circuits should be kept up for another reason, viz., the safety of the public.

For the insulation of apparatus and parts of apparatus used in electrical engineering, various substances are used. Hard wood, when dry, is a very good insulator for many purposes; wet wood is a very bad insulator for any purpose. Thus, a ringing key at a colliery shaft bottom, if mounted on wood, may work perfectly at first, and fail after a time, owing to the wood becoming saturated with moisture.

Vulcanite—hard, black vulcanized india-rubber—is a first-rate insulator for nearly every purpose, and it does not readily absorb moisture; but it is brittle and expensive, and moisture will condense on its surface. It is unsurpassed for small collars, knobs, etc., designed to insulate two parts of an apparatus between which a high difference of potential exists, yet which must from the construction of the apparatus be close together.

Vulcanized fibre, another substance somewhat similar to vulcanite, is of great service in many places where the brittleness and expense of vulcanite forbid its use. It is tough, and, as its name implies, of a fibrous nature. Its one drawback is, that it absorbs moisture, and then its insulation resistance diminishes very considerably. It must not therefore be used where it will be exposed to damp or oil, except where only a low E.M.F. is present.

The flexible fibre is not a good insulator.

Mica and asbestos are also used for insulation chiefly on account of their non-combustible properties; but they can only be used in certain cases. Asbestos, when worked into millboard, answers very well for many purposes, such as the insulation of commutator sections, coils of magnets, etc., always provided it can be arranged that the sheet shall not be torn; but it is not a perfect insulator.

The use of mica is more limited. Owing to its peculiar laminated character, you can have a plate of mica of a certain size as thin as you like, but it must be a plate of one thickness all through. It is not workable to section like other substances. It is somewhat brittle too, and it is doubtful if its insulating properties are as high as some people think. Slate and porcelain are now being used for the bases of electric light switches and fuzes; but the former is not a good insulator, and will not answer at all for high E.M.F.s; the latter has the disadvantage that it is difficult to work and is easily broken.

Once more, it must not be forgotten, that in the use of all these substances Ohm's law is the whole arbiter of the fittest, coupled, of course, with the law of dimensions and resistance. Thus, it may be quite practicable to use a comparatively poor insulator in the presence of a low E.M.F., especially if the insulation path is or can be made long and of small cross section, where it would not be if the conditions are reversed.

Induction.—A series of phenomena in connection with electricity that have a very important bearing upon the working of all electrical apparatus, are what are known as electrical induction, or electrical action at a distance.

It has been explained how electrical currents pass through conductors where continuity exists—where continuity does not exist, another series of actions takes place—induced electro-static charges are formed, and induced currents are generated.

When an electro-static charge is held upon a conductor completely isolated from other conductors, a charge of an opposite name is *induced* upon all other conductors in the neighborhood, that are not insulated.

Again, when a current of electricity passes round a piece of iron, magnetism is *induced* in the latter, and will be rendered visible on closing the magnetic circuit.

When a permanent steel magnet is brought near a piece of iron or steel, magnetism is *induced* in the latter, provided it lies in the path of the magnetic circle.

But the most important phenomena of all are magneto-electric induction, and the induction of currents upon each other.

If a permanent or an electro-magnetic be brought into the neighborhood of a conductor, so that the latter lies at right angles, or nearly so, to the path of the magnetic circuit, or to the lines of force as it is usually expressed in the text-books, an E.M.F. is generated in the conductor, which will give rise to a current, if a path be open for it; and this generation takes place as long as the motion continues, or as long as an alteration in the field in the neighborhood of the conductor is going on. Thus, suddenly exciting an electro-magnet whose magnetic circuit crosses a conductor, will generate an E.M.F. in the latter. Suddenly causing an electro-magnet to lose its magnetism will have a similar effect; but the E.M.F. in the former case will be in the reverse direction to that in the latter; that is, it will tend to produce a current in the opposite direction through the electric conductor. Varying the strength of an electro-magnet will have the same effects, though in a minor degree, as suddenly magnetizing it or causing it to lose its magnetism.

Upon the phenomena of induction the dynamo electric machine, the induction coil, and the transformer have been reared.

The property of inducing currents also extends to wires in the neighborhood of other wires. If, for instance, a second wire be wrapped round an electro-magnet, in addition to the exciting wire; each time that the exciting circuit is closed, an E.M.F. will be generated in the second wire; and each time the exciting circuit is broken, an E.M.F. will be generated in the second or secondary wire, as it is usually termed, the exciting wire being called the primary; but the direction of the E.M.F. generated in the two cases will be opposite to each other.

A variation in the strength of the current passing in the primary or exciting wire is also followed by a generation of E.M.F. in the secondary, though in a minor degree.

The directions of the secondary E.M.F.s are always such as to resist the action of the primary current. Thus, the current which passes in the secondary when the primary circuit is closed, is in the opposite direction to that passing in the primary; that which is generated in the secondary when the primary circuit is broken, is in the *same* direction as the current that was passing in the former.

Similarly, weakening the primary current generates a current in the secondary in the same direction as that which is passing in itself. Strengthening the primary has the reverse effect.

It is not necessary even for two wires to be together on an electro-magnet for induction to take place. Suddenly making or breaking the exciting circuit of an electro-magnet, generates opposing E.M.F.s within the coils of the exciting wire itself; that when it is made opposing the current, and that when it is broken assisting it. The latter has been known as the *extra* current, having been so named by Faraday, to whom we are indebted for so many researches upon electro-magnetic induction. It is the *extra* current that gives such a smart and often fatal shock, when the circuit of a high-tension electric light machine is broken; the coils on the field magnets of the dynamo generating, by induction, a very much higher E.M.F. than the working E.M.F. of the machine.

The secondary E.M.F. generated in all these cases depends upon the primary E.M.F., the number of coils taking part in the induction; or, what amounts to the same thing, the lengths of the wires exposed to induction; upon the speed of motion where one or both bodies move; and inversely upon the distance between the exciting and secondary apparatus.

It must be remembered, however, that in all these cases induction only takes place while motion is proceeding, or changes of magnetism are taking place, and the currents generated are therefore usually only of very short duration.

But it is not even necessary that iron should be present for induction to take place. If two wires be near each other and parallel; when a current passes in one, an E.M.F. is induced in the other at the moment the first starts and at the moment the first ceases, and these two are in opposite directions, and obey the same rule as before, viz., the secondary current is in the opposite direction to the primary, when the latter commences, and in the same direction as the primary when the latter ceases.

A variation in the current passing in one wire also gives rise to induced E.M.F.s in the other, just as in the case of the electro-magnet, with two wires wound on it.

The induction in the case of two wires also follows the same rule as to distance apart, and to the lengths of wire exposed to induction. The induction, for instance, between two telephone or telegraph wires running parallel for several miles, and within a few inches of each other, as on ordinary telegraph poles, will be very great; while that between wires separated by the width of a street, or only running together for a short distance, may be inappreciable.

The reason for E.M.F.s being generated in conductors under