from the center of the shop, and presents only one-half of its full length. Here the forging for the A-tube, which forms the major part of the gun, is bored, given its finish reaming and turned on the outside. Then the jacket, a large cylindrical forging which has been bored to the required diameter, is shrunk on over the A-tube, and above this a number of shorter tubes are shrunk, to reinforce the gun over the powder chamber where the heaviest stresses occur. When all the hoops are in place, the gun is put in the lathe and turned to its final dimensions. It is then placed in a rifling machine, and shallow spiral rifling grooves are cut through the bore from the powder chamber to the muzzle. Then follow the construction and fitting of the breech mechanism; after which the gun is taken to the proving grounds of the company and put to the final tests.

A NEW insulator for cables has been obtained by Mr. Heyl-Dia, of Germany, which has cellulose as a base. To the ordinary paper paste is added a non-hygrometric substance, such as oil, pitch or a solution of resin. The mixture is well stirred to render it homogenous, and from this paper is made by the usual process. The quantity of oil or resin varies, according to the nature of the paper paste, from 5 to 40 per cent. Another method is to add to the paste solid insulating substances, such as chalk, talc, etc. The quantity to be added to the paper varies in this case from 10 to 50 per cent.

Science Notes.

The Proceedings of the Accademia dei Lincei contain a memoir of P. Tacchini, upon the earthquake which ravaged the Roman Campagna, on July 19, 1899. It commenced near the Alban Mountains, its epicenter being at Frascati in that city and in the environs the houses and public edifices suffered greatly. The shock was felt at 130 kilometers from the epicenter and was registered by the seismograph at the Observatory of Catania, which is 520 kilometers distant, its rate of propagation was about 4 kilometers per second. A series of interesting curves has been traced by the seismograph placed in the vaults of the Roman College.

Astronomy has recently lost two scientists who have contributed largely to its progress, R. Luther and G. Rünker. The former occupied the post of Director of the Observatory of Düsseldorf, and has discovered 24 asteroids; he died at the age of 78 years. Mr. Rünker was director of the Hamburg Observatory, and published an excellent catalogue of 12,000 stars; he devoted considerable time to the subject of chronometers and introduced a number of improvements in these instruments. The Observatory contains a large number of marine chronometers on account of the importance of the port of that city. Mr. Rünker was 68 years of age. Meteorology has also been deprived of one of its prominent workers, Mr. G. Symons, who was a member of the Royal Society, and president of the Meteorological Society of Great Britain.

The second International Congress of Hypnotism is to be held at Paris from the 12th to the 16th of August. The organization committee in convoking the congress recall the fact that the first congress, held in 1889, united a considerable number of physicians, professors of philosophy, magistrates, advocates and sociologists, and that the communications gave rise to a series of interesting discussions. The second congress has for its aim, first, to fix in a definite manner the terminology of the science of hypnotism, and second, to record and examine the acquisitions made up to the present time in the domain of this science. In order to give to the congress an exclusively scientific character, the committee will only accept communications relating to the clinical, medio-legal, psycho-physiological, pedagogic, and sociologic application of hypnotism and the phenomena relating to it. The congress will be held in the Palais de Congres of the Paris Exposition, the membership fee is 20 francs. All communications relating to the congress, such as requests for admission, manuscript or printed works, etc., should be addressed to M. Bérillon, 14 rue Taitbout, Paris.

A series of observations on the absorption spectra of gases has recently been made by P. Baccei, an Italian savant. As the gases have but feeble absorbent power, the action should be observed when they are submitted to great pressure. The experimenter has made a study of carbon dioxide, nitrogen, carbon monoxide, acetylene, oxygen and hydrogen sulphide. The first three gases do not present any appreciable absorption for a thickness of 70 millimeters under pressures varying from 22 to 10 atmospheres. For acetylene, oxygen and hydrogen sulphide, the absorption spectra become more complex as the temperature is higher. The spectrum given by a thickness of 25 millimeters of acetylene under a pressure of 16 atmospheres shows the following bands: a large band in the red between $\lambda = 0{\cdot}6842\,\mu$ and $\lambda = 6815\,\mu$, which is more intense on the side of the orange, being diffused next the red; a narrow and very distinct band is shown in the orange, at $0\ 6421\,\mu$; a second narrow band near the former ($0{\cdot}6417\,\mu$); a thick and well-marked band in the orange ($0{\cdot}6395\,\mu$); a band in the yellow ($0{\cdot}5707\,\mu$) and one in the green ($0{\cdot}5419\,\mu$) with a scarcely visible band beside it at $0{\cdot}5435\,\mu$. When the pressure is diminished the absorption bands disappear successively, and at 10 atmospheres the band in the yellow is no longer seen; at 9 atmospheres those of the orange and green disappear. The spectrum of a thickness of 70 millimeters of acetylene at 16 atmospheres shows that the three rays in the orange form part of an obscure band, going from $0{\cdot}6426\,\mu$ to $0{\cdot}6395\,\mu$, and there is a very faint band in the violet at $0{\cdot}4062\,\mu$, which disappears when the pressure is lowered to 14 atmospheres. The spectrum of oxygen shows a faint band in the blue, one in the yellow at D, and two groups of bands in A and B, which disappear successively in the order named when the pressure is diminished. The spectrum of 70 millimeters of hydrogen sulphide at a pressure of 12 atmospheres shows in the red a band extending from $0{\cdot}6735\,\mu$ to $0{\cdot}6781\,\mu$, which disappears at 7 atmospheres. As it has been generally admitted that a gaseous mixture gives an absorption equal to the sum of the absorbent effects of its components, M. Baccei wished to verify this supposition, and thus finds that for a mixture of acetylene and hydrogen in the proportion of 1 to 3, to obtain a given absorption band in the spectrum of the mixture, a quantity of the absorbent gas must be taken which would have given the same effect when used alone; other gaseous mixtures give similar results. His experiments show besides that the absorption spectrum of dry air is the same as that of oxygen under one-fifth the pressure.

Electrical Notes.

The erection of a lofty mast on the Nantucket South Shoal lightship, is advocated. This is about 240 miles from Fire Island. This will enable vessels to communicate with New York fifteen or sixteen hours before they reach their piers, by telegraph.

Dr. Friedlander, of Wiesbaden, says Electricity, recommends galvanism to relieve the pain and irritation and to reduce the swellings caused by the bites of insects. The negative electrode is placed over the seat of the sting.

In a newly invented Jacquard loom 600 hooks are controlled electrically. The twill as well as the pattern is under complete control. The pattern of this cloth is woven directly from a photograph or print of the artist's design mounted on a metallic sheet; the threads of the web being picked up by electro-magnetic action owing to the figure of the pattern being cut away and thus allowing circuits to be completed by the metallic sheet.

By the aid of an English apparatus blue-printing can be done by electric light. It consists of a large cylinder of glass around which the tracings and the blue print paper are wrapped. They are held on the outside by a sheet of canvas. An enclosed arc light is lowered into the cylinder at any desired rate of speed, with the help of an escapement wheel and pendulum. A glass cylinder 9 feet 3 inches high and 2 feet 9 inches in diameter is in use at the Elswick shipyards.

A prize of $300 and a gold medal is offered to the designer of the best system of high speed and heavy traffic electric railways. The prize will be awarded by a committee of the German Society of Mechanical Engineers. The conditions call for plans of a railway connecting two distant cities upon which trains, having a minimum seating capacity for 150 passengers each, may be operated at frequent intervals at a speed of not less than 124¼ miles per hour. The contest closes October 6, 1900. It will be extraordinary if any meritorious plans are submitted for a prize of $300. It is doubtful if such great speed is desirable.

A new form of resistance for electric heating devices has been devised by M. Parville. It consists of a mixture of 60 parts nickel in powder and 40 parts of white clay. The mixture, which contains not more than 6 per cent of water, is brought to the desired form by compression, using a pressure of 2,000 pounds per square inch. The parts which form the contact points are made by a mixture of 90 per cent of nickel powder and 10 per cent of clay, in order to diminish the resistance at these points. As it is necessary that a resistance of this kind should not melt under the action of heat or otherwise deteriorate, the solidity possessed by the new compound is greatly in its favor.

Electric smelting on a large scale is to be tried in Switzerland near Meiringen, in the Bernese Oberland, and a concession has been obtained from the State for the working of an outcrop of hematite, says The Engineer. The vein has a thickness of 7 feet and is visible for a length of two miles along the mountain face. The ore will be transported by an aerial ropeway to Innerkirchen below. The concession obtained for the water power amounts to 60,000 horse-power. This will, of course, be more than sufficient to drive the machinery required and to supply the power for the electrical furnace. One of the difficulties which have beset the metallurgical industry in Switzerland hitherto has been the lack of fuel for smelting.

A system of telegraphy by which signals are transmitted by means of rays emitted from an arc lamp has been invented by Carl Zickler of Brunn, Austria. Rays of short wave length (mostly ultra-violet rays) are made use of, says The Western Electrician. These rays are sent out from the sending station at intervals corresponding to those of telegraphic signals, and in the direction of the receiving station, where they produce weak electric waves, by which the signals are made visible as sparks, or are made audible by telephone or electric bell, or, if preferred, may be printed by Morse apparatus. The most serious objection to the apparatus, however, is said to be the lack of speed, for so far it has been impracticable to arrange transmitters and receivers to accomplish more than eight to 12 words a minute.

Zinc plates are now covered with a layer of material in imitation of lithographic stone and the invention forms the subject of an English patent. The zinc plates are cleaned and laid in a solution of potassium bicarbonate, either with or without the application of an electric current. The zinc carbonate is thus deposited upon the surfaces of the plates forming a layer to which the imitation stone material to be subsequently applied firmly adheres. This stone material is composed of sulphate of lime, calcium chloride and aluminium oxide, and is produced by the action of hydrochloric and sulphuric acids upon limestone and aluminium, the yellowish shade natural for lithographic stone being obtained by the addition of a little ferric chloride. The mass is mixed with a solution of soda and is sprayed on the plates with the aid of an injector.