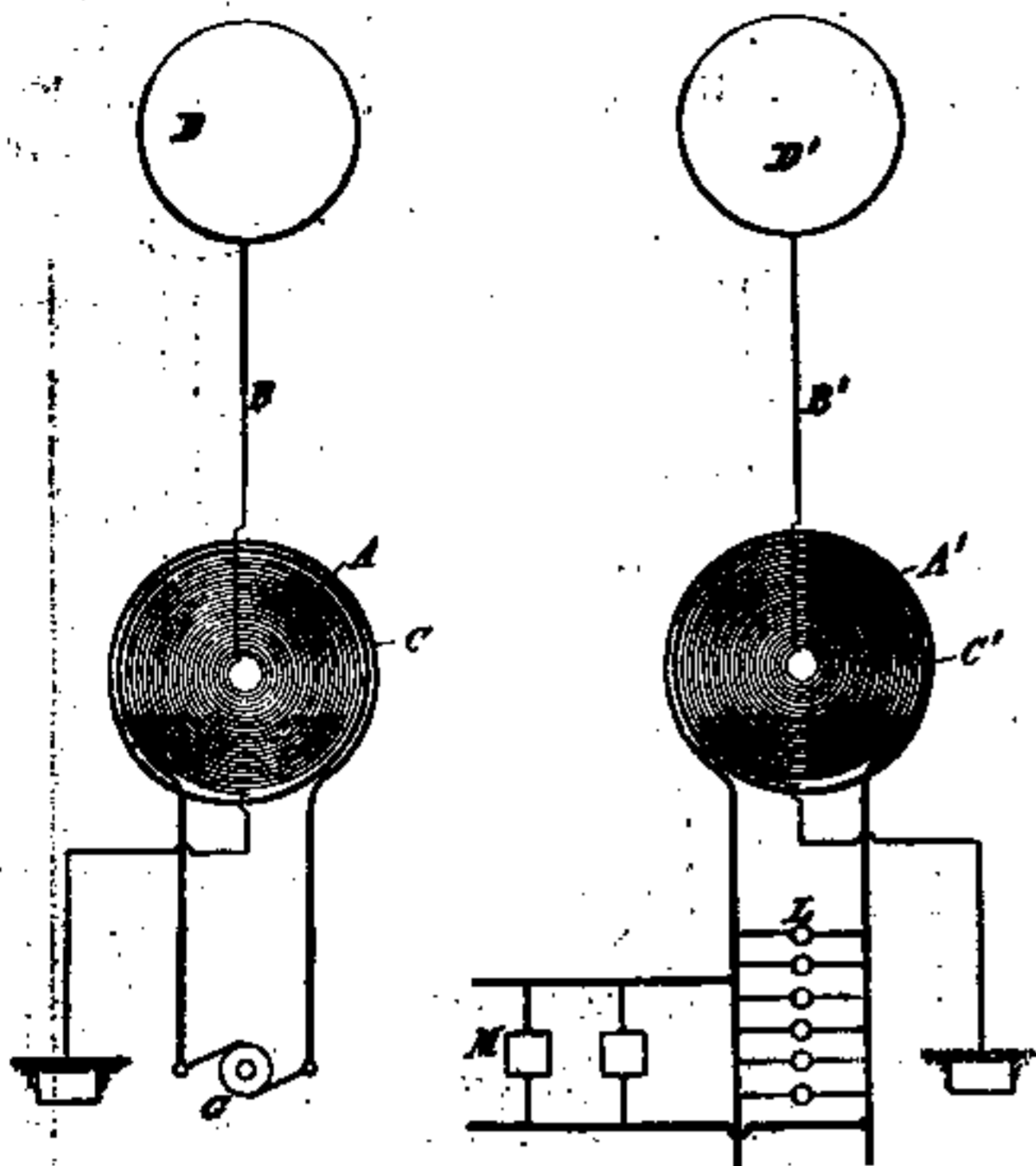


pressure than the boiler pressure. Two stop valves are coupled to the cylinders from the duplicate main range. The normal load of the engine is 2,500 I.H.P., but it is capable



TESLA'S HIGH POTENTIAL AND HIGH FREQUENCY WORK.—FIG. 1.

of giving out fully 25 per cent. above this load. A heavy fly-wheel is keyed to the crankshaft, and the wheel boss is also prepared to fasten to the dynamo. The sides of the engine are entirely enclosed, and forced lubrication is adopted. Two ram pumps are fixed on this engine for this purpose, and pump the oil under pressure (which can be regulated at will) to the main bearings under and over, also to the crank pins, cross-head pins and slide blocks. A gauge is fixed in the pipes showing the pressure of oil supplied. The engines are very massive in appearance, and work noiselessly, and no vibration is discernible. The moving parts of the engines are balanced in the cranks. White anti-friction metal is used in all the bearings. The engine is also supplied with a large platform surrounding both cylinders, and an intermediate platform to enable the attendant to get at the cross-head, slides, and indicating apparatus.

The engine is made to work condensing and non-condensing, the condenser being on Kortling's principle, and is supplied by water from a large tank over the boiler house.

The generator has been made by the Electric Construction Company, Limited. The normal output is 3,500 amperes at 410 volts, the range of voltage extending to 430 with 4,750 amperes as an emergency load, or with normal output up to 500 volts when required for tramway work. The somewhat high speed of revolution had the effect of limiting the number of poles, which was fixed at 12, each of which is energized by a double-coned shunt coil. The yoke frame, on account of its magnitude, and to facilitate erection and accessibility, is divided into six parts, and measures overall 20 feet 6 inches. The total weight of the machine is, approximately 120 tons. The armature core is carried by a balanced centre, provided with a double set of arms of oval section. The armature is tunnel wound, and the coils are formed in one piece, *i.e.*, without joint between one commutator segment and another, the commutator itself being 9 feet 10 inches in diameter. The brush gear includes an endless rack operated by worm gear and double hand wheels, so that when standing on the brush platform the attendant may replace old brushes by having the whole of

the brush holders successively rotated past him. The current is taken off to the main terminals from the circular positive and negative brush bus bars by special terminal brushes, the current being too large to permit the use of flexible leads. Notwithstanding the magnitude of the machine, the number of parts involved and the difficulty of erection, it was started under load without incident, and was at once put on to Corporation supply mains, and has been in use almost daily from the end of December until recently, when the exigencies of the load no longer demanded it. The electrical efficiency of the set is over 98 per cent. The commercial efficiency has not yet been determined, owing to the machine having been required for service.

### TESLA'S HIGH POTENTIAL AND HIGH FREQUENCY WORK.

Few inventors, in this last decade of a century of invention, have made a greater impression on the popular imagination than Nikola Tesla. Though by race a Southern Slav, he has now been settled for many years in the United States of America. From his race, it is to be presumed, he inherits his soaring scientific imagination, while from his environment he no doubt receives an extra stimulus to carry his fancies into practical effect.

Tesla, in the early part of his career, did some good work in connection with polyphase currents, but some 10 years ago he turned his attention to a comparatively new and unexplored field, namely, the production and utilisation of alternating currents of high frequency and high potential. Tesla's labours in this field have up to date revealed many new and startling phenomena, which, though they have as yet not found much practical application, may yet lead to the most astounding social and industrial revolutions.

A letter from Tesla, giving a sketch of his work and describing some recent experiments, appears in the *Electrical*

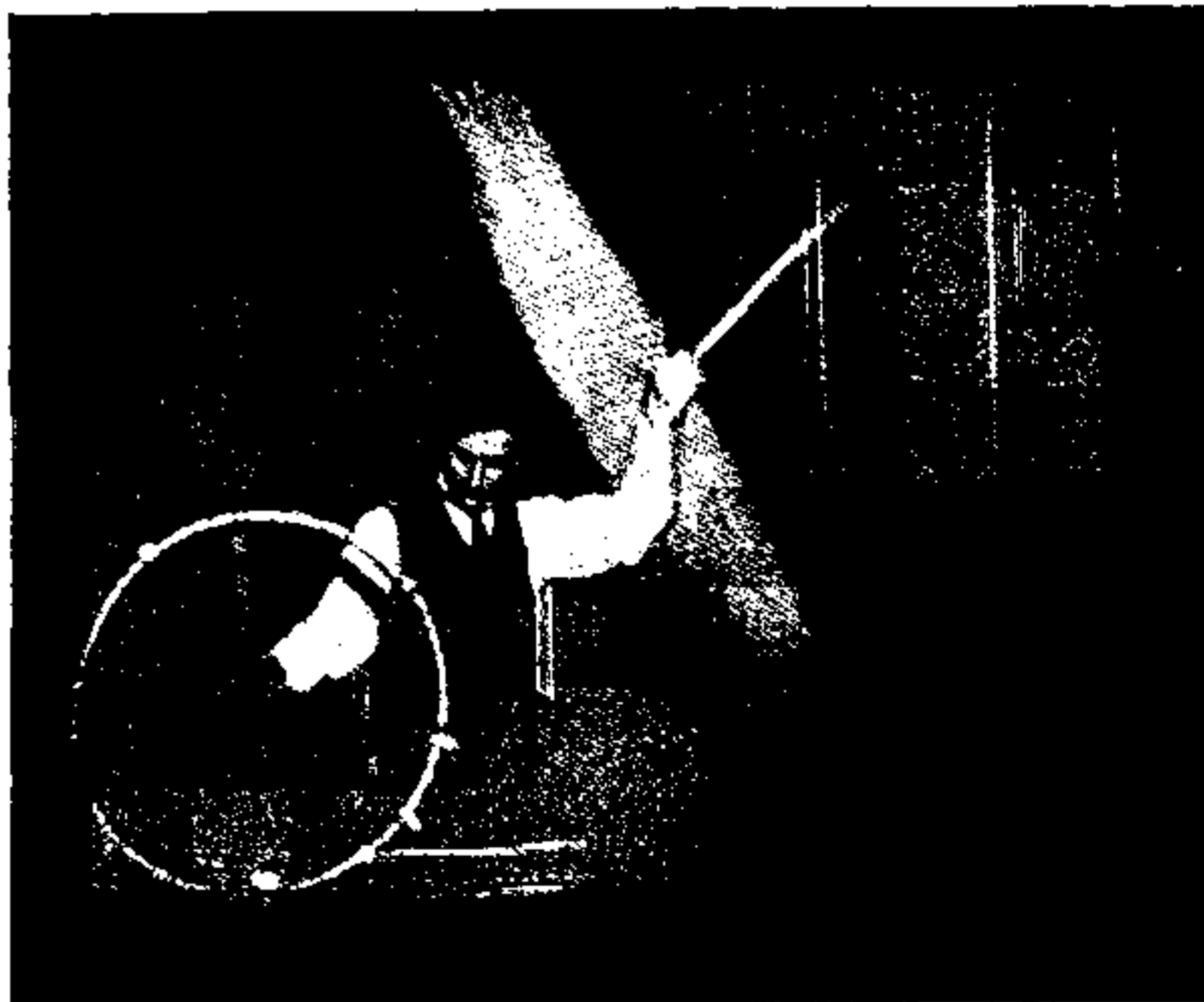


FIG. 4.—"SOME EXPERIMENTS IN TESLA'S LABORATORY WITH CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY."

The operator's body, in this experiment, is charged to a high potential by means of a coil responsive to the waves transmitted to it from a distant oscillator, and a long glass tube waved in the hand is lighted to great brilliancy by the electrical charges conveyed to it through the body.

*Review* (N.Y.), March 29th, 1899. From this and other sources we have derived the material for the following account of Tesla's investigations on the production of currents of extremely high potential:—

At the beginning of his work Tesla found himself con-

fronted by three attractive lines of investigation: "there were the excessive electrical pressures of millions of volts, which opened up wonderful possibilities, if producible, in practical ways; there were the currents of many hundreds of thousands of amperes which appealed to the imagination by their astonishing effects; and, most interesting and inviting of all, there were the powerful electrical vibrations with their mysterious actions at a distance."

The production of high electrical pressures was finally chosen as, necessarily, the first step in the exploration of the whole field. Some attention was given to static electricity with the experiments of Franklin as a starting point. Various generators of static electricity were tried, and some new ones were designed. Tesla has not as yet published any account of these static generators which he has designed; it is to be hoped he will do so soon. The most valuable outcome of these experiments was the discovery of a method of operating any kind of low tension devices from such high pressure sources with perfect ease and safety.

Tesla, however, soon convinced himself that his object was not to be attained by the use of the steady pressures produced by static machines. "It was exactly," he says, "as if one attempted to drive piles into the ground by the application of continuous pressure. This would require cumbersome and powerful machinery, and would be very inconvenient. An incomparably better way of developing high pressure is by delivering violent blows as with a hammer." The kinetic energy of a hammer, when suddenly arrested, develops very high pressures, proportional to the rigidity of the body struck. In the same way, reasoned Tesla, enormously high

potentials will be developed in the most convenient way by the electro-magnetic energy of a suddenly arrested current. This turned Tesla's attention to the use of transformers and induction coils for obtaining his high pressures. Those already in existence were evidently not adequate for the end in view, so Tesla set about improving them. First he tried the closed core transformer. This type was soon found to have several drawbacks; the insulation could not be made very high, and a very high frequency was impossible. Nevertheless, an arrangement of several of these transformers in series was devised, by which a pressure of 200,000 volts was attained. The secondary coils of several ring transformers

were connected in series, while the primaries of all, except the first, were excited by insulated dynamos. This, however, was found to be practically a very inconvenient arrangement.

The straight open core type was then tried; several improvements in the insulation and arrangement of coils were tried, which appear to have been much the same as what has long been known to the makers of induction coils, such as winding in compartments, making the insulation thicker where a greater D.P. existed between adjacent parts of the coil, and so on. The first real advance made by Tesla

appears to be his coil with a unipolar secondary. One terminal of the secondary wire is connected to the primary, the free terminal, as far distant as possible from the primary, being used for the discharge. A curious discovery made by Tesla in connection with this type of coil, was that the best results were got when the secondary wire was equal to a quarter of the wave length, as calculated from the frequency and velocity of light. This discovery Tesla has utilised in his most recent induction apparatus, with which he proposes to transmit electric currents through the air. It is difficult to explain this result; it appears as if something of the nature of a stationary wave of potential, with anode at the earthed terminal, was generated in the secondary wire.

During these experiments Tesla discovered that air played an important part in the breaking down of insulation, and by the exclusion of air, and the use of insulating liquids, he was able to increase the potential to 10 times the amount, without breaking down the insulation of the secondary. Tesla complains that the industrial world does not appear to have profited by the

recognition of this discovery, since no attempt has been made to utilize it in cables for high potential transmission, to prevent streamers. It is a fact that the liquid insulation is less in favour in practice than when attention was first called to it by Tesla's experiments. It appears to have many practical inconveniences, and it is doubtful whether it is really superior to the solid insulation except for the high frequencies employed in the Tesla apparatus. An induction coil with viscous insulation was brought out a short time ago by Rochefort and Wydts,\* and was said to be



FIG. 2.—"SOME EXPERIMENTS IN TESLA'S LABORATORY WITH CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY."

Lighting a disconnected vacuum bulb of 1,500 C.P. by high-frequency currents—photograph taken by the light of the bulb itself, exposure about two seconds.

a great advance in efficiency, but it, like all the rest of such apparatus, has apparently dropped into disuse.

The final result of Tesla's experiments with high tension generators was the coil or transformer illustrated in adjacent figure. In this coil the secondary coil is wound in a spiral lying practically in one plane perpendicular to its axis; its external terminal is earthed, and its length is made equal to a quarter wave length. The primary consists of a few turns of thick wire wound outside the secondary, lying thus adjacent to the part of the secondary whose potential is zero. It is with this apparatus that Tesla has made his experiments in the transmission of power through the atmosphere. The figure shows two transformers, a transmitter, and a receiver. The central terminals are connected to elevated plates, D, D', which require to be supported at a considerable height on a kite or a balloon. Tesla thinks a

such a calamity and yet go on with his experiments? Evidently the Tesla transformer is what Sir William Crookes wants to increase our supply of nitrates, and keep the wheat crop up to the demands of the world's increasing population; it is to be hoped Tesla's experiments will not solve the food problem in another way by reducing the population to zero.

The large size illustrations we publish show some remarkable results obtained in Tesla's laboratory by this coil. Fig. 2 shows a vacuum tube giving 1,500 C.P. illuminated by electric waves from a Tesla oscillator. Fig. 3 is a photograph showing a part of the laboratory with a disconnected resonating coil supported on an insulating stand, and illuminated by the streamers produced, other coils remaining unaffected. The pressure developed in the resonating coil is over half a million volts. In a similar experiment

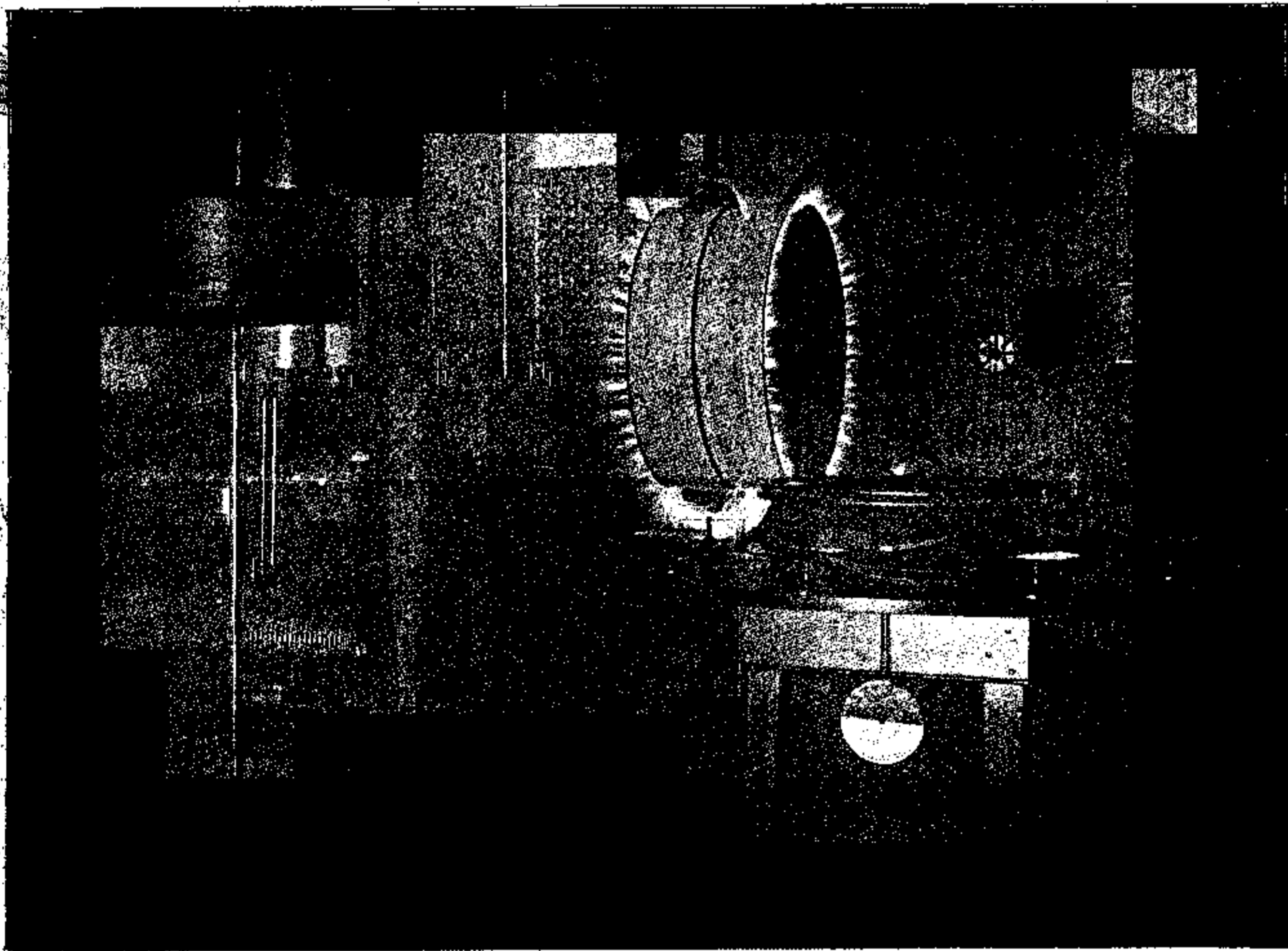


FIG. 3.—"SOME EXPERIMENTS IN TESLA'S LABORATORY WITH CURRENTS OF HIGH POTENTIAL AND HIGH FREQUENCY."

Photograph showing a part of the laboratory, with a disconnected resonating coil supported on an insulating stand, and illuminated by the streamers produced, other coils remaining unaffected—the pressure developed in the resonating coil is over half a million volts.

height of four miles will be sufficient. The air at such a height is supposed to break down under the enormous potentials developed, and become dissociated into a good conductor. This system of Tesla's has yet only appeared on paper, or, at least, no experiments on a large scale have been carried out in public. The criticisms with which this scheme was received when announced last November were by no means favourable. But Tesla is a pioneer in this field, and probably knows more about it than his critics. It is to be hoped that we shall soon see such a practical trial of his system as will finally determine its true value.

Tesla hints at a fearful catastrophe which might result from the introduction of his system of wireless transmission of power. The discharges of his coil when of an electromotive force of a few million volts, excite powerful affinities in the atmospheric nitrogen, causing it to combine readily with the oxygen and other elements, particularly in the presence of aqueous vapour. So energetic are these actions, and so strangely do such powerful discharges behave, that, says Tesla, "I have often experienced a fear that the atmosphere might be ignited." Can Tesla seriously believe in the possibility of

Tesla grasped, without danger, a nodal point in a coil developing half a million volts. Fig. 4 shows a receiving coil illuminating a vacuum tube through the human body.

Very few details of the construction and operation of these latest fruits of Tesla's inventive genius have yet been published. For instance, we are left in the dark as to whether Tesla excites his high tension transformer by an alternating dynamo, or by a continuous current and a contact breaker. It is evident that lately he has been giving considerable attention to the latter device, in connection with an induction coil which has been exhibited in this country, and is generally known as Tesla's oscillator.

In 1891 Tesla patented a method of producing high frequency and high potential currents, in which an alternating generator sends currents through a primary, the secondary of which is in circuit with a condenser. This condenser lies also in a shunt circuit containing the primary of a second coil and a spark gap. The discharge of the condenser across this spark gap produces high frequency oscillations in the shunt circuit, and these oscillations are raised to an exceedingly high potential in a secondary coil wound round the

second primary. It was with an arrangement such as this that Tesla obtained the marvellous results which he showed before the Institution of Electrical Engineers at the Royal Institution in 1892. The discharge from his apparatus appear to penetrate with ease the best insulators; electrodeless vacuum tubes were illuminated at a distance of several yards from the poles of his coil; unipolar lamps gave out a light of dazzling whiteness, but unfortunately of very small candle-power. It appears to be one of these unipolar lamps that is held in Tesla's hand in fig. 2. If so, very considerable progress has been made since the Royal Institution lecture in 1892.

It is a coil of the above type that is generally used for producing Tesla currents for electro-medical purposes. Their use for certain purposes in electro-therapeutics is said to have been highly successful. It is a curious fact that such discharges of a potential of tens of thousands of volts can be passed through the body without any injury. A satisfactory explanation of this strange phenomenon has not yet been given; it has been suggested that it is because these rapidly varying currents must be purely superficial; it may, perhaps, be due to the fact that such currents are almost completely wattless, owing to the displacement of phase between the current and the electromotive force being almost a maximum.

In 1896 Tesla patented an improved generator of high frequency currents, which is known in this country, at least, as Tesla's oscillator. The spark gap in his first type of generator was replaced by a mechanical contact breaker, and the arrangement of the circuits was somewhat different. A condenser is connected in shunt in a circuit containing a continuous current generator, choking coils, the primary of the coil, and a contact breaker. When the circuit is closed by the contact breaker a direct current flows through the circuit. The circuit is then suddenly broken, and the condenser is charged to a very high potential by the self-induction of the choking coils. The contact breaker again closes the circuit, and the condenser discharges through the primary, which, being of few turns, has a comparatively small self-induction. The result is, that the frequency is considerably higher than in the ordinary induction coil where the choking coils would form part of the primary coil. This oscillator has been shown more than once in this country; it can be worked from lighting mains, and its working appears to be highly satisfactory.

It is apparently in connection with this oscillator that Tesla has devoted himself to the improvement of the mechanical contact breaker. In his original patent for the oscillator (No. 20,981, A.D. 1896) he describes a rotary contact breaker, which creates by its motion a current of air about the contact points, with the view apparently of removing the dissociated air, and improving the insulation of the spark gap. It is in a more recent patent (No. 12,866, A.D. 1898) on electric circuit controllers that we find embodied Tesla's latest discoveries in this field. The contact breakers there described are mechanical, of a very elaborate construction; too elaborate, we should think, for general use with induction coils, unless their superiority to the present simpler forms is very great. Two new ideas appear to be embodied in these interrupters; first, the break takes place in compressed air or other suitable gas, and second, a jet of mercury discharged against a metal plate, or another jet of mercury is used to complete the circuit. The metal plate is rotated by an electro-motor, and is notched on the periphery where the jet of mercury impinges, so that contact is broken when the jet passes through one of the notches between the teeth. Tesla has expressed a somewhat ungenerous contempt for the Wehnelt break, which has recently given such remarkable results in the hands of experimenters here and abroad. Its inferiority to Tesla's break appears to be known as yet only to Tesla; in simplicity, at least, it is certainly superior.

We, however, wish Tesla success in the working out of his grandly conceived, and if realised in practice, undoubtedly epoch-making ideas.

**The Royal Society.**—Among the papers down for reading yesterday afternoon was one by Mr. A. E. Tutton, "The Thermal Expansion of Pure Nickel and Cobalt."

## TELEGRAPH AND TELEPHONE NOTES.

(Continued from page 728.)

**Glasgow Telephones.**—The Glasgow Chamber of Commerce last week considered the Government Telephone Bill. The chairman said that the Bill which Mr. Hanbury had introduced had disappointed those who desired to see the telephones of the country handled by a department of the Civil Service, Post Office, or otherwise. This Bill was in some measure a retrograde step. It seemed that the Treasury desired not to go through with the matter at the present time, or it might be that the Bill might lead pretty directly to what they desired, because the very production of this measure had lowered the value of the National Telephone Company's shares so much that it was a very much easier thing for the Government to buy up the Telephone Company than it was three months ago. If there had been no such thing as a National Telephone Company in existence, he quite believed that the great Corporations might have gone into this business and done it very well. It was arranged to send a deputation to Mr. Hanbury on Wednesday.

Glasgow Corporation Sub-Committee on the Opening of Streets has decided to appeal to the Railway Commissioners against Sheriff Berry's decision that the Postmaster-General is entitled to lay wires under the public streets, and that the municipality cannot attach the condition that they shall not be allotted to a licensee. The appeal will probably be heard by the Commissioners along with a somewhat similar appeal taken by the Corporation of Edinburgh.

**International Complications in British Telegraph Offices in the Far East.**—The following correspondence has recently appeared in the *Times* (previous to the semi-official announcement regarding the Pacific cable agreement):—

Sir,—Mr. Hanbury's courage in grappling with the telephone difficulty is of happy augury for the Government's action in a kindred department—that which has to deal with the Imperial cable question. In that problem, too, a similar solution is obviously demanded, namely, State ownership and State exploitation. No half-and-half arrangement of subsidy and partial control will be satisfactory for two reasons—it will be more expensive and the control will prove illusory and inefficient. Owing to the conditions surrounding cable work it is exceedingly difficult to exercise sufficiently close supervision on "the man in possession"; indeed, everything points to the necessity for tightening the grip of the State in this direction, and it is to be hoped that the Government will not seek to make a devotion of its Imperial responsibilities upon any company or corporation whatsoever.

Rumour has been busy with this subject lately, and it is confidently affirmed in certain quarters that the working of the projected all-British cables is about to be entrusted to the companies known as the Pender group. The supposed inertia of officialdom—an idea which has been somewhat rudely dispelled by Mr. Hanbury—gave an air of probability to the rumour. It is true that the course foreshadowed would save the Government a world of trouble, but there are considerations which do most effectually put that group out of court. This is not the place to enter on a review of their treatment of the public and the Press—that is another story; I refer to a matter of more importance than either.

Some years ago the Pender group effected an amalgamation of office in Hong Kong with the Great Northern Telegraph Company of Copenhagen, whose cable connects with the Russian Government Telegraph Administration. It would seem that the Danish company handed over its rights in that agreement to Russia, inasmuch as the company's representative in London declared in an interview some months ago that the cable worked from the joint office and introduced as a Danish cable is now Russian property. Consequently the Pender group are responsible for the existence of this dangerous anomaly—that Russian officials are admitted to an important telegraph office in an outpost of the empire, through which all telegraphic communications with our Government, public, and Press must necessarily pass! There, at any rate, the door is wide open. It will not do for the Pender group to plead ignorance of the intimate relations existing between the Danish company and the Russian Government; that was a matter of common knowledge in China long before the amalgamation.

But apart from considerations of public safety, it may well be doubted whether any great cable service should be left to the mercy of City vicissitudes and the ebb and flow of City morality. There is a period in the history of many companies when the Board know nothing, and the wirepullers respect nothing. The public have never realised what golden opportunities a cable service presents to the latter; they can favour certain clients at the expense of others; they can run rivalry with clients in their legitimate business, and they can appropriate the clients' property. We do not suppose that cable companies differ greatly from others as regards their management, but this we do know, that no other conditions offer such temptations, nor render detection so difficult.

These being some of the abuses to which telegraph services are liable, it will be seen that there are weighty arguments in favour of State ownership and State exploitation.

The colonies, I understand, are ready to provide five-ninths of the subsidy for the projected cables. To the Government I say, with all respect, "Do not put our money on the wrong horse."

Your obedient servant,

COLONIAL.

Sir,—The letter in your issue of Saturday, April 1st, under the above heading, signed "Colonial," states that the Great Northern Telegraph Company's "representative in London" declared in an interview some months ago that the cable worked from the joint office (in Hong Kong), and introduced as a Danish cable, is now Russian property.

Permit me to point out—first, that I am not aware of having had any "interview" with anybody on the subject referred to for a whole year, or not since April, 1898 and the gist of my observations on that occasion to a representative of the *Westminster Gazette*, as quoted in that paper of April 27th, 1898, was quite the reverse of the statement attributed to me by "Colonial"; secondly, that I never made, nor could have made, any such statement—(1) because, as pointed out at the said interview, one of the very objects of the joint working arrangement of the two companies in the Far East was to leave the leadership and control of the Hong Kong station to the British company (the Eastern Extension Telegraph Company); (2) because the cable from Hong Kong to Amoy and further to Shanghai, Japan, and Siberia is, and always has been, the property of the Danish company, the Great Northern Telegraph Company, in whose service there is not a single Russian, but a number of Englishmen, and whose shares are more largely held in this than in any other country, while not a single share is held in Russia.

As to the relations of the company with foreign Governments, they are, happily, as intimate with the British as with the Russian and other Governments on whose territories our cables are landed.

The other invidious insinuations of "Colonial" I may safely leave unanswered; they are beneath notice.

I am, Sir, your obedient servant,

F. C. C. NIKLSEN, the company's representative in England.

Great Northern Telegraph Company,  
8, St. Helen's Place, E.C., April 10th.