

altered except by the movement of electrons; electric currents are streams of moving electrons; magnetism is caused by revolving electrons, luminous and electromagnetic waves by oscillating electrons; peculiar rays (cathode and X-rays) consist of electrons moving at great velocities, unhampered by material atoms.

IV. CONCLUSIONS.

It appears from this discussion that recent progress in electrical theory has been, in many respects, retrograde, and we may well wonder what direction its development will take in the future. Two elements of uncertainty deserve special mention.

In the theory of Lorentz, the ether is assumed to be absolutely motionless, while electrons and atoms

are free to move. Now, as every movement of an electron develops an electromagnetic field, the motions of the earth and the sun must give rise to terrestrial electromagnetic disturbances. Lorentz has demonstrated that in certain very special conditions these disturbances should be perceptible, but experiments of great delicacy have failed to detect them. Hypotheses have been advanced to explain this discrepancy but the problem, in all probability, will long remain unsolved.

The second uncertainty attaches to the mass of the electron. Its effective mass is found to depend on its velocity—an apparent paradox, for invariability seems a necessary property of mass. But the electronic

theory, particularly in the form which Abraham has given it, leads inevitably to the conclusion that the mass of the electron consists entirely of energy. Hence the mass is fictitious, and the electron is an immaterial point attached by indestructible bonds to the electromagnetic field. But the electromagnetic field is an electrical phenomenon, hence we are explaining electricity by means of electricity. Again, if the atoms of all matter are composed of electrons, and these are only centers of force, the entire universe is immaterial. Nothing is left except electricity, and to the question: "What is electricity?" we can give no answer.—Abridgment of a paper read before the Keplerbund at Frankfurt.

REBUILDING THE PARIS TELEPHONE SYSTEM.

A RECORD-BREAKING PERFORMANCE.

BY S. E. BROWN.

COMMERCIAL speechless—such was practically the condition in which thousands of business men of Paris found themselves on the morning of September 21, 1908. Berlin, which the day before was at their elbows, now lay to the northward distant six hundred miles; London, only a moment's time away twelve hours before, was now across the sea; and the provinces of France, which had lain within the shadow of the walls of the capital, now stretched from Alsace-Lorraine to the Pyrenees.

The burning of a single building in Paris—the great Central Telephone Exchange—was what isolated and paralyzed her commercially. A fire of a few hours' duration ate up much valuable property, took the business district out of a single structure, spread it over a wide area, and pushed the city back in history more than twenty years.

Rob any modern city of its telephone system, and it goes back to where it stood before the telephone became a commercial necessity. But what makes the modern city helpless when its telephone equipment is destroyed, is that it cannot go back. The reason for this is that the telephone made the modern city possible. Try to imagine New York's skyscraper district without the telephone!

Business for one day in Paris was carried on by means of what telegraph lines had not been ruined when the telephone building burned, by messenger service, by special conveyance, by every method possible that would give a greater speed than mail. The next day saw an emergency telephone equipment caring for crippled business as best it could. Meanwhile hurried conferences were being held by the Paris telephone managers with the Paris representatives of an American manufacturing company relative to an equipment to take the place of that destroyed; for emergency equipments at best are but first aids to the wounded, and are to be put aside as speedily as possible.

The building of equipment for a telephone exchange the size of the one destroyed requires time, and the people of Paris were clamoring for telephone service. This explains why the managers of the Paris Telephone Company immediately after the fire took their problem up with the largest manufacturers of telephone apparatus in the world. Speed was the controlling factor; speed and quality. So they turned to a company that held the record for both.

The task assigned to the Paris house of the company in question was staggering.

When the request from Paris was telegraphed to the United States, the men in charge of the telephone manufacture figured coolly and swiftly. They knew what they had done in similar cases could be done again. September 22 Paris had the cabled reply that the Americans could furnish their part of the equipment complete in less than thirty days.

A diversion was created on the 24th by Paris asking for switchboard cable—a request which terminated a few days later in an order for 135,000 feet. The full amount of the size desired was in stock. Shipping cable by steamer differs from shipment by rail. The cable must be fully protected from salt water. Nevertheless, the 25 miles of cable was unwound from reels, the ends paraffined, the cable rewound on reels, packed in waterproof cases, and placed on cars in less than two days after receiving the order.

On September 29 the New York house gave orders to begin work on a switchboard, and stated that the Paris house had agreed to have the entire installation completed in sixty days and that a \$600 daily penalty was attached to the contract.

Men trained to the minute in switchboard building began their tasks. In a trifle over three weeks after a definite order had been given by the managers of the telephone exchange in Paris, the finished switchboard was ready for shipment.

Reservation was made on a French Line steamer that sailed on October 29, and arrangements were made with railroads that special attention be given the shipment. It was. The six carloads of material came 1,000 miles to New York in about two days.

The shipment together with a large amount of additional material which the New York house had manufactured was sent to Paris on the French Line steamer "La Provence," that sailed from New York on October 29. Thus only a few days more than a month elapsed from the date the fire occurred in Paris until a complete switchboard from the United States was on the sea; a switchboard, by the way, which stands 180 feet long, requires 90 operators to operate, and will accommodate more than 10,000 subscribers. While the back of this switchboard would appear as unintelligible to the layman as a page of Sanskrit, it may be of interest to know that it contains about a million soldered connections and 3,000 miles of wire. It is of some interest also to know that approximately 40,000 feet of lumber were used in packing the completed board, and that 10,000 square feet of paraffine paper was used in the cabling boxes alone.

EXPERIMENTS ON THE CONSTITUTION OF THE ELECTRIC SPARK.

By photographing on a rapidly-moving photographic film the spectrum of the ordinary oscillatory spark with small self-induction, T. Royds has obtained some valuable results. The method has now been applied to study the spark when the self-induction of the circuit is gradually increased. On account of the feebleness of the light in these cases it has been found necessary to remove the prisms, photographing directly the image of the slit, in order to avoid the loss of light due to dispersion by the prism. It is still possible under these conditions to differentiate by their character the streamers in the metallic vapor from those in the air. Condensers, whose capacity amounted to about one-third of a microfarad, were charged from a large Wimshurst machine and the spark of 8 millimeters length passed between metal electrodes. Self-inductances, ranging in value up to 0.026 henry, could be inserted in the circuit. The velocity of the photographic film was about 100 meters per second. The commencement of the spark is marked by a sudden and almost instantaneous luminosity of the air, showing on the photographs as a narrow vertical line. The duration of the luminosity is not appreciably affected even when the period of the circuit reaches a value of about 2×10^{-4} seconds. This initial air discharge does not start quite simultaneously at all parts of the spark length. It is followed by another type of streamers through the air in which the duration is comparable with the interval between the oscillations; in some cases the oscillation is divided into more than one air streamer. After the initial air discharge has passed, the light from the spark is chiefly due to the metallic vapor which is produced. The moment of vaporization of the metal is simultaneous with the passage of the initial air discharge. The first streamer in the metallic vapor often reaches to the center of the spark. The slope of this streamer gives the velocity with which the vapor first produced is moving along the line joining the two electrodes. The luminosity of the metallic vapor afterward consists of streamers starting from the electrodes. At the instantaneously positive electrode the luminosity of the streamers is of longer duration than at the negative; the streamers are not so numerous nor so distinct. There is not, however, the marked difference in the intensity of the streamers at the instantaneously positive and negative electrodes which was noticed in a previous paper on the spark with small self-induction. It is again found, however, that at the commencement of the spark, vapor is produced at both the positive and negative electrodes. Dark spaces at the electrodes

separate the oscillations of the circuit and serve to measure the period of the oscillations.

The Velocity of the Metallic Vapor.—The measurements of the photographs show that the velocity of the metallic vapor first produced is smaller in the spark with self-induction than in the ordinary spark. In the case of mercury, for example, the velocity becomes 620 meters per second; the velocities found in the ordinary spark are 1,150 and 940 meters per second, for two different types of spectral lines. This is more probably due to a reduced temperature rather than to the supposition that the quantity of metal vaporized is not sufficient in the former case to produce the difference of pressure required to make the velocity of diffusion attain its maximum value. The introduction of self-induction brings out the "arc" lines of the metal. The evidence now obtained that the arc lines are due to, or accompanied by, a lower temperature confirms Lockyer's supposition which forms the basis of his researches on star temperatures. When the self-inductance of the spark is increased, it is seen that during a single oscillation several streamers start from the electrodes; they are more distinct with magnesium than with lead, bismuth, or mercury. The streamers are too numerous and close together to make useful the supposition that they are due to harmonic overtones of the fundamental period of the circuit. The streamers are found to recur at definite intervals after the commencement of each oscillation of the spark, though they are not invariably present in every oscillation; generally not more than about ten appear in a single complete oscillation. These intervals are the same in different photographs of the spark under the same conditions; but the individual streamers are not always reproduced in the same oscillation in different photographs.

THE WORLD'S WINE CROP.

CONSUL JAMES E. DUNNING, of Milan, in a statement dated April 7, 1908, gives out the figures on the world's wine crop for last year as compiled by the Italian trade, thus:

Country.	Gallons.
United States	40,000,000
Italy	1,495,126,400
France	1,744,255,207
Germany	50,160,000
Austria	92,400,000
Hungary	81,400,000
Spain	464,640,000
Portugal	118,800,000
Switzerland	23,760,000
Russia	68,640,000
Mexico	500,000
Argentina	35,000,000
Chile	55,000,000
Brazil	8,000,000
Bolivia	650,000
Cape Colony	5,000,000
Corsica	6,654,800
Algeria	227,072,400
Tunis	7,920,000
Azores, Canaries, and Madeira...	3,960,000
Luxemburg	2,772,000
Turkey*	39,600,000
Greece	32,000,000
Bulgaria	50,000,000
Servia	10,000,000
Roumania	68,740,000
Persia	450,000
Peru	2,400,000
Uruguay	2,300,000
Australia	7,000,000

Total 4,744,200,807

The Italian crop for 1906 was 786,288,880 gallons.

*Including Cyprus.