Department of Physics.

EVANS

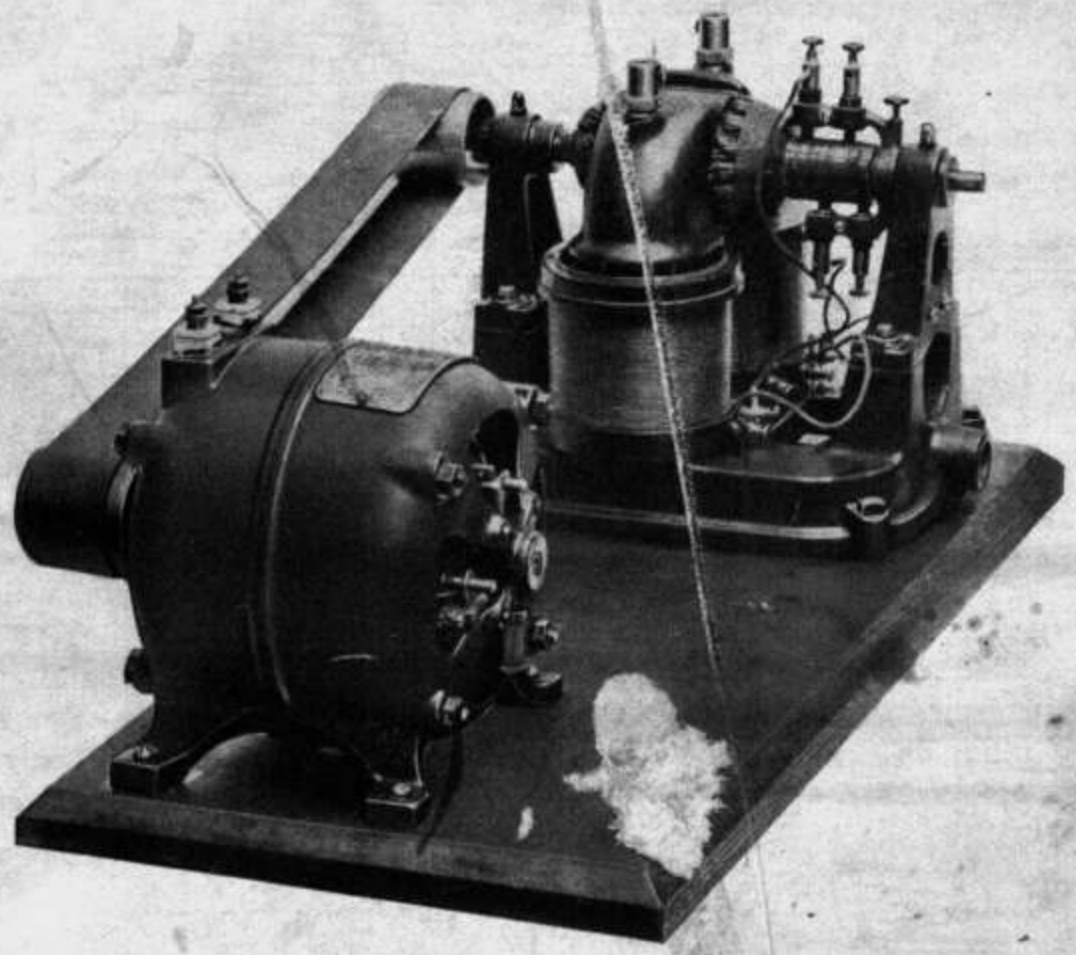
PROGRESSIVE ELECTRO-DYNAMIC

EQUIPMENT

TENTH YEAR

BULLETIN No. 12.

JANUARY, 1914



EVANS MOTOR-GENERATOR

Central Scientific Company

412-420 ORLEANS STREET

CHICAGO

WARNING:

Teachers and Boards, and others purchasing apparatus are warned that Letters Patent 742408 granted to H. J. Evans, and owned by him, covers the use of separate Poles or other Parts upon or about the Cores of Generator Field Magnets; also the Mounting of Field Rings in a horizontal plane on a Stand, for the support of Whirling Bodies or Armatures, to show Rotations due to Multiphase Currents; also the use of other Designs and Parts described in this Patent for EDUCATIONAL PURPOSES; and therefore Manufacturers and Dealers as well as Purchasers making, selling or using any other apparatus embodying any of the Specifications or Designs or Devices as described in this Patent No. 742408 are infringers, and will be dealt with according to law.

H. J. EVANS,
CENTRAL SCIENTIFIC CO.

ANNOUNCEMENT

NEW SERIES.

The following pages give full details of the Evans P. E. D. Equipment as now offered. Improved wherever its manipulation might be made more easy or certain, or its range widened, it is offered with confidence for the consideration of Teachers of Physics who want the best; and the list of schools on the following pages, ranging from great Universities to High Schools, shows that it has had successful tests in very able hands, and under widely differing educational conditions. Up to this time it has been meagerly advertised, and has had no adequate selling organization back of it; and yet it has gone into some of the greatest schools in the country, and entirely on its merits as a real help in maintaining an effective course.

The present writer is glad to call attention to the announcement made immediately below, since the arrangement thus completed establishes much more favorable conditions for the making and marketing of this equipment. The personal experience of ten years will not be lost to it; while the vigor, ability and resources of a strong and centrally located company will henceforth be back of it.

H. J. EVANS.

To the Customers of Central Scientific Company

We take pleasure in presenting to our customers this circular describing the Evans P. E. D. Equipment with the announcement that we have concluded an arrangement with Mr. H. J. Evans by which this well known apparatus has been added to our line.

Mr. Evans will continue to give his personal supervision to the apparatus and will now have the advantages of the resources of our well equipped factory and laboratory.

Cooperating with Mr. Evans, new pieces will be added from time to time to keep pace with educational demands in electrical science. We would especially appreciate suggestions from those who have used the equipment.

The quality and efficiency of this valuable laboratory and lecture table set will be maintained at a high standard.

CENTRAL SCIENTIFIC COMPANY.

Schools Using this Equipment

CANADA.
University of Manitoba, Winnipeg.

CHINA.
Christian College, Canton.
Royal Polytechnic University, Shanghai.
St. Johns University, Shanghai.

TURKEY.
Robert College, Constantinople.

ALABAMA.
Marion Military Institute, Marion.

CALIFORNIA.
University of California, Berkeley.
Christian Brothers College, Sacramento.
Los Angeles Polytechnic School, Los Angeles.
Pomona College, Claremont.
St. Ignatius College, San Francisco.
St. Mary's College, Oakland.
Hanford High School, Hanford.
Los Angeles High School, Los Angeles.
Ontario High School, Ontario.
Redlands High School, Redlands.
San Bernardino High School, San Bernardino.
San Jose High School, San Jose.

COLORADO.
Colorado College, Colorado Springs.
Colorado Springs High School, Colorado Springs.
Greeley High School, Greeley.

CONNECTICUT.
Bridgeport High School, Bridgeport.
New Haven High School, New Haven.
Normal Training and Industrial School, New London.

GEORGIA.
Emory College, Oxford.
Wesleyan Female College, Macon.

ILLINOIS.
Normal University, Normal.
Eastern Illinois State Normal School, Charleston.
Lake Forest University, Lake Forest.
St. Francis Solanus College, Quincy.
St. Ignatius College, Chicago.
Armour Institute, Chicago.
Lewis Institute, Chicago.
A. G. Lane High School, Chicago.
Bowen High School, Chicago.
Carl Schurz High School, Chicago.
Faragut High School, Chicago.
Harrison Technical High School, Chicago.
Joseph Medill High School, Chicago.
Lake High School, Chicago.
Richard T. Crane Manual Training High School, Chicago.
Nicholas Senn High School, Chicago.
Joliet Township High School, Joliet.
Peoria High School, Peoria.
Sycamore High School, Sycamore.

INDIANA.
Purdue University, La Fayette.
Shortridge High School, Indianapolis.

IOWA.
University of Iowa, Iowa City.
State Normal School, Cedar Falls.
Parsons College, Fairfield.
Simpson College, Indianola.
Central University, Pella.
High School, Iowa City.

MASSACHUSETTS.
Boston University, Boston.
M. C. M. A. Trade School, Boston.
Milton Academy, Milton.
Wellesley College, Wellesley.
Classical High School, Lynn.
English High School, Lynn.
Medford High School, Medford.
Milton High School, Milton.
Mount Hermon Boys' School, Mount Hermon.
New Bedford High School, New Bedford.
New Bedford Industrial School, New Bedford.
Revere High School, Revere.
Central High School, Springfield.
English High School, Worcester.
South High School, Worcester.

MAINE.
Central High School, Portland.
Deering High School, Portland.
Yarmouth High School, Yarmouth.

MARYLAND.
Baltimore City College, Baltimore.

MICHIGAN.
University of Michigan, Ann Arbor.
Michigan School of Mines, Houghton.
State Normal School, Marquette.
Detroit University School, Detroit.
Detroit Y. M. C. A., Detroit.
Hackley Manual Training School, Muskegon.
Ann Arbor High School (two) Ann Arbor.
Calumet High School (two) Calumet.
Central High School, Detroit.
Hancock High School, Hancock.
L. L. Wright High School, Ironwood.
Ishpeming High School, Ishpeming.

MINNESOTA.
University of Minnesota, Minneapolis.
State Normal School, Faribault.
South Side High School, Minneapolis.

Schools Using this Equipment—Continued

MISSISSIPPI.
St. Stanislaus College.

MISSOURI.
State Normal School, Kirksville.

NEVADA.
University of Nevada, Reno.
Reno High School, Reno.

NEW HAMPSHIRE.
Dover High School, Dover.
Nashua High School, Nashua.

NEW JERSEY.
Bayonne High School, Bayonne.
Hackensack High School, Hackensack.
Montclair High School, Montclair.
New Brunswick High School, New Brunswick.
Passaic High School, Passaic.

NEW YORK.
Teachers' College, Columbia University, New York City.
Cornell University, Ithaca.
Adelphi College, Brooklyn.
Packer Collegiate Institution, Brooklyn.
Buffalo Y. M. C. A., Buffalo.
Hamilton College, Clinton.
Colgate University, Hamilton.
Sibley College, Ithaca.
Ethical Culture School, New York City.
Mechanics' Institute, New York City.
Mechanics' Ass'n, Niagara Falls.
College of St. Francis Xavier, New York City.
Vassar College, Poughkeepsie.
St Lawrence University, Canton.
De Witt Clinton High School, New York City.
Erasmus High School, New York City.
Morris High School, New York City.
Wadleigh High School, New York City.
New Rochelle High School, New Rochelle.
Oleans High School, Oleans.
Yonkers High School, Yonkers.

OHIO.
Dennison University, Granville.
Miami University, Oxford.
Rayen School,
St. John's College,
St. Xavier College, Cincinnati.
St. Mary's Convent, Dayton.
Akron Y. M. C A., Akron.
Cleveland Y. M. C. A., Cleveland.
Columbus Y. M. C. A., Cleveland.
Akron High School, Akron.
Hughes High School, Cincinnati.
Woodward High School, Cincinnati.
South High School, Cleveland.
Steele High School, Dayton.
Stivers Manual Training School, Dayton.
Youngstown High School, Youngstown.

PENNSYLVANIA.
Pennsylvania State College, Gettysburg.
Girard College, Philadelphia.
Braddock High School, Braddock.
Peabody High School, Pittsburg.
Reading High School, Reading.

RHODE ISLAND.
Rogers High School, Newport.

UTAH.
All Hallows College, Salt Lake City.

WASHINGTON.
Auburn High School, Auburn.
Seattle High School, Seattle.
Tacoma High School, Tacoma.
Everett High School, Everett.

WASHINGTON, D. C.
McKinley Manual Training School.

WEST VIRGINIA.
University of West Virginia, Wheeling.

WISCONSIN.
State Normal School, Oshkosh.
State Normal School, River Falls
Lawrence College, Appleton.
Beloit College, Beloit.
Central Continuation School, Milwaukee.
Marquette University (two) Milwaukee.
Milwaukee Medical School, Milwaukee.
Sacred Heart College, Prairie du Chien.
Northwestern University, Watertown.
Carroll College, Waukesha.
Stout Normal Training School, Menomonie.
Antigo High School, Antigo.
Central High School, Appleton.
Beloit High School, Beloit.
Brillion High School, Brillion.
Columbus High School, Columbus.
Chippewa Falls High School, Chippewa Falls.
Fort Atkinson High School, Fort Atkinson.
Kenosha High School, Kenosha.
Lake Mills High School, Lake Mills.
Madison High School, Madison.
Manitowoc High School, Manitowoc.
Merrill High School, Merrill.
Neenah High School, Neenah.
New London High School, New London.
Oshkosh High School, Oshkosh.
Platteville High School, Platteville.
Portage High School, Portage.
Port Washington High School, Port Washington.
Sheboygan High School, Sheboygan.
Two Rivers High School, Two Rivers.
Waupaca High School, Waupaca
Wausau High School, Wausau.

THE MOTOR-GENERATOR A NECESSITY IN ALL SCHOOLS OFFERING COURSES IN ELECTRICITY.

No argument is necessary to convince experienced teachers that a Motor-Generator of some sort is necessary in schools where electricity is taught. Hand machines are futile. A service current is more or less dangerous, and its range of usefulness limited.

The choice must fall between the ordinary Commercial Motor-Generator, or one made specially and exclusively for Educational Purposes.

The Commercial Machine has only one idea in its construction; to transform one form of current into another with the smallest loss possible. Its make-up neither invites nor satisfies the curiosity of students. The important facts of its construction are in prison, behind double-locked bars. Not even a "line of force" can get outside.

Considering its **One Function,** the Commercial Motor-Generator is extremely expensive.

A multi-polar Field, while excellent in Commercial machines, cannot be used educationally except within a very narrow range of work. Nor apparently is the direct-connected Drive the best suited to courses in Electricity. The slight loss in mechanical efficiency, due to the belt, is far more than made up in the added flexibility and adaptability of the belt-drive. The handicap of the Siamese Twins is a far too serious one to put on two such potentialities in a course as Motor and Generator A belt allows of the ready uncoupling of the two so that each can be put to many separate uses, and when they are coupled again the work is done in a moment.

In a word, the constantly recurring need of changes in conditions, demanded as the work progresses, is easily met by the belt-drive.

The uncompromising rigidity of direct-connection needs only to be mentioned to suggest its lack of adaptability in educational work.

A BI-POLAR GENERATOR THE BEST.

Even a slight consideration will readily show why a bi-polar generator is chosen for this special line of work. This type of Generator can be made with removable poles, and the Field Coils can be built so that when taken off the cores, they are available, in connection with other parts, for many vital and impressive experiments. After working out these experiments, a student can put these field coils back on their cores again with a realization of the inter-play of force involved in their usual function, difficult if not impossible to get in any other way.

THE MATTER OF COST.

The reader of this Bulletin is asked to go over and summarize the work suggested throughout its pages; and when the important matter of expenditures is in his mind, let him consider, first, whether the ground covered is essential.

The experiments follow the line of discovery. They reproduce the phenomena which originally led to discovery. That there was something unusually stimulating and suggestive in these phenomena is proven by the effect they first had on the human mind. If the decision is made in favor of these experiments, and many experienced teachers endorse them with enthusiasm, the other question is concerned with the apparatus needed, and how best to secure it.

If bought in Unrelated Units, where each device is in the straight jacket of a single function, the cost is large. There is much duplication of material and labor.

Indeed, **the expense is not small in any case.**

The difference in cost between a thermometer and a volt meter is inherent in the construction of these instruments; and this larger cost is characteristic.

If the price of any Commercial Motor-Generator, of the same power as the one described in this Bulletin, is compared with the price of this equipment, including all the parts needed for the work planned, it will be found that the cost of the commercial machine is nearly as large as the price of the whole equipment. And this fact shows the economies effected by co-relating and organizing these devices. Summarize the whole work, and the conclusion is unavoidable that the equipment idea means a marked enlargement of usefulness **at less cost.**

The advantages of multi-functional devices over uni-functional need hardly be argued in these days of universal organization.

TWO IMPORTANT FEATURES OF THIS EQUIPMENT.

The work based on the phenomena produced, aids materially in developing a working Knowledge of the subject.

Theory and **Practice** in educational work should always be Direct-Connected. The Siamese Twins idea is good here.

And Second, the form of this equipment lends itself readily to any development made necessary by new educational demands. Under the new conditions announced on the first page, revision of the Manual is assured, and there will be increased responsiveness to suggestions for improvements or additions.

GROUP ONE.

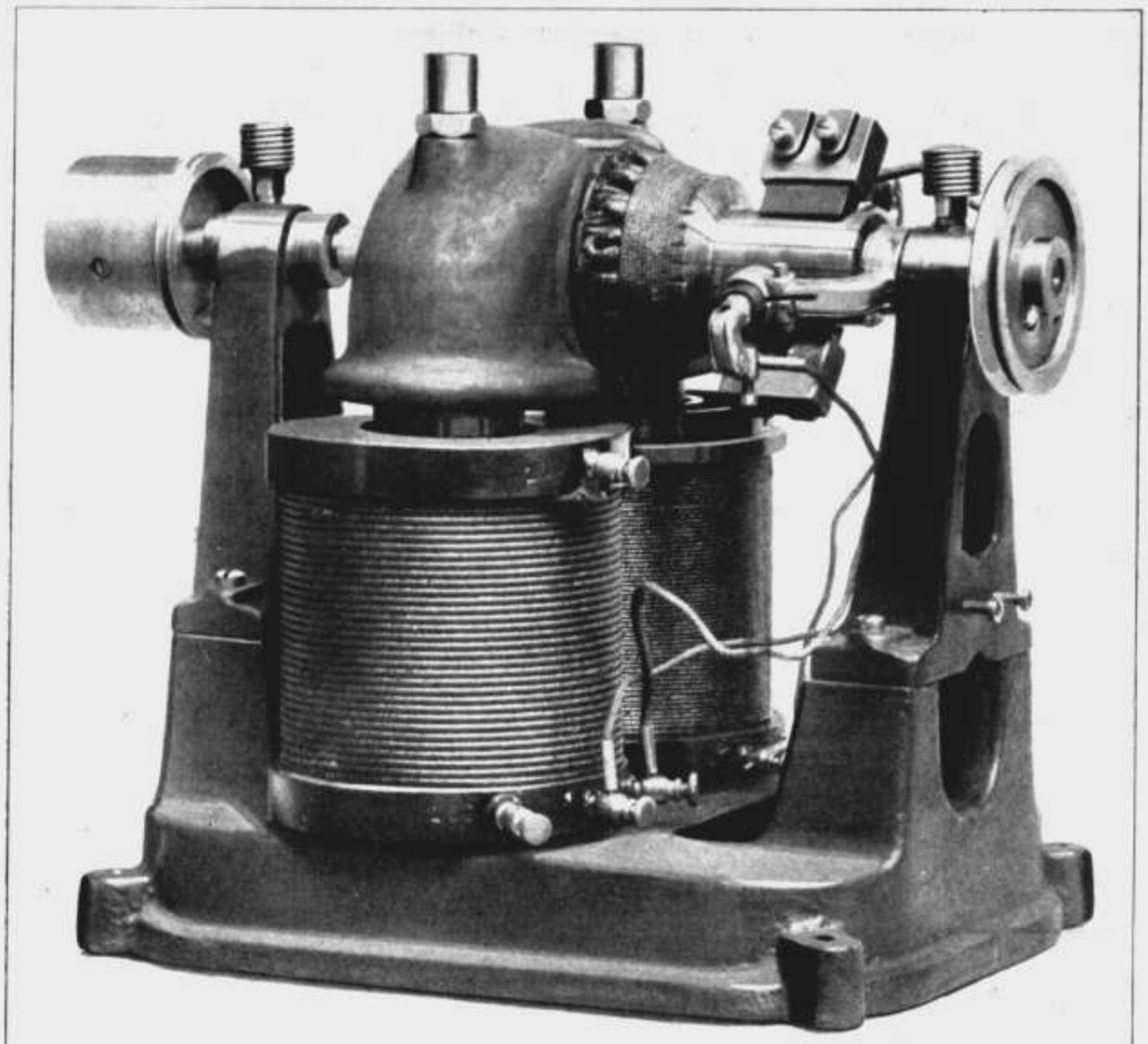


Illustration 1.
Two Armature Type Generator With D. C. Armature Shown.

It has been decided that it would be of material assistance in cases where for one reason or another, the whole equipment is not purchasd, to list the Parts in Groups having closest relation to each other, so that the largest range of usefulness would result in these cases.

Following out this idea, naturally the Motor-Generator is the largest Unit of Group One, because, while it is the basis of much of the work planned in the Manual, its cost, too, makes up a large part of the whole expense of the equipment. As will be seen by following the account given of the work possible with the Parts in Group One, quite a respectable amount can be accomplished by the addition to the Motor-Generator of just a few parts. Group One, then, is made up of the Motor-Generator and a few Parts, closely related to it, and having maximum usefulness, until the rest of the equipment can be purchased.

GENERATOR.

In the new series of these equipments some improvements have been made in the Generator. For the D. C. Work an improved form of Brush is furnished. These are carbon-gauze, 1⅛x¾x⅜ inches and are supported so that adjustments and tension can be changed with ease. The new Compound Winding also is much more effective than in the old Series. The base of this machine is 9x11½ inches; the cores are 7¼ inches long and the Coils are carefully made, having slotted zinc bodies and hard wood ends, and they are 5x5⅛ inches in diameter and length respectively. The laminated core of the Armature is 3$\frac{5}{16}$ inches in diameter and 2¾ inches in length, having 16 slots, with lap-winding.

As a D. C. Generator this machine can be run as a Series Machine, a Shunt Machine and as a Compound Wound Machine, and methods of control may be forcefully shown in each case. The machine can also be used in all the forms of D. C. Motors, Series, Shunt, and Compound-Wound, and it is a thoroughly good and commercially efficient machine except when used as a Series Motor. The practical facts connected with their running and the principles governing the action of these forms of motors are readily shown. As a help in the Laboratory, also, since it runs on any current from 6 volts up, and its speed can be made (by use of the Variable Resistance in the Fields) anything from a few hundred up to several thousand, this machine serves many purposes. It generates 20 volts pressure at 2200 r. p. m., and the amperage is ample for all work naturally falling to it, including all forms of testing work.

But we are now able to offer still another generator as an option, and the attention of teachers is called specially to this **NEW MACHINE.** As will be noted, it has but one Armature of the double-ended type, with A. C. collector rings on one end and a very massive D. C. Commutator on the other. A 45-volt direct current is taken from one set of

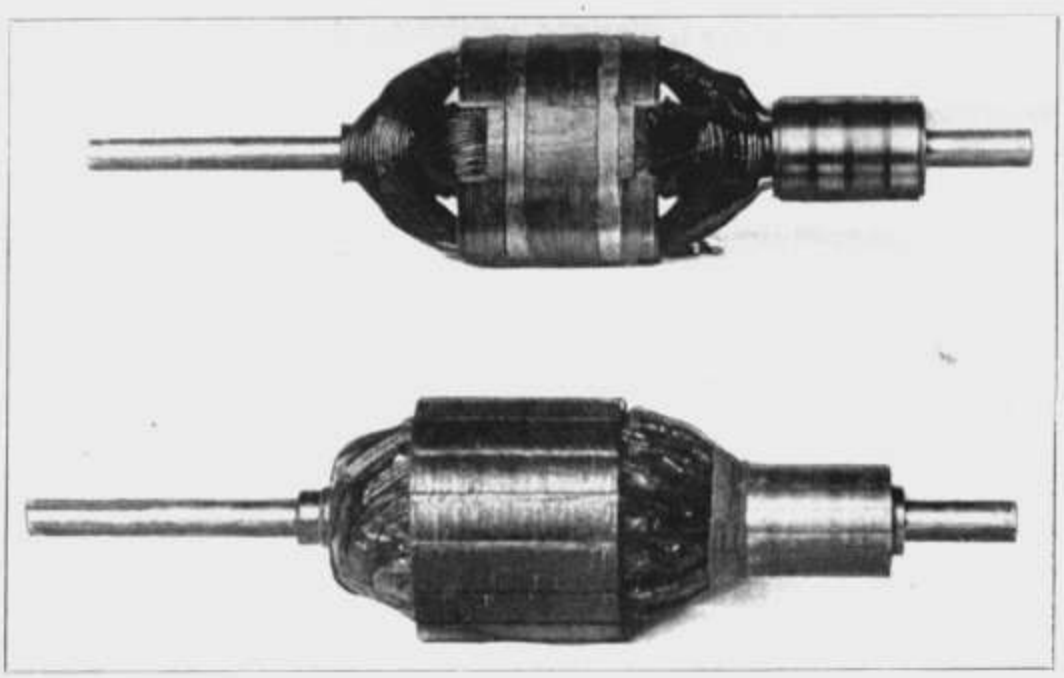


Illustration 2.
Interchangeable A. C. and D. C. Armatures for Two Armature Type Generator. See Illustration 1.

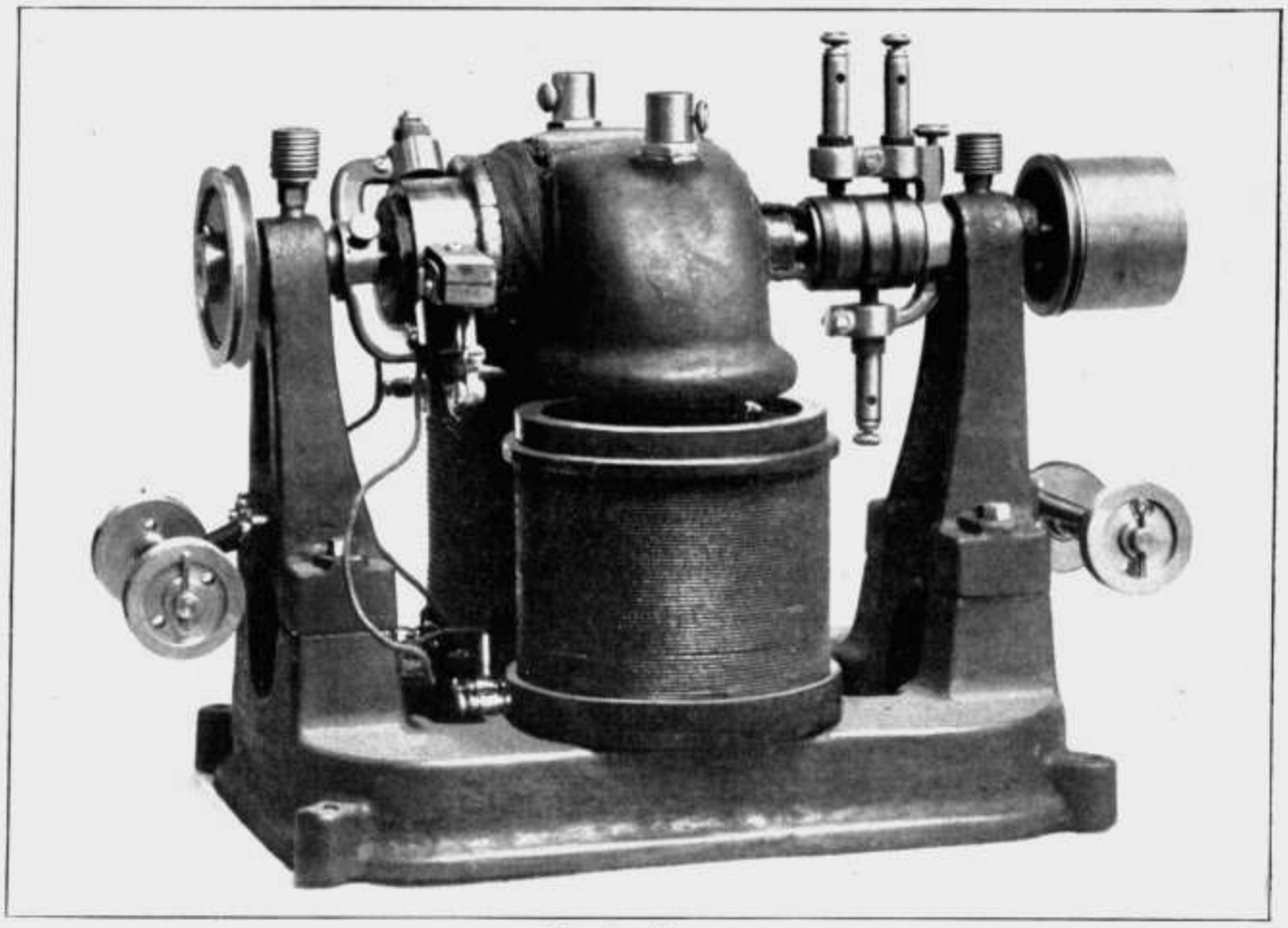


Illustration 3.
Generator, Double End Armature Type.

brushes, and an alternating 30-volt current from the other. The A. C. may be either Single Phase or Three-Phase. As a D. C. Generator or Motor this machine tests out with all the marks of a first-class machine. The brushes are very large, being ⅝x¾x2 inches, and are carbon-gauze, having four layers of gauze. There is no visible sparking at the brushes, and the machine runs very quietly as either motor or generator. As a D. C. Generator it can be used in all three ways: Series, Shunt and Compound-Wound, and the Compound winding is effective and satisfactory. From the A. C. end there is available a Three-Phase Current of ample power or a Single Phase Current, very completely answering the demands of the work as planned in the Manual.

Of course, it must be understood that this machine has the removable pole pieces and all the special fittings which go with the older type. With this new type generator the armature never has to be changed; all the work possible with the older type machine can be done with this; either current or both are instantly available, and in A. C. work, a separate excitation of the fields is unnecessary. It is thought that the special field for this machine might be in Colleges and Technical Schools. It is somewhat larger than the older type. The Armature of this machine is 3¾ inches in diameter, and 2¾ inches long, has 19 slots, and is wave-wound.

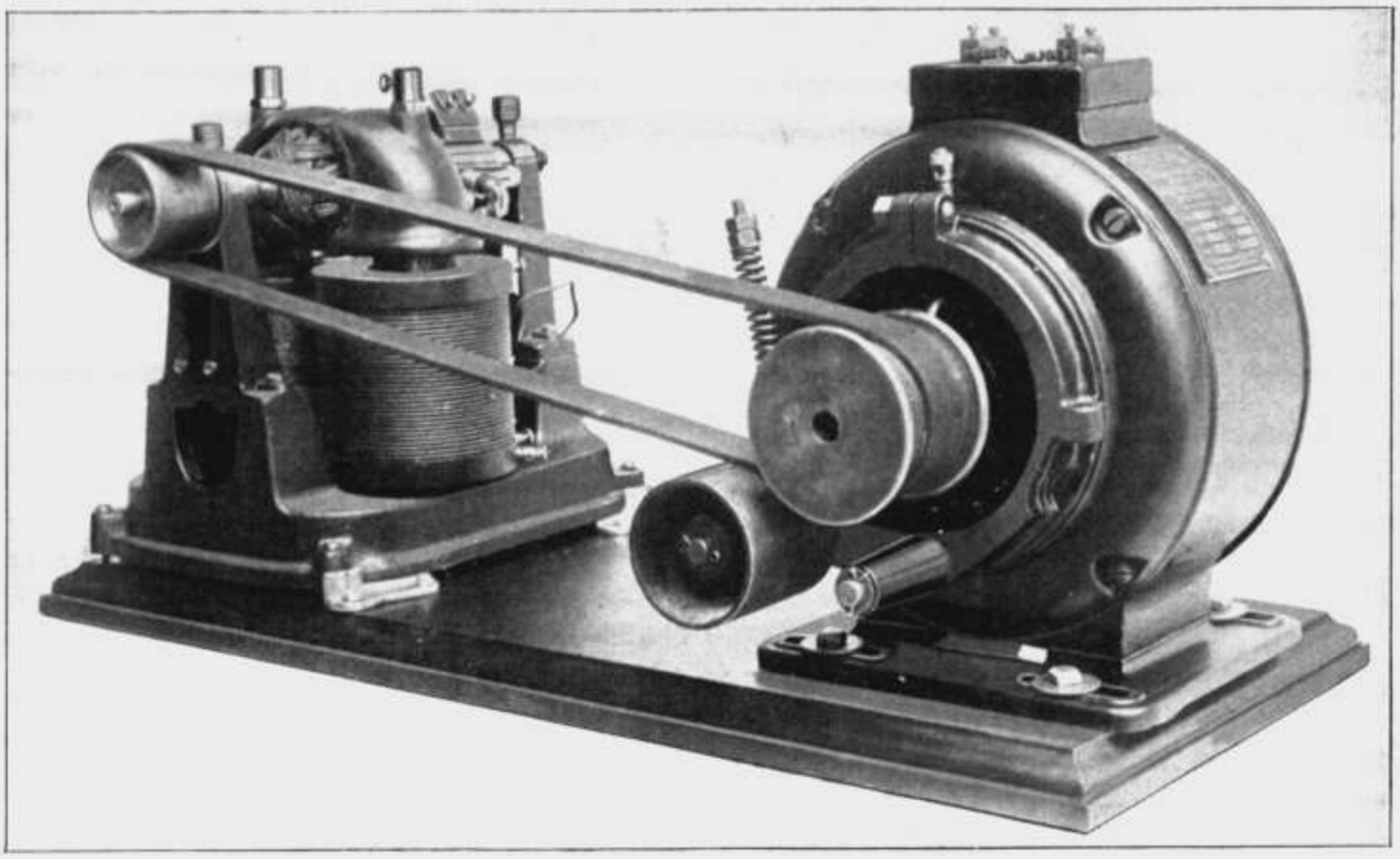


Illustration 4.
Two Armature Type Generator With Emerson Drive Motor.

MOTOR-GENERATOR.

Either the two-armature or double-end armature type generator is mounted as represented in illustration 4. The machines are belt-connected. The motor represented in the picture is an Emerson with a special belt tightener, which is very easily used, and any tension required can be given the belt instantly. This drive motor is somewhat more expensive than the one furnished heretofore, and made by the General Electric Co. Both drives are fine machines; either would prove highly satisfactory; and the choice of either is offered.

The hard wood base on which the Motor-generator is coupled is 13x30 inches. There are two angle pieces placed at the corners of the generator, toward the Drive, for the purpose of securing a line-up after the generator has been used away from the base. The screws are put into the corners of the generator base for security in shipment only. This makes the coupling and uncoupling of the two machines free from any possible difficulty. In all forms of the generator there are four heavy rubber cushions at the base corners to prevent injury to tables and to prevent slip when in use. The workmanship on these machines is on a level always with good machine-shop practice, and they are commercially efficient in performance.

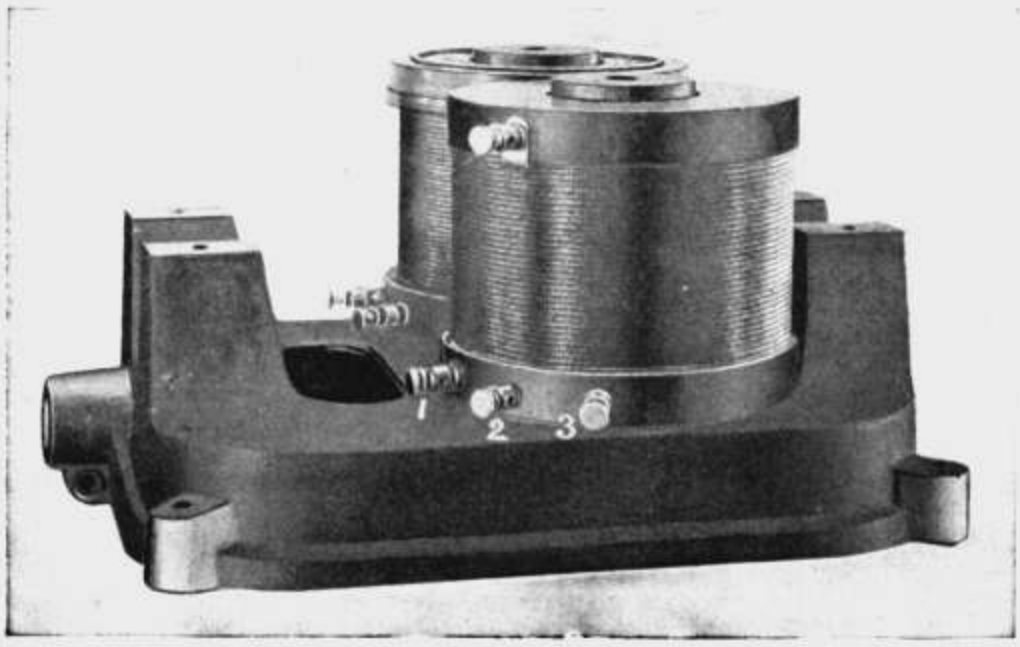


Illustration 5.
Field Magnet With Poles Removed.

FIELD MAGNET.

Illustration 5 shows the Field Magnet with Generator Poles removed. The cores are of Norway iron, and the ampere-turns are sufficient with proper excitation to produce a field having ample power for impressive experiments in Damping Effects, Heating Effects, and Dia-Magnetism. A heavy Armature of careful design is furnished also for lifting experiments.

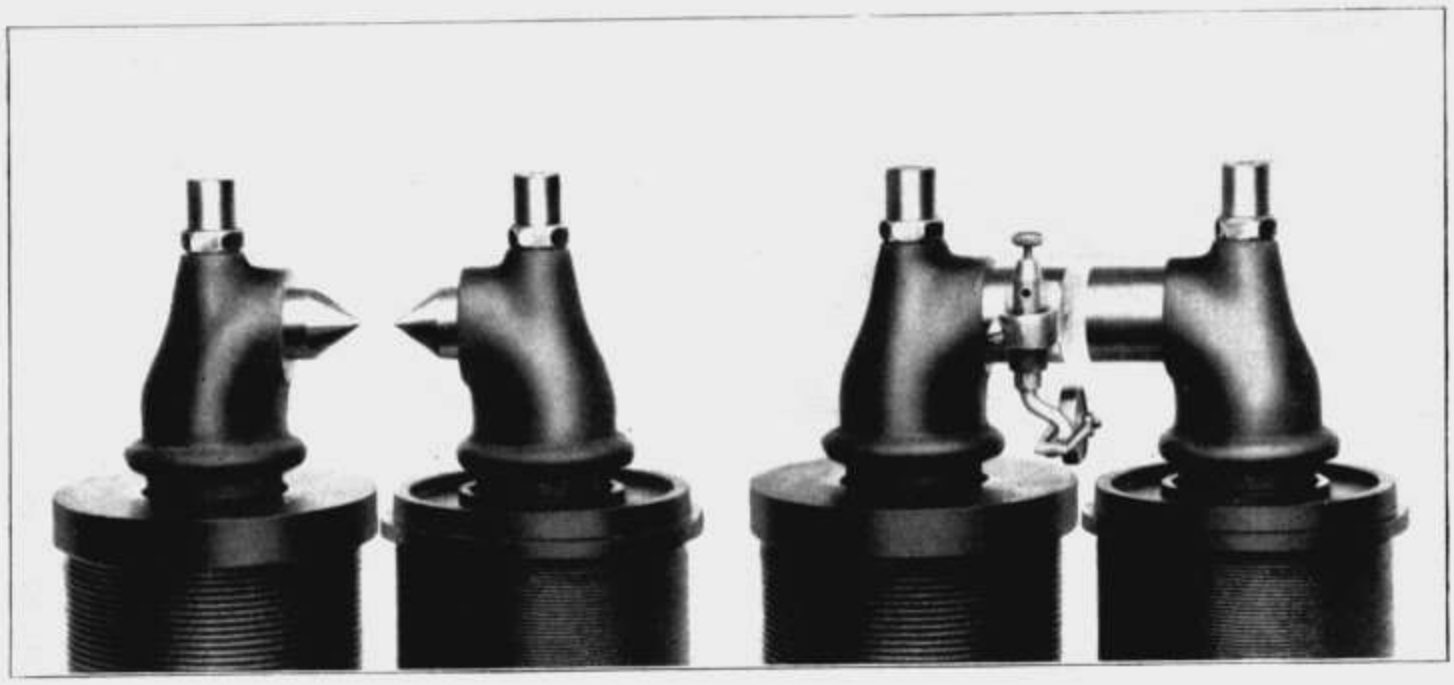


Illustration 6
Pole Pieces With Detachable Faces.

POLE PIECES.

Illustration 6 shows the Conical and Cylindrical Pole Pieces now offered for use with the Field magnet. Having removable Faces makes it possible to machine and finish these to much greater advantage. The Dia-magnetism of Bismuth Crystals can be shown by use of the field magnet with pointed Poles; and the method of suspension is suggested in illustration 43, page 30. The Points actually furnished are much larger at the base than those in the picture; and are in the form of truncated cones.

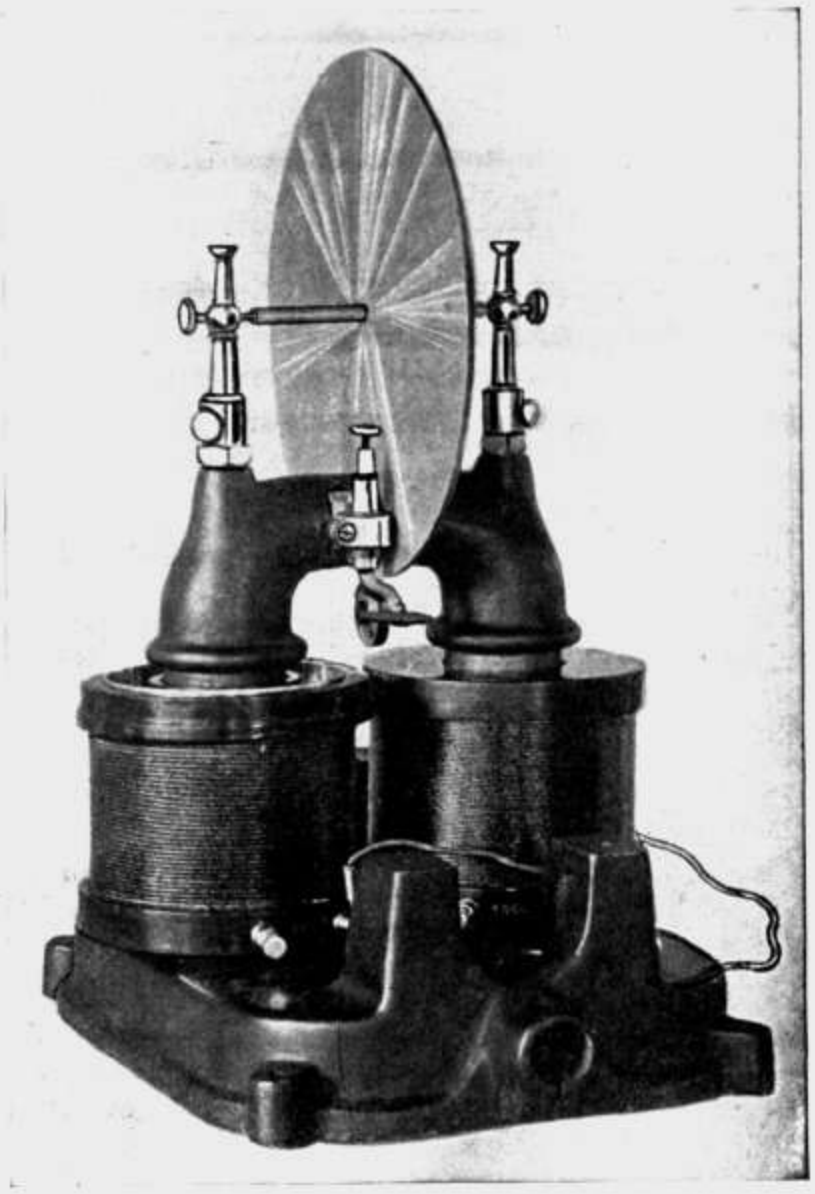


Illustration 7.
Faraday Disk Dynamo.

FARADAY'S DISK DYNAMO.

Recurring to illustration 6 it will be noted that the heavier ends of the pole pieces are attached in the same manner as the Pointed Pole Pieces. With these heavier ends, and the Trolley shown in the picture, with a few fittings which cost little, it is easy to build up a Faraday Disk Dynamo than which there is no more valuable device to aid in the study of foundations in Electricity. The slightest acquaintance with costs would show that the expense of building this device as a separate unit or piece would be prohibitory for most schools.

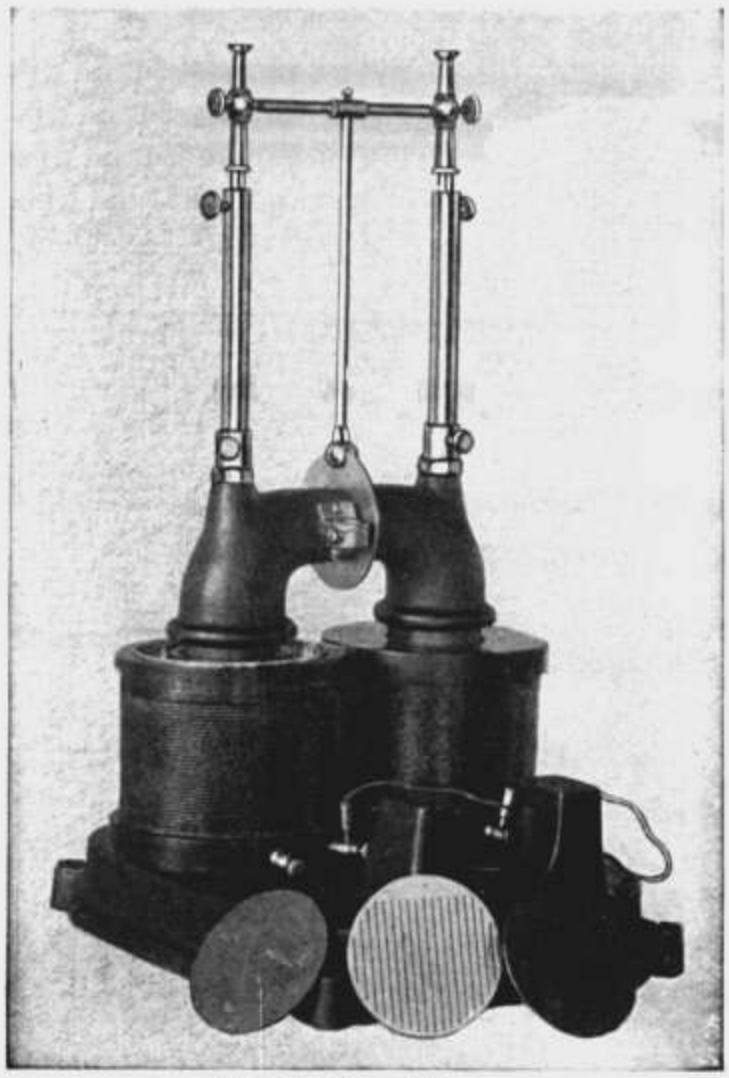


Illustration 8.
Damping Pendulum.

EDDY CURRENTS.

Then the Damping Effects. Illustration 8 shows the arrangement of parts. There is a pendulum, suspended as shown, provided with disks of different metals for bobs, to show that the amount of Induction depends on the conductivity of the metal cutting the lines. Then to show how slotting prevents the formation of Eddy Currents, two aluminum disks, one slotted, the other plain, are provided; and the marked difference in the behavior of the two as they swing through the field lines is impressive.

Illustration 9.
Heating Effect of a Magnetic Field.

TYNDALL'S EXPERIMENT.

But this strong Field, when fitted out for the purpose, reproduces in an interesting way the classic experiment of Tyndall in showing the heating effects of a Magnetic Field. The pointed pole pieces are used to concentrate the lines, and a whirling system, consisting of a heavy copper tube, properly mounted, revolves between the points. In the copper tube is a small cylinder of Lipowitz's metal. Illustration 9 shows how a high speed is given to the copper tube. There is a minute hole in the copper tube near the bottom of the tube, and when the metal melts it is sprayed out in minute but visible globules.

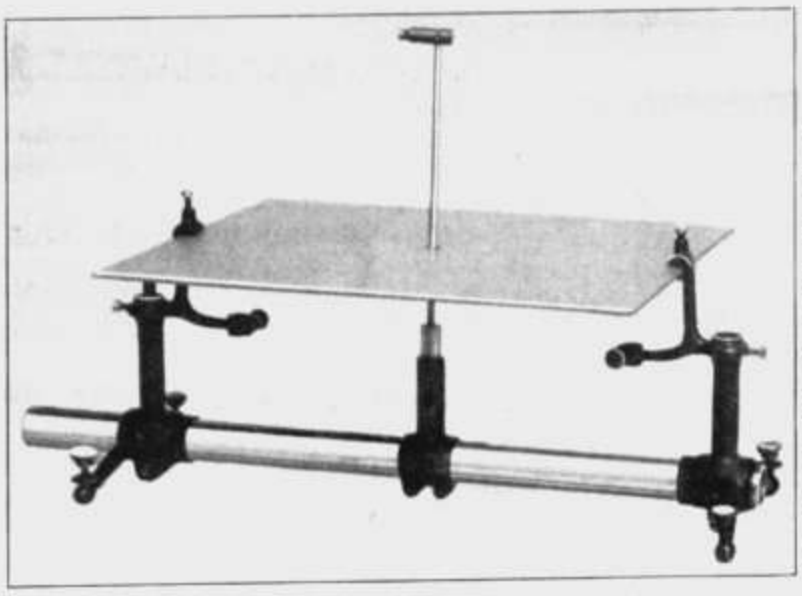


Illustration 10.
Magnetic Field, Single Wire.

MAGNETIC FIELD.

But the purchase of the First Group in this equipment furnishes, besides the Motor-generator and the parts for the work already described, some other parts of great service. The well-made Field Coils must not be overlooked; and the following series of four pictures, illustrations 10, 11, 12 and 13, show how these coils can be used to bring out decisively the facts and principles necessary to an understanding of Electro-Magnetic Action, and how power is developed and controlled in Electro-Magnets. In illustration 12 the coil is supported so that a square of heavy card board is fitted around it, and another strip of card board is

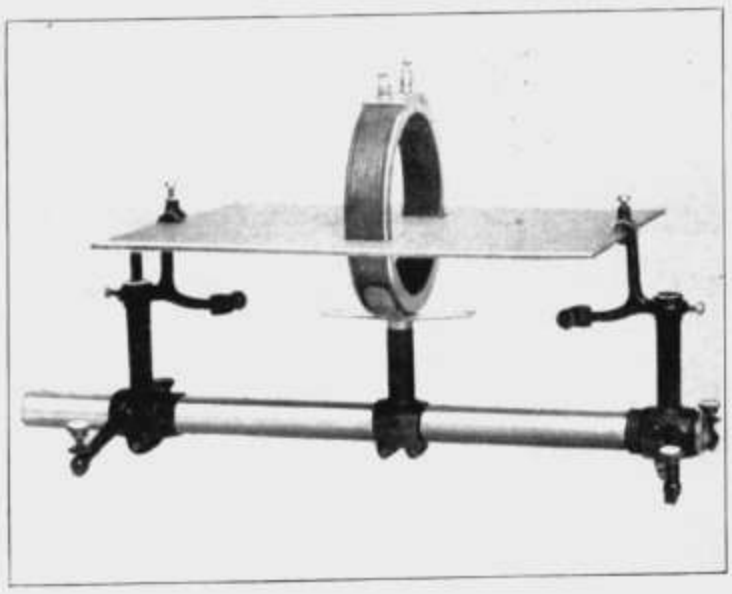


Illustration 11.
Magnetic Field, Several Turns.

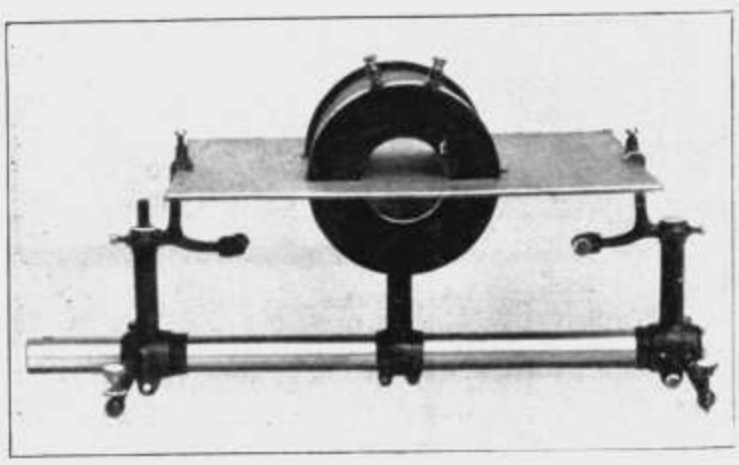


Illustration 12.
Magnetic Field, Many Turns.

placed in the same plane as the outside card board, and extending through the center of the coil. If a current of sufficient strength is sent through the coil, and iron filings are scattered about and on the card board running through the core hole, the "lines" of the magnet will form in the filings.

The same can be shown by using the Auxiliary Coil, see illustration 11; and the same method shows how the lines form about a single wire, see illustration 10.

The order of presentation would be, the "lines" about the single wire, illustration 10; the looping of the single wire to show the "lines" around each wire a diameter apart; the "lines" about the narrow Auxiliary Coil, illustration 11; and finally the "lines" about the Field Coil, illustration 12.

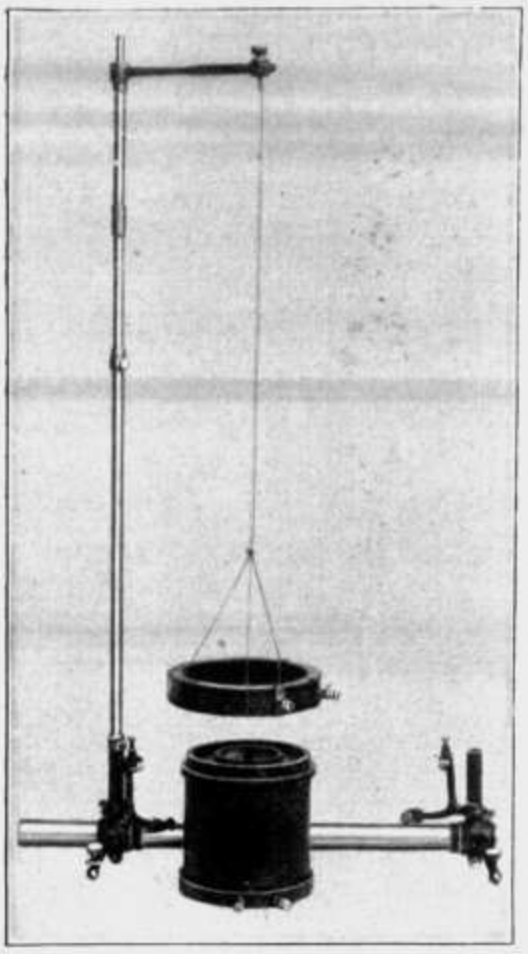


Illustration 13.
Magnetic Field Developing Power.

Again, by suspending the Auxiliary Coil as shown in illustration 13 and placing the Field Coil beneath, the steps in the development of electro-magnetic power are strikingly shown. Have a small battery current flowing through the Auxiliary Coil, using flexible wires looped up out of the way. Connect the Field Coil to a storage battery of several cells, and have the currents in both coils flowing in the same direction. When the circuits are made, of course there will be attraction. In this first trial there is air only in the core hole of the field magnet. Place a small cylinder of hard steel in the core hole, and again make the circuit. Raise the Auxiliary Coil till there is no attraction. Now put a cylinder of soft iron of the same size as the hard steel. Again raise the Auxiliary coil till there is no attraction. And now put the field coil on a core of the generator magnet, and try again for attraction. The power of the Electro-magnet is shown to be much greater. These steps, properly discussed, summarize into the underlying Laws.

Again this arrangement may be used to show very nicely the laws of parallel current in the same, and in the opposite directions.

And finally, by cutting off the battery current from the Auxiliary Coil, and connecting the two binding posts by a short wire to make a closed circuit, leaving it suspended by the same special spring, it is easy to prove the truth of the law that an induced current is always in a direction to oppose the motion producing the induction. It is necessary simply to use the Conventional Primary Coil, strongly energized, and given sudden motion up or down while in the position shown by the picture.

The field coil can be used in place of the conventional primary, and with no other change in the arrangement, the direction of the induced current at "make" and "break" can be shown. The Manual describes these experiments fully.

MAGNETIC ROTATION.

And now put the field coil with upper end turned to form a circular mercury bath back on its core: use one of the clamping bolts of the generator to support the part shown in the picture (one side of the Side Supports for the Faraday Disk Dynamo), and with the addition of an inexpensive aluminum rectangle, supported by a steel pivot, at the top, the truth that a current flowing in a wire will perpetually revolve about a magnet in a direction depending on the pole, whether north or south, and the direction of the current, is shown.

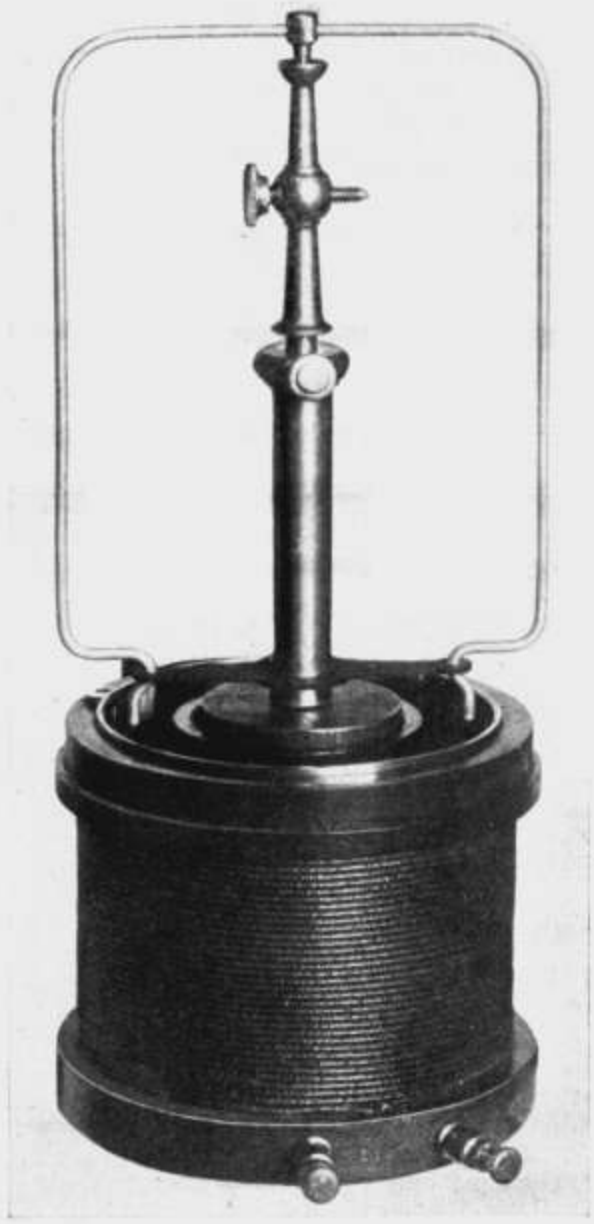


Illustration 14.
Reaction of Magnetic Pole on a Current.

Illustration 15.
Gore's Railway.

Illustration 16.
Magnetic Rotation of Liquid.

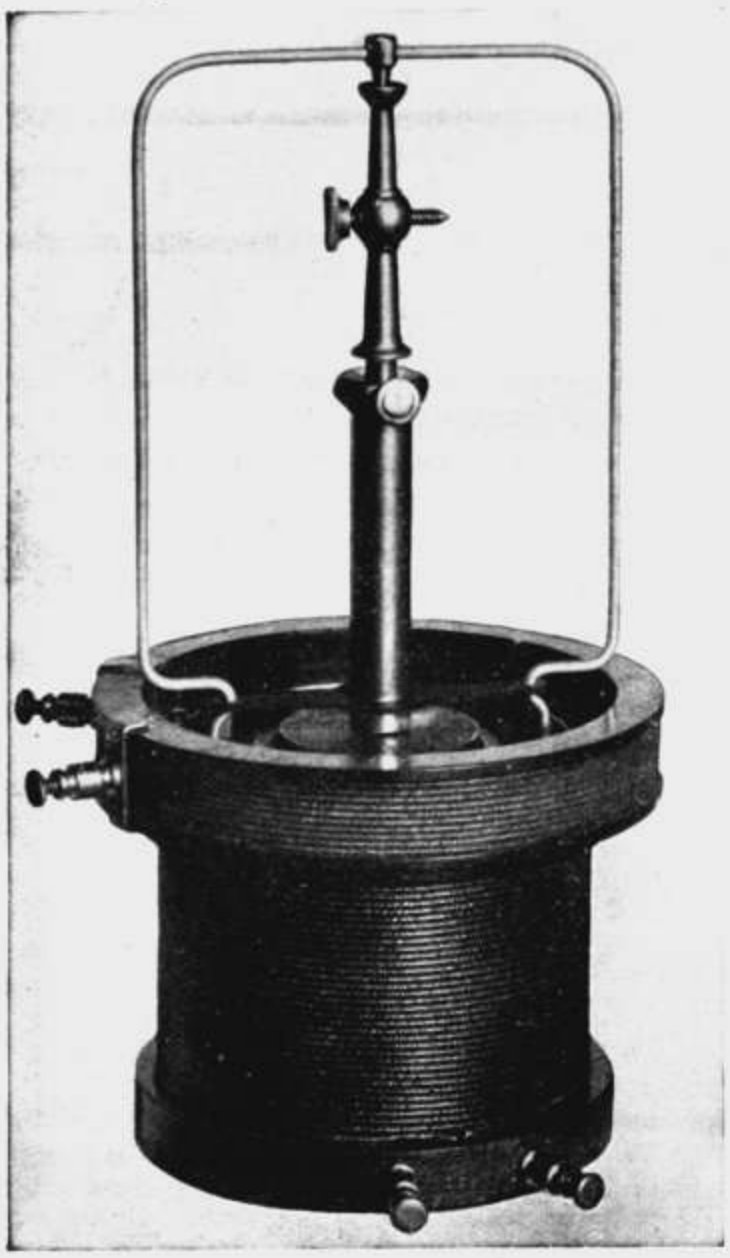


Illustration 17.
Reaction of Angular Currents.

To reinforce this the modified Gore's Railway, illustration 15, is added; and the cost of the Cap and hollow brass ball, the only additional parts needed, is trifling.

But if the current happens to be flowing in a liquid instead of a solid the result is the same; and the hard rubber mercury bath, with the vane to make the revolution more evident, adds but slightly to the cost, see illustration 16.

Using only parts already mentioned, and setting up these parts as in illustration 17, tne action of angular currents on each other is demonstrated. Thus all the cases, viz.: the action of parallel currents in the same direction; of parallel currents in opposite directions; and of currents flowing at some angle, may all be studied as actualities. See also illustration 18, showing details of this apparatus.

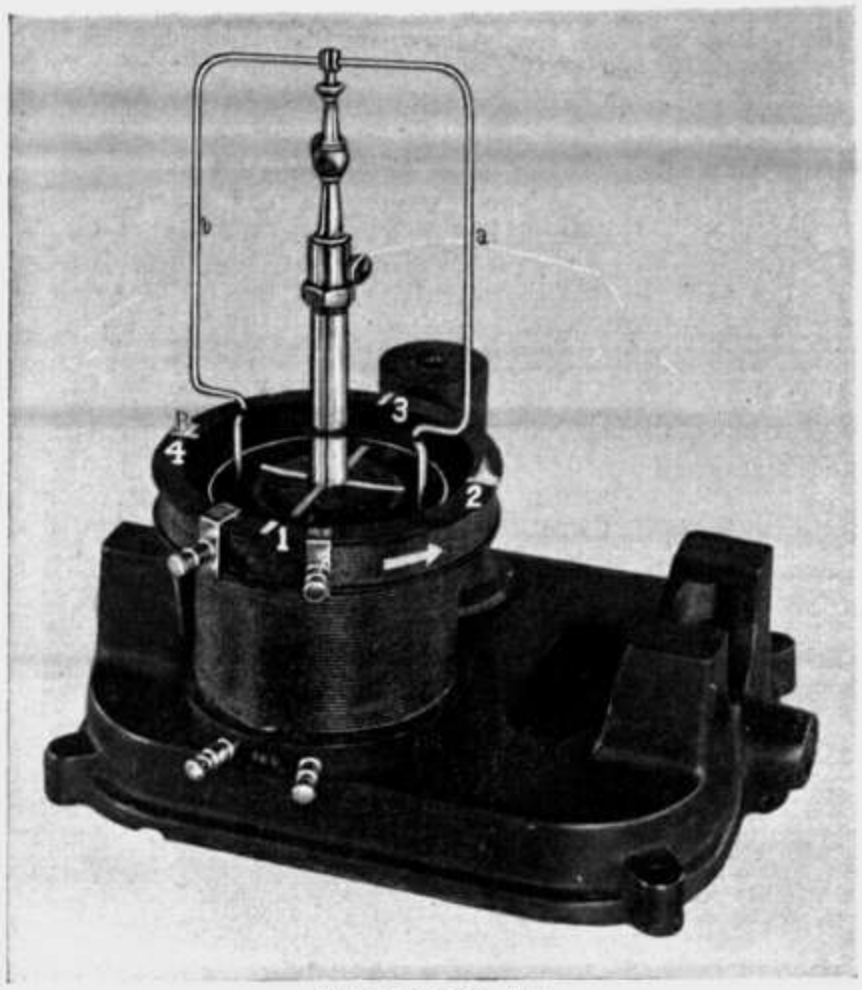


Illustration 18.
Reaction of Angular Currents.

This picture is taken from the Manual and was made to assist in the Analysis of the Reaction of Angular Currents on each other.

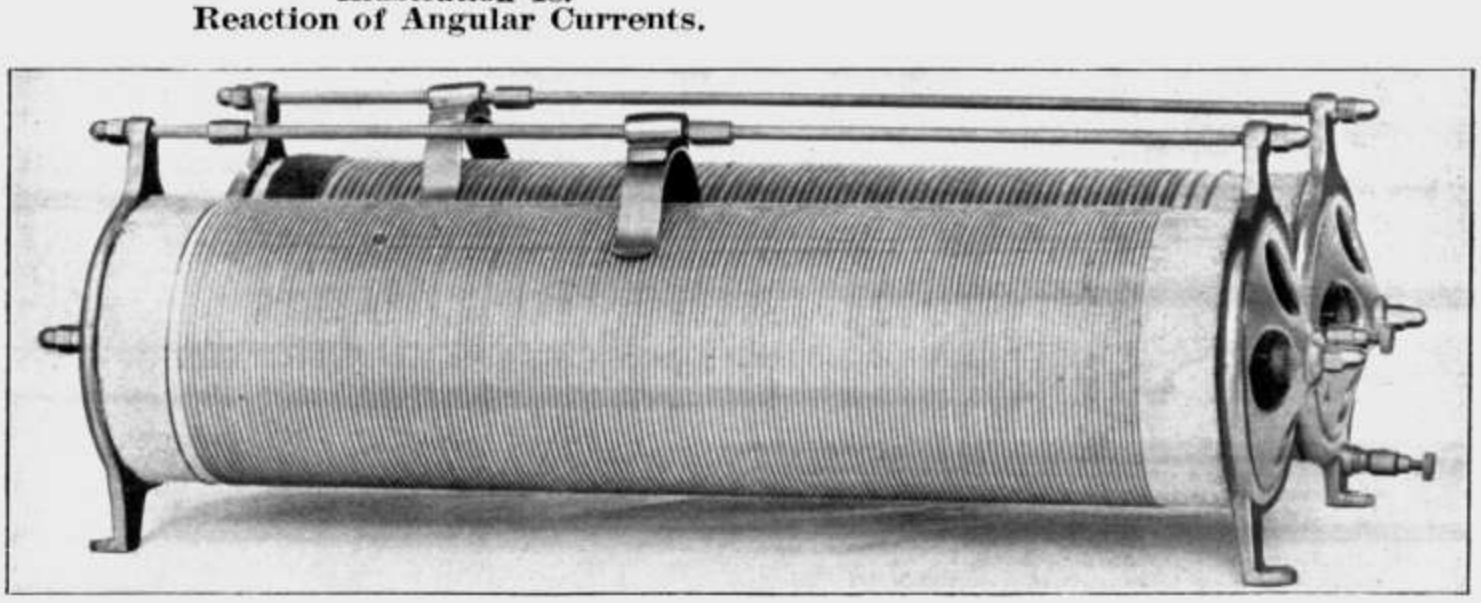


Illustration 19.
Variable Resistance.

VARIABLE RESISTANCE.

This picture shows the last part of Group One: The Variable Resistance. This instrument has just the right range for the work with the Motor-generator, and serves many other purposes in the course. It is wound with two sizes of German silver wire, Nos. 19 and 14, and the resistance of the windings of large wire is four ohms, that of the smaller wire 22 ohms, approximately. This form of resistance is excellent for the reason that very fine shadings in control are possible. There cannot be any violent jumps or changes in a circuit of which this is a part, since the sliders cut in or out but one turn at a time.

The parts thus far described are all that are included in Group One. For this reason: the cost of the Motor-Generator is the principal item of expense in this equipment, and with it once purchased the remaining parts occasion no large outlay. Hence in this group, enough parts are added to the motor-generator to insure quite a range of interesting work, so that schools buying this group of parts alone, can get their money's worth, while waiting till the opportunity comes for the purchase of the rest of the equipment.

GROUP TWO.

In many schools, there is a strict limit of time on the amount of work which can be done in any subject of Physics. It would seem that such schools should be so equipped that none of this precious time shall be wasted. This means that the time of the teacher in charge is to be conserved by putting at his disposal apparatus manipulated easily, and with the fewest parts possible, with the widest range of usefulness possible. It means, too, that the lines of work should be laid in a direction toward practical knowledge. Certainly there should be no hap-hazard dodging, here and there, following the exigencies arising from lack of equipment.

It is believed that in Courses strictly limited by time the use of apparatus in Groups One and Two, following the work as suggested in the Manual will aid materially in giving effectiveness and direction to such Courses; and the assertion is made with confidence that far more can be accomplished by the use of this equipment than by spending the same amount of money on apparatus covering the same ground, but bought in separate, unrelated units.

Let it be understood that there is no limitation on the sale of Parts of this Equipment. No part is reserved from sale. But there are parts that work together to best advantage; and this method of Grouping has for its sole object the assistance of teachers in making selections that will insure the widest possible usefulness for the money spent.

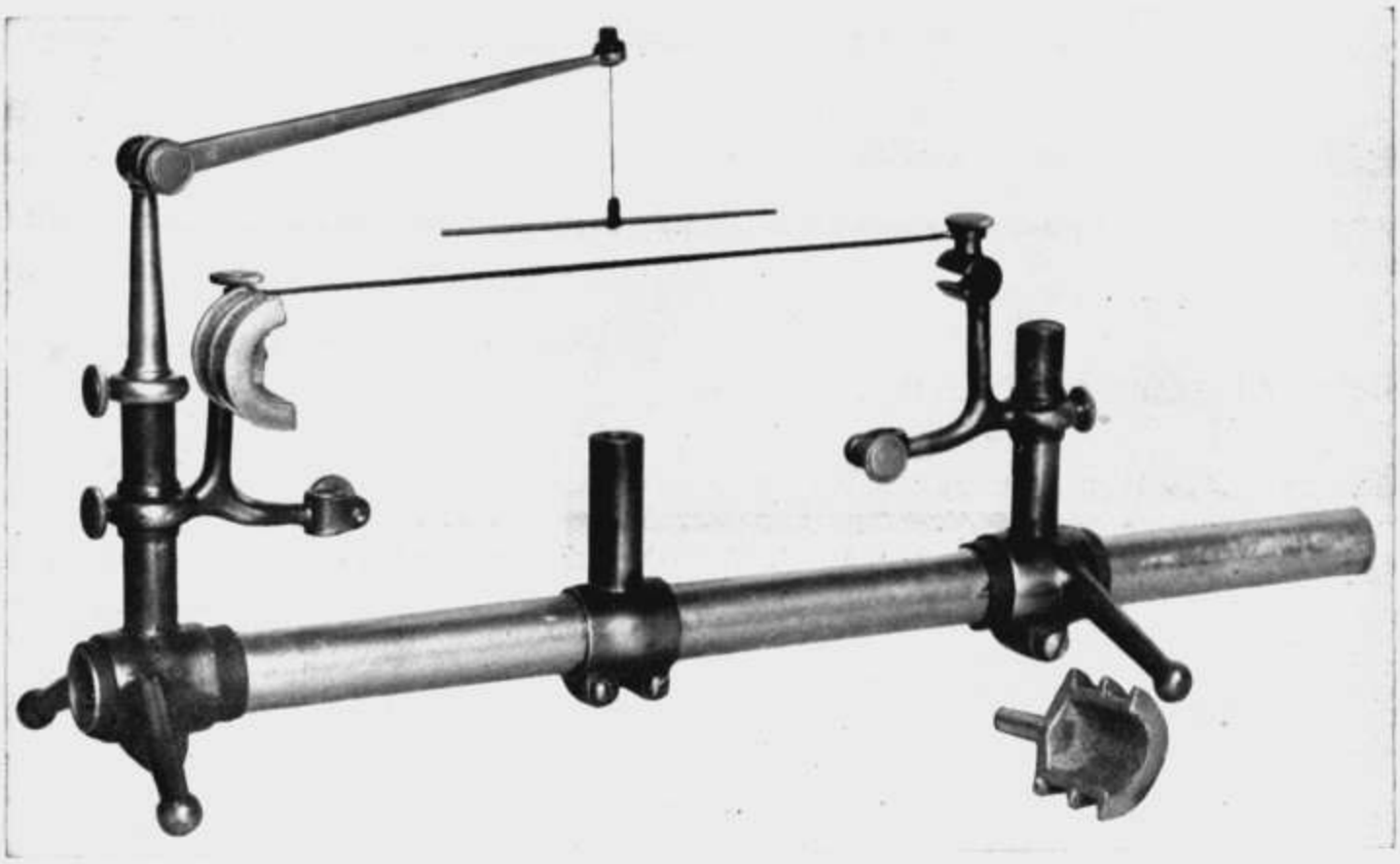


Illustration 20.
Stand for Whirling.

OERSTED'S EXPERIMENT.

This picture gives a clear representation of the whirling stand. It consists of a nickeled brass tube for the body, 18 inches long by 1 inch in diameter, and of heavy stock; a journal, accurately turned and bored, which slides on the tube, as do the two side pieces. These latter are provided with pointed leveling screws, not only for leveling purposes, but to prevent slip when the belt is used. In this first picture of the Group, the stand is used to develop the actions in Oersted's Discovery. It will be seen that the needle can be set in any plane above or below the wire; and that provision is made for the support of two Coil Holders (one is in position) so that the effect of multiplying the "turns" can be shown. Indeed, later in the course, this same arrangement can be used to develop step by step, with astatic needles, a respectably sensitive galvanometer.

FREE POLE ROTATION.

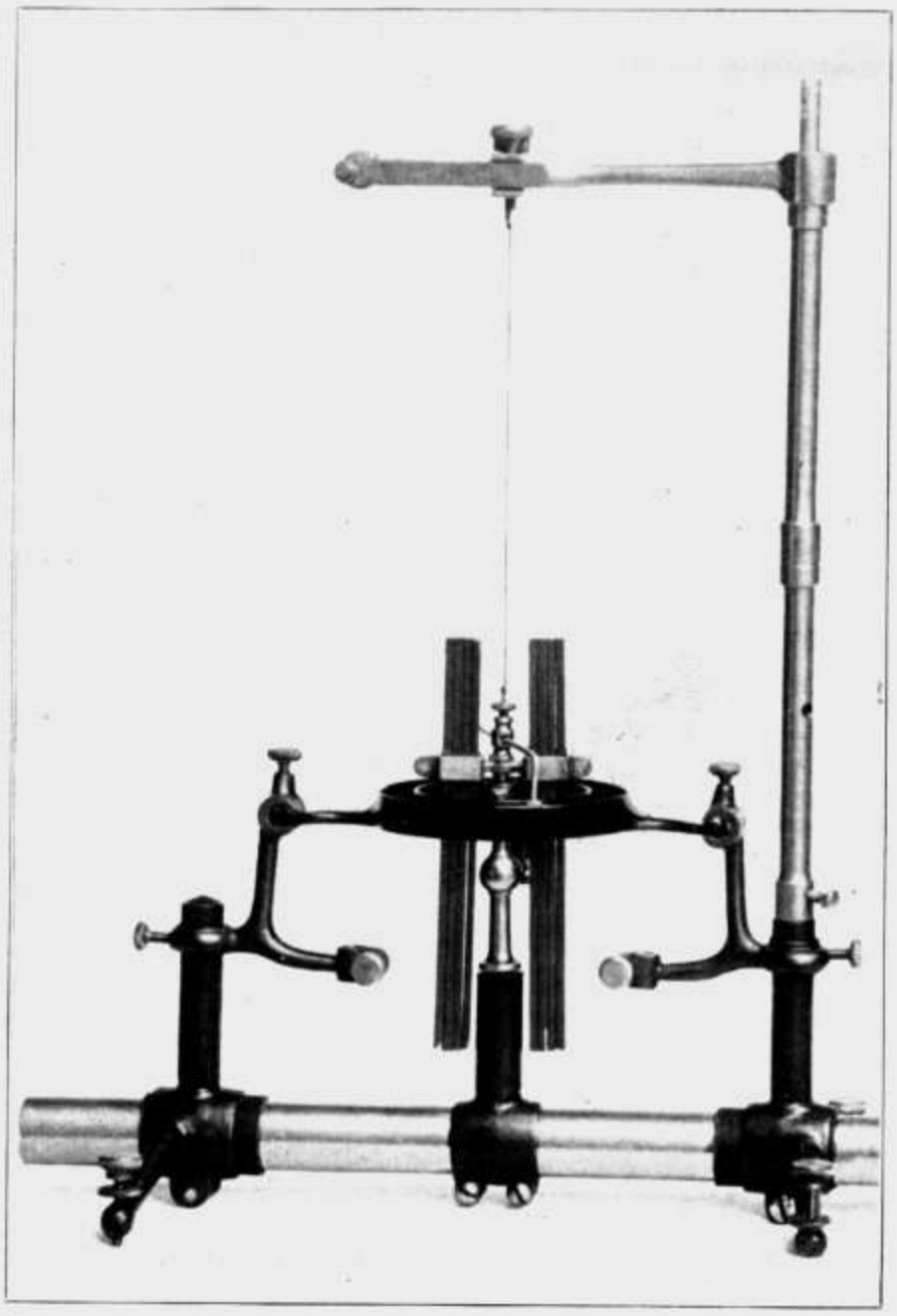


Illustration 21.

The main value of this demonstration is not in its inherent interest, though this is considerable, but in the fact that without a comprehension of the truth brought out, the Oersted actions would not be understood at all, and therefore the student, instead of getting a start toward clear-cut foundational notions, would be mystified if not misled. He might, for instance, get the conception that the poles of Oersted's needle are repelled by the current flowing in the wire, in the same way that a magnet would repel them. Thus the real conception would be lost to him. If Faraday had accepted this surface notion, the actual relations between magnets and electric currents might not have been discovered for years. Science can advance only by getting true conceptions in logical order, and the **historical order** is the logical order.

In some way, Faraday got the notion that if one pole of a magnet could be freed from the counter-balancing action of the other, when exposed to the action of a current, the **pole would revolve.** It took him a long time to get a complete demonstration of the truth of this surmise. But he needed this demonstration before he could **go a step further.** So do all students.

In the Parts provided for this demonstration are two cylindrical magnets yoked together by a cross piece, to the center of which is attached a tapered though not sharp point of iron. Above this point, the cord sustaining the magnets is fastened; and it is attached, also, at the top, to a support having a sliding block which enables the experimenter to get a center for the system without difficulty. The leveling screws of the Stand assist in this. It may be noticed that the Pendulum Side Supports make up the vertical addition to the Stand, and the Goose Necks, which are free to move up and down, sustain the circular Mercury Bath at any level required. A length of aluminum wire, bent at right angles, and pointed, makes a light moving contact with the surface of the Mercury. The point of iron of the whirling system rests very lightly (the tension of the sustaining cord determines this) in a drop of mercury at the top of the cupped Side Support, used in the Faraday Disk Dynamo. The course of the current is along the tubular body of the stand, up the Journal, up the cupped Side Support, to the Iron Point, across the aluminum wire to the Mercury Bath, and thence out through a binding post at the bottom of the Bath. If care is taken in raising the whirling system so that the iron Point floats free in the big drop of mercury at the top of the Support, two or three amperes will cause a steady revolution. If so desired, this apparatus is furnished with the Whirling System made up of Compound Magnets, as in the picture, at a cost slightly greater.

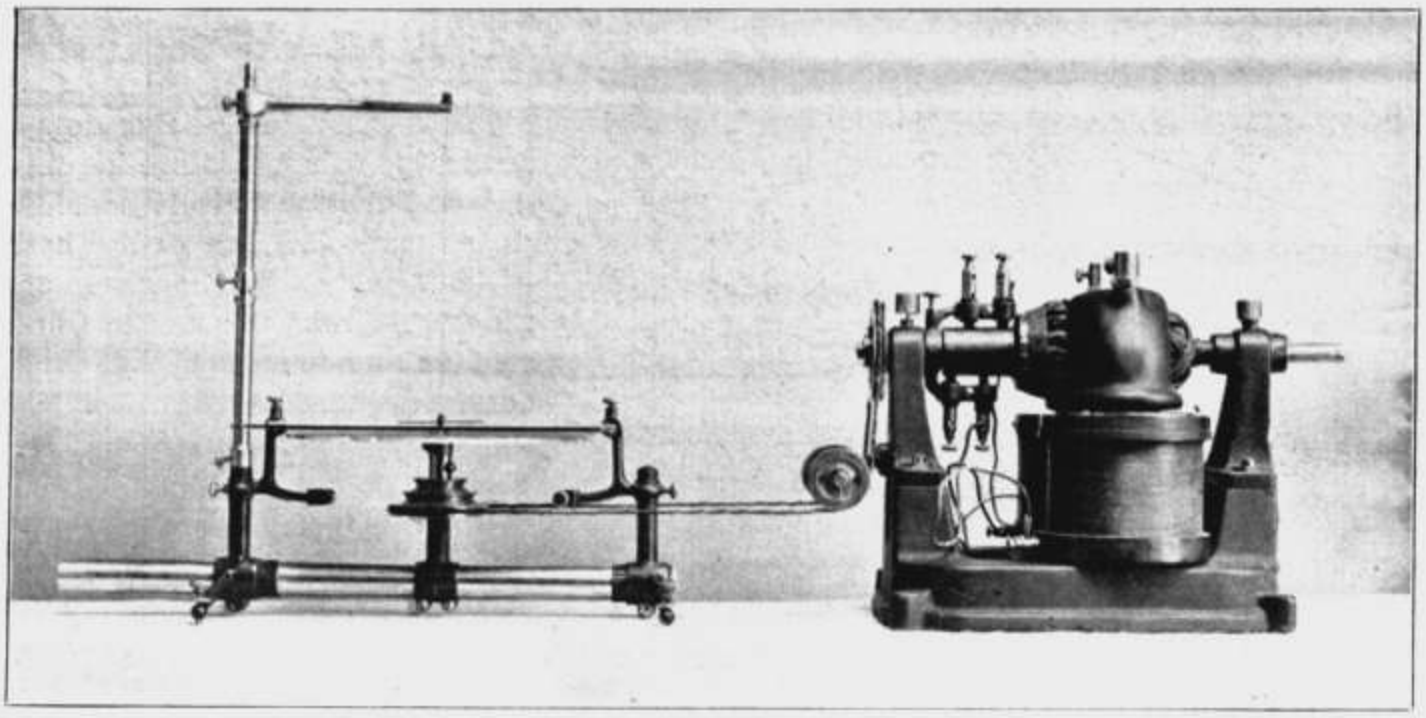


Illustration 22.

ARAGO'S ROTATION.

Here the Stand is used, with the D. C. Generator as a shunt motor for drive, to develop Arago's Rotations. The driving arrangement consists of a 3 inch drive pulley, a pair of Idlers attached to the bearing of the motor, a three-speed Cone Pulley and a small shaft. The Aluminum Disk, used in many other experiments, is carefully turned and centered and has a steel hub riveted to its center, so that it runs true. A glass plate to cut off any currents of air which the whirling disk might cause, is placed directly over and very close to the disk. The suspension piece at the top is supported by the two pendulum side supports, and has a slider which secures an exact centering of the needle. This beautiful experiment, so full of historic interest, and so full of suggestion, always makes an appeal to gray matter.

The same action is produced when a large magnet, 2x¼x9 inches, is dragged around by the whirling of the non-magnetic disk. See illustration 23.

A point of special interest in connection with this experiment is that the whirling of the magnet over the disk is a sort of an inverted prophesy of the Induction Motor which came so many years later. In the Rotations experiment the magnet whirls because of the reaction produced by the currents induced in the disk by the "lines" of the magnet. In an Induction Motor, the armature revolves because its whirling magnetic field induces currents in the Armature.

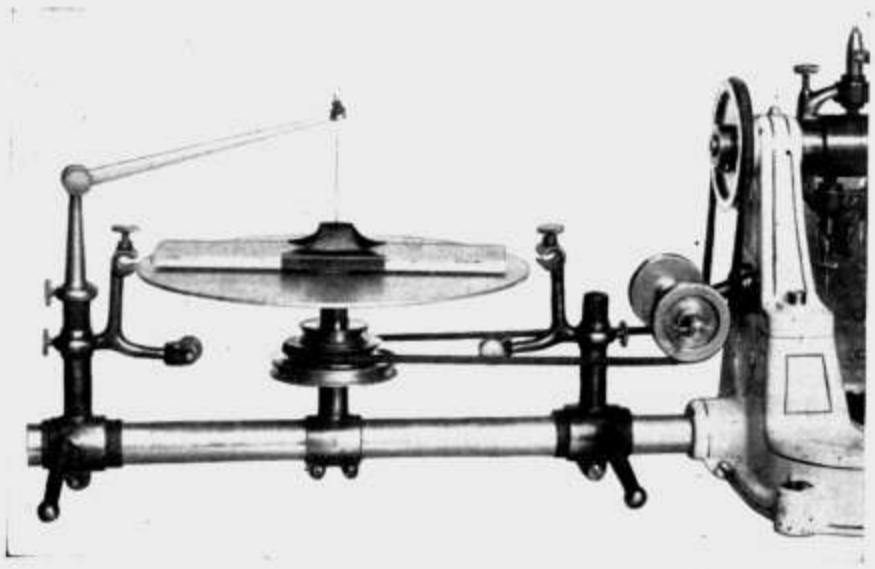


Illustration 23.

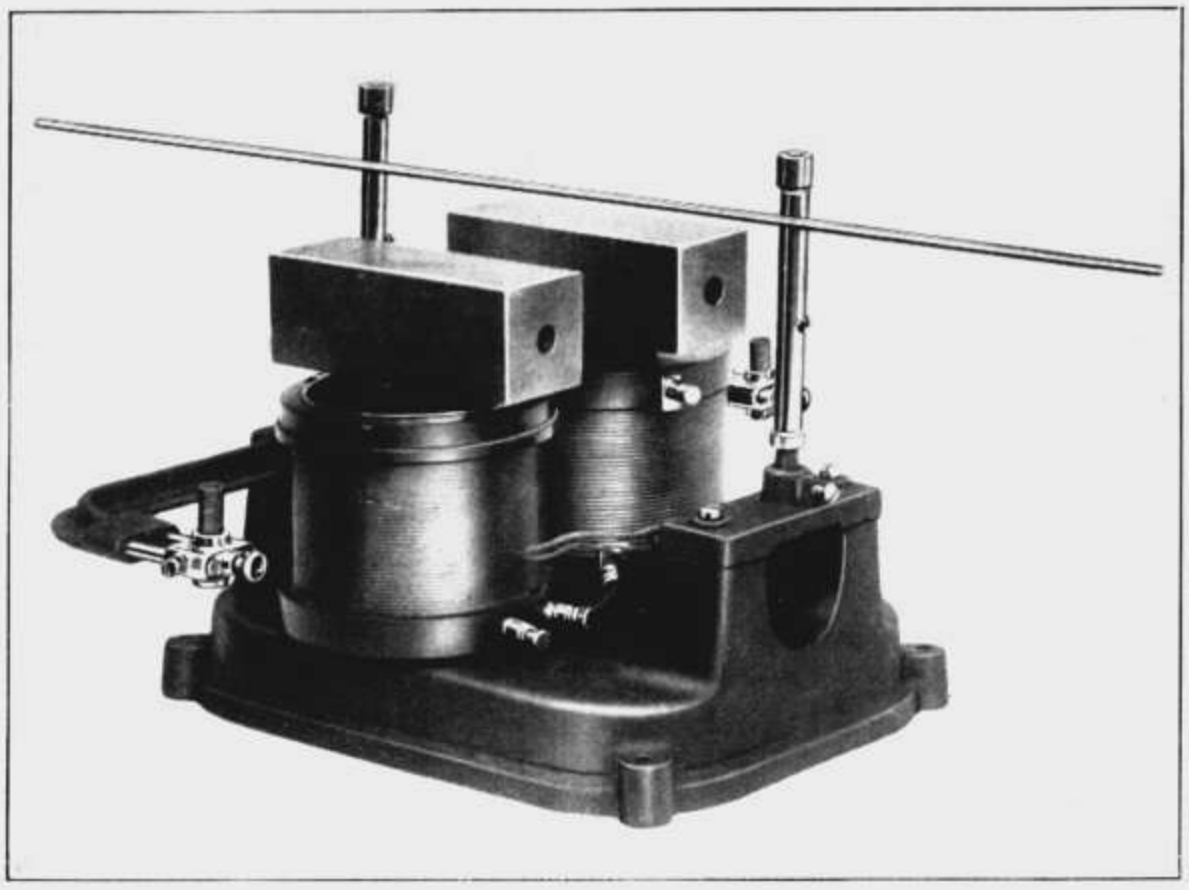


Illustration 24.
Summing up Laws of Induction—First Step.

EXPERIMENTS IN INDUCTION.

It will be very easy for the experienced teacher to see that abundant provision has been made to cover thoroughly the subject of Induction. First: there are the Field Coils, and these with the Auxiliary Coil and the Conventional Primary Coil, offer quite a wide range of experiment in this field. Then there is the Field Ring, which in many ways, reminds one of the first transformer ever made, now preserved in the Museum of the Royal Institution, London, Indeed, with the appliances furnished by this equipment, the exact historical steps can be taken, following Faraday, up to the Laws he eventually formulated. The Telephone and the Milvoltmeter come in here to add certainty and interest. The Manual suggests the line and range of these Induction Experiments.

Finally to sum up this work, the use of the Uniform Field Pole Pieces, with a few simple adjustments and parts, puts before the student the opportunity to sum up with authority the Laws of Induction. In illustration 24, the Field Magnet is provided with rectangular Pole Pieces, 5x2x2 inches and with a hole bored through the center of each.

The Pendulum Side Supports are held in an upright position by rectangular blocks fastened securely to the magnet base, and the ends of these side supports, which pass through the blocks, are insulated by hard rubber bushings. Provision is made also, at the ends of the side supports, for the attachment of the wires leading to the Milvoltmeter or other suitable galvanometer. A Key, also, of approved form, is furnished so that the Milvoltmeter can be cut in after the establishment of the current in the rod circuit. The copper rod is held by the experimenter so that it is in firm contact with the upright side supports. With the field coils excited by a current of two or three amperes, the rod may be slid down from a field of less lines through one having many, coming to rest midway, and then moved again down from a position cutting many lines to one where there are less. Then if the rod is slid horizontally the rod cuts a field of uniform lines. An assistant must manipulate the Key at the right instant in these movements, and there must be absolutely no jarring of the wires going to the Milvoltmeter. (If these wires are moved almost in any position about the excited field, there is movement of the Milvoltmeter index, thus nullifying the test.)

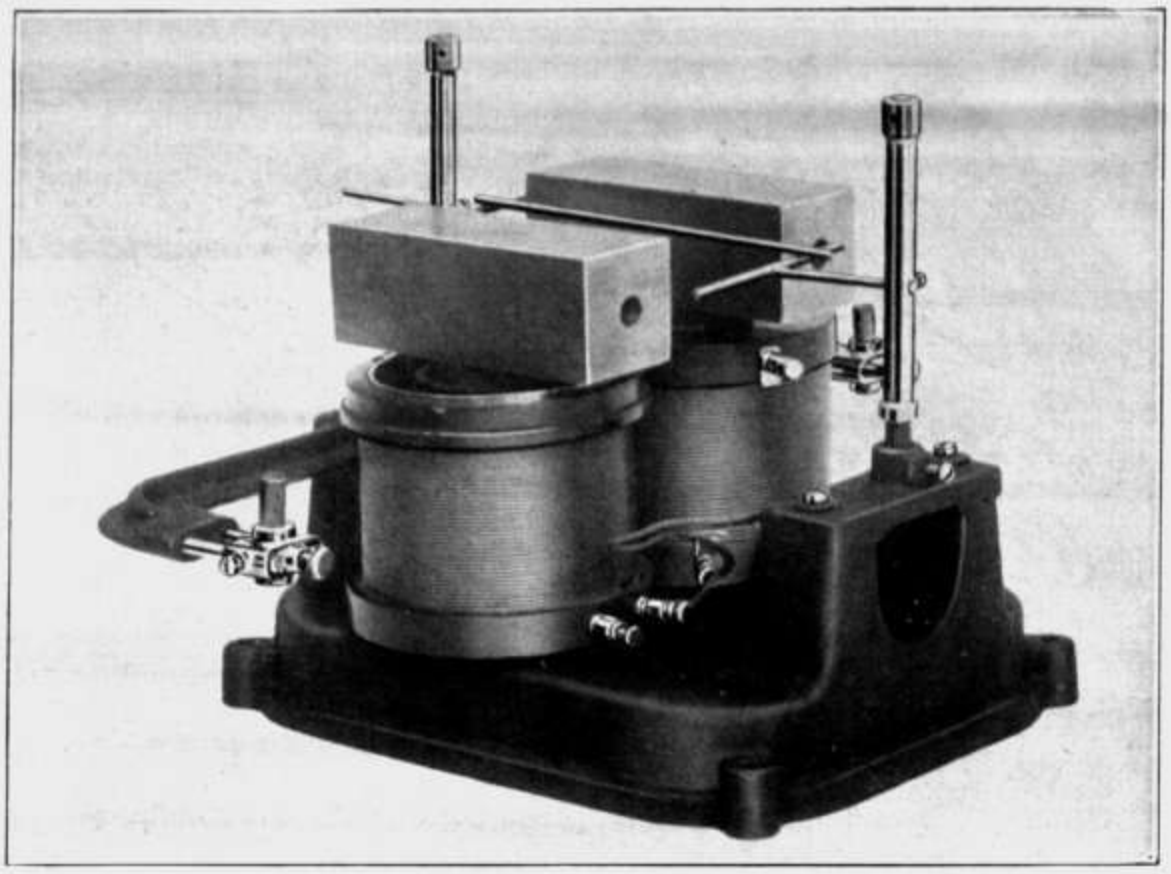


Illustration 25.
Summing Up Laws of Induction—Second Step.

Illustration 25 shows the method by which a movement of the conductor (a short length of copper rod supported by two Copper T rests, which are placed in holes for the purpose in the side supports) is made in a uniform field in the direction of the lines of force, and with its length crosswise to the lines.

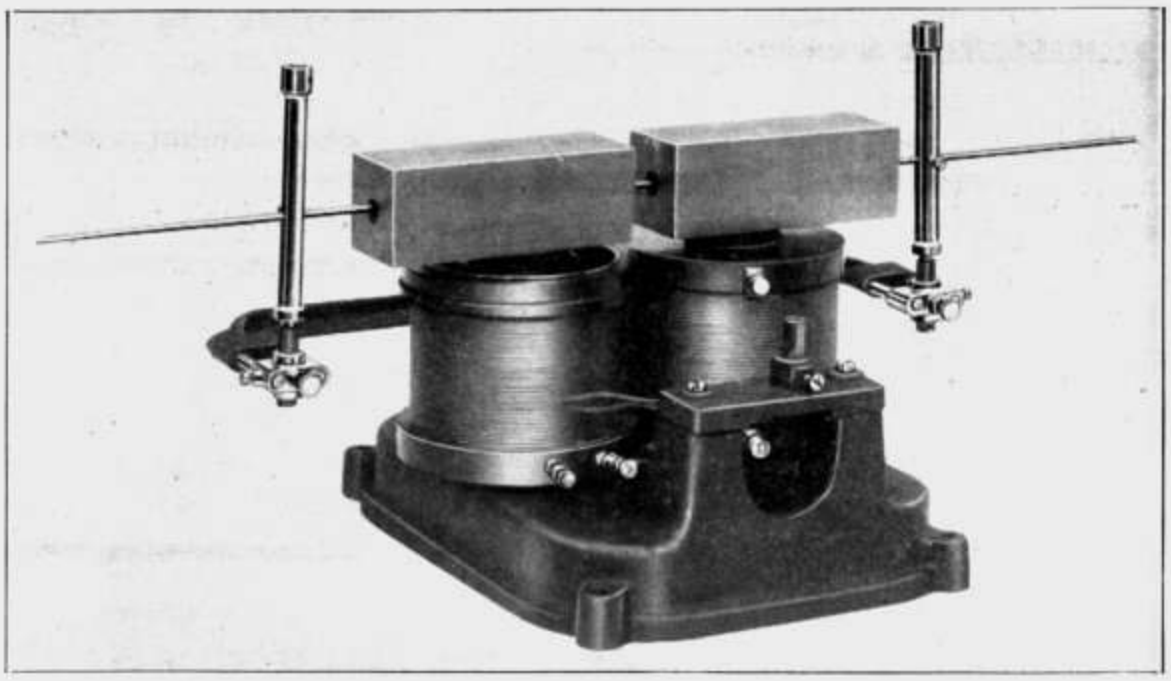


Illustration 26.
Summing Up Laws of Induction—Third Step.

Here it will be seen that the long copper rod is kept in contact with the side supports through the small holes in the side supports, and a movement of the conductor can be made in a uniform field and in the direction of its length, the motion being in the same direction as the lines. These tests cover the possible cases, and with a little practice so that there is synchronism in the action of the two experimenters, there is little difficult in making an authoritative summing up of these important laws. All of these fundamental principles and facts are important since the first essential in the attainment of practical knowledge is a clear and vital comprehension of these facts and principles. But it adds strength and vigor to a course when the aim of it, kept constantly in view, is a working knowledge of the subject dealt with.

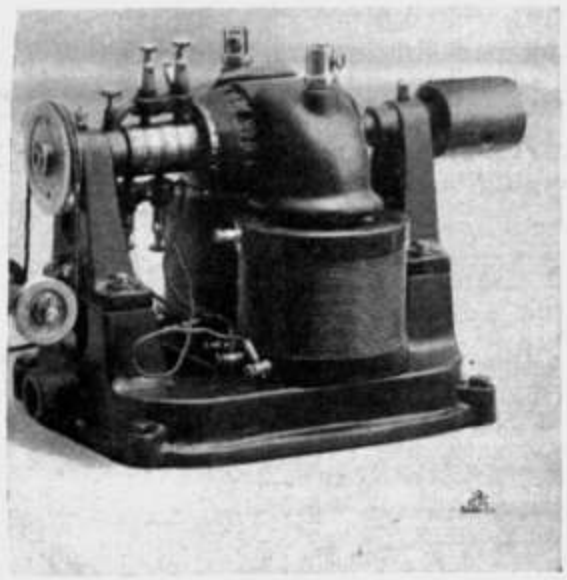


Illustration 27.

D. C. Generator, Two Armature Type.

The Faraday Disk Dynamo, shown on page 10, is a valuable device in bridging over from the theoretical to the practical. Here is shown the first form of Generator, a conductor constantly revolving in a field and producing a current so long as it revolves. When the trolley is placed against the edge of the aluminum disk, the latter being mounted as shown, and the fields energized, any slight movement of the disk in either direction generates a currnt. Also, if a current is sent into the disk through the trolley, when the field magnet is energized, motion is the result, showing that the dynamo is reversible. Then there is marked disparity between the amount of energy put into the disk when turned, and the amount of current produced. It is a poor practical dynamo. If a recurrence is made to the Tyndall Heat Experiment, page 11, where the metal is melted when placed in a copper tube whirled in a magnetic field, the reason why the disk dynamo is a poor one is suggested. Too much energy is lost in the solid whirling disk in the form of heat. The method of getting rid of this heat loss is shown, and as a matter of fact, the resources of the equipment allow a very complete study of the D. C. Generator in all its forms, as well as all forms of D. C. Motors.

HAVING THE WHOLE PLANT.

The great advantage of having the whole "plant" before the student, so that he has under his eyes constantly the relations between the constituent parts, becomes apparent when one considers the problems or questions that cannot help intruding themselves on his curiosity and his desire to know.

There is, for instance, the method of control by which a generator furnishes a current of constant pressure even when the "load" is constantly changing; how this is accomplished in Shunt Machines and in Compound Wound Machines; the weakness of the Series Machine when confronted with these problems of output distribution. Then there are the Series and the Parallel systems of wiring, and how a fan motor and one of a hundred horse power may automatically draw their shares of energy from the same mains. Then there are the methods employed in measuring the current; the Voltmeter, its theory, and how it is connected up in the circuit; the Ammeter, and how it also is connected up; and then how the Recording Wattmeter combines both methods of connection and why.

THE STUDY OF ALTERNATING CURRENTS.

This equipment has pioneer honors in the field of A. C. educational work, because this subject was given strong emphasis in the Manual, and an effort was made to furnish suitable apparatus for this study, long before there was any demand for it in most schools. But the increasingly louder call for **practical education** has brought this subject to the front, though in many schools it still lacks adequate recognition. The use of Alternating Currents has amazingly increased, chiefly because the problems of distribution are more economically met by this system. But there is another reason why this subject is educationally important: its study furnishes **the very best science training;** nothing in the whole range of Physics is better. All that is needed is a fairly adequate provision in apparatus and time. Those who look over the pages following will be able to determine whether the parts of the equipment intended for this work will materially help in meeting these demands.

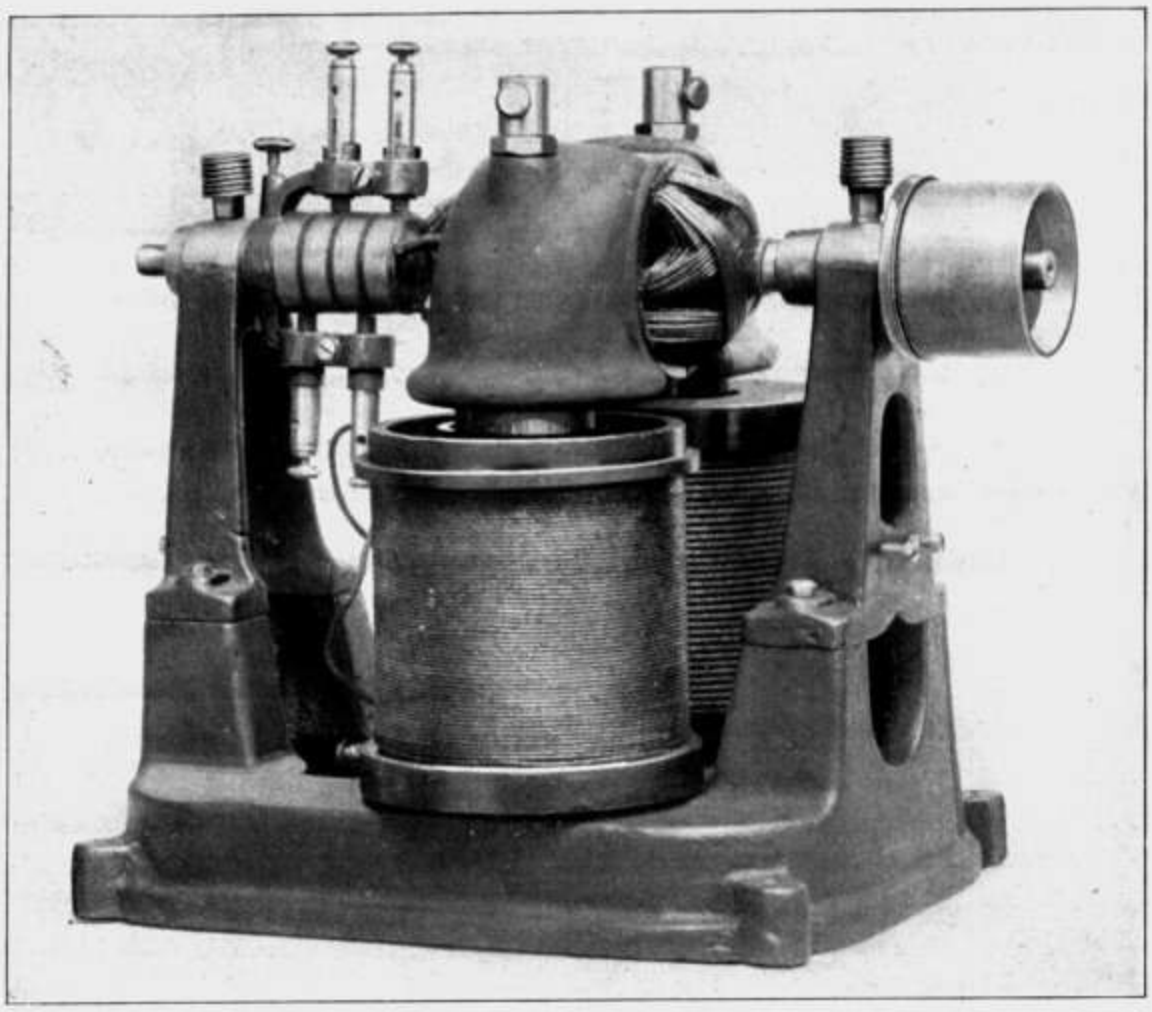


Illustration 28.
A. C. Generator, Two Armature Type.

With the two armature type Generator, single phase and two-phase currents are available.

Illustration 28 shows the two armature type generator with A. C. Armature in place. The armature is laminated, and has very substantial collector rings, and the brushes are of the carbon-gauze type, pencil form, arranged for easy and sure adjustment.

This A. C. Generator runs very quietly, its cycle is 35, and the voltage 20 when a storage battery of eight to ten volts is used to excite the fields. Of course, this voltage can be varied by changing the field current. The speed is the same as that for the D. C. Generator, 2200 R. P. M. Every condition for commercial efficiency is met in this machine except in size; and its size enables it to meet its many requirements without being cumbersome. A two phase winding was selected for the reason that this probably is the simplest form of multi-phase winding, and its effect in producing a rotating field can probably be more readily understood..

A THREE-PHASE WINDING.

But if it is thought that a Three-Phase (and single phase) winding would on the whole be preferable, this equipment now furnishes a machine thus wound. A general description of this machine has already been furnished on a preceding page; but because of the fact that confidence is great in it, and we wish to give emphasis to its all around availability, we are putting in again on the next page the illustration first used on page 3.

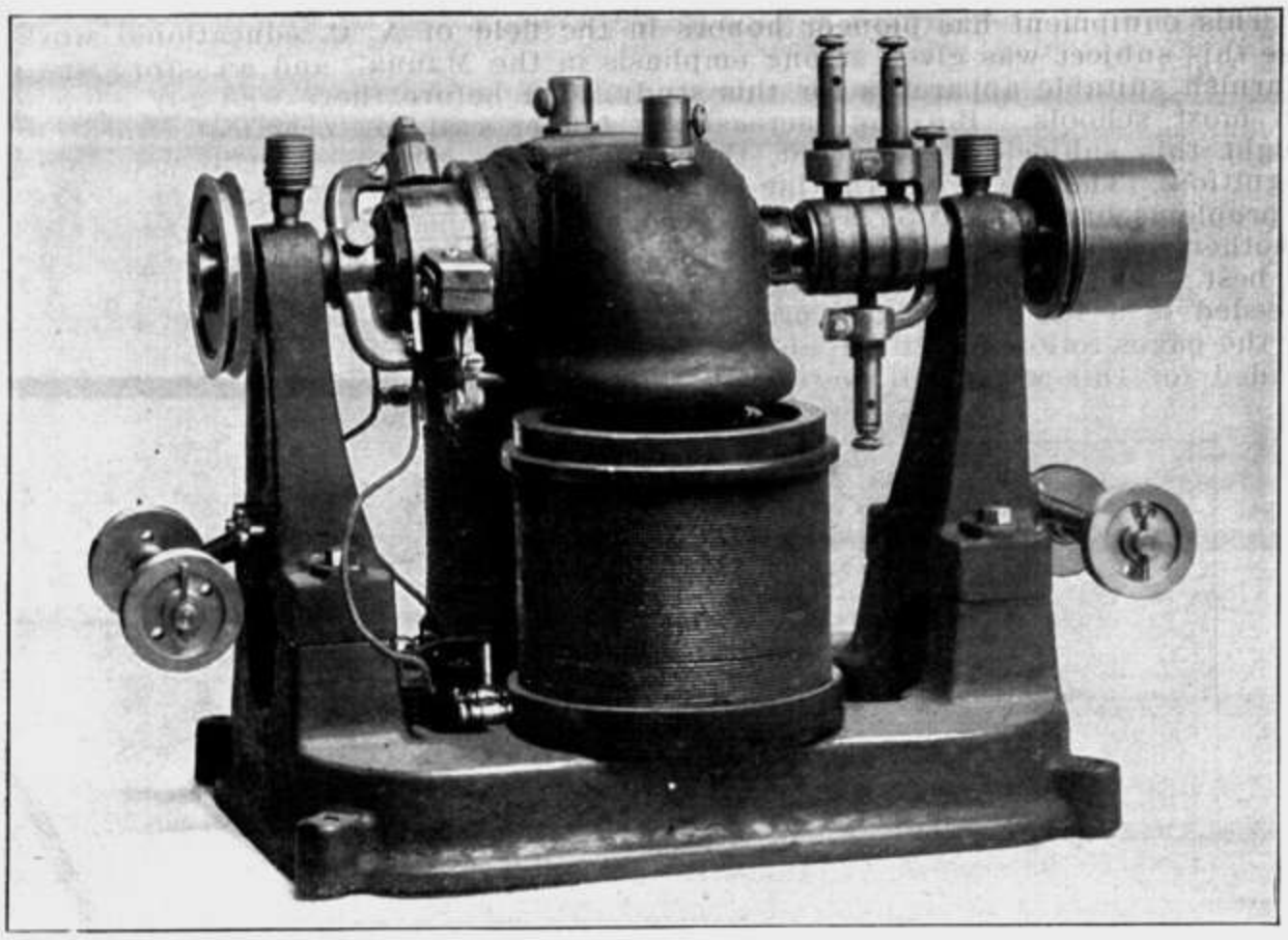


Illustration 29.
A. C. Generator, Double End Type.

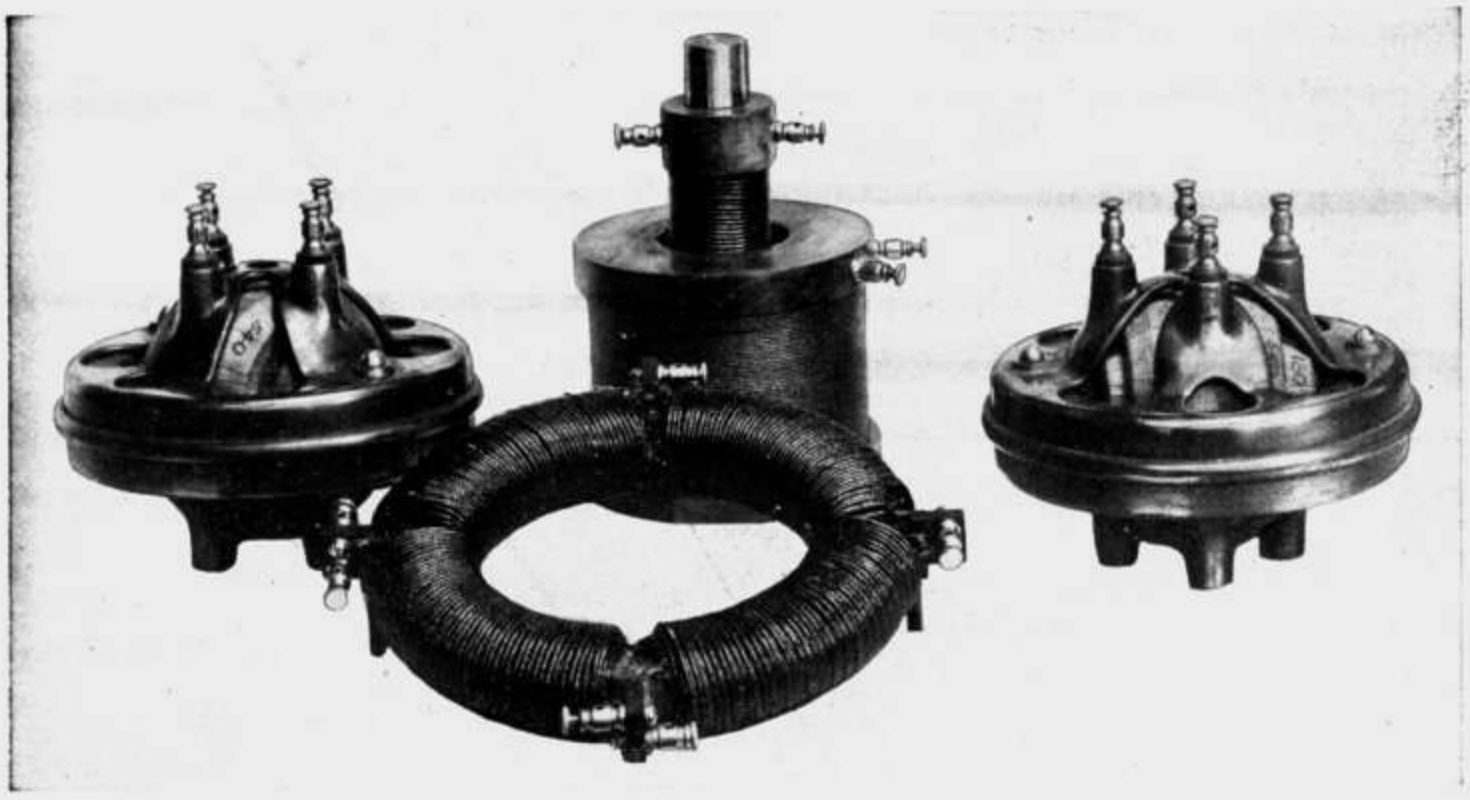


Illustration 30.

TRANSFORMERS.

Of course the limits of this Bulletin will not allow of lengthy detail, and without detail it is difficult to give a clear idea of the uses of this apparatus as applied to the requirements of Alternating Current study. The main subject of study, in a limited course, would without question be the **Transformer,** and the effort has been made to furnish at a minimum expense the devices of widest use in this study. The Manual shows more minutely and fully just how this has been accomplished; but a few suggestions and illustrations will have to suffice here.

The above illustration 30 gives some idea of the Transformers furnished. There

is first the crude beginning in the Conventional "primary" coil placed, in the familiar way, in the core hole of one of the field coils, used as a "secondary," and with a solid iron core in the primary. This has value, because, with it, the reasons why it is not a real transformer can be discussed; and the way is opened to a conception of the conditions necessary in an actual transformer. By "discussed" here is meant a series of experiments which show the inherent defects of this arrangement.

Putting a **laminated** core into the "Primary" changes the results markedly, and there is less heating of the laminae. Then the **magnetic circuit** can be closed about

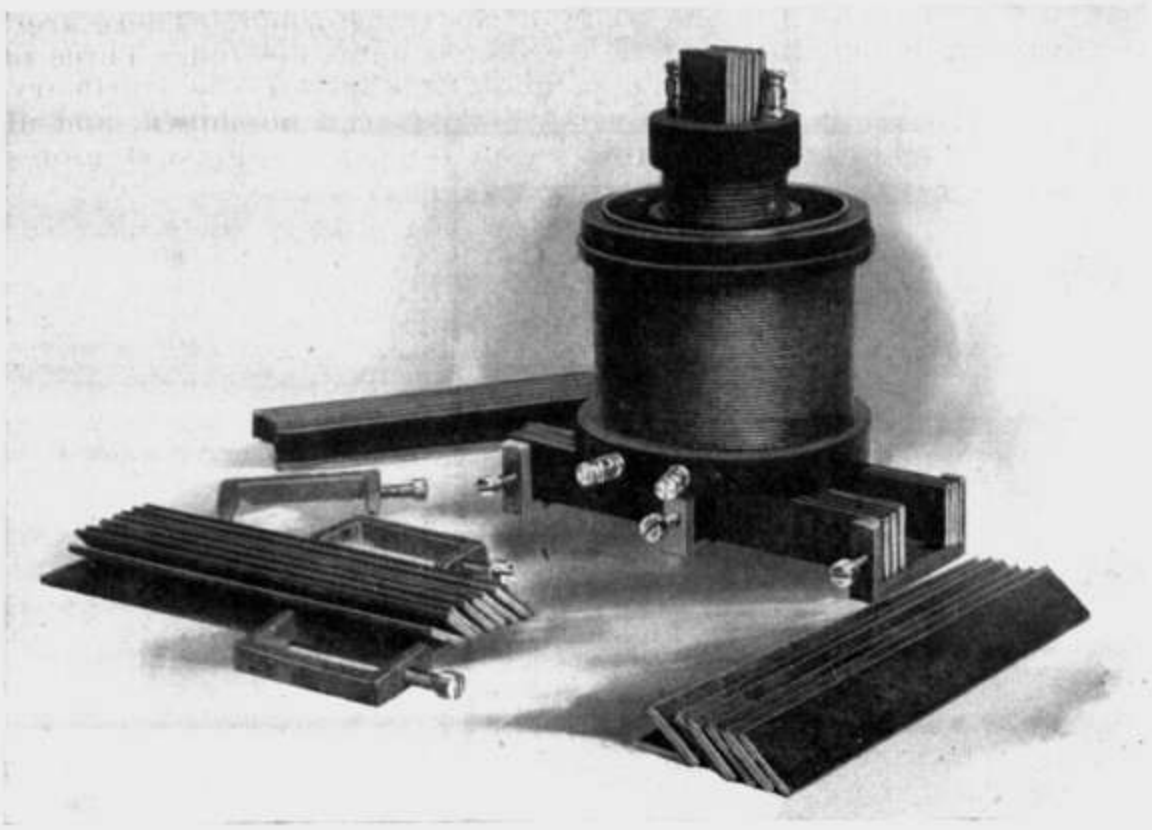


Illustration 31.
Transformer in Process of Building.

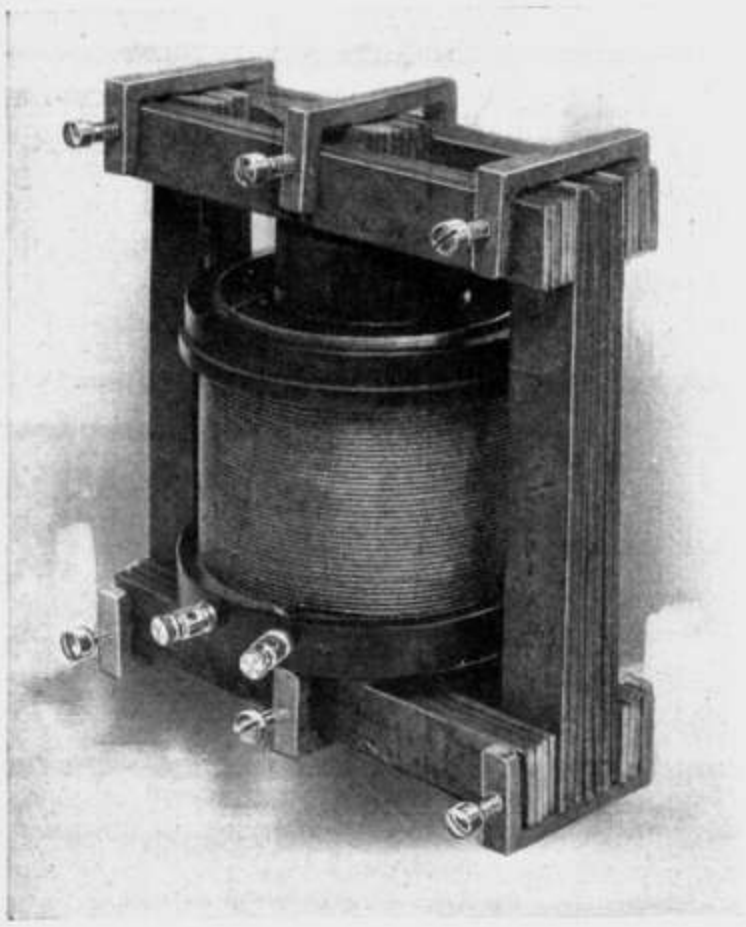


Illustration 32.
Transformer with Magnetic Circuit Wholly Closed.

the two coils, and a very fair transformer is built up, thus taking the necessary steps from vague theoretical beginnings to substantial performance, worth while commercially.

Illustrations 31 and 32 show how the actual work is done, and the only expense is the trifling cost of the laminae and the six clamps.

But cut 30 shows two other forms of transformers. First there is the Field Ring. This serves many purposes, and its main function is performed when it is used as a two phase field for an induction motor.

But it is of much service in the study of the transformer. There are four coils, with ends so arranged that these can be connected up as desired. Three of the coils can be connected in series for a secondary, and the other used as a primary for a 3:1 step up, or vice versa. Its defects as a transformer can be shown, and also how it can be used as a good transformer. The use of this device adds a step or so towards commercial efficiency.

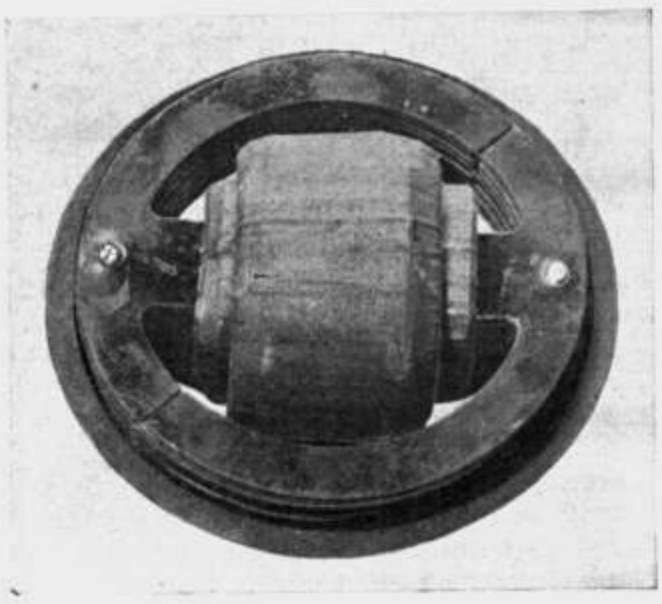


Illustration 33.
Transformer With Case Removed.

And here, illustration 33, the equipment offers a real transformer, having all the requirements of efficiency and which can be studied from every angle, tested for efficiency, and used with utmost freedom, without danger, a **point of importance** as every teacher realizes. It will be seen that this transformer has a closed magnetic circuit and the stampings are from thin electrical sheets, specially manufactured for this purpose. The case protects the transformer without hiding details. Its primary or secondary can be used as inductances, and these serve in many other ways outside of their regular function. A brief description of a strikingly useful experiment with this transformer will sum up this account. The purpose of this experiment is to show the foundational principle or law governing the action of the transformer. A single phase current is led through the primary winding of the transformer, and also through a 20 volt lamp in series with the primary, with the result that the lamp is lighted very dimly, on account of the self-induction of the primary. Now while the lamp has its brightness thus dimmed, **close the secondary** of the transformer by placing a bare wire across its terminals on the transformer. At once the dimmed light comes to its full glow, and will every time the secondary is closed. Again open the secondary, and when three or four 110 volt lamps are switched into the secondary circuit, one at a time, the addition of each lamp will increase the glow of this pilot lamp in the primary, showing that loading the secondary increased the current in the primary, and that the amount of current flowing through the primary at any time depends almost wholly on **the amount of load** in the secondary circuit. In other words the action of a transformer is automatic in taking current from the service mains. When no current is being used from the secondary, there is almost no current flowing in the primary.

Illustration 34.
A. C. Induction Motor, Two-Phase.

A. C. MOTORS.

The apparatus offered in this second group includes devices to show how alternating currents are harnessed for driving machinery. The Induction Motor is the type in use most extensively, and the picture shows the field ring mounted on the whirling stand, with the aluminum disk officiating as armature. It is curious that one may go back to Arago's Rotations and get a strong start at least in the explanation of the disk's rotations as an induction motor armature.

A beautiful demonstration of the whirling field is possible with the two-phase ring. Put a 10x12 inch plate of glass in the goose neck slots (as in Arago's Rotations) with the two-phase ring energized by the two phase current from the generator. Scatter fine iron filings over the plate and note the play of force in the whirling particles. If the table top is smooth, filings scattered under the ring, on the table, will also whirl, but in a direction opposite from those on the glass plate.

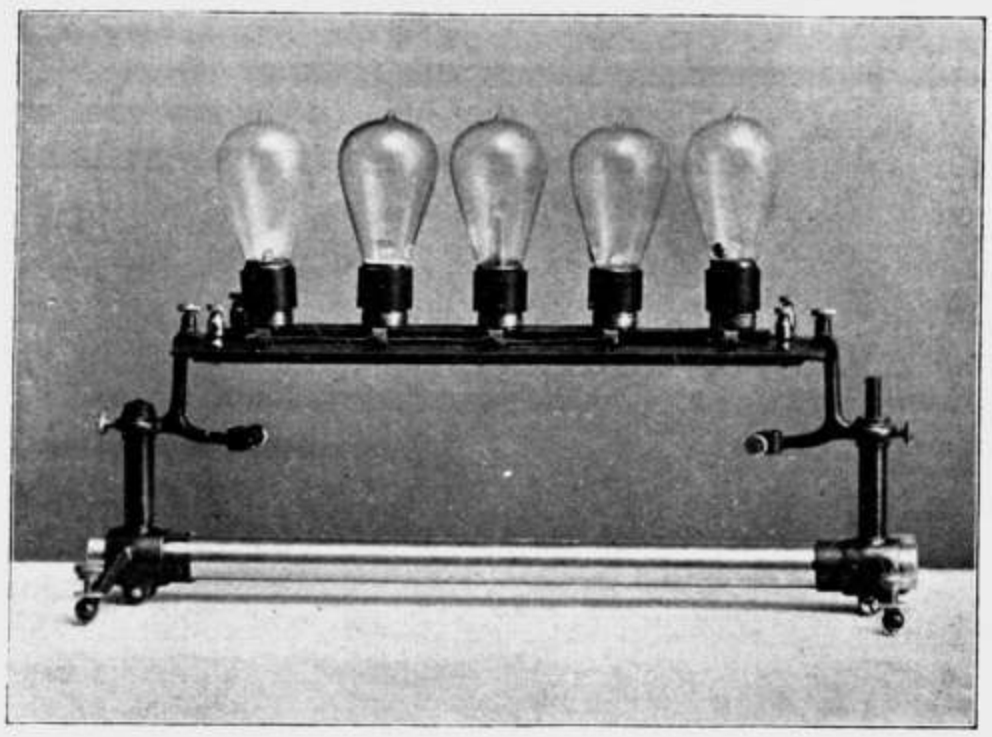


Illustration 35.
Lamp Circuit.

The scheme of work arranged for in the Manual calls many times for the use of a Lamp Circuit. It is useful not only with the Generators, but also on many occasions where a non-inductive resistance is called for. Four of the lamps are in parallel, and the other one can be used separately as need arises, or can be connected with the other four.

GROUP THREE.

The general trend educationally is markedly toward a wider recognition of Electricity as a study of great value, both from the scientific training possible from it, and on account of its multiform usefulness. There are very few employments above the grade of common day laborer in which some knowledge of Electricity is not required. And in the professions, and in the callings in which more or less technical training is needed, a good foundational knowledge of electricity is a **sine qua non.** Every year sees an increase in the number of schools offering longer and more thorough-going courses in Electricity. Group Three contains a number of devices intended for use in these schools. If the parts composing Group One and Two are already supplied, then at comparatively small expense, some very telling and useful work can be added to widen and strengthen the course. Let it be noted also that this additional work is all in the direction of a working knowledge of the subject.

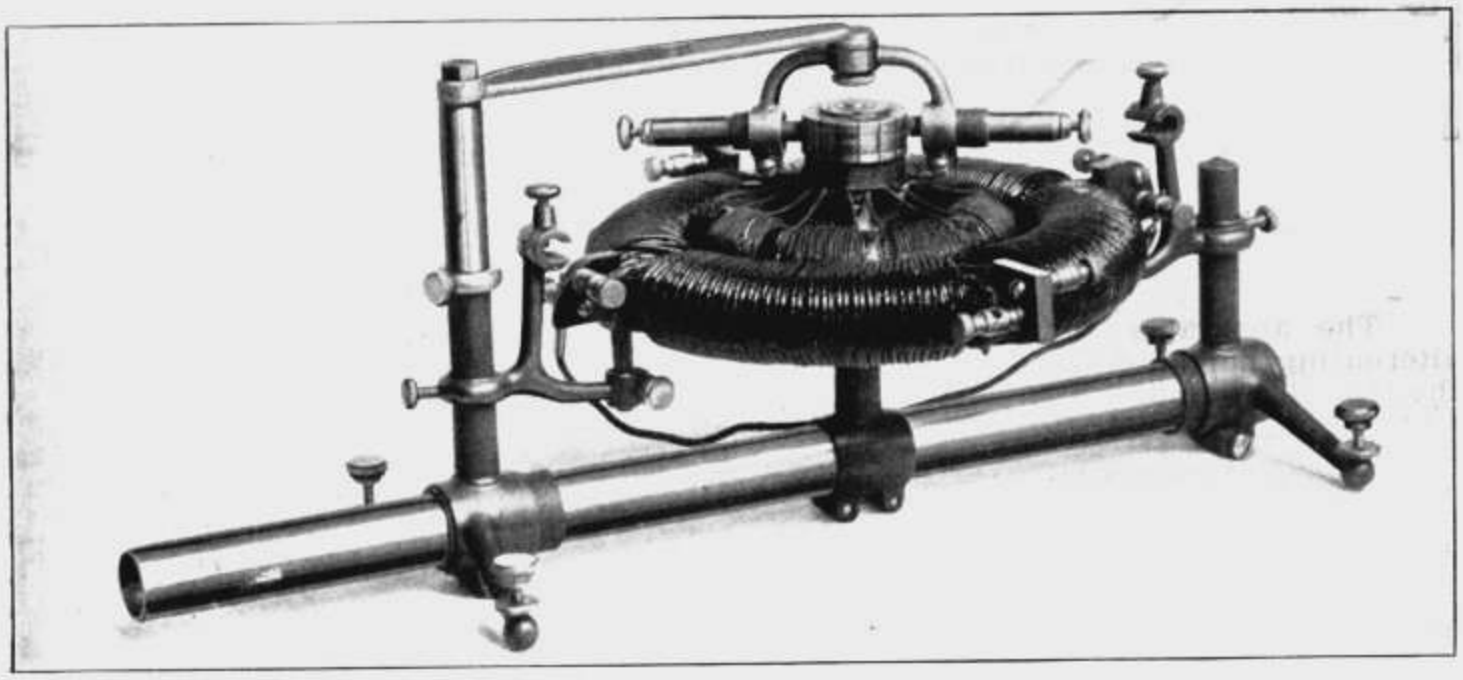


Illustration 36.

GRAMME RING ARMATURE.

This illustration shows the new Gramme Ring armature, mounted in the two phase field ring, and using the same stand already shown many times. The method of holding the brushes allows of a complete revolution of the brushes around the commutator, so that they can be set at any point in its circumference: The field ring can be connected for two poles or four, and a brush holder holding four brushes instead of two can be substituted for the one holding only the two brushes. The Gramme winding is probably the easiest to understand: and is certainly the best for beginners to study. The Armature can be driven by the same arrangement of belt and idlers as is pictured in the Aragos Rotation Experiment, page 18 of this Bulletin. The finding of the **points of commutation,** and the demonstration of the **development of voltage** from the point of no voltage at the negative brush, around on both sides, to the point of maximum at the positive, are important matters to investigate, and this Gramme Ring Armature is well fitted for the purpose, if a voltmeter is available. A study of it also enables the student to get at the relations of the number of poles to the **speed** in D. C. motors. It runs beautifully as a series D. C. Motor thus making up for the one weakness of the D. C. Generator as a motor.

VALUE OF THE GRAMME RING.

A little pains in looking up the matter will show any teacher that almost all standard writers regard the Gramme Ring winding as the best for study in getting elementary facts. Indeed a graphic representation of this winding is almost universally used in text books. On the other hand it is difficult indeed to obtain an actual Gramme Ring armature for study purposes; and it is believed that the armature just described will serve a very good purpose in filling this gap. Nor should it be overlooked that the mounting of the field ring with its long axis horizontal is a decided advantage in the study of the generator, for this makes it possible to study the lines of force of the different "fields" (the two rings produce a number). How could a commercial machine or indeed any machine with its armature running in a vertical plane be used for this purpose?

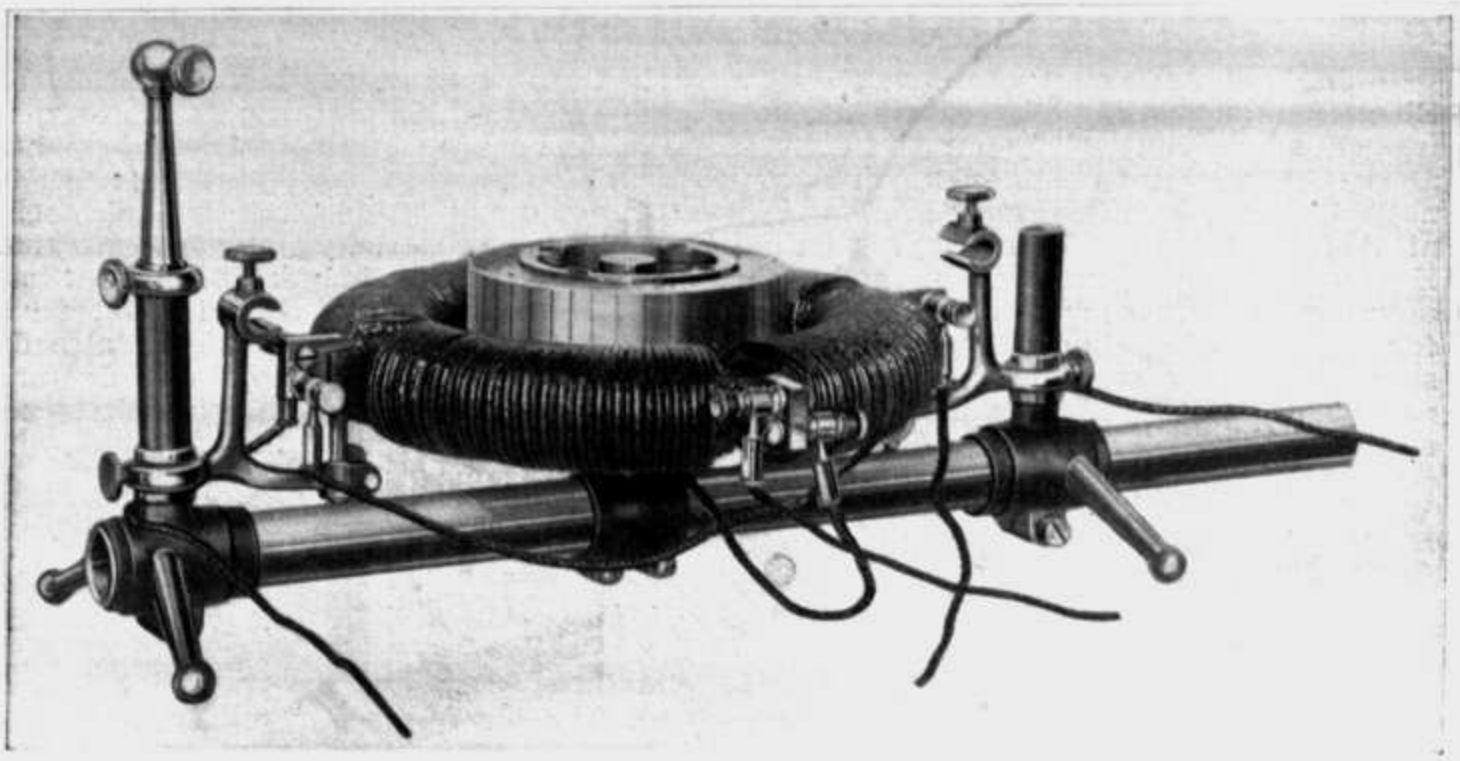


Illustration 37.

SQUIRREL-CAGE INDUCTION MOTOR, TWO-PHASE.

These half-tones give a good idea of the method of mounting the two and three-phase field rings, and how the squirrel cage armature is supported so as to run smoothly in the journal of the stand. The economy of such an arrangement is evident. Two rings and one armature, mounted on a stand **which has already paid for itself over and over again,** in other functions, make two complete motors.

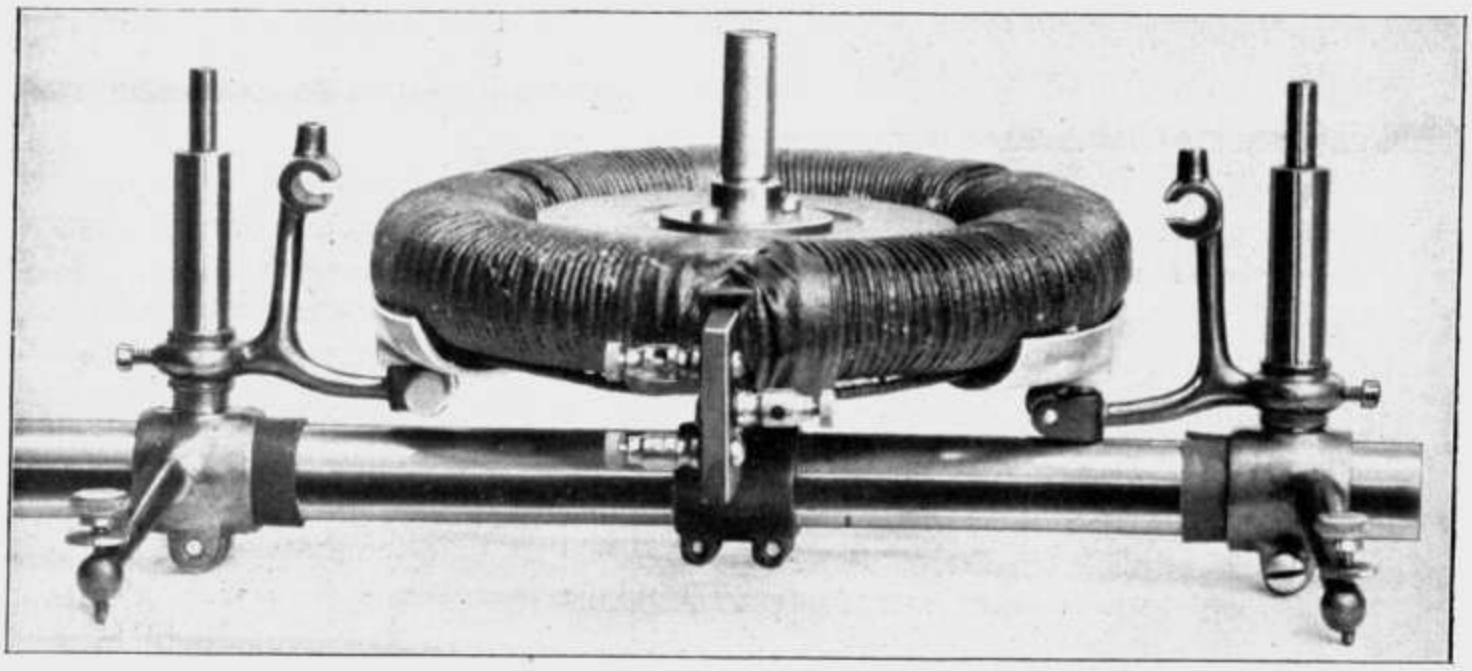


Illustration 38.

SQUIRREL-CAGE INDUCTION MOTOR, THREE-PHASE.

But these A. C. Motors serve other purposes besides being models for elementary study. They add much interest and variety to work where they serve as "loads," for instance, in testing. The Equipment furnishes several forms of loads, the Variable Resistance, the Lamp Circuit, and the Gramme Ring Motor for D. C. study, and for A. C. work, these (except the Gramme Ring Motor, and even this could be used in A. C. work if its circuit was closed by short-circuiting the brushes) and the Induction Motors just described and also the Synchronous Motor described on the next page. Giving a student a chance to see (or discover) some action or fact from different angles is profitable; and it is next to getting actual experience to furnish him with the widest possible chances to observe and test.

SPLITTING A PHASE.

This Equipment also shows how a Single Phase current is "split," by use of an Inductance (primary of the Transformer) and how the method is applied in making single phase motors self-starting. See Manual.

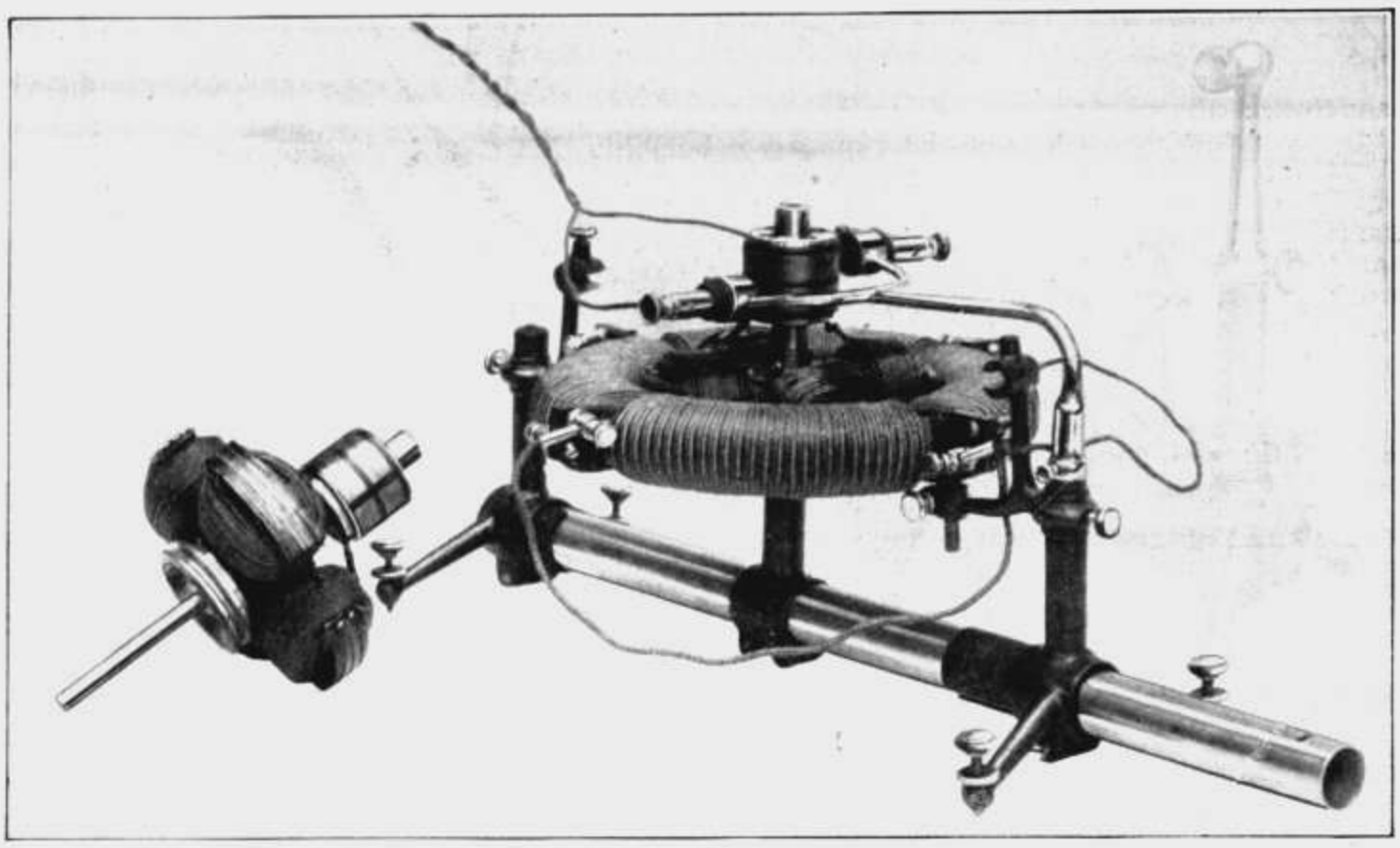


Illustration 39.
Synchronous Armature.

Illustration 39 is an excellent picture of the two-phase field ring with the coils connected to produce a field for the Synchronous Armature, mounted in the journal of the stand, and provided with suitable collector rings and brushes. The picture shows every thing as furnished except that the Brush Arm and Support are now more substantial and of better design. With the addition of a suitable armature, then, and the brushes with arm and support, a complete Synchronous A. C. Motor is provided, at no expense whatever except for these parts.

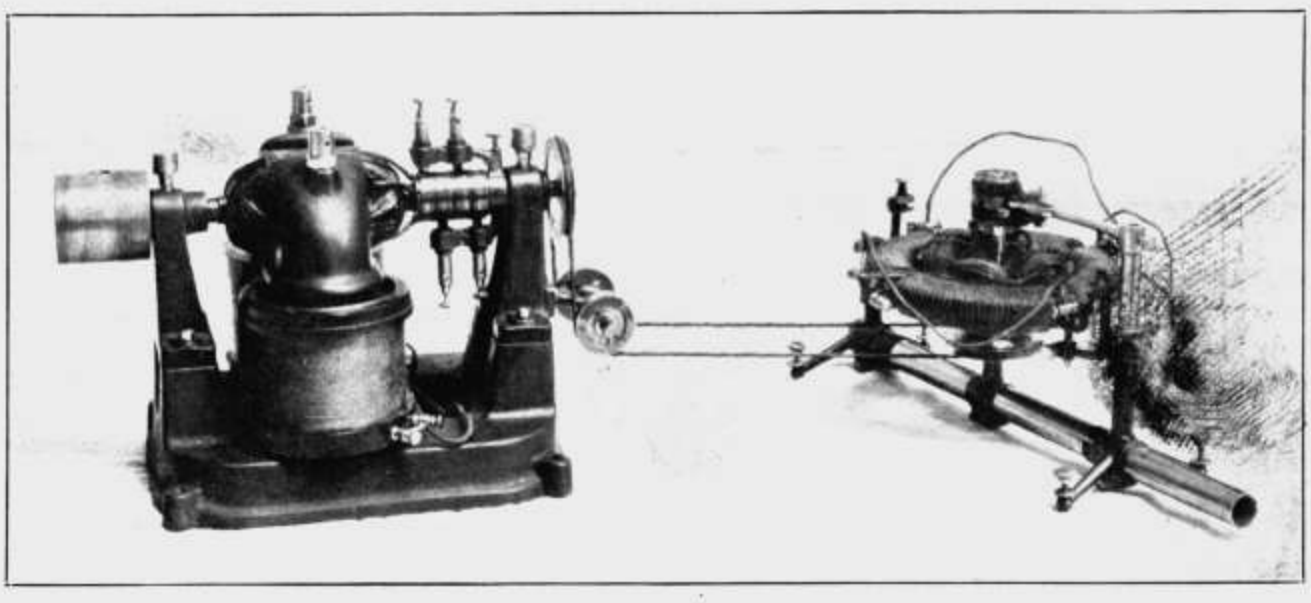


Illustration 40.
Synchronous Motor.

This illustration shows how the Synchronous Motor is started. The method of drive used in Arago's Rotations is used in this case also. The single phase current from the equipment A. C. Generator may be connected to the armature brushes, and a battery current used for the fields; or the battery current can be used in the armature and the single phase current in the fields. This motor runs very well when a 110 volt alternating current energizes the fields and a battery current is used for the armature. Five minutes practice will enable anyone to start the motor. Thus practically all the forms of A. C. Motors used industrially are made available, and in a form best suited to students' needs, at an expense only a fraction of what it would be if separate motors were bought.

RECORDING WATTMETERS.

It is possible, and not difficult to calibrate the regular Integrating Wattmeter of Electric Light and Power Systems so as to be made available in efficiency tests where the Generator of this equipment, either A. C. or D. C., is the source of current. Most forms of Wattmeters are expensive, but this one described above is not. This Wattmeter calibrated as described, will be listed hereafter in Group Three of this equipment. Very interesting and instructive tests in efficiency, using the motors described above, the Transformers already described and the Generators themselves, for the tests, will thus be made available to schools having the equipment. This work is developed in the 1914 Manual which consists of the original Manual with a newly revised Supplement.

The change of a Two-Phase current to a Three-Phase current is an interesting process, commercially, because it saves one wire in a transmission line, and educationally, because of an easily understood application of mathematics to the problem. Illustration 41 shows the apparatus used, though of course, the three-phase ring is mounted on the stand.

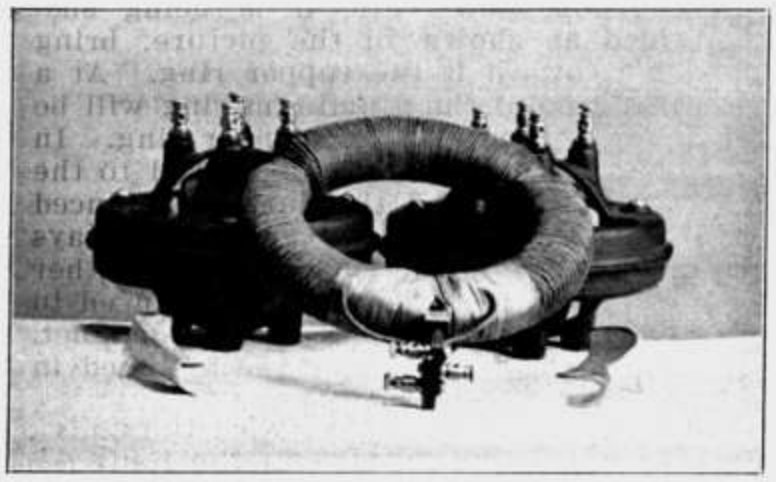


Illustration 41.
Three-Phase Ring with Two Special Transformers.

Illustration 42 shows the method of connecting the transformers, and the Manual Supplement fully describes the experiment.

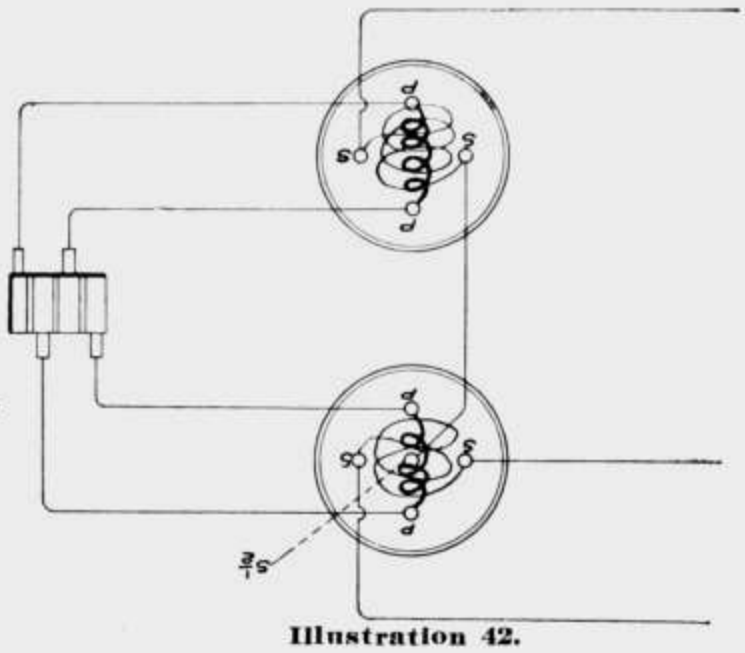


Illustration 42.

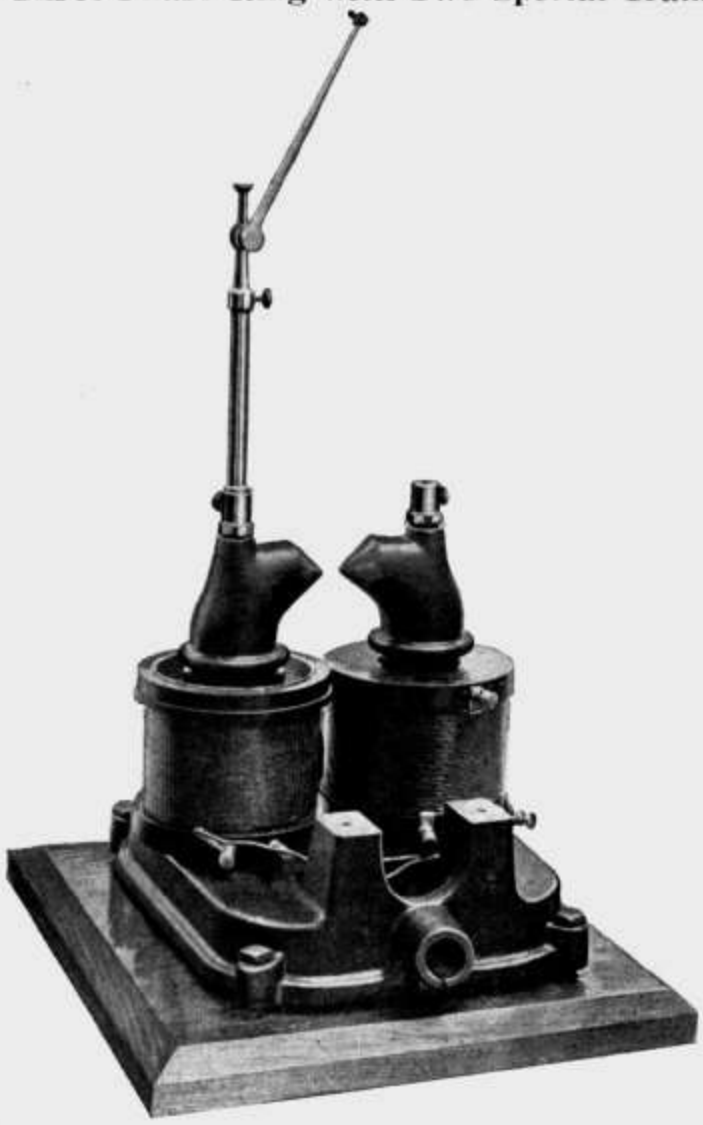


Illustration 43.

Illustration 43 is put in here merely to show how substances to be tested for Dia-magnetism may be suspended. In the pole-pieces now furnished there is quite a range of adjustment possible for the Polar Gap, and by using a strong energizing current the Field Magnet does surprisingly well in these tests.

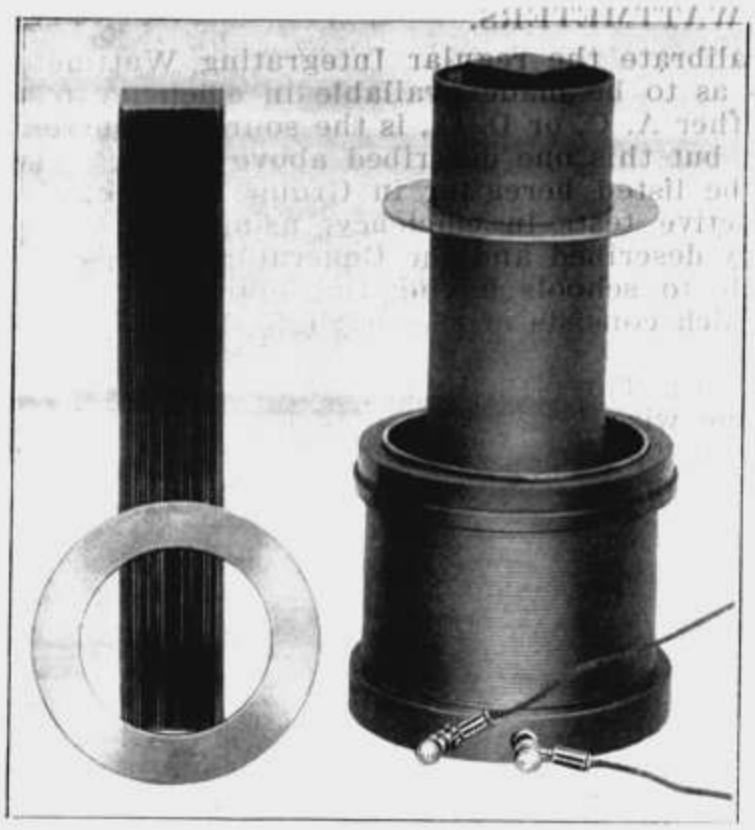


Illustration 44.

REPULSION IN OUT OF PHASE CURRENTS.

The puzzling action of a copper conductor in the form of a ring and placed over an electro-magnet which is being energized by an alternating current of 110 volts, in assuming the position pictured in illustration 44 is here shown. One would naturally expect that the ring would be alternately drawn to, and repelled from the Electro-Magnet, keeping time with its alternations when energized. **But there is always repulsion.** This arrangement shows the action unmistakably. A striking modification of the experiment is to use the aluminum ring (two rings are furnished) for the repulsion, and while it is being sustained as shown in the picture, bring down toward it the copper ring. At a certain point the aluminum ring will be drawn strongly to the copper ring. In this case, both rings are exposed to the same "lines" and the currents induced in them are in phase and are always in the same direction. In the other case, of course, the currents induced in the repelled ring are always out of phase with the currents in the Electro-magnet. The core of the Electro-magnet is a laminated one, carefully made, and is listed in this third group, as are also the copper and aluminum rings.

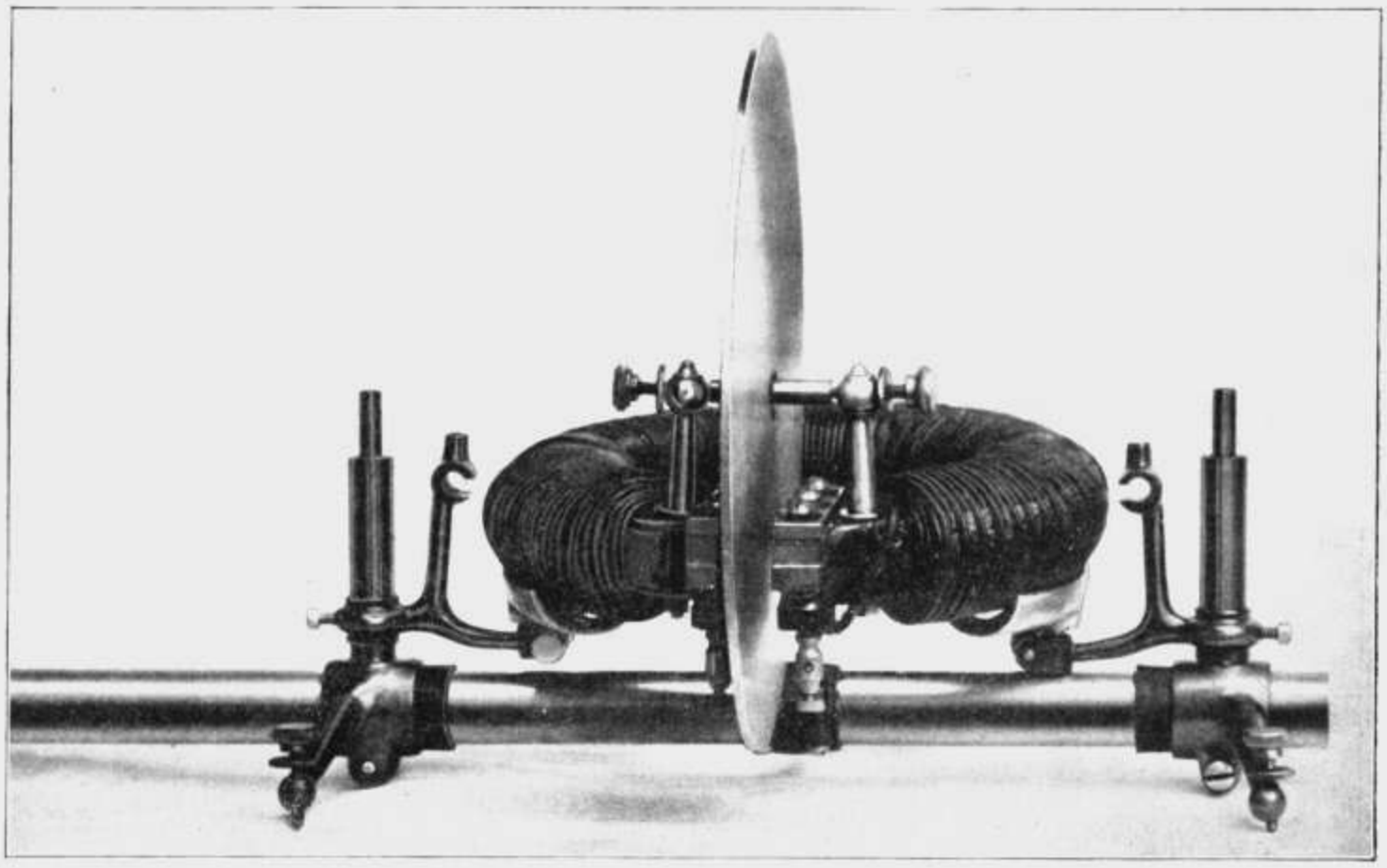


Illustration 45.

SHADED POLE EFFECTS.

Following along this line of out of phase conditions, the powerful ring magnet with laminated core and wound for 110 volt currents, shown in this picture, can be used to excellent advantage. There is a very short polar gap, and over each pole but not surrounding the pole are conductors made of heavy blocks of copper, insulated from each other. The picture shows how the aluminum disk is supported so that it is free to turn in the gap between the "shaded" poles. When a 110 volt alternating current is connected with the magnet, the disk begins to turn steadily tho' not with great rapidity. This case is an interesting one to study.

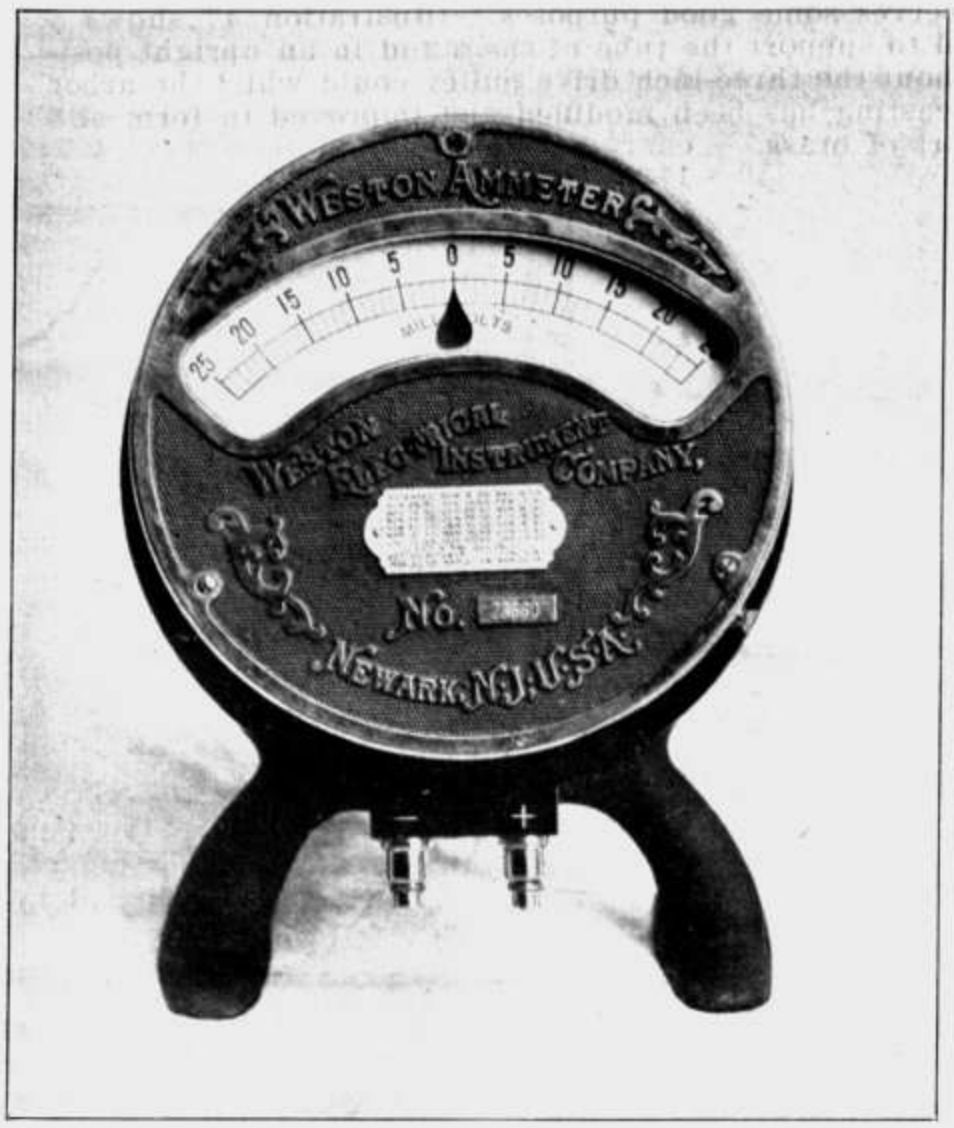


Illustration 46.

MILVOLTMETER.

The Milvoltmeter, mounted as in the picture, makes a very efficient and easily set up Galvanometer. Its coil has low resistance (one ohm) but it is very sensitive because of the power of its field magnet. Of course there are other galvanometers that might serve as well. But this instrument is not only a Galvanometer of approved worth and reliability, but it is also a Voltmeter and an Ammeter calibrated suitably for the work of the course. The Shunt for the Ammeter calibration is put on permanently, and this shunt is cut out by the use of two blocks having a tapered hole between them and a plug tapered likewise. With this method of connection there is very slight variation in the resistance of the shunt, and hence the calibration is permanent. The resistance used to calibrate for volts is placed out of harm's way. The calibrations are sufficiently accurate for consistent results in any tests where the instrument is used. As Voltmeter and Ammeter this instrument, it is a Weston, is better than the cheaper types, sometimes purchased because they are cheap. It would be difficult to buy a galvanometer, a voltmeter and an ammeter anywhere near as good for twice the money.

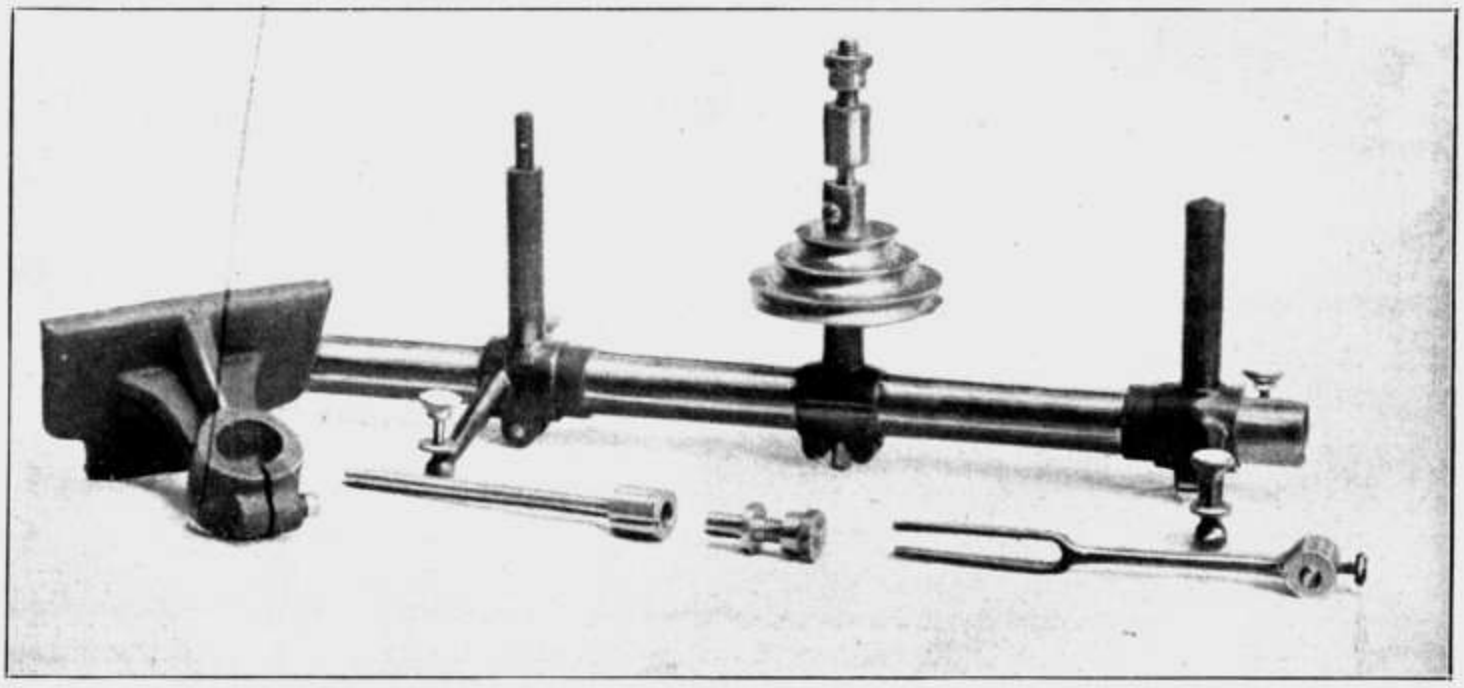


Illustration 47.

Here is shown the whirling stand provided with a special arbor with a socket in its head made to whirl any object needing such a support. A screw with milled

nut is also provided for the support of disks. As almost any speed can be commanded, the stand thus fitted serves some good purposes. Illustration 47 shows a heavy iron casting formerly used to support the tube of the stand in an upright position, and so placed that a belt about the three-inch drive pulley could whirl the arbor already described. This heavy casting has been modified and improved in form and is now a lighter gun-metaled part of brass.

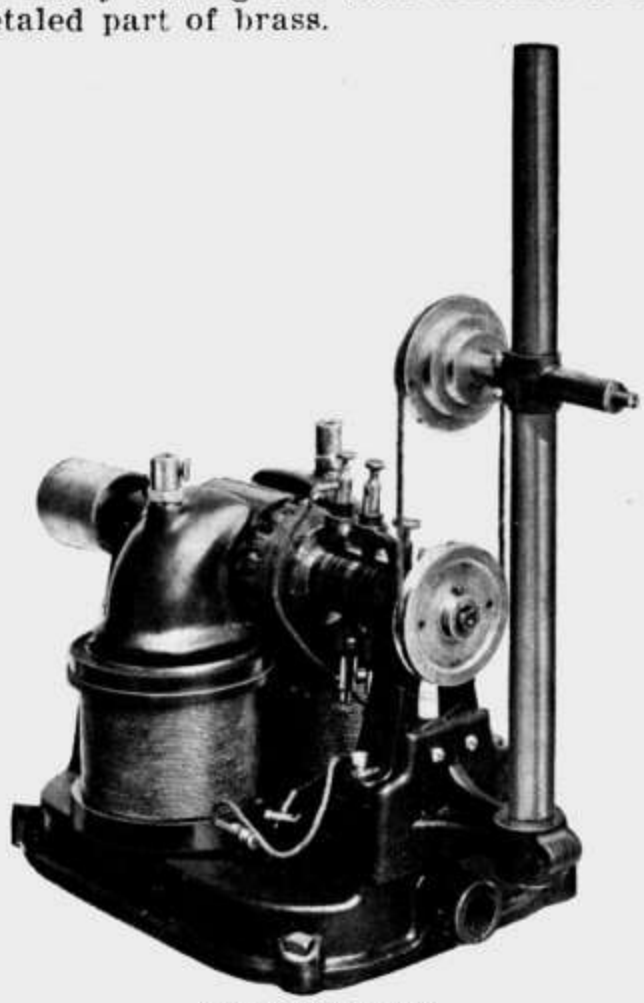


Illustration 48.

Illustration 48 serves to show the arrangement for vertical whirling. The support piece just described and the special arbor are all the extra parts needed. With a storage battery of three to six cells, and the Variable Resistance in the fields, any speed, from slow to high, can be commanded, and at any reasonable speed, such as would be used for most whirling, the motor runs very quietly.

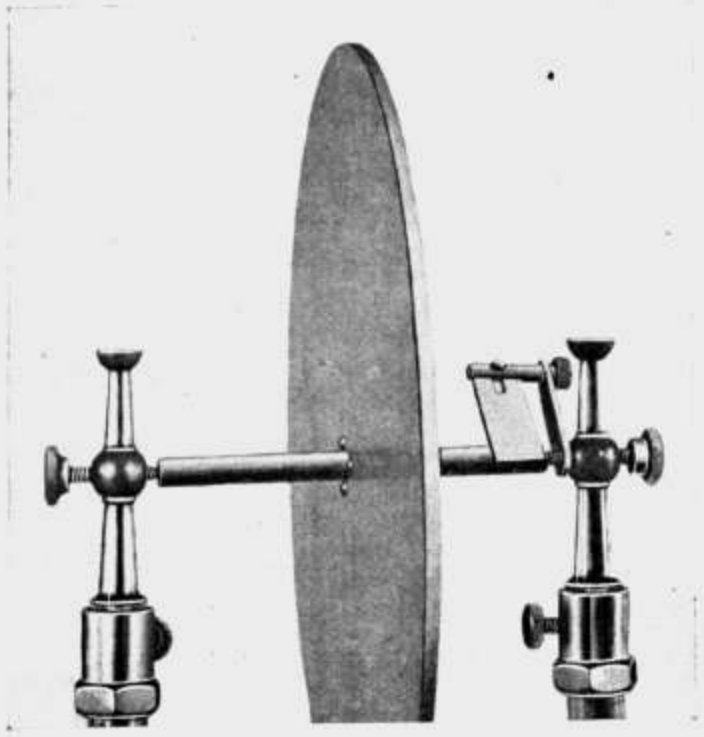


Illustration 49.

This illustration shows the brush arrangement in the Faraday Disk Dynamo, to save loss of current at the points of suspension.

Model 155.

Model 156.

WESTON

ALTERNATING CURRENT.

Portable Meters, Model 155.

These instruments are perfectly dead beat, extremely sensitive and quickly and accurately respond to the most minute as well as to the greatest fluctuations in current strength, or in potential difference in the circuit. They may be used on circuits of any frequency, within the limits of engineering practice of today, wthout sensible error in their indications. Provided with hardened steel pivots, jeweled bearings and mounted in neatly finished dust-proof wood cases.

2560.	**Voltmeter,** 0-75 volts	Net	$ 18.50
2561.	**Voltmeter,** 0-125 volts	Net	18.50
2562.	**Ammeter,** 0-10 amperes	Net	17.00
2563.	**Ammeter,** 0-25 amperes	Net	17.00

Switchboard Meters, Model 156.

These instruments are of a high standard of excellence, indicate the same whether left in circuit for a minute or permanently, may be used on circuits of any ordinary frequency, are entirely dead beat, and are provided with a remarkably uniform scale. Diameter of case, 7.25 inches; depth of case, 3.15 inches.

2570.	**Voltmeter,** 0-75 volts	Net	14.50
2571.	**Voltmeter,** 0-125 volts	Net	14.50
2572.	**Ammeter,** 0-10 amperes	Net	13.50
2573.	**Ammeter,** 0-25 amperes	Net	13.50
2574.	**Ammeter,** 0-50 amperes	Net	13.75

No. 2189.

A good Storage Battery of from eight to twelve volts is extremely useful in work with the Equipment, and since the motor-generator makes a capital charging outfit, there is no difficulty in maintaining such a battery. The cells of 40 and 60 ampere hours answer the requirements, though, of course, the 60 hours is preferable.

CENCO PORTABLE STORAGE BATTERIES.

These batteries are especially made to stand transportation. Under ordinary conditions they should last for at least five years, and they are guaranteed for one year against everything except abusive handling. The jars are of the best vulcanite and are enclosed in hardwood cases provided with a handle and finished with acid-proof paint. Strength is added to the jar when placed in the case by entirely surrounding it with an elastic sealing compound. Short circuiting is prevented by an exceptionally wide distance between the plates. The acid cannot spill under any ordinary conditions of service.

Catalog No.	Voltage.	Ampere Hours.	Length, Inches.	Width, Inches.	Height, Inches.	Weight, Pounds.	Price, Net.
2189A	6	40	8 7/8	4 7/8	8 1/8	22	$ 9.90
2189B	6	60	10 1/2	5 3/4	9 1/8	30	13.50

SHIPPING WEIGHT.

The shipping weight of an Equipment depends upon the number of Groups ordered. If all the Groups are specified, the weight, boxed, will be about 375 lbs. The Motor Generator alone, boxed, weighs approximately, 200 lbs.; and, in any case, the weight will vary between these limits.

INSTALLATION.

The Drive Motor of the Motor Generator is furnished wound to fit any given service as specified in the order. It is always a ½ H. P. Motor unless some other size is specially named. If there is some other form of power available, it might be feasible to arrange a suitable drive, without incurring the expense of a regular drive motor.

The actual installation of one of these Equipments involves no difficulties. There is merely the selection of fuses having the right cross section, the putting in of a simple single throw switch, and the use of flexible leads having sufficient carrying capacity. If a minimum of noise is desirable, the selection of a table having pronounced sounding-board qualities should be avoided, of course, and one of the solid, heavy variety should be chosen. Two or three thicknesses of heavy linoleum under the Motor Generator, and even under the legs of the table will aid materially in reducing the noise. All drive motors furnished are of the self-starting type, and if any form of starting box is required, this is always furnished without extra charge.

PRICES.

The List of Parts, with the **Net Prices** of these when less than a complete Group is ordered is mailed on request. Quotations on any Group, or any combination of parts, or on any single part, promptly furnished.

One of Our Chemical Stock Rooms, Showing Packing Tables at Right.