ELECTRICAL SECTION.

Stated Meeting, held Thursday, March 3, 1904.

Circuit-Breakers.

By W. M. Scott.

The topic which has been assigned for this evening's discussion is one of such breadth that I will confine my discussion to but a single type of circuit-breaking apparatus, the "Reverse Current" Circuit Breaker, and will dwell more particularly on the form of this device which has been developed by the company with which I am associated, and who have for some years past been closely identified with the development of the "Reverse Current" circuit breaker.

A "Reverse Current" circuit breaker, or, as it is sometimes very aptly called, a "Discriminating Cut-out," is a circuit breaker which automatically severs the circuit in the event of the flow of current being abnormal in direction, and which, unless interrupted, would result in misapplication of energy. The "Reverse Current" circuit breaker most perfectly adapted to the requirements of engineering practice is one which is dependent for its operation solely upon the occurrence of reverse current flow. It is desirable also that loss of voltage shall not cause the opening of the "Reverse Current" circuit breaker, and it should be so constructed that it can be closed upon open circuit. In order to meet the varying conditions which may arise in the use of the circuit breaker, the volume of reverse current necessary for its actuation should be subject to convenient adjustment. The operation of the circuit breaker should be independent of voltage variations throughout the normal working range, and should be positive at all voltages to which it is liable. The force tending to cause the opening of the circuit breaker upon reversal should increase with the volume of the reverse current. In these last respects, particularly, many of the reverse current devices on the market are conspicuously defective. Considering, as an instance,

those which depend for their opening force upon a tripping coil which, when brought into circuit by means of a polarized relay actuated by a reversal of the current, is energized by the voltage of the system, it will be seen that where the reversal reaches the magnitude of a short-circuit, the voltage of the system may be reduced to but a fraction of its normal value, and the tripping coil may, as a result, be insufficiently energized to effect the opening of the circuit breaker.

Where, in order to avoid this very evident cause of failure, the tripping coil is connected in an independent circuit, new complications are introduced without corresponding advantage.

Obviously the operation of any safety device should depend entirely upon the conditions prevailing in the circuit to be protected, and its effectiveness should not be determined or limited by the condition of some independent circuit or appliance, the failure or disconnection of which may render the safety device inoperative at the critical moment. The following is a description of the I-T-E "Reversite" circuit breaker, upon the perfecting of which we have been at work for a number of years. In its operation all of the foregoing requirements are fully met.

Referring to the accompanying illustration (Plate I), it will be seen that the reversal feature of this circuit breaker is secured by the co-operation of two electro-magnetic systems: one consisting of a pivoted core and pole pieces depending for excitation upon a coil connected in the main circuit; the second of two independent cores, parallel with the first and excited in sympathy with each other by two magnetizing coils which are subject to the full voltage of the circuit. The pole pieces of the series magnet normally stand just midway between the polar extensions of the cores of the shunt-wound system. In this position they are supported from below by suitable stops. They are free, however, to move upward into engagement with the upper core, and in so doing cause the release of the latch restraining the switch. The windings and connections of the exciting coils of these two systems are so related that

during the flow of current in the direct sense the movable pole pieces are held in their medial position by the attraction of the lower core acting in addition to the effect of gravity, while upon a reverse current flow the pole pieces are drawn upward in opposition to gravitation into engagement with the upper core, these opposite reactions being due to the fact that the magnetism induced by the

PLATE I.—I-T-E "Reversite" circuit breaker, with overload actuation.

shunt coils is not subject to change in direction upon a reversal in the main circuit. Upon direct current flow, therefore, the series magnetism compounds with that of the lower shunt magnet, while upon reverse flow it compounds with that of the upper one. It will thus be seen that the operation of the

circuit breaker is dependent upon the co-operation of voltage and current. Although on account of the location of the movable pole pieces midway between the shunt-excited cores, the voltage alone will not cause the operation of the circuit breaker; nevertheless, at and considerably below normal voltage, the shunt excitation provides quite sufficient power for this purpose, when made effective by placing the movable pole pieces above their neutral position; but upon reversal the magnetism due to the flow of reverse current supplements that of the shunt-excited core toward which the movable pole pieces are attracted. The effect of this in insuring positiveness in the operation of the circuit breaker may be best understood by an inspection of the accompanying diagram (Plate II), illustrating the performance of a 600-ampere "Reversite" circuit breaker, designed for the protection of a 500-volt generator operating in multiple with others similarly protected.

The ordinates of these curves correspond with the various voltages upon which the circuit breaker was tested, the abscissæ with the corresponding reverse currents required for the operation of the circuit breaker and consequent opening of the circuit. The three curves coincide respectively with 8, 20, and 75 amperes adjustment, which are correct at 500 volts pressure. It will be noticed that for variations of 100 volts either way from normal the performance of the instrument corresponds closely with the calibrations, that as the voltage of the circuit falls the value of reverse current necessary for the operation of the instrument continues to increase; but within the limits of the test, which was carried down to 30 volts, the operation of the instrument was uniformly reliable and positive. When at any voltage the reverse current had reached such a value as to cause the initial motion of the movable magnetic system away from its neutral position, there was ample energy supplied for the tripping of the circuit breaker. An inspection of the curves shows that they are of the nature of rectilinear hyperbolas, the asymptotes corresponding respectively with a vertical line drawn through the zero value of the current, and with a horizontal line somewhat below the zero volt-

PLATE II.

age, the form of the curves bring represented approximately by the equations $X(Y + K) = C$, in which X corresponds with actuating current, Y with voltage, and C a constant, while K depends on residual magnetism, which, as will be seen, has the effect of reducing the values of the operating current, at the lower voltages, below that which would be required were the magnetism exactly proportional to the current. That the residual magnetism corresponds in direction with that induced by the reverse current is due to the fact that the only closing of air gaps in the magnetic system is such as results from reverse current flow.

Whatever may be the interest in the properties of these curves, they clearly indicate the reliability of the I-T-E "Reversite" circuit breakers under all conditions which may arise in practical service.

The I-T-E "Reversite" circuit breakers described above are provided with a convenient adjustment determining the value of the current upon which they will operate. This adjustment is obtained by the movement of a counter-balance along a calibration plate, the scale being long and easily read. The normal range of adjustment is from 5 per cent. of the normal capacity of the circuit breaker to 25 per cent., but any other specifications can be met.

The principles of the I-T-E "Reversite" circuit breakers are such as lend themselves with suitable modifications to designs for alternating current service.

Where alternating current work is considered instead of direct, the necessarily high inductance of the shunt coils of the reversal feature introduces an entirely new and highly important factor. By means, however, of designs which have been the result of much careful research and experiment, this and other difficulties have been overcome, and the engineer now has at his disposal for alternating current service, as well as for direct, a reverse current circuit breaker which will fully meet the most exacting requirements. The design of the alternating reverse current feature is such that on a circuit of ordinary power factor, the magnetism due to the shunt coils during normal conditions is approximately in phase with that due to the line

current. The reactions between the two magnetic systems of the reversal feature are determined not only by the magnitude of the current, but by its phase relation to the E.M.F. The reverse current may be considered as made up of two components; one in phase with the E.M.F., representing reverse energy flow, and a second lagging 90° behind the E.M.F., representing a wattless flow. The construction of the I-T-E reversal feature is such that it responds only to the first-named component, the wattless currents having no appreciable effect on its operation. For this reason the calibrations are marked in units of power, not in units of current, and indicate, therefore, the energy reversal which will cause the opening of the circuit breaker. It will be seen that these indications can be checked by ammeter readings only when the phase of the current and the voltage of the system are also taken into consideration.

THE APPLICATION OF REVERSE CURRENT CIRCUIT BREAKERS TO THE PROTECTION OF GENERATORS.

So long as generators are operated singly, their protection is fully insured by the use of simple overload circuit breakers. When, however, generators are operated in multiple, new conditions are introduced which require protective appliances having features not found in the simple "Overload" circuit breakers. Where generators are run in this manner, in case of accident to one of them or to its prime mover, not only will this unit cease to deliver its quota of current to the external circuit, but the other units in parallel with the damaged one will begin to force current into it. The normal generators will, therefore, supply not only an undue share of the effective load, but also additional current delivered to the crippled unit, resulting in unnecessary overloading of the normal generators and a possibility of injury to the crippled one. The use of simple "Overload" circuit breakers would, in such a contingency, result in cutting out the disaffected generators as well as the crippled one, with the result that, momentarily at least, the service would be interfered with. It is evident that the protective device for the generators should be of

such a character that the crippled unit shall be automatically disconnected before it shall have taxed the others. Thus the load will at once devolve upon the normal units without even a momentary interruption of the current supply. The only protective device which adequately meets these requirements is the I-T-E "Reversite" circuit breaker. Where each generator of the system is thus protected, crippled units will be immediately disconnected.

The protection afforded by "Reversite" circuit breakers is of especial value in power plants, the demands upon which are such that reserve units must frequently be thrown into service. Such a requirement is often of the nature of an emergency, and it is of the utmost importance, therefore, that the necessary connections shall be made promptly. If, however, the engineer connects the reserve unit to the bus bars an instant too soon, in the absence of proper protective devices, the current reverses into it and it thus adds to the load upon the other generators. Where each generator is protected with an I-T-E "Reversite" circuit breaker, no unit can be effectively thrown into parallel with the others until it is up to the voltage. The use of this type of circuit breaker gives the engineer confidence, saves delay and affords the generator complete protection.

"Reversite" circuit breakers also have an incidental value, in that they serve to automatically disconnect each generator, as its prime mover is slowed down when the generator is being taken out of service, as the instant the slowing down results in a drop in voltage of the generator, a reversal takes place which opens the circuit breaker.

The method of connecting "Reversite" circuit breakers for the protection of generators operating in multiple is shown in the accompanying cut, Plate III. The two poles of the circuit breaker are introduced in the usual manner into the circuits of the generator leads; the shunt coil is then connected so as to receive full line pressure. One terminal of the coil is to be attached to the small spring contact located back of the left-hand switch member of the circuit breaker; the other terminal must connect with the

PLATE III.

bus bar of opposite polarity. The actual passage of current from the generator is perhaps the best method of ascertaining whether the shunt coil has been connected so as to make the circuit breaker operative upon reversal. If, upon trial, the reversal feature responds to current flowing in the direct sense, the connections of the shunt coil should be reversed.

Alternating current generators operating in parallel are subject no less than are direct current generators to reversals of current. Some idea of the correctness of this statement may be gathered by an inspection of the ammeters on the switchboard in any alternating current plan. Obviously, the total current delivered to the bus bars by a number of generators in multiple, should closely approximate the total current delivered from the bus bars to the external circuit. The excess of the former as compared with the latter is a measure of the current passing between generators and thus diverted from the external circuit.

To many engineers in charge of alternating current plants, the operations of the alternation current are filled with mystery, and they are, therefore, inclined to accept the guarantee of manufacturers of the generating apparatus of which they are in charge, rather than to reckon with the obvious facts of the case. The protection of alternating current generators with "Reversite" circuit breakers places a check upon the operation of these generators and will enable the engineer, by suitable adjustments of generators and prime movers, to get the best possible performance from them, or to locate such apparatus as is hopelessly at fault in this respect.

THE APPLICATION OF REVERSE CURRENT CIRCUIT BREAKERS TO THE PROTECTION OF ROTARY CONVERTERS.

The operation of rotary converters in parallel is analogous to that of other generating apparatus, and corresponding conditions may readily arise, causing one or more rotaries so connected to operate in the reverse sense; that is, taking current from the direct current side and delivering power to the alternating current mains. Where the rotaries are

protected by "Reversite" circuit breakers, such tendencies are arrested in their incipient stages. The "reversal" feature of the circuit breaker may most conveniently be installed in the direct current side, the switches of the breaker controlling either the direct or alternating current side, or both, as the requirements of the installation may demand.

Where rotaries are started from the direct current system, the reverse current breaker, in order to conveniently permit the passage of the starting current, may be made inoperative during the starting period by opening the circuit of the shunt coils of the "reversal" feature. This is most readily accomplished by means of a small switch in the shunt coil circuit interlocked with the line switch of the rotary on the alternating current side, so that the shunt coils will receive current only when the rotary is connected with the alternating current mains.

THE APPLICATION OF REVERSE CURRENT CIRCUIT BREAKERS TO THE PROTECTION OF TRANSMISSION LINE IN MULTIPLE.

Where power is delivered to a single receiving point by more than one system of feeders, it will be seen that in the absence of suitable protective devices properly disposed, a short-circuit upon one set of feeders will be fed not only through the portion of the feeder located between the short-circuit and the source of supply, but also by means of the portion of the damaged feeder beyond the short circuit, with current flowing in the reverse sense from the receiving station. "Overload" circuit breakers at both generating and receiving ends of the cables form a means of isolating the damaged lines. Their use alone, however, is liable to cause momentary interruption of service in the uninjured cables, which will be repeated until the damaged line is finally located and put out of service. Circuit breakers having reverse current operation located at the receiving end of the transmission lines will automatically sever the damaged cables at this end and prevent the receiving station from feeding back into the short circuit; this being attained without even momentary interruption of the service. These

considerations have equal importance in both direct current and alternating current practice, with perhaps a wider scope of application in the latter field. In combination with "overload" circuit breakers at the generating end of the feeders, "Reversite" circuit breakers at the receiving end should give adequate protection under all conditions of service which are likely to arise.

THE APPLICATION OF REVERSE CURRENT CIRCUIT BREAKERS
TO THE PROTECTION OF STORAGE BATTERIES AND SYSTEMS
OF WHICH STORAGE BATTERIES FORM A PART.

The wide application of storage batteries in connection with electrical installations of various types renders desirable a knowledge of the forms of protective apparatus best suited to the requirements of this class of service. The manner in which the storage battery is handled plays a very important part, both in determining the length of its life and its efficiency. Where batteries are charged at too high a rate, the plates are subject to sulphating and other forms of injury, from which the battery is slow to recover. Discharge of the battery under abnormal conditions is also likely to cause serious damage. Where storage batteries are constantly under the eye of skilled attendants, guided by suitable indicating instruments, these dangers are perhaps somewhat reduced. They may in all cases be minimized and in most cases entirely eliminated by the installation of suitable protective devices.

Considering first the protection of automobile storage batteries, these are quite frequently charged from a generating plant devoted exclusively to this purpose. Among the contingencies likely to arise, are: connecting the battery into circuit incorrectly, so that its electro-motive force shall be cumulative with that of the generators, thus subjecting the batteries to an abnormally high discharge rate; or, where the battery is properly connected, it may be subjected to a charging current in excess of its safe limit. Disastrous results from such causes may be entirely prevented by the use of "overload" circuit breakers.

During the period of charging, should the charging

generator lose its field, or for any other reason drop its voltage, the storage battery will tend to reverse into it and operate it as a motor, and this without such indication of abnormal conditions as would attract the eye of the attendant. The battery would thus, to all appearances, be charging, while in point of fact it would be undergoing discharge, resulting not only in undue waste of energy, but wear and tear on the battery and loss of time as well. A somewhat similar condition is likely to arise where the battery is charged from a generator engaged in supplying current to an external circuit. Under these conditions, the causes of reversal of the battery into the generator would be the same as those already cited, and in addition thereto, should the generator for any reason be cut out of service, the battery would take up the load on the external circuit, and thus again the attendant might readily be misled as to the real condition of affairs. Particularly would this be the case if the generator were remote from that point in the circuit to which the storage battery was connected. A "Reversite" circuit breaker in the circuit of the storage battery would serve automatically to disconnect the battery coincident with the first flow of current from it into the external circuit.

Sometimes in automobile charging stations, a number of batteries may be left in connection with the same charging mains at a time when the generators are disconnected. Where this occurs, the stronger or more highly charged batteries will discharge themselves into those more nearly exhausted, and should any one of the batteries be short-circuited, this would result in injury to all of the others. This contingency also may be guarded against by the installation of a "Reversite" circuit breaker in each battery-charging circuit as shown in Plate IV, which represents a panel such as may be employed in charging a battery from a constant potential circuit, the current being regulated by the line rheostat shown in the lower section of the panel.

Very frequently batteries, particularly those of automobiles, are charged from a motor generator especially installed for that purpose. In such instances, most fre-

PLATE IV.

PLATE V.

quently the circuit from which the motor side of the charging set is driven is in connection also with other apparatus. If for any reason there should be an interruption of the motor circuit, as might be occasioned, for instance, by the opening of the circuit at the power-station, the storage battery, if not promptly cut out, would run the motor generator in the reverse sense, the motor end acting as a generator and supplying current to the other apparatus on the feeder. The installation of a "Reversite" circuit breaker in the charging circuit of the storage battery provides the only effective means of protection against this contingency.

Conditions identical with these are frequently met with in telephone work. The suitability of the "Reversite" circuit breaker to this class of service is perhaps best instanced by the large and constantly growing use of this piece of apparatus by the leading telephone companies of the country.

A convenient and effective method of installing the "Reversite" circuit breaker for the protection of systems referred to is suggested in the accompanying diagram—Plate V. *M* is the motor, and *G* the generator, the voltage of the latter being controlled by the field rheostat *R*. At *D* (frequently combined in a single case) are the voltmeter and ammeter, the latter in the battery circuit, while the former, by means of a two-way switch, may be used to measure either battery or generator voltage.

C is a three-pole combine overload and "Reversite" circuit breaker with independently operating arms. The pole "2" of the circuit breaker, which includes the overload and reverse current operating coils, is located in one of the mains leading to the storage battery, whose connection with the generator is completed through pole "3" of the circuit breaker, pole "1" of which is included in the motor circuit.

In starting up, the motor circuit is first closed through pole "1" of the circuit breaker; by means of the field rheostat *R* the voltage of the generator is equalized with that of the battery, which is then connected with the generator by closing the two remaining poles of the circuit breaker, after which the voltage of the generator is increased until the

PLATE VI.

proper charging current flows. While this plan is simple in its arrangement, it is very effective in operation, and provides for the immediate opening of both motor and battery circuit in the event either of the battery being too rapidly charged, or of its reversing into the generator. It will be seen that the construction of the circuit breaker embodied in this equipment is such that the battery cannot be effectively brought into circuit, either upon reverse current or upon overload conditions. Two independent poles being included in the circuit of the battery, the instant opening of the circuit is insured should an attempt be made to connect the battery under conditions resulting either in an overload or a reverse flow of current. Plate VI shows a similar panel employing a double-pole circuit breaker, of which one pole only is connected in the battery circuit and one in the motor circuit.

Very frequently storage batteries are installed in multiple with motor-driven generating units, acting under normal conditions as an auxiliary thereto, relieving the generator of the peaks of the load, and carrying the load entirely during interruptions of the main source of power. Such installations as these are constantly increasing in use in connection with electrically operated signals, where interruption of the current supply must at all hazards be avoided. In this case it will be seen that the current in the battery circuit may, under normal conditions, flow either in the charge or discharge direction. A reverse current circuit breaker installed between the battery and the external circuit on the one hand, and the generating side of the motor generator on the other hand, will serve, however, to keep the current in this part of the circuit flowing in one direction only, a reversal of the current from the battery into the generator at once throwing the generator out of circuit, leaving the storage battery to carry the load.

A plan embodying these principles is shown in the accompanying Plate VII. Its distinctive feature is that it provides two sets of batteries as a safeguard against shut-down. The arrangement is such that both batteries may be charged or discharged at the same time, and either or both

PLATE VII.

may, if required, carry a whole or a part of the load with or without the assistance of the generator.

These batteries are indicated at *A* and *B*. The double-pole, double-throw switch *S* serves to connect either one with the charging generator through the Dublarm overload and "Reversite" circuit breaker *C*. The power is supplied by a two-phase alternating current circuit controlled by switch *D*. The feeders, two in number, are connected with the hinges of two double-pole, double-throw switches, the upper and lower terminals of which connect respectively to batteries *A* and *B*. The voltages of generator and batteries are indicated by voltmeters *G* and *H*, the latter of which is controlled by a two-point switch, so that it may be connected with either battery. A field rheostat affords means of varying the voltage of the generator, which is shunt-wound. By using a circuit breaker with sufficient number of poles, the motor side also of the charging set may be disconnected simultaneously with the opening of the generating side. This, however, is in many cases a refinement of economy rather than necessary means of protection.

In lighting and power-work a storage battery is sometimes installed in multiple with the generator, charging from it at low loads, assisting it by carrying a portion of the heavier loads. This class of service demands treatment somewhat different from the foregoing, and its requirements may usually best be met by installing a "Reversite" circuit breaker, the series actuating coil connected in the main circuit of the generator, between it and the storage battery, the switch member being in the battery circuit. The battery will thus be free to charge from the generator or discharge into the external circuit, but any tendency to reverse into the generator itself will cause the immediate severance of the storage battery circuit, leaving the load upon the generator.

For all of the classes of storage battery work referred to in the foregoing paragraphs, it is believed that the I-T-E "Reversite" circuit breaker (with or without overload actuation, as dictated by the conditions to be met) affords the best possible protection.

For the charging of storage batteries at constant voltage, the "I-T-E Underload" often affords entirely satisfactory protection. It is to be remembered, however, that this device will not remain closed unless there is flowing in the circuit a sufficient current to restrain the underload armature. Where the voltage of the circuit is liable to fluctuations, this would result in frequent and unnecessary opening of the "Underload" circuit breaker, a condition that is entirely absent with the use of the "Reversite" circuit breaker, which will not only remain closed when no current is flowing in the line, but, as before explained, requires an actual reversal in the direction of the flow of current to cause its operation.

THE APPLICATION OF CIRCUIT BREAKERS TO THE PROTECTION OF STORAGE BATTERY BOOSTERS.

The discussion of the protection of storage batteries leads naturally to the consideration of means for protecting the booster sets commonly used in connection with battery installations. In the majority of cases, where boosters are employed in such systems, they are used reversibly, that is, they are employed to regulate both the charge and the discharge of the storage battery. Obviously, therefore, reverse current circuit breakers, as usually understood, are not suitable for the protection of this portion of the circuit. The I-T-E combined overload and "Reversite" circuit breaker may, however, be admirably adapted to these conditions. When intended for such service, the reverse current adjustment is made to correspond with the maximum safe charging rate of the battery, the overload adjustment conforming with the maximum safe discharging rate. Adequate protection is thus afforded to the battery with either direction of the current flow.

Boosters of the compound or series type, if left connected with the system when the circuit of the driving motor is interrupted, will act as series motors rotating in the reverse direction, and, if not promptly disconnected, will attain a destructive speed. Similar conditions occur should the booster circuit be closed before the motor has been started,

PLATE VIII.

PLATE IX.

or should the motor for any reason lose its field. Proper protection under these conditions is secured only by having an overload and no-voltage circuit breaker in the motor circuit inter-connected with the circuit breaker in the battery circuit in such a manner that the motor circuit breaker must be closed before the booster circuit breaker can be made to latch, while the opening of the first-named instrument instantly causes the opening of the second.

The inter-connection of the circuit breakers may be either electrical or mechanical. Where the electrical method is employed, the booster breaker is provided with an auxiliary tripping coil brought into circuit by means of a contact device operated by the opening of the motor circuit breaker. In the mechanical arrangement, a lever suitably connecting motor and booster breakers is actuated upon the opening of the former, to release the latch of the latter. This method of inter-connection is illustrated in the accompanying cut, Plate VIII.

THE APPLICATION OF CIRCUIT BREAKERS TO THE PROTECTION OF BOOSTERS SUPPLYING FEEDERS.

Boosters employed to compensate voltage losses in feeders, incident upon transmission over considerable distances, are either series or compound wound; if, therefore, when for any reason the driving motor is not receiving current, the booster should be left in connection with the system, it will run reversely as a motor, and in view of its series field winding will attain destructive speed. This condition may be adequately dealt with by the employment of inter-connected circuit breakers as described in the foregoing section, the motor circuit breaker being of the overload and "no-voltage" type, while the circuit breaker in the booster circuit will, as a rule, need no other actuation than that transmitted from the motor breaker by the inter-connecting device.

Plate IX shows a type of circuit breaker which has been very successfully employed in connection with booster sets having a generator on each side of the line. The outer switches serve to connect the two boosters to the positive

and negative sides of the line respectively; the center circuit breaker operating upon either overload or "no-voltage" serves also to cause the opening of the booster switches.

THE PENETRATING POWER OF " N_1 -RAYS."

Professor Blondlot recently drew attention to a novel kind of N-rays, diminishing, instead of augmenting, the phosphorescence of calcium sulphide. These rays, called by him " N_1 -rays," are given off from a Nernst lamp simultaneously with the N-rays, and are also produced by stretching out a copper, silver or platinum wire.

In a memoir recently presented to the French Academy of Sciences, Mr. Julien Meyer describes some experiments with these N_1 -rays, produced by an extended glass or copper wire or else by a closed glass tube in the interior of which the pressure is diminished. The glass of the tube, on account of the strain resulting from the difference in pressure, was in fact found to be a powerful source of N_1 -rays. The brilliancy of a screen covered with sulphide spots and introduced into a glass bulb resting on the plate of an air pump would diminish when the machine was started, but would recover its initial value as the air was allowed to re-enter. If the sulphide screen be placed outside of the bulb, the phosphorescence would likewise diminish from the very first stroke of the piston. An incandescent lamp bulb, not traversed by any current, a hydrogen Geissler tube, a Crookes' tube, were all found to be sources of N_1 -rays without being actuated by a Ruhmkorff coil.

While the N_1 -rays from a Nernst lamp are arrested by an oxidized lead plate or by a sheet of moistened paper, those issuing from the sources named are gifted with a high penetrating power; in fact, the action of incandescent lamp bulbs on the screen is not appreciably diminished if between the bulb and the screen there be inserted a board 10 centimeters in thickness or a sheet of oxidized lead 1 millimeter in thickness and folded around itself so as to be traversed eight times, or else a glass vessel filled with pure water. Pasteboard, paraffin, aluminum, zinc, iron, copper, silver, gold, mercury and the hand are also transparent to these radiations. The only opaque bodies found were platinum of a thickness of 1 millimeter and opalescent glass 3 millimeters in thickness.

While examining the refraction of the rays by means of an aluminum lens, the author stated that this metal would store the rays in great amounts, giving them off again for more than twenty-four hours after it had been withdrawn from the source. A similar power, though of smaller intensity, was found in the case of ordinary glass; while lead, copper and pure water did not show it.

Salt water and a solution of sodium hyposulphite in water, on being submitted to the action of a source of N_1 -rays, would become active themselves, acting as sources for a very long time.

When the hand is held for some time at a small distance from a source of N_1 -rays or touching the latter, the hand would diminish itself the phosphorescence of the screen, this property being kept for some minutes.

N_1 -rays as given off from the above sources are refracted by glass, copper and aluminum prisms and diffracted by a grating.—*Scientific American*.