lead in such abundance, the rays reflected by the operating table are almost entirely excluded. In the cover of the box is a rectangular opening 15⅝ by 15⅝ inches. Over this opening, corresponding to plates 11·7 by 15·6 inches and 15·6 by 19·5 inches in size, leaden screens are laid having openings 5·8 by 7·8 inches square and 7·8 by 9·7 inches square.

In Roentgen tubes of greater power, not only the platinum used, but also the entire tube, sends forth rays which cross the rays coming from the platinum, thus producing negatives lacking in definition. To shut off these rays a second leaden screen is mounted on two supports above the aperture in the first leaden screen. An opening is made in the screen of such size that the cone of rays coming from the platinum shall not be crossed. In photographing with this apparatus, plates coated on both sides, or better still, films placed in a plate-holder between fluorescent screens, should be used. To shut off the rays reflected by the plate-holder, a leaden lining is employed. In order to render the manipulation of Roentgen apparatus as easy as possible for the practical surgeon, Kohl has grouped the various parts on a movable table, as shown in Fig. 4. This table on its upper portion carries the spark coil, the interrupter, the current regulating devices, and measuring instruments. On the lower platform the storage batteries are carried. The manipulation by means of this arrangement has been considerably simplified.

In their practical application Roentgen rays are no longer used exclusively for setting bones or for locating foreign bodies, for it has been determined that they also have a healing effect in cases of lupus—an effect characterized by the production of very smooth scars with but little disfigurement of the features. Recently gout and rheumatism have been treated with Roentgen rays, and the results are very encouraging. Experiments are being made to determine the effect which the rays have on bacteria, but no definite conclusions can as yet be drawn. As a whole, the results obtained since Roentgen first made his brilliant discovery have been very beneficial for suffering humanity.—Illustrirte Zeitung.

ELECTRIC PROPULSION AT PARIS.

An interesting application of electric propulsion has just been made at Paris by the French Thomson-Houston Company upon the tramway lines of Place de Republique of Aubervilliers and at Pantin. In Paris the tramways operate through accumulators and externally through overhead trolley. The two lines just mentioned have a total length in Paris of 3¾ and 4 miles. The length outside of the city walls is 1 mile and 1¼ miles. There exist likewise three other lines, which do duty for various villages at the gates of the city.

The track was laid by the Paris and Department of the Seine Tramway Company, and consists of Broca grooved rails weighing about 30 pounds to the running foot in the middle of the roadway, and of Vignole rails where it approaches the sidewalks. The cars employed (Fig. 3) are large coaches with seats on the roof. They are capable of carrying 56 passengers—4 upon the platform, 24 in the interior, and 28 upon the roof. Contrary to what happens almost everywhere, they may be criticised as being too capacious. In order to assure a proper service, it is preferable to use small cars and run them at short intervals. Let us add that the present cars, apart from this, comprise a whole series of improved apparatus. They rest upon trucks jointed in front and behind that permit of utilizing adhesion upon the two driving axles.

The cars are perfectly symmetrical in front and behind, and so it is unnecessary to turn them around at the terminal points of the line. At the upper part is the trolley pole, which is fixed in a groove in order to permit of the passage beneath the railway bridges of the city.

Each driving axle is actuated by a 25 horse power electric motor. The controllers that are used for the coupling and maneuvering of the various apparatus are placed upon the front and rear platforms. We must not forget to mention that each car is provided with sand boxes for spreading sand upon the tracks when necessary, and with ordinary brakes and electromagnetic ones on each axle. These latter have permitted of stopping, within less than 50 feet, a car carrying 4·4 tons, upon a gradient of three-tenths of an inch to the foot at a speed of 12 miles an hour.

The accumulators, which are those of the Société pour le Travail Electrique des Metaux, are 224 in number, with seven-plate elements of a capacity of 35 amperes-hour. The plates, which are 12 inches in height and 3 in width, are inclosed in ebonite boxes. The box that contains the battery, and which is placed under the car (Fig. 3), is 5·6 feet in length, 6·5 in width, and 2 in height. The electric equipment of each car, upon which we cannot dwell here, permits of sending to each the current from the trolley, or that from the accumulators, or the current from the trolley for actuating the car and at the same time charging the battery of accumulators. Each car is lighted with ten 16-candle incandescent lamps.

The electric works that furnishes the necessary energy is at the depot of Aubervilliers. It is divided into two principal parts. On one side is the boiler room, the engine room, and the shop for repairing the accumulators, and on the other are the tracks for the cars not in use, with arrangements for thorough inspection. The boiler room contains three Roser multitubular boilers of a heating surface of 2,200 square feet. These boilers are placed below the surface. The coal coming in at the surface is emptied through hoppers into cars.

In the engine room, which is situated back of the boiler room and parallel with it, there are three single cylinder horizontal expansion engines of the Corliss type, of 250 horse power and 75 revolutions per minute. Each of them, through a belt, actuates a 6-pole Thomson-Houston dynamo of 150 kilowatts and 550 volts, at 400 revolutions a minute. They were constructed by the Postel-Vinay establishment. These apparatus are capable likewise of operating as shunt dynamos at 575 volts for charging accumulators. Two main circuits start from the distributing board, one at 530 volts for supplying the trolley and the other at 575 volts for charging the way stations. The feeders are capable of being branched one upon the other at will.

Such are the principal arrangements of a new installation of mixed propulsion by accumulators and an overhead trolley, which seems to us to fully respond to the present exigencies of travel in Paris.

For the above particulars and the illustrations we are indebted to La Nature.

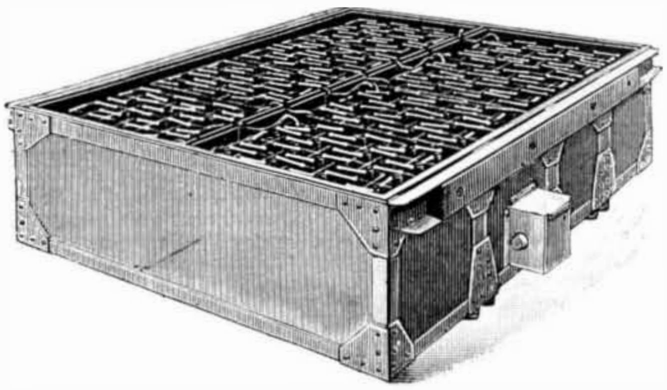

Fig. 2.—BOX CONTAINING THE ACCUMULATORS.

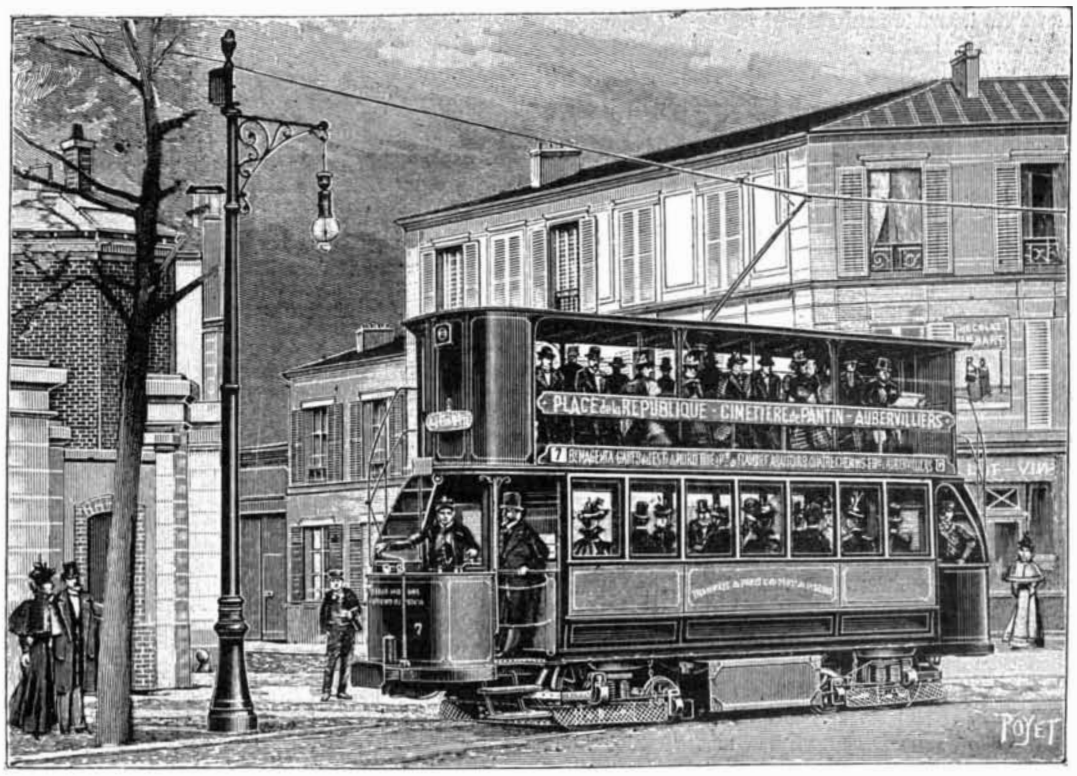

Fig. 3.—VIEW OF A CAR AND OVERHEAD TROLLEY.

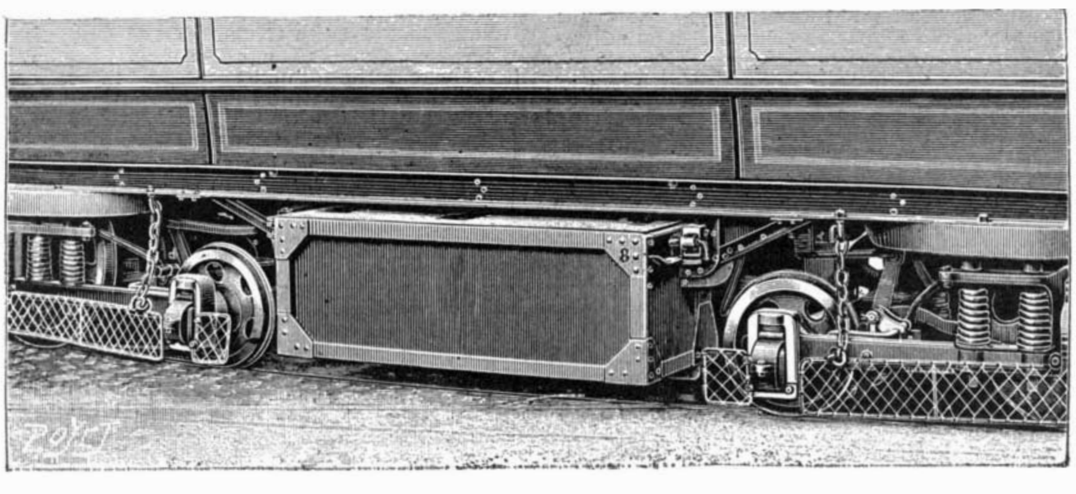

Fig. 1.—VIEW OF THE TRUCKS UPON WHICH THE CARS REST. THE BATTERY OF ACCUMULATORS IS PLACED IN THE MIDDLE.

ALUMINUM AS A RIVAL OF COPPER AND BRASS FOR ELECTRICAL CONDUCTORS.

By Alfred E. Hunt, S.B., in The Aluminum World.

Copper has been used for electrical conductors very largely in the past, due to its comparatively high electrical conductivity, power of withstanding corrosion, ease of soldering and brazing, malleability, tensile strength, and ductility. The exceptions in the past have been in telegraph wires of soft wrought iron and the brass, iron, and steel used in the parts of electrical machinery.

Aluminum has already been used successfully for the purpose, and this article is written to call attention to its comparative merits as an electrical conductor.

The following facts regarding the metals copper and aluminum, in bars, rods, and wire suitable for electrical conductors, need first to be considered:

Copper has a specific gravity of 8·93 (Authority—Association of Copper Manufacturers of the United States, 1893); an electrical conductivity, when pure and soft annealed, reckoned at 100 in the Matthiessen scale, but as ordinarily used in electrical conductors of about 98—97·61 (Authority—Prof. W. C. Roberts-Austen); a tensile strength of from 16,500 pounds per square inch in soft annealed pure copper (Authority—Carnegie's Hand Book) to 65,000 per square inch in hard drawn bars; and a selling price of about fourteen cents per pound in the United States, and an equivalent selling price of 130 marks per 100 kilogrammes in Germany, for wire, bars, and rods such as are used for electrical conductors.

Aluminum has a specific gravity of 2·68; an electrical conductivity (commercially pure metal) of 63·00 (Authorities—Chas. F. Scott, of the Westinghouse Electric Company, and Prof. Jos. W. Richards, of Lehigh University); a tensile strength in pure soft wire of 26,000 pounds per square inch, and in hard drawn rods or wire of 40,000 pounds per square inch.

Special selling price: The firm of Aron Hirsch & Son, of Halberstadt, Germany, are ready to sell aluminum conductors in the form of rods, bars, plates, and wire drawn to 2¼ millimeters in diameter, at the special low rate of 280 marks per hundred kilogrammes, for large quantities of metal, and similarly the Pittsburg Reduction Company will sell rods, bars, plates, and wire drawn down to No. 12 Brown & Sharpe gage (eight hundredths of an inch diameter), in large special orders for electrical conductors, at the rate of twenty-nine cents per pound at their works in the United States.

These prices are special rates, below the regular prices for aluminum which these concerns have decided to make for electrical conductors alone, in order to favor the introduction of aluminum for this purpose and to overcome the handicap which aluminum has occasioned by its lower electrical conductivity than copper, in the matter of special low relative prices.

From these facts it is evident that:

1. Any given volume of copper is $\frac{893}{268}$ or 3·332 times heavier than an equal volume of aluminum.

2. The equivalent price of fourteen cents per pound for copper for any length of any equivalent section of aluminum wire or bar would be 14 cents times the factor 3·332, or 46·65 cents per pound. That is, one thousand feet of wire of, say, one-tenth inch diameter would cost equally as much if bought of copper at 14 cents per pound or aluminum at 46·65 cents per pound. Aluminum, therefore, sold at 29 cents per pound is only about 62 per cent. of the cost of copper at 14 cents per pound, section for section.

3. Reckoning the copper conductor to have its maximum of 100 per cent. conductivity, and the aluminum to have a conductivity of 63 per cent. (which the Pittsburg Reduction Company are ready to guarantee for their special pure aluminum metal for electrical conductors), then for an equivalent electrical conductivity a given section of copper that can be placed at 100 should be increased in area in round numbers to 160 to give an equal conductivity.

4. Due to their relative specific gravities, the weight of the given equal length of the aluminum conductor with 160 sectional area will be only forty eight per cent. of the weight of the copper conductor with sectional area of 100 having the same electrical conductivity.

100 × 8·93=893, weight of the copper.

160 × 2·68=428·8, weight of the aluminum.

$\frac{428 \cdot 8}{893}=48$ per cent.

5. As to their relative cost for electrical conductors of equal conductivity, aluminum at twenty-nine cents per pound is the most economical conductor as compared with copper at fourteen cents per pound.

Taking as an illustration an aluminum conductor to replace a copper wire of No. 10 B. & S. gage (about one-tenth of an inch diameter), the aluminum wire of equal, in fact somewhat superior, electrical conductivity would be of No. 8 B. & S. gage (slightly over one-eighth of an inch in diameter).

The weight of a mile of No. 10 copper wire is 162·32 pounds; and its cost at 14 cents per pound would be equal to $22.72.

The weight of a mile of No. 8 aluminum wire would be 79·46 pounds and at 29 cents per pound would cost $23.04.

Forty-eight per cent. of the weight of the No. 10 copper wire, which will give equal electric conductivity in aluminum wire, would only weigh 77·91 pounds; so that more accurately, $22.59 would be the cost of a mile of aluminum wire at 29 cents per pound to replace a mile of No. 10 copper wire at 14 cents per pound, costing $22.72.

6. The Continental requirements in tensile strength for soft copper wire, rods, and bars used as electrical conductors is twenty-two kilogrammes per square millimeter; the English requirement being similarly fourteen tons per square inch; and our American requirement is about its equivalent of 32,000 pounds per square inch.

Aluminum wire, rods, and bars will be furnished of 63 per cent. electrical conductivity, which will have an equal tensile strength per unit of area with the copper, and therefore with the electrical conductivity equivalent of forty-eight per cent. of the weight of the copper and sectional area of 160 against the areaof the copper section 100, the tensile strength of the aluminum conductors will be as 100 for the copper is to 160 for the aluminum. This would mean if a square inch of copper conductor was used of, say, 32,000 pounds per square inch tensile strength, the equal conductivity area of 1·6 inches of aluminum would have a tensile strength of 51,200 pounds.

It has been already determined that with aerial lines, the snow and ice load is practically as heavy on length of small wire as upon larger sections, so that no objection upon this score can probably be found to the use of the larger sections of aluminum wire.

Both on account of having 48 per cent. of the weight and on account of having about 60 per cent. more strength, the aluminum conductor could be used in much longer spans between supports, and the number of expensive poles and insulators can be materially diminished. Properly drawn aluminum wire is as tough and will stand bending as severely without breaking as soft copper wire. The toughness of aluminum wire is, however, greatly modified by the care and skill used in manufacture. If it is drawn too severely through the dies or is not well annealed at the proper intervals in the drawing operation, it is finished much more brittle than when properly manipulated.

Hard drawn copper wire, especially that in the smaller sections drawn through diamond dies, is furnished with a tensile strength of 65,000 pounds per square inch. What the maximum tensile strength of the best pure hard drawn aluminum will reach under similar favorable conditions for developing the maximum tensile results has not yet been determined, but from experiments already made it can quite surely be predicted that at least 50,000 pounds per square inch can be obtained, and perhaps even higher strength still.

Aluminum hardened with a few per cent. of alloying ingredients can be furnished in wire with a tensile strength far in excess of what can be obtained in pure aluminum. Experiments are now being made by the Pittsburg Reduction Company, to determine just what alloy will furnish the maximum tensile strength, together with maximum electric conductivity. From results already obtained, it can surely be predicted that an alloy of aluminum can be furnished which drawn into wire will have a tensile strength of at least 65,000 pounds per square inch and electrical conductivity of more than 50 in the Matthiessen scale. This material to rival hard drawn copper wire and the silicon bronze materials which are now in use, where maximum tensile strength together with good electrical conductivity are required.

The power of withstanding corrosion is greatly in favor of aluminum as an electric conductor over copper. Copper does not change in dry air, but in moist air it becomes covered with a green layer of basic carbonate of copper, which itself has a corroding action and does not coat and protect the underlying copper from further corrosion. Ammonia in contact with copper absorbs oxygen and the copper dissolved in consequence of the formation of a soluble cupric oxide and ammonia. This action is especially a source of trouble where copper wire is used in connecting rail joints in the tracks of electrical railroads where the ground is often subjected to ammoniacal solutions.

Aluminum similarly is not acted upon in dry air and the corrosion in moist air is of the oxide of aluminum, alumina, a harmless salt which forms an impenetrable coating on the metal and protects it from further corrosion to a considerable extent. Ammonia solutions act on aluminum only upon the surface, attacking it and leaving behind a more resisting surface coating of a brown color containing silicon, which resists corrosion from dilute mineral acids and dilute solutions of organic acids as well as moist and dry air. Subject to sulphur gases such as locomotive flue gases, aluminum withstands corrosion better than copper.

If kept free from galvanic action with any other metals, electro negative to itself, aluminum is far less easily corroded than copper.

The difficulty of soldering or brazing aluminum is the chief drawback to its use as an electrical conductor. Aluminum can be soldered strongly, but it is a more difficult and slow operation at best as compared with copper, and there is much more rapid weakening of the soldered joint, due to galvanic action between aluminum and the metals of the solder, than with the less electro positive metal, copper.

In many places the aluminum can be first coated with copper and the soldering or brazing operation made on the copper surfaces thus formed.

Several forms of joints have been successfully used to avoid the necessity of soldering; the best forms being to use thin aluminum sheets to wrap the joints and to twist or otherwise bind with the aluminum bars or wires to be joined. These wrapped and twisted joints with aluminum sheets can be left smooth on the outside when desired, can be made much stronger than the body of the conductors, and are really a more serviceable job than soldered or brazed work in many cases with copper. One very practical way of making joints of aluminum wire is to roll the thin aluminum sheet of about six inches width into two cylinders from opposite edges of the sheet. These double cylinders are very cheaply made on mandrels in a lathe. The ends of the wires to be joined are inserted in these cylinders from opposite ends and both the wire and the sheet twisted with pliers until a firm joint is secured, much stronger than the body of the wire. The joint can readily be made impervious to the air and moisture.

The C. McIntyre Company, of Newark, N. J., have a patented joint which is made very much along the lines of this joint. Information regarding their patented form of joint can be obtained by correspondence with them as above. Also the American Electric Fuse Company, Chicago, Ill., make a very satisfactory joint.

Another disadvantage which handicaps aluminum in special uses for electrical conductors will be where the material has to be insulated that the cost of insulation will be approximately one-third greater for the larger section required in aluminum over the cost for the smaller section of copper required for the given conductors; and where aluminum is to economically compete for insulated conductors, the price of the aluminum will have to be further reduced to meet this contingency.

Aluminum is soon to be placed in an extensive line of conductors, where this added extra cost of insulation will be determined by actual fabrication, the Pittsburg Reduction Company, in this particular case, agreeing to pay the added costs, in order that actual experience may be gained as to their relative amounts.

There are certain places where aluminum will be at a disadvantage over the smaller section of equal conductivity of copper, in ducts or conduits, where space is a considerable item. In such cases, the use of aluminum would necessarily be prevented.

An ample field for the employment of aluminum for some time to come, however, seems open at the present time for bare transmission lines, especially for high potential long distance work, and for long distance telephone lines and for rapid transmission telegraph lines.

Aluminum, next to gold, is the most malleable of all the metals, and is much more malleable than copper.

Aluminum, in ductility, stands next to copper, and is easily drawn into all sections that are furnished in copper for electrical conductors.

Aluminum can be furnished fully as uniform in its composition as copper.

The metallurgy of copper is comparatively complicated, owing to the difficulty of converting its ores into the oxide free from impurities. In most of the copper ores used sulphur, lead, and iron are contained, as well as small quantities of other elements, as arsenic and antimony. All of these elements in metallic copper very materially lower its electrical conductivity. The native pure copper of the Lake Superior region enjoys the preference, due to its uniformity and freedom from impurities, for many purposes, but for electrical conductors the electrolytic copper is most used.

Aluminum can now be furnished for electrical conductors at least 95·50 per cent. pure. It is granted not as yet rivaling in purity of composition the best electrolytic copper used for the purpose of electrical conductors. When as pure a metal is obtainable, undoubtedly it will nearly rival copper in electrical conductivity, section for section.

Aluminum has been already in successful operation as an electrical conductor for some time. The first use in a large way was with the conductors for the electric current at the Niagara Falls Works of the Pittsburg Reduction Company, where it has been used since the year 1895. The currents were of several thousand horse power each and of very large volume and comparatively low voltage. Both in conducting power, freedom from heating effects, power of withstanding corrosion, ease of making, wear and efficiency of joints, the aluminum conductors have given better results than copper used for the same purpose.

In the Chicago Stock Yards a mile of aluminum wire of No. 11 gage has now been in use for some time, upon a telephone line that had been badly corroded out in copper wire, due to its being frequently subjected to sulphur gases from passing locomotives. The aluminum line is giving good satisfaction and is withstanding corrosion much better than did the original copper wire subjected to the same influence.

If the theory be true that the passage of high voltage alternating currents of great frequency is largely upon or near the surface of the conductors only or mainly, then the larger section of the proposed aluminum conductors will make them especially adaptable for such currents.

On telephone lines it has already been determined that as good sound transmission is obtained with aluminum of equal section as with copper, in ordinary lengths of less than ten miles of wire. No comparative results, however, have as yet been determined on long distance telephone transmission; but the evidence would seem to point that a much less section than 160 of aluminum to 100 of copper will give equally good results.

Aluminum is now being used to replace brass very considerably in the arts, as it is sold in the open market at rates which make it ten per cent. cheaper, section for section, than brass.

For electrical purposes, the metal can be advantageously used to replace brass in a good many ways. Commercially pure aluminum as furnished to-day contains less iron than does commercial brass, and is, therefore, more non-magnetic than brass.

The electrical conductivity of aluminum is far superior, section for section, to brass. Almost every electrical apparatus of present construction in which an iron core—usually a laminated iron core—is used in motors, generators, or transforming machinery, has spaces for ventilation, and the spacing is made by the means of drawn bars, flat rods, or angles or tee shape pieces. Brass has been almost invariably used for this purpose in the past—probably on account of its non-magnetic properties as compared with iron or steel. Drawn aluminum sections can be furnished at a price which is ten per cent. cheaper than brass, section for section, and, on account of the lightness of aluminum, it can be advantageously used.

Where a low electrical conductivity is desirable, as in parts that are moved in a magnetic field, to prevent the occurrence of eddy currents, aluminum can be alloyed with zinc and other metals that will lower its electrical conductivity to the desired point.

COST OF MACADAM ROADS IN MASSACHUSETTS.

In compliance with an order of the common council, Winslow L. Webber, city engineer, and F. R. Wheeler, superintendent of highways of Gloucester, Mass., have made estimates of the cost of macadamizing Eastern Avenue, Prospect and Washington Streets, Essex Avenue, East Main Street, and Maplewood Avenue. They state that the cost of State highway construction under the contract system during the last three years has ranged from $6,600 to $24,547 per mile, and has averaged $10,033, divided as follows:

For grading and excavating	$1,241
For gravel	520
For Telford and drains	367
For macadam and shaping	5,694
For masonry	448
For guard rail	188
For paved gutters	191
For engineering, superintendence, and inspection	679
For minor construction, drainage, catch basins, culverts, etc	431
For stone bounds	54
For advertising	18
For weighing stone	24
For sundries	178
Total	$10,033

They state that the elements of the cost of a macadam road are so numerous and variable that it is always a local question which depends upon the cost of labor, superintendence, transportation, tools, machinery, character of stone, drainage of roadbed, etc. The estimates which they submit are based on the contract system. If the work is done by day labor under the direction of the highway department, 25 per cent. should be added. These estimates are as follows: Eastern Avenue, $10,000; Prospect Street, $5,500; Washington Street, $63,250; Essex Avenue, $47,250; East Main Street, $6,500; Maplewood Avenue, $4,900; Western Avenue, $1,400; Main Street, $3,400; total, $142,200. This estimate is for a total of about fourteen miles of macadam.—Municipal Engineering.

Though not a new thought, the superintendent of the gas works at Cracow, Austria, has proposed a new method designed to prevent the freezing of gas pipes. According to this plan, there is employed a brass cylinder, soldered upon the gas main and containing a basket of chloride of lime. The gas on passing through the basket causes the chloride to deliquesce and fall to the bottom of the box and there to liquefy, the liquid being drawn off from time to time and the chloride revivified by heating in a furnace to drive off the water. When the chloride begins to deliquesce its ability to absorb water is not great as when dry, but remains considerable still. Whatever the drawbacks to success involved in this method, it is admitted that, by means of some of the processes of manufacture now in vogue, chloride of lime is no longer very expensive and might come within the scope of this application; at any rate, it is acknowledged that the removal of water from gas would have the effect of increasing its lighting and heating power and largely preventing rusting and bursting of the pipes during freezing weather.

One Millionth Part of a Second.—A chronograph has been invented which is said to excel by far all former achievements in this field and to admit of measuring one millionth part of a second and even smaller spaces of time. The apparatus is based on the following principle: At the end of a tuning fork of a very high number of vibrations, a hole is provided, through which a pencil of rays falls upon the case of a revolving cylinder, whose circumferential velocity is 30 meters per second. In consequence of the quick vibration of the tuning fork and the rotation of the cylinder, the said luminous tuft describes upon the cylinder (which is doubtless covered with paper sensitive to light) a curve whose dimensions correspond to certain particles of time.—Deutsche Uhrmacher Zeitung.