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G. A. PERSONS

VOLTAGE LIMITING DEVICE

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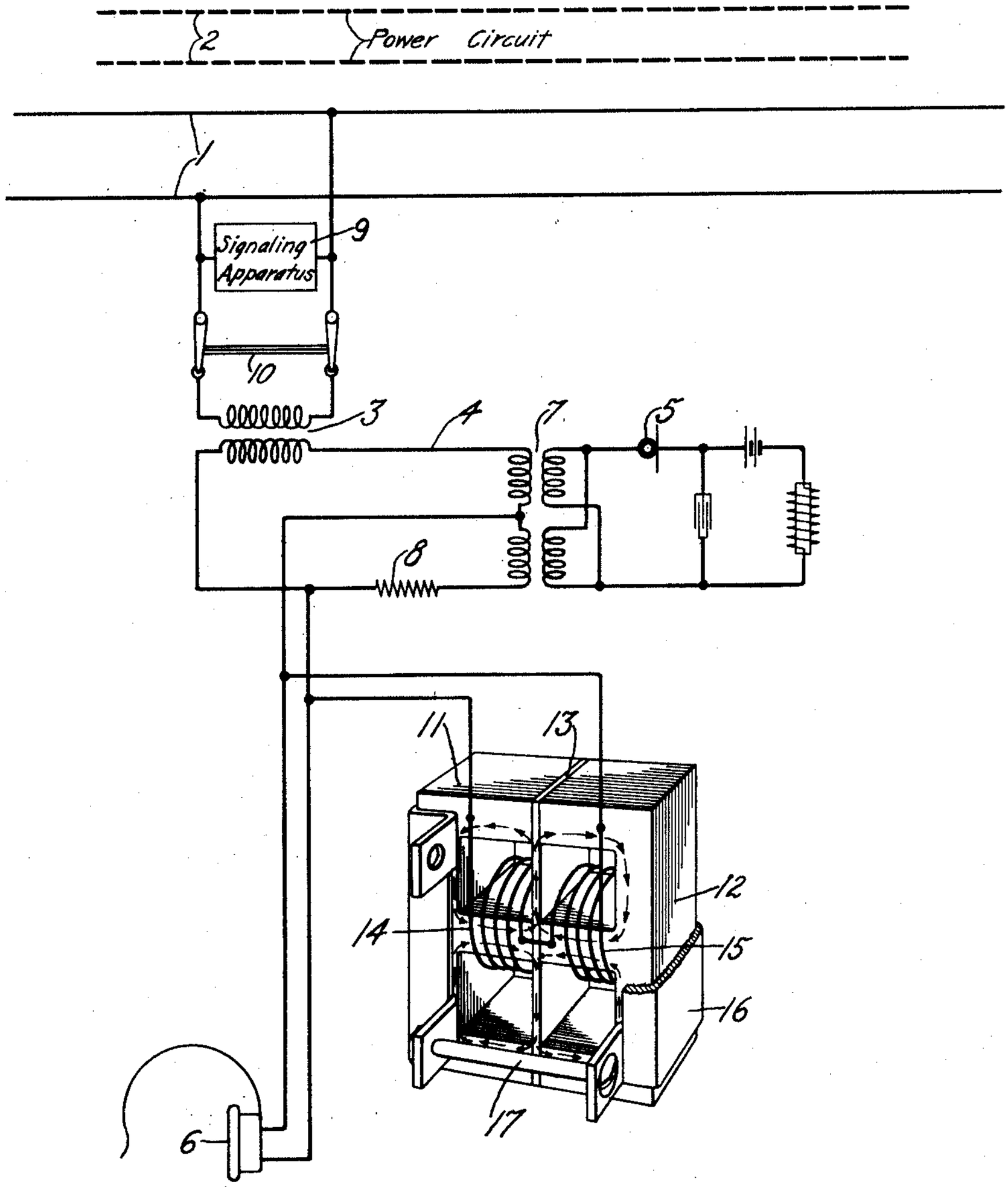

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VOLTAGE-LIMITING DEVICE.

Application filed February 27, 1926. Serial No. 91,218.

This invention relates to voltage limiting devices.

An object of the invention is to provide an improved magnetic device for limiting the power delivered from an electric circuit to a translating device.

A related object of the invention is to guard the user of a telephone receiver against shocks that might be caused by excessive currents in the receiving circuit.

Another object of the invention is to provide a protective shunt for electric circuits which will offer a relatively high impedance to voltages which are ordinarily employed in the operation of the circuit, but which when excessive voltages are impressed upon the circuit will offer a low impedance short-circuit path for the excess current.

There are numerous situations in the electrical arts where it is desirable to limit the voltage across a circuit. An example is found in the case of telephone circuits which are exposed to inductive interference by neighboring power lines operated at relatively high potentials. If the power line becomes accidentally grounded, for example, an abnormally high potential is set up in the telephone circuit which may cause serious acoustic shock to the telephone operator.

In order to overcome the undesirable effects of abnormally high potentials it has previously been proposed to provide a magnetic device for limiting the potentials that may be impressed upon a translating device to a predetermined value regardless of the potential, due to the above and other causes, applied to the circuit to which the translating device is connected. Such a device is described and claimed, for example, in a copending application of F. E. Field, Serial No. 87,208, filed February 10, 1926.

The present invention provides an improved magnetic protection device of this general class which comprises a retardation coil having two windings connected in series opposing relation across the circuit or device to be protected. The magnetic circuit of the coil is arranged to provide independent paths for the flux produced by normal currents in the windings, and to provide mutually opposing paths for the flux produced by excessive currents in the windings. When the latter condition prevails, the impedance of the windings is reduced, thus allowing the excessive currents to be shunted through these windings.

A particular advantage of the invention is that it provides a simple and efficient device which may be applied to any existing circuit which it is desired to protect from excess voltages without otherwise altering the circuit, and which requires no maintenance expense after installation.

In the accompanying drawing there is illustrated diagrammatically a telephone circuit equiped with the invention for protecting a telephone operator's receiver from excessive line potentials. While this specific circuit has been chosen for presentation in the description, the invention may, of course, be used to advantage in many other types of circuits.

The drawing illustrates a telephone transmission line 1 which is exposed to inductive interference fom an adjacent power circuit 2. The transimssion line 1 is connected by means of a transformer 3 with a switchboard circuit 4, which has connected thereto an anti-side-tone operator's telephone set comprising a transmitter 5 and a receiver 6 connected in a well-known manner to avoid side tone. The usual induction coil is illustrated at 7, and resistance 8 is employed in circuit with one side of the induction coil to balance the impedance of the incoming line. The block 9 represents the usual signaling apparatus employed by the operator. Since in circuits of this type the potentials of the outgoing ringing currents are of the order of 100 volts, a switch is usually employed to disconnect the local telephone apparatus from the line whenever ringing currents are transmitted. A switch 10 of any suitable construction may be provided for this purpose, but is not essential to the invention.

The protection device, which is provided to prevent transmission of excessive voltages on the line 1 to the receiver, consists of a retardation coil provided with two similar E-shaped core sections 11 and 12 of silicon steel or good magnetic iron. These core sections 11 and 12, which may be composed of a plurality of plates or laminations, or may be of any other suitable construction, are separated by a sheet or plate 13 of a magnetic material having a reluctance which is much less than that of core sections 11 and 12 for small magnetizing forces but is

much greater for comparatively large magnetizing forces.

A suitable magnetic material for the plate 13 is permalloy, which, when subjected to the proper heat treatment, develops and retains an extremely high permeability for low magnetizing forces. A suitable variety of permalloy is a composition of nickel and iron in the respective proportions of 78½% nickel and 21½% iron. The proper treatment of this material in order to obtain the desired properties is described in detail in a copending application of G. W. Elmen, Serial No. 473,877, filed May 31, 1921. While 78½% and 21½% have been mentioned as a preferred proportion of the ingredients of nickel and iron to be employed in preparing the magnetic material for the plate 13, it will be understood that the composition may deviate from these figures and that other ingredients may be added to vary the characteristics of the alloy. The particular thickness of the permalloy plate 13 will depend, of course, on the particular constants of the magnetic circuit in which the material is to be used.

It is a property of permalloy that its permeability at very low magnetizing forces is extraordinarily high, values of the order of 6000 for zero magnetizing force being easily attainable, whereas the corresponding value for the best grades of iron is only about 300. The value of the permeability at zero magnetizing force is obtained by determining a series of values for exceedingly low forces, say of the order of .01 to .05 gauss, plotting the results linearly and extrapolating back to the value for H=O.

Other important qualities of this composition are its comparatively low value of magnetization when magnetically saturated and the relatively low magnetizing force required to saturate it. The maximum magnetization of a commercial grade of permalloy containing 78½% nickel and the rest iron is about 10,500 lines per square cm. and it is nearly saturated with a magnetizing force of 1 gauss.

The center limbs of the core sections 11 and 12 are provided with windings 14 and 15, respectively, which are connected in series-opposing relation across the terminals of the telephone receiver 6. The windings 14 and 15 should preferably be closely balanced for inductance. Clamping plates 16 and bolts 17 may be employed to hold the assembled structure intact.

The particular construction of the retardation coil having been been described, the principle of operation which enables the benefits of the invention to be secured will now be explained.

The magnetic circuit of the coil is so designed that when the telephone line is operating at normal voltages, the reluctance of the plate 13 is much less than that of core sections 11 and 12, which result is easily attained because of the magnetic characteristics of permalloy. The paths of the magnetic flux produced by current in the windings 14 and 15 is then as shown by the arrows in the drawing, the windings 14 and 15, in effect, operating as the windings on two separate coils connected in series across the line. The coil is so designed that under this condition the impedance of the windings is sufficiently high to prevent excessive shunt loss.

When the voltage across the telephone line rises for any reason, the magnetic flux through the core sections 11 and 12 and the permalloy plate 13 becomes greater and the permeability of the permalloy plate 13 increases rapidly until it reaches a maximum. The core should be so designed that at this point the permeability of the sections 11 and 12, which are composed of silicon steel or iron, is still far from a maximum. As the voltage increases the reluctance of the permalloy plate 13 increases rapidly and soon becomes greater than the reluctance of core sections 11 or 12. Part of the flux then tends to follow the path through core sections 11 and 12, but since the windings are connected in series opposing relation the flux produced by the current in one winding tends to neutralize the flux produced by the same current in the other winding, with the result that the impedance of the coil is reduced. This allows a still greater current to flow through the coil, thus increasing the reluctance of the permalloy plate 13 which in turn causes a further decrease in impedance. This process continues until at some point a balance is reached above which it is impossible to increase the voltage across the terminals of the telephone receiver.

The voltage at which the impedance of the coil begins to decline may be varied by designing the magnetic circuit of the retardation coil to meet the requirements of a particular circuit to be protected. In each particular situation the coil will be designed to insure the proper protecting action with a minimum shunting effect on the circuit to be protected.

The invention is also susceptible of various other modifications and adaptations not specifically referred to but included within the scope of the appended claims.

What is claimed is:

1. The combination with an electro-responsive device, of a protective inductance comprising a plurality of windings connected in shunt with said device and a magnetic structure for said windings which causes the value of the inductance to decrease when the voltage applied to said device increases above a predetermined value.

2. The combination with a circuit and a

responsive device connected thereto, of a protective shunt comprising a plurality of windings, and a magnetic structure therefor arranged to provide independent paths for the magnetic flux produced by normal currents in said windings and to provide mutually opposing paths for the magnetic flux produced by excessive currents in said windings.

3. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a plurality of windings connected in series opposing relation across said circuit, and a magnetic circuit for said protective device including means for establishing independent paths for the flux produced by the current in said windings, said means being inoperative when the voltage across said windings exceeds a predetermined value.

4. The combination with a circuit and a responsive device connected thereto, of a protective shunt comprising a plurality of inductance elements, and a magnetic structure therefor arranged to provide independent paths for the flux produced by the current in said inductance elements when normal potentials are present on said circuit and to provide mutually opposing paths for the flux produced by the current in said inductance elements when excessive potentials are impressed upon said circuit.

5. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two magnetic core sections, windings on said core sections connected in series opposing relation across said circuit, and means for providing independent paths including the respective core sections for the flux produced by the current in said windings, said means being inoperative when the voltage across said windings exceeds a predetermined value.

6. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two magnetic core sections, windings on said core sections connected in series opposing relation across said circuit, and a magnetic element interposed between said core sections and adapted under predetermined conditions to provide a plurality of paths for the flux produced by the current in said windings.

7. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two magnetic core sections, windings on said core sections connected in series opposing relation across said circuit, and a magnetic element interposed between said core sections and composed of a material the reluctance of which is much less than that of said core sections for comparatively small magnetizing forces but is much greater than that of said core sections for comparatively large magnetizing forces, whereby said element forms with the respective core sections a magnetic path for the normal magnetic flux produced by the current in each of said windings but forces excessive magnetic flux produced by the current in said windings to pass in opposite directions through both of said core sections.

8. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two magnetic core sections, windings on said core sections connected in series opposing relation across said circuit, and a magnetic element interposed between said core sections and comprising an alloy of iron and nickel having a higher initial permeability at low magnetizing forces than the material of said magnetic core sections.

9. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two silicon steel core sections, windings on said core sections connected in series opposing relation across said circuit, and a magnetic element interposed between said core sections and comprising an alloy consisting chiefly of iron and nickel in which the nickel content is substantially 78½% of the whole.

10. The combination with a circuit and a responsive device connected thereto, of a protective device comprising a retardation coil having two E-shaped core sections forming a magnetic circuit, windings on the center limbs of said core sections connected in series opposing relation across said circuit, and a shield interposed between said core sections and formed of an alloy of iron and nickel the reluctance of which alloy is much less than that of said core sections for comparatively small magnetizing forces but is much greater than that of said core sections for comparatively large magnetizing forces, whereby said shield forms with the respective core sections a magnetic path for the normal magnetic flux produced by the current in each of said windings but forces excessive magnetic flux produced by the current in said windings to pass through both of said core sections in such a direction as to substantially neutralize each other and thereby to reduce the impedance of said windings.

In witness whereof, I hereunto subscribe my name this 26th day of February, A. D. 1926.

GEORGE A. PERSONS.