LOCATION OF GROUNDS IN ARMATURES, FIELDS, ETC.

BY CLARENCE E. GIFFORD.

This paper presents no novel scientific principles. The methods herein described are but simple adaptations of the principle of the Wheatstone bridge. They have been in use by the writer for several years, and he, having devised them for his own use, and found them very rapid, accurate and simple, is led to believe that they may be of considerable service to others. *The Electrical World* "digest" of March 16th notices a slightly similar, but evidently less perfect method, published by Mr. Bronsson in the London *Electrical Review*. The insufficiency of Mr. Bronsson's method in cases where two grounds, at some distance apart exist, is admitted. The methods herein described deal successfully with such cases.

If the work can be performed in a very quiet room, two or three cells of battery, a telephone receiver and connecting wires, comprise the necessary apparatus. In some cases two "table binding posts" and a foot or two of No. 18 or No. 20 bright iron wire will be a convenient addition. Where noise will not permit the use of a telephone, a dead-beat reflecting galvanometer, a milli-voltmeter, or some other form of delicate and rapid working visual indicator must be used instead. If an armature is to be tested without removing it from the machine; connection with the battery may be made through the brushes, first making certain that the short-circuiting switch is opened, if dealing with an arc machine. The points of connection with the battery need not be diametrically opposite, and may be made by the wires

being firmly pressed against the commutator by an assistant, if more convenient.

Good electrical contact between metallic surfaces can better be secured by cleaning the same thoroughly with kerosene, which removes foreign matter, and is so fluid that it will in no way interfere with perfect contact, when moderate pressure is applied. Especially when making measurements of resistance of armature sections, it is even advisable to have the surface of the commutator quite wet with kerosene during the operation, as this avoids trouble from grease or dirt which might get on the surface from handling, subsequent to cleaning, and it also prevents the contact points becoming oxidized by any sparks which may occur at the moment of breaking contact. True, the oil is an insulator, but we use it in this case as a detergent simply.

Returning to the armature; connection being made between battery and commutator, first determine whether the armature circuit is complete throughout. If the circuit is complete, a click will be heard in the telephone when the two terminals of the same are brought in contact with any two contiguous bars of the commutator, or when contact is broken. If an open circuit exists on either side of the circuit, of course no sound will be heard in the telephone when used on that side, except when connection is made or broken by it between the bars lying on opposite sides of the break. See Fig. 1.

Close any open circuit temporarily by bridging between the two bars with a drop of solder. Two or more breaks can evidently be located by suitably shifting the battery contacts and searching as before. Open circuits will, of course, when an armature continues in work, soon cause burns between the bars that will indicate unmistakably their location. Having closed any open circuits, and the battery being connected to two points of the commutator, approximately opposite each other, one terminal of the telephone is connected to the armature shaft, or frame of the machine, and the other terminal is drawn completely around over the surface of the commutator, while the telephone is held to the ear. If only one ground exists, two balancing points, or points giving the least noise in the telephone will be found.

In an armature of ordinary construction, one of the points so found will be on the bar nearest the real ground, while the other balancing point bears what might be termed a "bridge relation"

to the first, being at practically the same potential; the armature itself forming in reality a veritable Wheatstone bridge.

Now, shift the points of battery contact a few bars either way and the true ground, if but one exists, will be indicated in precisely the same position as before, while the other balancing point will shift every time the battery contacts are shifted. See Fig. 2.

If two grounds exist, two balancing points will be found, as before, but both points will shift more or less when the battery contacts are shifted, provided the grounds lie on opposite sides of the same battery contact. This case will be considered later.

FIG. 1

FIG. 2

In the case of one ground, having determined its location approximately, fix it as closely as may be by making and breaking contact with the telephone terminal on each of the more quiet bars, separately, until by comparison, the two giving the faintest clicks are determined. If your hearing has served you correctly these two bars lie nearest the trouble, the fainter one being the nearer. Prove the non-existence of a second ground by placing one of the battery contacts on the first bar to the right of the apparently permanent balancing point just found, and then on the first bar to the left of said point, the other contact being nearly diametrically opposite. This balancing point should still remain unchanged if no other ground exists.

The next step is to connect the battery to these two bars just fixed upon as lying nearest the trouble. The armature still forms a "bridge," the portion included between the two contiguous bars to which the battery is now connected forming the one side, and the remainder of the armature, the other side. See Fig. 3.

One of the telephone terminals is now connected to the shaft as before, and the other terminal again drawn around the commutator. If the balancing point is found, say one-sixth to one-half, the long way around from one battery contact to the other, (these contacts being on two contiguous bars) the trouble lies in the coil between those two bars, and the point of trouble divides the coil in the same ratio as the balancing point divides the remainder of the armature, the ground and the balancing point being respectively nearest the same battery contact. If the balancing point falls on the same bar as one of the battery contacts, the ground is located on that bar or on the lead between it and the armature, provided the balancing point is found to be upon the same bar when the battery contacts are both shifted one bar to the right or left of their original position. See Fig. 4.

If the balancing point appears to be found within three or four bars from one of the contacts, the precaution should be taken to test its correctness by moving both battery contacts one bar toward the balancing point. If the trouble was between the battery contacts when in their previous position, this shifting of the contacts will now throw the balancing point clear around onto the contact which was, in the previous position farthest away from the balancing point. If, on the contrary, the balancing point remains unmoved by this shifting of the battery contacts, it shows that this balancing point is the point nearest the real ground, and that the ear was deceived in its first supposed approximation, which, with due care, however, is not likely to occur.

If such error has been made, the new point, as indicated, together with first the bar on one side of it, and then on the other, must be tried as points of battery contact; or, much better, make a new start with the contacts nearly at opposite sides of the commutator and proceed as before. A single 20,000 ohm ground on a one ohm armature should be located accurately in not over three minutes, in a quiet room. Higher resistance grounds require more battery and more care. Armatures of very low resistance also offer greater difficulty.

Where two grounds are found to exist, as indicated by the change of location of both balancing points, under the conditions

before stated, when the battery contacts are shifted, the following mode of procedure will answer the purpose well, and is simple. Fix the battery contacts at any two points of the commutator nearly opposite each other, preferably at points to be determined by trial, that will cause the balancing points to fall nearly diametrically opposite to each other, and determine and mark the two balancing points, as then shown. Now place the battery contacts on the balancing points just found. If only one ground exists, the two balancing points and one battery contact will all be coincident in one point. If two grounds exist, both balancing points will be shifted from their former position. Open the arm-

FIG. 3.

FIG. 4.

[Analogue to
Fig. 3.]

ature circuit by unsoldering one of the ends of a coil connecting with the lead of the bar that is marked in the first part of this test, as one of the balancing points. Place one of the battery contacts on the armature shaft, and the other on the marked balancing point that is farthest from the point where the circuit has been opened. Next place one telephone terminal on the first bar to the right of the opened wire, and draw the other terminal from the same point, toward the right, over the surface of the commutator. The telephone will be absolutely silent until the moving terminal has just passed the ground nearest to it, and strikes the first bar beyond the same, when it will click. This

ground lies in the coil between this first bar giving a click and the one passed just previously, or else in the said previous bar.

The other ground is obviously to be located in a similar manner, by placing one telephone terminal on the bar just to the left of the open wire, and from that point searching toward the left with the other terminal. Only in cases where one ground is of very low, and one of very high resistance will any difficulty be experienced in locating both accurately before either is removed.

The coils thus indicated may have their terminals unsoldered, when it can be readily ascertained with each, whether the ground be in the coil or in the bar just preceding it.

If scientifically inclined, or if otherwise preferable, the circuit may be opened at a point somewhere midway between the two indicated coils instead of disconnecting those coils, and the exact location of each ground determined as follows: Take a piece of "broom wire" about 18 inches long, new and clean, screw the ends firmly into two clean, brass table binding posts, and into the other holes of the same posts, screw the battery terminals. Have an assistant press the corners of the bases of the binding posts into very firm contact with the two bars that lie at the ends of the indicated coil, observing the directions previously given for securing clean contact. Place one telephone terminal in contact with the shaft, and with the other find the balancing point on the wire. This point will indicate the relative position of the ground in the coil, or commutator bar, as the case may be. If more than two grounds were suspected, the two lying the farthest apart would be approximately located by the first part of the two-ground process, and if these coils were not disconnected before proceeding farther, it would be well to make two openings in the circuit, close to and lying between these outer grounds, then locate definitely these two extreme grounds, and proceed with the remaining section somewhat as with a complete armature, except that you would commence by connecting the battery to the terminals of this section, and would then bridge the telephone from the shaft to the different portions of the section, and would complete the process by applying the remainder of the two-ground test.

In dealing with a cross-connected Gramme ring, an obvious change would be made in the points of application of the battery; and as many points of apparent trouble would be indicated as there were series of cross-connections.

After location of these points it would be necessary to use the auxiliary wire loop, as before described, between these points, to determine which is nearest the trouble. This fact being determined, it would in case of a single ground (indicated by the permanency of the balancing point) become necessary to remove the cross-connections from two bars before proceeding farther. The auxiliary wire loop would properly be used to complete the process.

The ordinary "closed coil" ring or drum armatures are types to which these methods are directly applicable.

The sections of open coil armatures would receive the same treatment as field coils.

Familiarity with any special forms of armature will doubtless suggest to the ingenious mind, modifications of these methods suited to those forms, but it would be improper to attempt here to deal with specialties whose names are legion.

Where wet grounds exist it will always be better, when practicable, to dry them out before making the final test, as certain sections may show faults which will not be permanent. Wet grounds will of course give a click in the telephone when bridged from the commutator to the shaft when no battery is attached, owing to galvanic action of the water on the copper winding and the iron core.

Whenever necessary to deal with wet grounds in testing, it is better to make at least four tests, reversing the battery after each test, and taking the mean of the four determinations.

Field coils, also any wires of uniform cross-section, the extremities of which are accessible and within a reasonable distance of each other, can of course be easily tested for grounds by soldering or firmly clamping a bare wire of suitable size between the extremities of the conductor to be tested, applying a battery to the junctions, and bridging with a telephone between the bare wire and the object upon which the conductor is grounded. This will give only the location of a single ground, or the "resultant" of two grounds. A "T.-H." rheostat should have the battery connected to the two extremities, and the point of apparent ground determined by bridging with a telephone between the frame and the several contact plates. Then apply the battery to the frame and point of apparent ground, connect one terminal of the telephone with each extremity successively, and search from it toward the center

with the other terminal, as in the case of searching for two grounds in an armature.

In determining the location of grounds that are of very low resistance, a good induction coil similar to that used in the Blake transmitter may be used with advantage in connection with the telephone receiver. The receiver is placed in circuit with the secondary of the coil, and the "bridging" is done with the primary. With high resistance grounds the best results are obtained by using the receiver only.

After the reading of Mr. Gifford's paper, a recess was taken until 8 P. M.

The afternoon was devoted to an inspection of the power house of the Niagara Falls Power Company, the electric plants of the Pittsburg Reduction Company, and of the Niagara Falls and Buffalo Electric Light and Power Company, and the mill of the Niagara Falls Paper Company.

The evening session was called to order at 8.20 P. M. by Vice-President Wm. A. Anthony, when the following inaugural address was delivered by President Louis Duncan: