Tesla's Egg of Columbus

How Tesla Performed the Feat of Columbus Without Cracking the Egg

PROBABLY one of the most far-reaching and revolutionary discoveries made by Mr. Tesla is the so-called *rotating magnetic field*. This is a new and wonderful manifestation of force —a magnetic cyclone—producing striking phenomena which amazed the world when they were first shown by him. It results from the joint action of two or more alternating currents definitely related to one another and creating magnetic fluxes, which, by their periodic rise and fall according to a mathematical law, cause a continuous shifting of the lines of force. There is a vast difference between an ordinary electro-magnet and that invented by Tesla. In the former the lines are stationary, in the latter they are made to whirl around at a furious rate. The first attracts a piece of iron and holds it fast; the second causes it to spin in any direction and with any speed desired. Long ago, when Tesla was still a student, he conceived the idea of the rotating magnetic field and this remarkable principle is embodied in his famous *induction motor* and system of transmission of power now in universal use.

In this issue of the ELECTRICAL EXPERIMENTER Mr. Tesla gives a remarkable account of his early efforts and trials as an inventor and of his final success. Unlike other technical advances arrived at thru the usual hit and miss methods and hap-

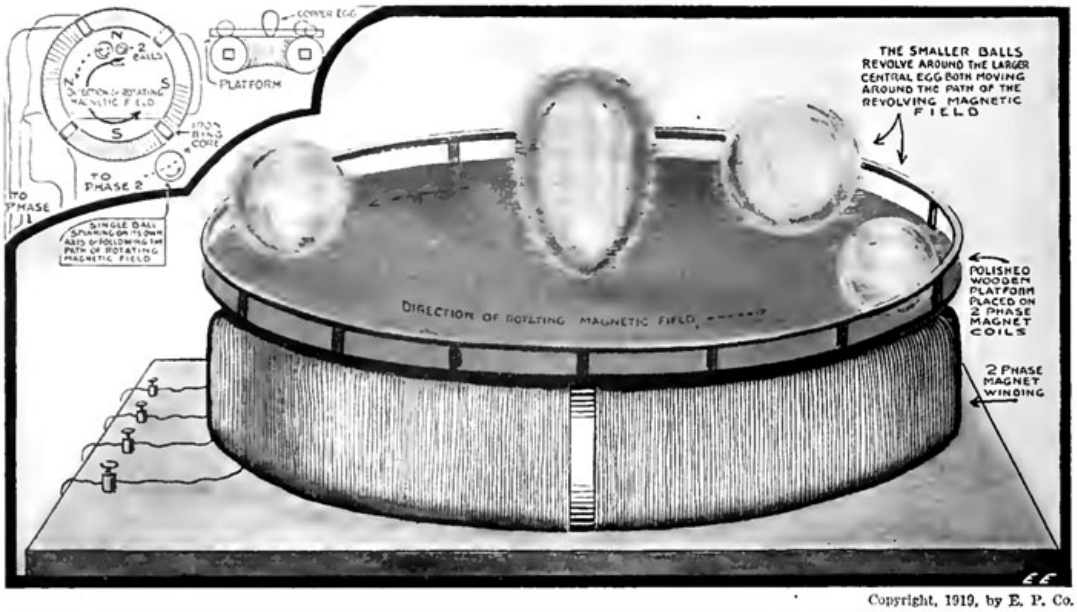

Fig. 2. Illustrating the Polyphase Coil and Rotating Megnetic Field Which Caused Copper Eggs to Spin. Fig. 3. Insert: Detail of Coil Apparatus Showing Coil Connections to Different Phases.

Fig. 1. This hitherto unpublisht photograph is extremely interesting as it shows not only "Tesla's Electric Egg" apparatus in the center of the background, but also a comprehensive view of a corner of his famous Houston Street laboratory of a decade ago. At the left may be seen a number of Tesla's oscillators or high frequency generators, while in the rear may be noted a large high frequency transformer of the spiral type, the diameter of which was a little over nine feet. The electric egg apparatus comprising a two-phase A.C. circular core and winding, rests on a table, and this particular model measured about two feet across. In making the demonstrations, Tesla applied as much as 200 H.P. from a two-phase alternator to the exciting coils, and so intense was the revolving magnetic field created in the surrounding space, that small delicately pivoted iron discs would revolve in any part of the hall, and a great many other devices could be simultaneously operated from this magnetic field when thus excited. The frequency of the two-phase A.C. energizing the coils, was varied from 25 to 300 cycles, the best results being obtained with currents of from 35 to 40 cycles. This laboratory was lighted by Tesla's vacuum tubes, several of which may be seen on the ceiling, and each of which emitted 50 C.P. The coil resting on three legs and observed in the immediate foreground is the primary of a resonant Tesla transformer which collected energy from an oscillatory circuit encircling the laboratory, no matter in what position the transformer was placed. A low tension secondary of one or two turns of heavy cable (not visible) was provided for stepping down the energy collected by "mutual induction," and supplied the current to incandescent lamps, vacuum tubes, motors and other devices. When the circuit around the hall was strongly excited, the secondary furnished energy at the rate of about three-quarters of one horse-power.

hazard experimentation, the rotating field was purely the work of scientific imagination. Tesla developed and perfected, entirely in his mind, this great idea in all its details and applications *without making one single experiment.* Not even the usual first model was used. When the various forms of apparatus he had devised were tried for the first time they worked exactly as he had imagined and he took out some forty fundamental patents covering the whole vast region he had explored. He obtained the first rotations in the summer of 1883 after five years of constant and intense thought on the subject and then undertook

the equally difficult task of finding believers in his discovery. The alternating current was but imperfectly understood and had no standing with engineers or electricians and for a long time Tesla talked to deaf ears. But, ultimately, his pains were rewarded and early in 1887 a company bearing his name was formed for the commercial introduction of the invention.

Dr. Tesla recently told the editors an amusing incident in this connection. He had approached a Wall Street capitalist—a prominent lawyer—with a view of getting financial support and this gentleman called in a friend of his, a well-known engineer at the head of one of the big corporations in New York, to pass upon the merits of the scheme. This man was a practical expert who knew of the failures in the industrial exploitation of alternating currents and was distinctly prejudiced to a point of not caring even to witness some tests. After several discouraging conferences Mr. Tesla had an inspiration. Everybody has heard of the "Egg of Columbus." The saying goes that at a certain dinner the great explorer asked some scoffers of his project to balance an egg on its end. They tried it in vain. He then took it and cracking the shell slightly by a gentle blow, made it stand upright. This may be a myth but the fact is that he was granted an audience by Isabella, the Queen of Spain, and won her support. There is a suspicion that she was more imprest by his portly bearing than the prospect of his discovery. Whatever it might have been, the Queen pawned her jewels and three ships were equipt for him and so it happened that the Germans got all that was coming to them in this war. But to return to Tesla's reminiscence. He said to these men, "Do you know the story of the Egg of Columbus?" Of course they did. "Well," he continued, "what if I could make an egg stand on the pointed end without cracking the shell?" "If you could do this we would admit that you had gone Columbus one better." "And would you be willing to go out of your way as much as Isabella?" "We have no crown jewels to pawn," said the lawyer, who was a wit, "but there are a few ducats in our buckskins and we might help you to an extent."

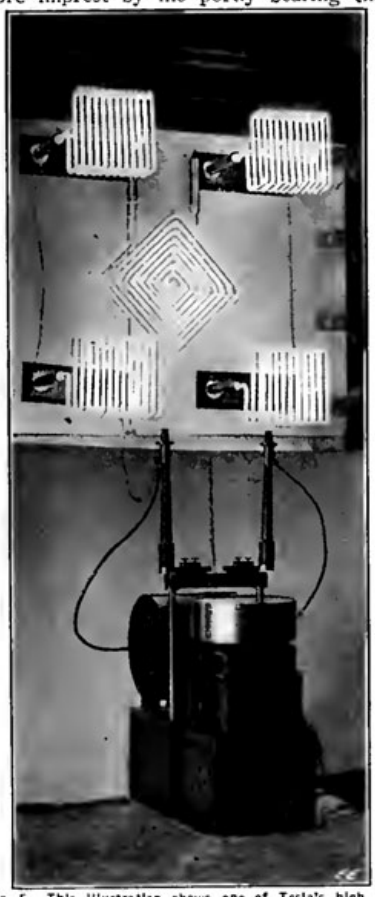

Fig. 5. This illustration shows one of Tesla's high frequency oscillation generators and a bank of his high frequency lamps lighted by the same. These highly evacuated, gas filled tubes were operated in different ways. In some cases they were connected to one wire only; in other instances to two wires, in the manner of ordinary incandescent lamps. Often, however, they were operated without any connection to wires at all, i.e., by "wireless energy". over quite appreciable distances, which could have been greatly extended with more power. The oscillator comprises a Tesla high potential transformer which is excited from a condenser and circuit controller, as described in his patents of 1896. The primary exciting element comprised a powerful electro-magnet actuating an armature, and this circuit was connected with 110 volt, 60 cycle A.C. or D.C. When the oscillator was put into operation, the interrupter actuated by the electro-magnet connected to the 110 volt circuit, became simultaneously the spark gap for the high potential exciting circuit, which included this vibrator, spark gap, a high tension condenser and the primary of the high frequency Tesla transformer. The lamps were connected to the secondary of the latter the terminals of which are seen in the rear of the machine.

Mr. Tesla thus succeeded in capturing the attention and personal interest of these very busy men, extremely conservative and reluctant to go into any new enterprise, and the rest was easy. He arranged for a demonstration the following day. A rotating field magnet was fastened under the top board of a wooden table and Mr. Tesla provided a copper-plated egg and several brass balls and pivoted iron discs for convincing his prospective associates. He placed the egg on the table and, to their astonishment, it stood on end, but when they found that it was *rapidly spinning* their stupefaction was complete. The brass balls and pivoted iron discs in turn were set spinning rapidly by the rotating field, to the amazement of the spectators. No sooner had they regained their composure than Tesla was delighted with the question: "Do you want any money?" "Columbus was never in a worse predicament," said the great inventor, who had parted with his last portrait of George Washington in defraying the expenses of the preparation. Before the meeting adjourned he had a substantial check in his pocket, and it was given with the assurance that there was more to be had in the same bank. That started the ball rolling. Tens of millions of horsepower of Tesla's induction motors are now in use all over the world and their production is rising like a flood.

In 1893 Mr. Albert Schmid, then Superintendent of the Westinghouse Electric and Mfg. Co. constructed a powerful rotating field ring with an egg made of copper, and larger than that of an ostrich, for Dr. Tesla's personal collection at the Chicago World's Fair. This piece of apparatus was one of the most attractive novelties ever publicly shown and drew enormous crowds every day. Subsequently it was taken to Mr. Tesla's laboratory and served there permanently for demonstrating rotating field phenomena. In his experiments it was practicable to use as much as 200 *horsepower* for a short time, without overheating the wires and the effects of the magnetic forces were wonderfully fascinating to observe. This is the very ring indicated in the accompanying photograph (Fig. 1), giving a view of Mr. Tesla's former laboratory at 46 E. Houston Street, New York. It is shown in detail in Fig. 2, and the mode of winding is illustrated in diagram (Fig. 3). Originally the two-phase arrangement was provided but Mr. Tesla transformed it to the three- and four-phase when desired. On top of the ring was fastened a thin circular board, slightly hollowed, and provided around its circumference with a guard to prevent the objects from flying off.

Even more interesting than the spinning egg was the exhibition of *planetary motion*. In this experiment one large, and several small brass balls were usually employed. When the field was energized all the balls would be set spinning, the large one remaining in the center while the small ones revolved around it, like moons about a planet, gradually receding until they reached the outer guard and raced along the same.

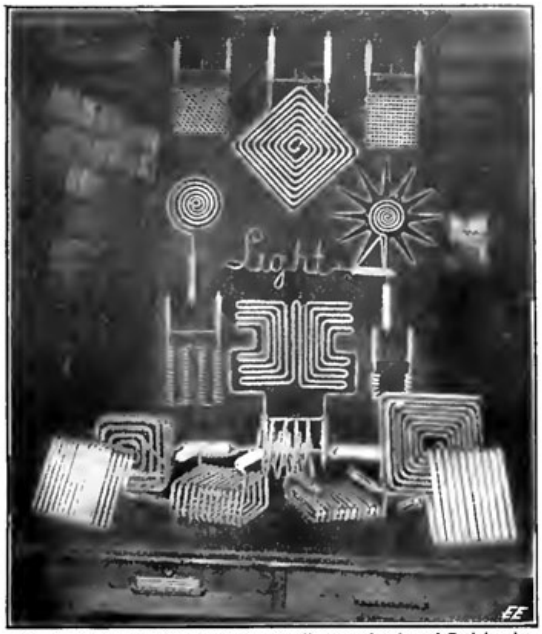

Fig. 4. This photograph represents a collection of a few of Tesla's wireless lamps, such as he proposes to use in lighting isolated dwellings all over the world from central wireless plants. The two lamps at either corner at the bottom are illuminated, owing to the fact that a high frequency oscillator was in operation some distance away when this photograph was being taken. These tubes were filled with various gases for experimental research work in determining which was most efficient.

But the demonstration which most imprest the audiences was the simultaneous operation of numerous balls, pivoted discs and other devices placed in all sorts of positions and *at considerable distances from the rotating field*. When the currents were turned on and the whole animated with motion, it presented an unforgettable spectacle. Mr. Tesla had many vacuum bulbs in which small, light metal discs were pivotally arranged on jewels and these would spin anywhere in the hall when the iron ring was energized.

Rotating fields of 15,000 horsepower are now being turned out by the leading manufacturers and it is very likely that in the near future capacities of 50,000 horsepower will be employed in the steel and other industries and ship propulsion by Tesla's electric drive which, according to Secretary of the Navy Daniels' statement, has proved a great success.

But any student interested in these phenomena can repeat all the classical experiments of Tesla by inexpensive apparatus. For this purpose it is only necessary to make two slip ring connections on an ordinary small direct current motor or dynamo and to wind an iron ring with four coils as indicated in diagram Fig. 3. No particular rule need be given for the windings but it may be stated that he will get the best results if he will use an iron ring of comparatively *small section* and wind it *with as many turns of stout wire as practicable*. He can heavily copper plate an egg but he should bear in mind that Tesla's egg is not as innocent as that of Columbus. The worst that can happen with the latter is that it might be,—er—over ripe! but the Tesla egg may explode with disastrous effect because the copper plating is apt to be brought to a high temperature thru the induced currents. The sensible experimenter will, therefore, first suck out the contents of the egg—thus satisfying both his appetite and thirst for knowledge.

Besides the rotating field apparatus Mr.

(Continued on page 808)

EXPERIMENTAL PHYSICS.

(*Continued from page 806*)

near the electroscope, we find that the electroscope discharges rapidly. The Bunsen flame ionizes the air very rapidly. A small quantity of radio-active material will discharge the electroscope very rapidly, showing that *radio-active materials have the ability to IONIZE the air*. The larger the amount of radio-active material the faster the rate of discharge of the electroscope. A pinch of Uranium Oxid in the electroscope chamber, will ionize the air so rapidly that the leaf will fall practically instantaneously!

Experiment 113.

A third test for the presence of most radio-active substances is the "*Fluorescence Effect*"—which some of them have upon certain compounds, especially *Zinc Sulfid*. Any of the substances which give off alpha radiations (see figure 102) will cause a zinc sulfid screen to fluoresce. If the screen is observed thru a sufficiently high power magnifying lens, or microscope (say ten or fifteen diameters magnification), the continuous soft glow of the zinc sulfid seen by the naked eye becomes, on magnification, hundreds of tiny flashes of light, not unlike the sparks obtained by striking flint and steel together. Figure 101 shows the *Spinthariscope*, which can be easily made by the reader. A is small metal tube with a hole, S, in its cap. E and F are lenses. C is the fluorescent screen on the cap of tube B. D is a small particle of the radio-active substance. A practical use of the fluorescent effect of alpha particles is familiar to all of us in the *radium points, luminous dials*, et cetera. These compounds consist of specially prepared zinc sulfid, mixed with about 2,000 parts of radium bromid, or a radio-active compound having an equivalent of alpha-ray activity. Altho the period of half decay of radium itself is approximately 2,000 years, see table 102, the luminosity of the compound falls off, due to the fact that the *zinc sulfid loses its power to luminesce*, but not because the radium gives out. Some specifications for luminous paint, as for government work, stipulate that the zinc sulfid and radio-active substance shall be mixed in such proportions that the average useful life of the paint will be from 8 to 10 years.

The discovery of radio-activity has given us a vast field for research and as a result the physicist has been able to make subatomic investigations. Atoms are constantly exploding and shoot out as fragments, the alpha and beta particles. Altho the energy liberated by these explosions is fairly large, no diminution in the weight of the radio-active substance has been detected after the liberation of the energy. J. J. Thomson computed that the disintegration of one gram of hydrogen would liberate sufficient energy to raise a million tons 300 feet. See Fig. 103. If only this energy could be trapt, and recent research shows the possibility of it, Garfield and his coal-house gang would lose their job, for who would use ten tons of coal when one gram of hydrogen would give an equivalent heating value. Table 102 gives interesting data concerning the radio-active substances. In each series the first substance gives the second on disintegration and the second the third, etc. The second column gives the kind of radiation given off by the respective substances and the last column tells how long it takes for the substance to disintegrate to half of the original amount. This half-period means that after 2,000 years, for instance, one-half of the substance in question will have disintegrated. After 4,000 years, one-half of the remainder will have disintegrated or disappeared, etc., etc. The total life of pure Radium is computed from this law to be about 22,000 years.

(*To be continued*)

HISTORIC ELECTRIC SWITCHBOARD AND DYNAMO.

(*Continued from page 778*)

field magnet type with surface wound armatures. There are quite a number of these generators still in existence in various parts of the country, and in tribute to their designer, it should be said that they perform their duty very well indeed, considering the time at which they were built, for thirty to thirty-five years in the electrical industry has, we might almost say, witnest the entire development of the whole scheme of electrical generation, transmission and utilization of power, under the directorship of such men as Edison, Thomson, Houston, Tesla, Westinghouse and Sprague.

The wooden switch-board, shown in the photograph, contains four box-type field rheostats, and it is peculiar to note that they are mounted on the face of the board instead of in the rear, as in present day practise.—*Photo by Richard Nelson.*

THE TESLA EGG OF COLUMBUS.

(*Continued from page 775*)

Tesla had other surprises for his audiences, which were even more wonderful. So, for instance, the coil on three legs, visible in the foreground, was used to operate wireless motors, lamps and other devices, and the spiral coil in the background served to show extraordinary high potential phenomena, as streamers of great length.

ULTRAVIOLET ENERGY AND ITS USE.

By M. Luckiesh, Physicist, Nela Research Laboratory.

Since the discovery of ultraviolet rays, more than a century ago, their production and properties have been subjected to a great deal of investigation. However, notwithstanding the extensive literature on the subject we must agree with Sheppard, who says in his book on Photo-chemistry:

"We are only at the beginning of the conscious utilization of the powers of light, as distinct from the unconscious enjoyment of them."

Owing to the many unique properties of these invisible rays, they are extremely valuable in certain scientific investigations, tests, and industrial processes, and it appears certain, that with the progress of the development of sources of ultraviolet rays, and of media transparent to them, the usefulness of ultraviolet energy will be rapidly extended. The problems in which these unique properties may be utilized are manifold.

As to Sources:—There are many sources of ultraviolet energy, but few are powerful enough to be widely useful. The ideal source, which emits a continuous non-banded spectrum of high intensity thruout the entire ultraviolet region, does not exist. Some of the sources are here ranked in order: magnetite arc, old mercury arc, new mercury arc, and carbon arc.

The blue flame arc emits ultraviolet energy very strongly. It is a simple matter to construct an arc which will emit ultraviolet energy strongly, provided hand-control is satisfactory. An iron rod and a carbon rod may be employed successfully for the two poles, however two iron rods may answer the purpose very well. These poles may be kept cool effectively by means of heavy brass or copper sleeves, which may be wound along the iron rods as the latter are consumed.

Uses of Ultraviolet Rays:—Ionization of air; powerful bactericidal agent; kill germs in water; effect upon animal tissue to bronze the skin. In industrial processes such as acetylene and arc welding, which are attended by powerful ultraviolet energy, there is a demand for eye-protecting glasses.