ing three hundred and twenty-four needles in all. The main bar was supported by a wooden column sufficiently high (forty-eight feet at first, afterward one hundred and thirty-two feet) to secure protection for the building and its immediate surroundings. Several iron chains connected the main bar with the earth. The effect of the machine was to divide the lightning into as many sparks as there were needles (three hundred and twenty-four), and thus to lessen its force. It might, therefore, more properly be called a lightning divisor.

Scarcely had the rod been erected when a storm came rushing on from the north. Thunder clouds hung over Prendice, and occasionally white shafts of lightning were seen darting from the clouds and flying toward the conductor. In a few minutes a white cloud enveloped the machine, and the storm soon passed away without doing any damage. For two years Divis continued experimenting with his lightning rod; the results were published by Dr. Srinici in the Prague News (1754). Having satisfied himself in regard to the utility of his new machine, Divis offered to the emperor a plan for erecting a number of conductors in various parts of his empire. The emperor submitted the plan to Viennese mathematicians, who were, unfortunately, a little behind the times, and reported unfavorably upon the Bohemian's proposition. The plan was consequently never carried out. Abbot Marci, speaking about the report of the Viennese "connoisseurs," says, in a letter to Divis, "Blasphemant, quae ignorant" (They blaspheme that which they do not understand). And at last, in 1756, Divis was compelled to remove his lightning rod. There had been a very dry summer that year, which the farmers of Prendice and the neighboring places ascribed to Divis' machine! One day an angry crowd came to the parsonage and tore down the iron bars. The authorities then ordered Divis to take away his machine, and he accordingly removed it and deposited it at Bruck, where it has been kept to this day.

There is a marked similarity between the treatment which the invention of Divis suffered at the hands of his neighbors and that accorded to Franklin's conductor in America. When, in 1755, Massachusetts had experienced a sharp shock of an earthquake, the judgment of public opinion was pronounced upon Franklin's rods as the direct cause of the earthquake. As late as 1770 a Boston clergyman preached against the lightning rods as "impious contrivances to prevent the execution of the wrath of Heaven." The difference between the relative positions of the two inventors was that in America a divine denounced a layman, whereas in Moravia laymen denounced a divine. We unwillingly recall the words of Madler: "In all times and in all countries the enemies of truth and light pretend to be fighting for the honor and glory of God."

Thus Divis was prevented from perfecting his machine, which would have doubtless been wrought by him into a different, more advantageous shape but for the official order. Divis felt himself obliged to give up his studies and experiments in electricity, and his versatile genius turned to a new field—music. He was well acquainted with acoustics, and as a Bohemian he possessed likewise a personal liking for music, and before long his creative genius enriched the musical world with a new instrument which he named "denis d'or."* This instrument is played by both hands and feet, like an organ, and it can give the sound of almost any stringed or wind instrument, from the *pianissimo* to the *fortissimo*, as it has as many as one hundred and thirty registers. In its effect this instrument is equal to a full orchestra.

This was the last great work of Divis, and on the 25th of December, 1765, the untiring worker quietly departed this life.

Personally, Divis had the true appearance of a thinker. In his early youth his health was rather delicate, but it improved steadily after he began his electrical experiments and never failed him again, although he was constantly at work. Oftentimes he was so deeply absorbed in his experiments or observations that he would not notice his friends coming to see him, until a servant reminded him of their presence by pulling his sleeve. The steady mental work gave his face a serious, unfriendly mien, which disappeared, however, whenever he happened to be in a circle of his friends. His guests, among whom there were many distinguished persons, he always entertained courteously. Besides his mother tongue, the Bohemian, he also knew Latin, German, and French. From the papers he left there was printed, after his death, a treatise entitled *Langst verlangte Theorie der meteorologischen Electricitat* (The Long-sought Theory of Atmospheric Electricity), Tübingen, 1768.

Prokop Divis is an interesting example of an ideal scholar. Originally he studied science merely for the sake of finding out the truth; but when he saw that the truths discovered by him could be utilized for the benefit of mankind, he utilized them. Undoubtedly he knew nothing of Franklin, and there is no evidence that Franklin ever heard of Divis; their discoveries in electricity were wholly independent of each other. But Franklin was the happier of the two because he found a people who understood him—the French; while Divis, by his social position, was prevented from perfecting his instrument. We must remember that Benjamin Franklin was a public man, who stood conspicuously before three countries, while Prokop Divis was merely a parish priest of a small Bohemian village, with few or no connections. Yet we admire his genius evinced by inventions so vastly different—a lightning rod and a musical instrument. These are wittily characterized in his epitaph, written by one of his contemporaries:

"Ne laudate Iovem, gentes! quid vester Apollo?
Iste magis deus est fulminis atque soni."†

—Popular Science Monthly.

WATER ELECTRICITY.

FROM many observations and experiments M. Ph. Lenard finds that drops of water falling upon water or wet bodies generate electricity, the water becoming electrified positively, and the air escaping negatively electrified from the foot of the fall, and light impuri-

ties in the water diminish the effect considerably. The essential conditions of electrification are the concussions among the drops themselves and against the wet rock, no effect being due to the water's fall through the air and its dispersion by it. A jet of water falling from an insulated tank to an insulated pail electrified the latter positively, while the negative electrification of the surrounding air grew to several hundred volts. Sparks were obtained from waterfalls.

IMPROVED ELECTRIC FORGE.

GEORGE D. BURTON, of Boston, and Edwin E. Angell, of Somerville, Mass., have invented the following improvements, as described in their recent patent.

The object of this invention is to provide an electric forge for heating sheets of metal from which rakes, hoes, plates, shovels, and the like may be forged or stamped.

Fig. 1 represents a plan of this improved electric forge. Fig. 2 front elevation. Fig. 3 end elevation thereof, the segments of the converter ring being in transverse section. Fig. 4 front, side, and end views of a shovel forged under the electric heat of this improved electric forge. Fig. 5 a rake blank and a rake formed therefrom under electric heat. Fig. 6 plan and side elevation of a metallic dish blank formed under the electric heat. Fig. 7 hoe blank and a hoe formed therefrom.

A current converter for transforming an electric current of small volume, measured in amperes, and of high tension, measured in volts, into a current of low tension or voltage and large amperage or volume is employed in connection with this electric forge to furnish the heating current therefor. The converter which we have used for this purpose comprises an annular core, preferably composed of different lengths of uninsu-

lated or partially insulated heavy wire disposed side by side and arranged to break joints; primary coils composed of comparatively fine wire disposed at intervals around the annulus of the core and insulated therefrom; secondary coils composed of plates or sheets of copper disposed around said annulus between the primary coils and insulated therefrom and from the core, and two exterior heavy copper rings surrounding the structure. The primary coils are arranged in pairs, the coils of each pair being connected in series with each other and in parallel with every other pair and to the terminals of the primary circuit by binding posts mounted on a central support. The secondary coils are composed of copper plates, and all the positive terminals thereof are connected with one of the exterior rings and all the negative terminals with the other exterior ring, said rings thus constituting the positive and negative terminals of the converter.

Any converter capable of furnishing the required current may be used in connection with this improved forge.

In the drawings segments of the exterior converter rings are represented.

The upper converter ring 10 may be considered as the positive terminal of the converter and the lower converter ring 12 may be considered as the negative terminal thereof. The upper ring 10 is provided with a boss 11 and the lower ring 12 with a boss 13, said bosses being disposed at considerable distances apart on the circumference of the converter. A bracket 20 is attached to and depends from the boss of the upper ring 10, and a bracket 30 is attached to and depends from the boss of the ring 12, terminating in the same horizontal plane with the bracket 20. These brackets are composed of copper or other highly conductive material. The bracket 20 is provided with an arm 21 at its lower end, which extends substantially at right angles

BURTON'S IMPROVED ELECTRIC FORGE.

ward, whereby the upper jaws are closed upon and bite the ends of the blank. An electric heating current is then passed through the blank spanning the space between the clamps and heats said blank to a forging temperature. The blank is then removed from the forge and subjected to a metal forging, stamping, or shaping apparatus, whereby the desired article is rapidly and economically produced.

THE ELECTRICAL USES OF MICA.*

By CHARLES W. JEFFERSON and ARTHUR H. S. DYER.

AN armature and its commutator consist of the combination of two elements; namely, electric and magnetic conductors and insulators. In the earlier days of armatures, the electrical and mechanical dimensions and proportions of the conductors were considered of prime importance. The first armatures were small and the electromotive force low, and consequently little attention, comparatively, was given to the element, insulation. Later, simply paper, cloth, convolutions of ligatures, or these materials impregnated with shellac or similar insulating varnish or paint, were employed for the purpose of preventing leakage or short circuit. To remove the solvent of the shellac, the armatures were baked for twenty-four hours. Judging from the variety of materials used at present, and the changes from one material to another, it would seem that the insulators are now receiving their share of consideration, while the core, wires, commutator sections and other conducting portions are secondary details. Why so much difficulty with armature insulators and so little with other insulators, such as line

* Lately read before the American Institute of Electrical Engineers, New York.

* Denis is a French translation of the Bohemian name Divis. D'or means "of gold."

† "Do not praise Jove, nations! What is your Apollo?
This man, rather, is a god of both the lightning and the sound."

insulators? Because, in the former, not only must the material be of extremely high resistance, but also unaltered under the effects of heat, and must be crowded into very small quarters. Space must be economized. If the electric current or heat alone were present, and if space were not so much limited, the problem would be easily solved. It yet remains to be proved that any known substance is absolutely a non-conductor—nor is the resistance of a given conductor constant. Unfortunately for the armature constructor, the worse the conductor, the less the resistance with increase of temperature. An extra current is produced in metals upon variations of current. A diminishing of current occurs when first entering a substance of high resistance. Finally and gradually the current becomes constant. This action for convenience is often called polarization. As this property is noticeable only in long lengths of the insulating material, it has little bearing upon any of the armature elements other than in connection with the covering of the wires. The substance possessing the property of polarization in a marked degree is gutta-percha.

Paper or fabrics by themselves should never be used as an insulator, because when moist they conduct a current so well that they may properly be termed semi-conductors. A coating of shellac or oil on almost any substance enormously increases its resistance, and protects porous and deliquescent substances from water. Paper thus covered serves, with machines of low electro-motive force, the purpose of preventing leakage, but by no means perfectly in practice with large machines. Its advantages are more in the nature of convenience and cheapness than of efficiency.

Paper which has been thoroughly dried is of very much higher resistance, so high that it falls under the head of non-conductors, and, therefore, the shellacs should not be applied until after the paper has been subjected to a thorough drying process.

It is a peculiar property that a given substance in a

heat, its resistance is changed and generally lowered. Manufacturers of incandescent lamp filaments know that complete carbonization cannot take place except at a very high temperature, like 3,000° Fahrenheit. An armature may rise to 500°. At this temperature easily carbonizable materials, such as linen, cotton and other forms of cellulose, are weakened, blackened and the resistance reduced. Shellac, although blackened at this temperature, is converted into those compounds whose resistance is not lowered. Shellac forms an exception, therefore, in being charred by such a temperature without reduction of resistance.

There is a greater detriment than chemical change by heat. The material cracks, becomes somewhat comminuted, and the resistances, both mechanical and electrical, are therefore greatly reduced. If paper or cloth, or even shellac, is depended upon as the insulating material rather than as the binding material, it is not electric proof; because, principally, it becomes, when charred, fractured at numerous points, if not completely pulverized. As to why shellac is not appreciably lowered in resistance by partial carbonization may be because it is an animal substance.

One of the most important attributes of an armature should be its rigidity. It should be like a rock in this particular. If the insulation should consist of a soluble material, for example, and the same dissolved out after the completion of the armature; or of some material that would be reduced in size by heat, then the wire and bolts would soon become loose from the rapid rotation and vibration, and finally the armature would be useless. Change in volume of the insulators has caused nine-tenths of the armature breakdowns.

In the matter of insulation between the disks, it was found that oxidized or rusted laminated armature disks would insulate without any addition of paper or similar insulating films. The only difficulty with such a construction is one of degree. Iron rust insulates, and it is heat proof; but it does not insulate sufficiently to

of material in construction was allowed to counter-balance efficiency of action and durability.

Of all substances, mica probably is the best material for use in armatures, if it is desired to obtain not only efficient electric insulation, but also durability under the influence of heat. The highest temperature to which an armature is subjected, even by short circuit or bad construction, will have no injurious effect upon mica. Mica, thick or thin, may be held in a gas flame without cracking, burning, or melting. It remains unaffected. The reason of this is better understood when it is remembered that it consists of aluminic silicate, containing also potassic, sodic, and lithic silicates, and some ferrous and ferric and manganic oxides. Its chemical constitution varies.

One quality of mica is that which is commercially termed amber mica, and is usually mined in Canada. It is so named from its appearance, and not because it is amber or in any other way similar to it than in its color. India mica is a commercial form noted for its uniform cleavage, great thinness of its laminae, flexibility without fracture and its resistance, which is much higher than that of amber.

Carolina mica is another variety. It is obtained in sheets in the western part of North Carolina. It is the best mica for stoves, but it is too hard for electrical purposes. Mica occurs in so many specific forms that particular names have been given to it.

Muscovite is one of the most common varieties. It occurs in different colors, namely, a dark green, yellow, brown, white, and gray. This is the form usually found in small scales in granite, gneiss, and mica schist, and at the same time it occurs in larger, tougher sheets than any other form. A complete scale is irregularly hexagonal in shape. Lepidolite, or lithia mica, has a pearly luster, as distinguished from the vitreous luster of muscovite. Its scales are usually very small, and it is found in limited varieties of granite and gneiss.

Cryopholite is a sub-variety of lepidolite. A charac-

BURTON'S IMPROVED ELECTRIC FORGE.

compact condition is of very marked higher resistance than when powdered or comminuted; for example, pulverized glass is a semi-conductor, while sheet glass is as high in resistance as silk. This property has been noticeable in armature practice. If the insulating material is cracked here and there, it is unfit for armature use. The cracks are in nature of interstices between the particles of a powder, and at the cracks the material is in part ground. The explanation may lie in the distinction that the pulverized material has more surface, or that damp air exists in the spaces between the particles, or that a spark can traverse a gas better than a solid, or that each particle becomes coated with a film of moisture. The last seems the most probable, because the best surface concentrators of water usually exhibit the property most strongly.

The locations of insulation in an armature are between the armature disks to prevent eddy and Foucault currents; between the core and the windings to prevent the current from short circuiting the coils through the core and burning out the armature; between the commutator sections to prevent leakage from one coil to another; over projections or in grooves in the core; and around in the wire to guide the current in convolutions. All these parts, even in the best made armatures, become more or less abnormally hot. Means have been planned and sometimes put into practice for cooling the parts, and thereby saving the insulation. One method consists in constructing the armature after the style of a fan or with large radiating surface; another in equipping a device to blow out the sparks of the commutator, and again, in using cooling insulating liquids. With whatever precautionary means the machine is equipped, the parts, either accidentally or through inefficiency of means, will become abnormally hot. The machine will be injured if combustible materials form the bulk of the insulator. The materials of an ideal armature consist of copper, iron, and a heat-proof and water-proof non-conductor. If the material is combustible, or altered in its chemical nature by

compensate in most instances for its simplicity and cheapness, and, besides, it is not applicable to any other part of the armature than between the laminae of the core. The great advantage lies in the extreme thinness of the oxide coating, whereby a large amount of iron is obtained in the core. A modification has been suggested, which consists in placing thin mica sheets between every half dozen of the disks. Again, iron wire or ribbon rusted has been employed for armature cores. The wire or ribbon is formed into a ring, around which is the electric conductor. Another modification consists in "casehardening" the iron, and also in japanning the surface. As to commutator insulation, natural mica sheets have been almost universally employed.

If it were not for the matter of mechanical construction and heat, shellacked glass would be a good armature insulator. It could be moulded into any form and made of any degree of thinness. Its objections, however, are well known. Very gradually, and more so than would be conjectured, mica made its appearance in armatures. The introduction of mica into practice appears to have been brought about in the following manner:

An accident would happen to an armature, and before the next night it must needs be repaired. In order to make the temporary remedy, mica sheets or bars would be interposed. In the case of subsequent accidents, the portion repaired by mica was the last to yield. Therefore it was proposed to build the armature primarily with mica. But this change took place very, very gradually, but surely. Manufacturers of stoves, the leading houses being also importers of mica, soon experienced a growth in the mica department of their business, until at present some import more for the electrical industry, especially for armature use, than for stoves. Why it was not employed from the first, no one could positively assert, otherwise than to guess that no one probably thought of it, or insulation was not considered of much comparative importance, or cheapness

teristic feature of the form meionite consists in its occurring much cracked within. It has been found in geodes. Biotite is a form found in volcanic rocks in small scales. It contains much iron and magnesia compounds. Phlogopite occurs usually in limestone. Its sub-varieties are aspidolite and manganophyllite. A very brittle variety is lepidomelane. It is also practically opaque. Its sub-variety is astrophyllite.

The insulating power of mica is superior to that of any other substance applicable to armatures. An advantage peculiar to itself is its even, laminated structure. How wonderful is the thinness of its individual layers! A piece of ordinary writing paper is about 0.005 in. Mica layers have been obtained of a thinness of 0.00003 in. Mechanical difficulties prevent its being split thinner. By pasting it upon a hard surface and splitting it off as much as possible, the remaining fragments are so thin as to become beautifully iridescent. The builder of armatures can therefore split the sheets into any desired and uniform thickness with great ease and accuracy. An interesting property of mica, and one not generally recognized, is its homogeneity of structure and clear transparency, although so black when thick. The writer used a piece one-quarter of an inch thick for observing the late solar eclipse. The effect was better than with smoked glass and as efficient as black glass much thicker.

A valuable property of mica in connection with commutator insulation is its proper degree of hardness, whereby it does not wear away too rapidly under the action of the brushes. If rubber were used, for example, even if it did not burn, yet it would wear off and sparking result, because the commutator surface would not be truly cylindrical. The brushes would be set into vibration.

Again, mica is capable of the finest pulverization, so that any wearing which does take place does not result in the liberation of gritty particles, which would also cause sparking. Such mishaps occur with hardened artificial plastic insulators. The insulation should be

just so thick that the current cannot jump across from one section to the other.

Although so superior for armature insulation, mica is, in its natural structure, accompanied by certain objections, which, in trying to overcome, were more serious than had been anticipated, as it was not until after a long series of trials that a successful article was produced, and not until a novel apparatus for cheapening the process of manufacture was devised. The apparatus is now in operation on a large scale. The description at present is confined, however, to the article, and to full information of its structure, manner of using and properties.

The objections alluded to are: Mica as found in nature occurs in flat sheets only. It has a high degree of elasticity, so that when once bent and released, it assumes its original form. If folded, its brittleness causes fracture. If the natural sheets are compressed in a mould, to try to form armature insulator heads for instance, it is completely broken up.

Secondly, natural mica sheets correspond financially to plate glass. The larger the sheet, the higher the cost per square inch. Mica in small pieces, from four to six square inches, is exceedingly abundant and very cheap. It is often called waste mica, because very limited in its uses, and consisting often of trimmings from larger and more useful sheets. In medium and large sizes of armature the naturally built up mica is so expensive as to be objectionable, although not so much so as to entirely prevent its employment.

Thirdly, between the hundreds, nay, thousands, of thin layers, damp air can enter, and also water, accidentally, which cannot easily or effectually be removed.

Fourthly, mica splits so easily that handling causes injury.

Fifthly, mica cannot be cut transversely to advantage. The edges are unworkmanlike, being ragged and jagged. Neatness in drilling, sawing, and turning is difficult.

Micanite.—Among the attempts which have been made to overcome these objections are those involving the use of pulverized or comminuted mica, which is mixed with a liquid cement and stirred into a paste. While still soft, the mixture is rolled or compressed into any desired form, as if consisting of so much plaster of Paris. In order to give it sufficient strength, one-third of the product is cement. The mica sparkles here and there on the surface, as it glitters on granite. This article should be called a cement insulator, and not a mica insulator, because the current can flow in a straight circuit through the plate without encountering any mica. The cement forms numerous rectilinear paths for the current independently of the mica; and therefore the product in no sense is an equivalent of mica.

A modification of this type of insulator consists of a coarse and thick textile fabric, whose pores and meshes are filled with a mixture composed of comminuted mica and a suitable adhesive substance. Another consists of finely divided asbestos mixed with pulverized mica, silicate of soda and sulphur compounds. It is moulded by pressure into any desired form.

The comminuted mica cement type is useful in trolley wire supports and similar insulators, but for dynamos it is useless, not only for the reason stated, but because of its softening and running under slight heat, being so necessarily rich in cement. If the cement is that kind that chars, the mica crumbles apart. Mineral powders have been mixed with it to render it more fireproof.

An example of the manner of using non-comminuted mica between the core and the windings consists in covering the core with paper, laying sheets of mica over the paper, then laying on another sheet of paper, fastening the whole together by convolutions of cord or similar ligatures, and finally applying the coils. During operation, the paper and mica may shift from their positions, and thereby affect the rigidity of the armature as a whole. Again, the process of applying the pieces and keeping them temporarily in position requires repeated efforts and results in a display of crude workmanship.

The exhibits before you show practical results of work carried on for the purpose of overcoming the objections named.

Large Plates.—One of these plates is a yard square and 0.035 in. thick. Another is of the same size and 1 in. thick, and another about 4 x 12 in. and 1 in. thick. They have nothing to do directly with the armature, but could serve as foundation plates for a dynamo or motor. They are practically all mica. A natural plate of mica of the larger size would be a curiosity—a rarity. Any of the sheets may be cut up into any desired size and shape. The layers cling together much more tenaciously than in the natural plate. The path of least resistance from one side of the plate to the other is in a straight line, and a straight line intersects numerous mica sheets, and therefore the article is a mica insulator and not a cement insulator. These plates are made by such steps and apparatus that, when subjected to heat in the armature, no injury whatever is produced.

Further, they are superior to a sheet of mica as it comes from the quarry, in that they do not absorb water or damp air; in that they are stronger to resist either pressure or tension; in that they may be neatly and easily sawed and drilled; in that they are enormously less costly, and in that they are of about the same resistance. By picking the exhibit apart you can easily learn the structure. The mica of which it is composed is non-comminuted, but the pieces are exceedingly thin. The thickness is, by measurement, about 0.001 in., i. e., about as thin as tissue paper. The sizes vary from two to six or eight square inches. In each layer of mica you may notice that the sheets overlap at their edges, and the cement between the layers is hardly noticeable. The former mentioned plate weighs four pounds and the latter 100 pounds. It is a convenient quality in connection with mica that it can be split into pieces of the thickness required for the particular device under the process of construction. This property is also possessed by the plates exhibited. A thin and long knife may be caused to force its way in any of the many planes parallel to the surface, for the purpose of reducing the thickness or obtaining several thinner sheets from one thick plate.

Some tests were carried on to determine the relative values of these plates and plates of comminuted mica and cement. Using the words of the electrician who

originated and performed the tests, he says: "For the purpose of insulating armatures, any solid insulating material should possess considerable strength and should maintain its strength when submitted to a moderate degree of heat. One piece tested consists of ground mica and shellac, mixed together and rolled or pressed between plates to a uniform thickness. In order to test it, I placed it upon a steam table and left it for a minute, at the end of which period I tested its strength by pressing the end of a piece of wire against its surface with very light pressure. The end of the wire, which was blunt and made of copper, easily pushed its way through the sheet and left a hole when removed. In removing the sheet from the steam table it warped. The second plate consists of layers of sheets of mica, cemented together with overlapping joints. This sheet I placed on the same steam table used for the other sheet, and after one minute had elapsed, tried to thrust the same piece of copper wire through the plate, but without success, though exerting all the strength that could be brought to bear upon it by my hand. After the sheet had been on the steam table for five minutes, I placed it on a thick iron plate, laid a piece of the same copper wire upon its upper surface, put a second sheet of wrought iron on top of it, and put the whole into a hydraulic press. It was then submitted to a pressure of 2,000 pounds per square inch for one minute, and the result was the flattening of the wire and a very slight crumpling of the mica sheet on the opposite side. The plate was then placed between two copper plates, and a weight of about four pounds placed on the upper plate. The insulation resistance of the plate was then tested and found to be 25,500 megohms. I have used similar plates, similarly prepared, in motors, upon which a load of 50 horse power has been placed, the entire thrust of the motor being received by the plates, which in this case were less than one-sixteenth of an inch thick. The temperature was brought up to 650° F., sufficient to burn cotton and melt hard solder without injuring the insulation."

Curved Specimens.—Similar remarks substantially may be made about these as about the large plates. Natural mica plates could never be given a permanent set, or moulded into curved forms. The armature head consists essentially of an annular disk, provided with flanges around one or both peripheries. It is in one sense a continuous piece. The flanges, you may notice, are made separably and then fastened to the disks. There are no joints. Some of the peculiarly curved forms are furnished in order to illustrate that the article may be manufactured in any imaginable form of uniform structure, and in single pieces of uniform properties throughout.

Tubes.—In order to show the unlimited forms into which the material may be moulded, a tube several feet long is exhibited. It may be cut up for use in certain types of armature, or when long, for use on board ship, and in general interior conduit installations.

Stamped Forms.—The flat pieces of peculiar form could be made from the beginning in individual pieces, but it is much cheaper if stamped from larger plates. Before using the large plates for any purpose where an exact thickness is required, they are burnished or surfaced off by machinery. Some of the plates before you are in a crude state, and little scales here and there can be peeled off. The others are so different as to resemble a metallic surface, and, when struck, ring like metal. Some of the forms are for large commutators. Others are flat rings for field magnet cores. The very irregular flat pieces are for certain types of commutators. On account of the almost metallic qualities the product can appropriately be termed an "insulating metal." For convenience it is called micanite.

Commutators.—In equipping a commutator with this material, it is necessary to know something which has been learned by early users only through experience. The insulating and metal sections are put together in the usual manner, and the whole is heated to a temperature higher than that which it will reach in actual practice. While still hot, the elements are clamped tightly together.

Among the exhibits is a mass of odd pieces of mica, sometimes called waste mica; also you will find similar pieces split as fine as possible. These are the result of the first operation. The next step consists in putting them together in the manner shown in the exhibits; that is, in layers with overlapping edges. Between them are layers of a cement having those qualities which fit the product for the purpose intended. Until only recently these pieces were always laid on by hand. Their manufacture required one factory girl per cubic foot per hour. Now, one girl can do the work which formerly required twenty. The girl feeds the machine, and it does the rest. The amount of cement employed is practically infinitesimal, because while in a plastic condition the mass is subjected to such pressure that a mere trace remains, and yet sufficient to obtain proper adhesive qualities. From the beginning to the present improved processes and new machinery have been required.

Dr. James Bowstead Williams has carried on a long series of tests upon the comparative specific resistance of mica and micanite. The data and results are as follows:

The conditions of the tests were absolutely the same in all cases. The potential was constant, being over 3,000 volts. A dynamometer served to maintain the same pressure for different materials. All the samples were kept at the same temperature and under the same hygroscopic conditions for several days. Samples were of uniform thickness. The best samples of micanite gave approximately the same reading as the best India mica, indicating that the resistance of micanite is equal to that of the best commercial mica.

COST OF PREPARING CAUSTIC AND BLEACH BY THE ELECTROLYSIS OF SALT.

MANY processes have been proposed and tried, experimentally, for manufacturing caustic soda and bleach from common salt by electrolysis, but actual figures of the cost of such processes have never been ascertained, or at least published. The first time that impartial figures have been made public was in a communication to the Society of Chemical Industry, on December 5, 1892, by Messrs. Cross and Bevan. These chemists on that occasion gave a long account of the cost of the Le Sueur process, and, though the accuracy of some of the items is debatable, the estimate gives a

sufficiently correct idea of the cost of the electrolysis of salt to make it worthy of record.

A plant to treat 18 tons of salt per day of 24 hours would comprise a pair of engines, each of 1,200 indicated horse power, dynamos and electrolyzing vats. The cost of maintaining this 2,400 indicated horse power, with coal at 10 shillings per gross ton, and depreciation at 10 per cent. per year on engines and boilers, would amount, on very liberal allowance, to £60 per 24 hours, or ¼d. per horse power hour. The loss from indicated horse power to electric power delivered at the terminals of the vats may be taken at 17 per cent., so that the effective horse power would be 2,000 horse power. This would give a current of 331,555 amperes at 4½ volts, and the available ampere hours in 24 hours for the work of decomposition would be 7,957,320. Each ampere hour is theoretically able to produce 0.00292 lb. of chlorine and 0.0033 lb. of caustic soda, so that with a possible efficiency of 80 per cent. in the operation, the actual daily output in this case would be 8.3 gross tons of chlorine, equal to 22.43 gross tons of bleach, and 9.378 gross tons of caustic soda. The bleach at £7 10s. per gross ton would bring £168, and the caustic soda at £12 per gross ton would have a value of £112 10s. The total value of the product would be £280 10s. The cost of production would be made up as follows: Power, 57,600 horse power hours, £60; 18 gross tons salt at 12s. per gross ton, £10 16s.; 12 gross tons of lime at 12s. per gross ton, £7 4s.; labor, £10; casks, packages, etc., £18; depreciation at 10 per cent. per year on electrolyzers, dynamos, tanks, pumps and buildings, £10; cost of renewal of diaphragms and anodes, £30; superintendence, £5; total, £151. In addition to this there is the interest on capital to be reckoned for and minor expenses, amounting altogether to another £10, probably. This would bring the expenditure per 24 hours to £161, as compared with £280 receipts. The cost of the plant would be about £50,000. The item for £30 per day for renewal of anodes and diaphragms seems extravagant. The diaphragms are composed of parchment paper and asbestos cemented together with coagulated blood albumen, and they require renewal every 48 hours. The anodes are composed of rough rods of gas carbon, and have to be renewed every six or eight weeks. What the total consumption of anodes and diaphragms in this plant is, is not given, but £30 per day must surely be a mistake.

THE MANUFACTURE OF LIQUORS AND PRESERVES.*

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CHAPTER III.

LIQUORS BY DISTILLATION.

LIQUORS by distillation are obtained from compound perfumed spirits, which are often prepared at the very moment of the manufacture of the liquor. The aromatic materials are cut, sliced, or pulverized, according to their nature, and are submitted to the same treatment as indicated under the head of "Essences" (page 14143). Macerate the materials in alcohol, add the water, and distill, then rectify with another quantity of water, and draw off the finished product. The distillation finished, the treatment with sirup follows, and the liquor is brought up to the desired strength, colored, and clarified. The sugar is always dissolved by heat in the requisite quantity of water, and the sirup is cooled before the mixture with the perfumed spirit. The rest of the water is then added.

FIG. 44.—ABSINTHE.

The general method of making liquors having been described, the principal receipts for the various liquors will be given.

Absinthe. Grande Absinthe.

Small plant (Fig. 44), with a strong aromatic odor,

* Continued from page 14229, SUPPLEMENT No. 890.