THE PRESENT STATE OF X-RAY WORK.

BY PROF. WILLIAM C. PECKHAM.

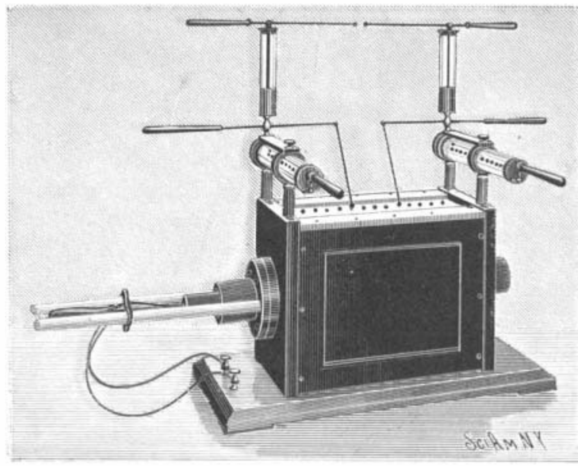
Five years have elapsed since Prof. Roentgen startled the world by the announcement of his discovery of the rays which are now quite commonly called by his name. We can now judge whether it is to be of permanent value to man.

We must admit that no more is known to-day as to the essence of the rays than was contained in Prof. Roentgen's original paper. Thus their identity in character with light rays has not been established by the usual tests. They do not behave like any other radiation known to science; yet scientific men are generally of the opinion that they belong in the ultra-violet region of the spectrum, perhaps having the shortest wave length of any known radiation—so short that it is not possible to deviate them from their course by any known form of reflecting or refracting substance. It is not settled whether the rays originate within or on the outside of the tube. Some hold that they proceed from the anode within the tube, pass through the glass and on in straight lines. This seems a most reasonable view, since the platinum of the anode is the seat of the highest activity while the tube is producing rays, becoming white hot under its terrific bombardment from the cathodic streams. But others hold that these streams, upon striking the glass of the tube, set up the X-rays, which therefore proceed only from the outside of the glass.

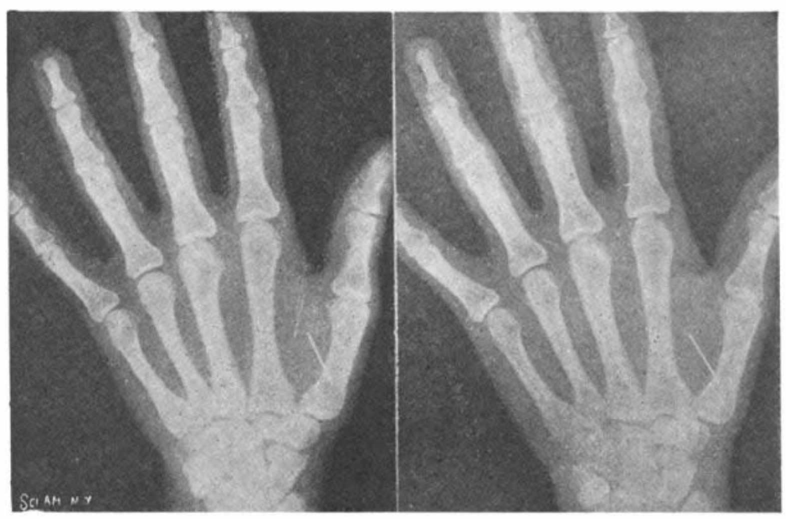
In disclosing and locating foreign bodies buried in the tissues, great progress has been made. There are now several apparatus by means of which the combination of two radiographs will show the location of the article sought at the intersection of two lines drawn through the body of the patient. A simpler method for reaching the same result has been devised by Dr. G. P. Girdwood, of McGill University, Montreal. He has succeeded in making stereoscopic radiographs. This is done by making two exposures, one after the other, from points two and a half inches apart. These points are accurately located, and the tube is placed with exactness in the positions determined for it. The two exposures are made exactly alike, and the plates are developed as nearly alike as possible. We reproduce herewith a hand in which is a needle. Before the stereoscope the appearance of solidity in these pictures is remarkable. The reader may verify this with a stereoscope. The exact location of the needle is easily seen. It is upon the palmar side of the hand, inclined from the thumb bone toward the center of the hand. The cut can be made with all the certainty of vision, down across the needle. In the case of fractures and dislocations, the stereoscopic view shows the exact location of the disturbing fragment of bone, and the setting can be made with certainty. A curious feature of these views is that they are reversible. If you look at the picture from one side, the view is as a front view; if from the other side, the view is a rear view.

Five years ago it was thought impossible to make a picture which would show the condition of the soft tissues of the body. This is now easily done. Almost every organ of the body can be depicted upon the sensitive plate. Enthusiastic practitioners with the rays claim to be able to detect the existence of certain diseases before the ordinary symptoms can be heard or seen, and while, in many cases, they are still curable. The various calculi of the bladder, gall sac, and the kidneys may be located. The surgeon may know when to operate upon a kidney with certainty. Consumption, even in its incipient stages, may be demonstrated, and the condition of the lungs may at any time be portrayed. An X-ray photograph will show a cavity of the lung, or a space filled with liquid, or an adhesion. Some claim that consumption in its early stages has been cured, and the dread lupus has been destroyed by direct application of the rays.

The later forms of tubes leave little to be desired. The penetration has increased with the development of the tube, until to-day a good picture of the thickest parts of the body can be had in a few minutes' exposure. In recent forms of tubes the vacuum is adjusted automatically by inclosing a substance which may be vaporized by heat.



THE A. W. L. UNIVERSAL COIL.



A STEREOPTICON RADIOGRAPH FOR LOCATING FOREIGN OBJECTS.

In the static machine many changes have been made since they have been employed for X-ray work. They are now built with sixteen plates, eight revolving plates, of 72 inches in diameter. Even greater advances have been made in the construction and design of the induction coil, and now few large coils are made with a cylindrical secondary. A spark length of one inch per pound of secondary was considered large not long ago; but coils are now built giving much more than this.

A coil recently designed by Dr. Rollins presents features of interest. It is a universal coil, giving sparks of all lengths up to its maximum length of 13 inches. There are thirteen sections in the secondary. These are joined to each other, and the junctions of the sections are brought out to balls upon the top of the box, as is shown in our cut of this coil. The sliding rods, bent at right angles, control the number of sections which are in action at once. When the rods rest upon adjacent balls, a spark of a quarter-inch is given. The rest of the secondary is idle. Above these discharging rods are seen two Leyden jars, to the inner coatings of which are connected two rods which may be brought together or separated, varying the character of the discharge accordingly. The horizontal glass tubes contain a multiple spark gap. By adjusting these the proper spark gap for the tube may be quickly obtained. The primary coil is also movable, and may be slid in and out by the handle on the left, so that the inductive action may be made weaker or stronger, as desired. With all these adjustments at one's disposal, a tube can be taken, which shows only a reddish Geissler discharge, and brought up to full power in a few seconds. Most of the separate features of this coil are not new, but their combination gives the operator a range of power and resources which he has not had in one apparatus.

ELECTRICAL GYROSCOPES.

BY HOWARD B. DAILEY.

The advantages of a gyroscope whose action can be maintained for any desired length of time are obvious. Mr. George M. Hopkins in "Experimental Science" has described several forms of this curious instrument in which the various agencies of steam, compressed air, and electro-magnetism are ingeniously employed to render the rotation of the disks continuous. The apparatus represented in the accompanying engravings are unique, as they are possibly the first examples of continuously-acting gyroscopes using static electricity as a motive agent. Fig. 1 is a modification of that familiar type known as the "gyroscopic top," or unbalanced gyroscope, whose singular gravity-resisting powers seem to defy all attempts at satisfactory explanation in any simple, popular way. In this experiment a 6-inch disk of sheet vulcanite 3-16 of an inch thick is mounted on a short pivot-pointed steel axle, in a frame formed of two parallel pieces of light vulcanite tubing. The upper ends of these tubes, which are of unequal lengths, are fitted into parallel grooves in the opposite sides of a 2-inch hollow wooden ball; and are secured in place by a slender binding rod of straight brass wire, whose threaded projecting ends are provided with polished aluminium screw knobs. The hollow ball is obtained by splitting a solid ball in halves, which are hollowed out as thin as possible and glued together again, after which it is given a conducting coating of tin-foil cemented on in small pieces with shellac varnish. The surface is then carefully rubbed down with some smooth instrument. Hollow balls and tubing are used for the reason that the less weight the gyroscope has to sustain, the slower and more stately will be its movement about its point of support. The shorter of the vulcanite tubes has passing through its lower end a cup-pointed brass screw, which serves as the outer bearing of the axle; the inner bearing being an indentation in a light brass sleeve embracing the longer tube at about its middle, and forming the anchorage for the 3-16-inch steel arm upon which the gyroscope proper is suspended. The lower end of the longer tube bears a small dumb-bell shaped aluminium receiver, presented endwise toward the disk, and adjusted, like the wooden ball, very close to its edge. The two insulated receivers gain opposite electrification from stationary points of supply through flexible rubber-covered conducting cords in a manner presently explained.

The vertical support for the gyroscope is a rod of vulcanite, eleven inches high. In its upper end is drilled a 5-16 inch hole 3 inches deep. A pointed steel pivot upon which the system revolves passes loosely through a brass bushing in the upper end of the hole and rests in a cone-shaped depression in a

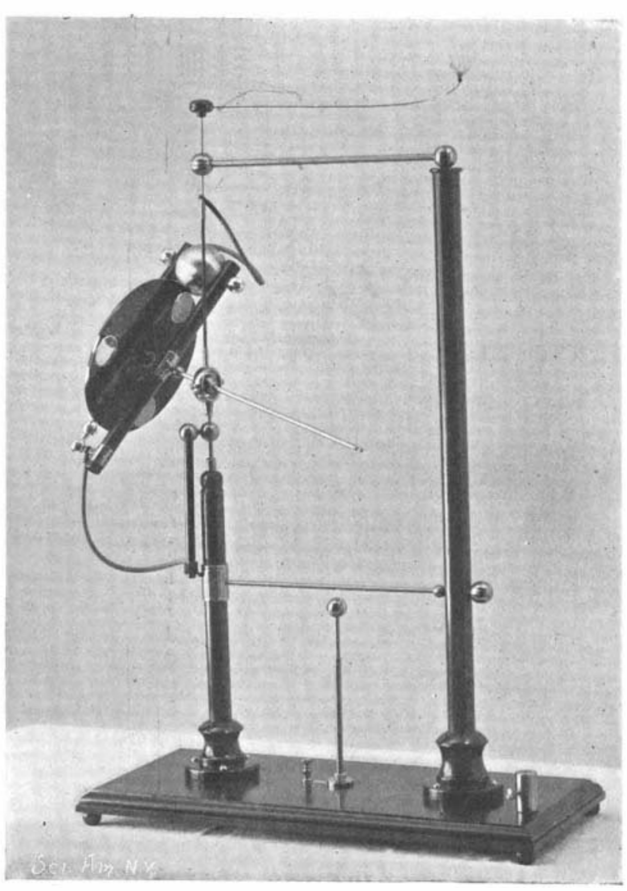


Fig. 1.—ELECTRICAL GYROSCOPE.

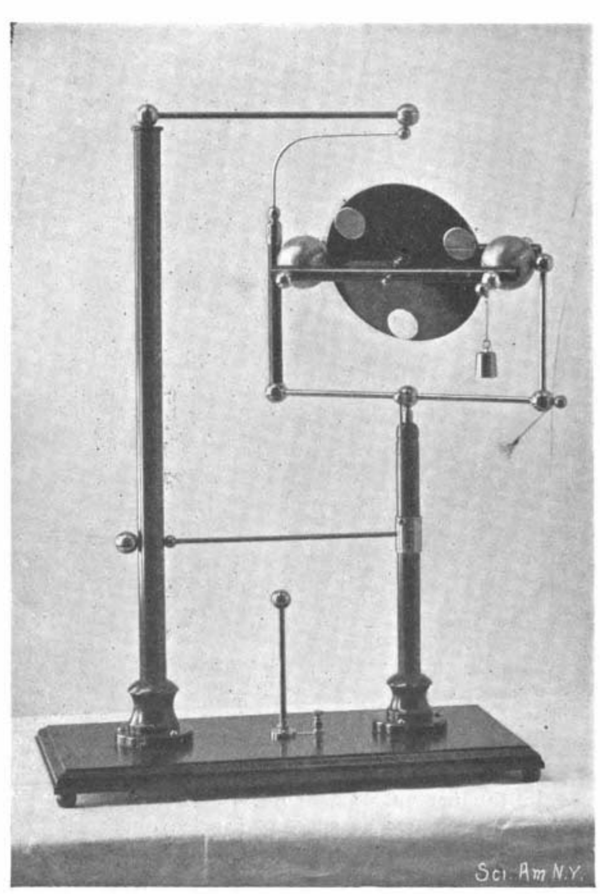


Fig. 2.—BOHNENBERGER APPARATUS DRIVEN BY STATIC ELECTRICITY.

piece of hardened steel at its bottom. The pivot carries at its upper extremity a brass ring in whose center is hung on two horizontal pivot points a brass ball through which the supporting arm of the gyroscope passes. This arm may be fastened in any desired position by a blind setscrew. The best adjustment for the frame is that which gives it an angle of about 45° with the vertical, when the axis of the disk is horizontal. The arm is prolonged several inches to the rear of the central mounting, to serve in the usual experiments requiring the use of the counter-balance, which is seen standing upon the base of the apparatus.

A tall vulcanite column at the right of the instrument carries at its top a horizontal brass arm terminating in a knob exactly over the center of the gyroscope vertical support. In electrical communication with this knob is one end of the flexible cord attached to the large receiver. The lower end of a similar cord depending from the smaller receiver is held nearly in contact with a stationary electrified brass sleeve on the rubber standard of the gyroscope; the cord being fastened to the lower end of a slender vulcanite rod carried by the revolving pivot stem of the instrument. A metal bar extending horizontally from the sleeve through the column at the right ends in a brass ball, which, with a similar one at the top of the pillar, are the points of connection with the opposite poles of the static machine; the upper one being made *positive*.

The wheel of the gyroscope has cemented upon each face, close to the edge, three round pieces of sheet aluminium 1¼ inches in diameter; the two sets of pieces being arranged in such relation to each other that the disks of one set come between those on the opposite face of the wheel. These pieces act as carriers for the electricity.

Experimenters with the gyroscopic top have observed that if the instrument's circular movement about its point of support be retarded, the gravity-resisting power is impaired, and the device falls rapidly. Conversely, if this orbital motion be accelerated slightly by the application of some gentle outside force, increased lifting power is at once apparent, and the horizontal plane of rotation of the system can be made to remain at a given level or even to rise, instead of gradually falling, as is the natural action of all overhanging gyroscopes not subject to the aforesaid outside influences, even when provided with power-driven disks; unless the axis of the disk be given a *very pronounced* upward inclination at the beginning. In the present case such an extra force as is mentioned above is conveniently supplied by the mechanical reaction produced by a current of electrified air—"electric wind"—emanating from a number of electrified metallic points at the end of a laterally curved horizontal wire sweep, carried by a vertical shaft passing loosely through the charged brass knob above the apparatus. The very mild torsional force thus secured is communicated to the vertical spindle of the gyroscope by a slender vulcanite rod, extending downward, and entering the top of the brass pivot ring. There is a position of maximum efficiency for the sweep to occupy in relation to the body of the gyroscope; this position being fairly indicated in the engraving. The points, which are of tinsel wire, are turned in a direction contrary to that of the natural motion of the system about its vertical axis.

A regulator for controlling the strength of this force is placed upon the base of the instrument between the two standards. Its operation depends upon the circumstance that the grounding of one pole of an influence machine greatly increases the electrical activity at the other; consequently, air currents from points attached to one pole of a generator will be made stronger or weaker, according as the opposite pole is more or less completely grounded. The regulator is a vertical sliding earth-connected brass rod with a ball at its top, which by being lowered or raised forms a longer or shorter spark-gap between itself and the horizontal supply-rod above it; thus grounding more or less perfectly, as desired, the negative side of the generator, and causing increased or diminished potential at the other pole. Like the pneumatic gyroscope of Mr. Hopkins, this machine raises itself automatically from its lowest position, by a spiral movement, into a horizontal plane of rotation, whose altitude above the base becomes constant at a point determined in the present instance by the adjustment of the regulator and by the speed of the generator.

A continuously acting Bohnenberger apparatus is shown in the second illustration. This arrangement utilizes the same base and supporting standards as are used in the preceding experiment; but instead of the overhanging gyroscope we have the disk revolving in a horizontal vulcanite frame at whose ends are located large balls of foil-covered wood. The frame is pivoted at its extremities so as to balance accurately in any position. The two vertical supports for the frame, which are of brass and vulcanite, respectively, rise from the ends of a horizontal metallic bar mounted at the top of the vertical pivot on which the apparatus turns. The ball at the left of the disk receives positive electrification through a stiff curved wire, rising from the top of the vulcanite support; the upper end of the wire terminating in a knob just below the charged conductor above the instrument. The other ball obtains negative electricity from its metal supporting connections, which are charged through a traveling conducting rod attached to the vertical pivot and reaching down very near to the excited brass sleeve below the gyroscope. Owing to the accelerative effect of a reactionary air current upon the azimuthal rotation of the apparatus, as in the preceding experiment, the small weights usually hung upon the side of the frame for throwing it out of balance in exhibiting the composition of rotations are continuously sustained. However, as these weights may be made as light as desired, the use of the regulator for intensifying the air jet is unnecessary; and the tinsel brush is fastened by a short piece of wire directly to the lower right-hand corner of the supporting frame of the instrument in such a manner as to admit of being turned in either direction.

INSHORE END OF THE STIFFENING TRUSSES OF THE NEW EAST RIVER BRIDGE.

The means by which the rotation of the disks is effected is in itself interesting, and affords a pleasing illustration of the law of electrical attraction and repulsion. The wheel is first given a slight impulse with the hand. As the aluminium carriers pass the oppositely charged receivers they gain from each one its own particular sign of electrification, and repulsion between carriers and receivers ensues. Rotation proceeds, and as each carrier approaches an oppositely excited receiver attraction between them results until, coming near enough, their electrification is reversed; repulsion replacing attraction as they pass by. Each receiver attracts the carriers on that half of the disk which is approaching it; repelling those on the half which has passed—a swift continuous motion being soon established. It is found that the direction in which the disks revolve most rapidly in both instruments is that in which their top edges approach the positively excited receivers. In dry weather, when other experiments in static electricity succeed, the action of these curious machines is very gratifying and instructive; and much might be said of the beautiful and intricate system of delicately correlated forces —electrical and gravitational—which their operation illustrates. They may be used with any static machine having four or more 22-inch revolving plates.

Several towns in West Virginia have free telephone service on account of competition between local and Bell companies. At Huntington, W. Va., the Bell company gives its service to all subscribers free until further notice. The home company has not cut its rates, and the number of telephones has increased.

CONSTRUCTION OF THE NEW EAST RIVER BRIDGE.

Now that the actual work of constructing the cables of the new East River Bridge is under way, it is opportune to consider both the cables and the broad and massive suspended roadway, the completion of which will mark the completion of the whole structure. The cables will be four in number, and each will consist of thirty-seven strands of wire, with 281 wires in each strand. There will, therefore, be in each cable 10,397 wires, or 41,588 in the four cables. The wire will be 0.165 inch in diameter, and it will have a breaking strength of 100 tons to the square inch. Before its acceptance from the manufacturers it must stand the test of being coiled cold around a wire of its own diameter without cracking.

In designing the cables and in the specification for the manufacture of the wire, particular care has been taken to protect the wire from rusting. At the mill the wires are passed through hot linseed oil. When the 281 wires of each strand have been laid parallel with each other and banded at intervals of every 5 feet to hold them temporarily in place, the interstices will be filled with a special, anti-oxidation filling. Then again when the 37 strands are assembled in the complete cable, the wire wrappings will be removed, and the interstices between the strands will be similarly filled with a non-corrosive preparation. As the strands are assembled in the cable the whole of the 10,397 wires will be drawn snugly into cylindrical form, the main cable bands being put on at intervals of 20 feet, and screwed up so as to take a firm grip upon the cable. In addition to the protective preparation, which thoroughly fills up the interstices between the wires, the whole cable will be protected by 1-16-inch steel cover-plates, which will extend from main band to main band, with ends overlapping, so as to shed the water.

The floor system of the new bridge is by far the widest and stiffest ever carried by a suspension bridge. Its extreme width is 118 feet, and its depth measured at the stiffening trusses is 40 feet. These dimensions may be compared with those of the Brooklyn Bridge, whose total width is only 80 feet and the depth of the trusses 17 feet. Moreover, the carrying capacity of the floor system is much greater, provision being made for six railroad tracks, two roadways for vehicle traffic, two 11-foot footways for pedestrians and two 10-foot bicycle tracks. The framework or skeleton of the floor system, or what we might call its backbone, are two massive latticed trusses, 40 feet in depth, which extend from end to end of the bridge. These trusses possess great vertical stiffness, and should there be any uneven loading, such as would be caused by a bunching of the elevated trains and trolley cars, and a crowding of people and vehicles at one particular spot, the trusses will take care of this load and distribute it indefinitely throughout the full length of the span and prevent any sagging of the cables at that particular point. Intersecting the bottom chord of the two trusses at right angles, at every 20 feet of their length, is a series of deep, plate-girder, floorbeams, which extend entirely across the bridge for its full width of 118 feet. Each floorbeam is suspended from the four cables overhead by 1¾-inch steel wire cables, which pass up and over curved saddles, formed in the main cable bands. These cables at their lower ends pass under a cast-steel saddle, from which four heavy bolts pass down and are bolted beneath the covering plate of the bottom chords of the trusses. At every 20 feet of the length of the trusses, and in the same plane as the suspenders, the top chords are connected by transverse steel trusses, from which two plate-steel suspenders are carried down and riveted to the floorbeam at two points intermediate between the trusses. These overhead trusses relieve the girders of the great concentration of the load due to the six railroad and car tracks, thereby permitting the floor beams to be much shallower than would otherwise be necessary, and gaining several feet of valuable headroom between the under side of the bridge and the water level of the river. The 20-foot gaps between the floorbeams are bridged over by plate-steel stringers which are so distributed that they will come approximately beneath the lines of the rails of the street car and elevated railroad tracks. The two roadways for vehicles will be carried on the cantilever extensions of the floorbeams outside the trusses. Immediately inside of each truss will be two tracks for street railway cars, while between these will be two tracks for the elevated railway lines. Immediately above the street car tracks, and carried by the trusses and the intermediate suspenders of the floorbeams, will be