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F. E. FIELD

VOLTAGE LIMITING DEVICE

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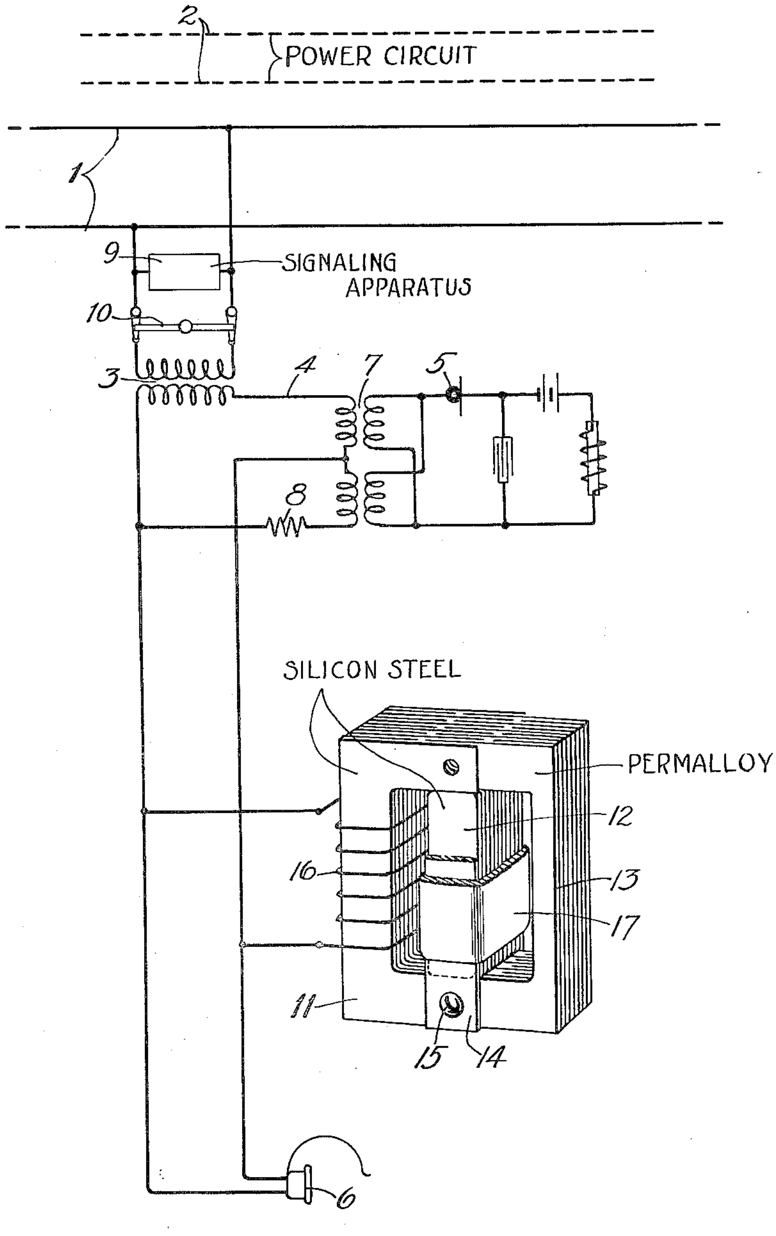

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VOLTAGE-LIMITING DEVICE.

Application filed February 10, 1926. Serial No. 87,208.

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 used in the operation of the circuit, but which, when excessive voltages are impressed upon the circuit, will offer a low impedance 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.

This invention provides an improved magnetic device for limiting the potentials that may be impressed upon the 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.

More specifically, the invention provides a protection transformer having a winding which is adapted to be connected across the line to be protected. The magnetic circuit of the transformer is so arranged, in accordance with the invention, that when the voltage across the line exceeds a predetermined maximum value the impedance of the transformer is decreased to provide a low impedance path for the excess current. This is accomplished by providing the transformer with a short-circuited secondary winding on a different portion of the core than the primary winding and providing the secondary portion with a magnetic shunt of material of high permeability at low magnetizing forces and a low saturating point so that this shunt normally carries most of the flux.

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 requires no maintenance after installation.

The drawing illustrates diagrammatically a telephone circuit equipped in accordance 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 different types of circuits.

The drawing illustrates a telephone transmission line 1 which is exposed to inductive interference from an adjacent power circuit 2. The transmission 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 subscriber set repeating coil is illustrated at 7, and resistance 8 is employed in circuit with one side of the repeating 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 by the invention to prevent excessive voltages on the line 1 from being transmitted to the receiver consists of a transformer comprising magnetic core sections 11, 12 and 13. The core sections 11 and 12 are constructed of the same material, which may be silicon steel or good magnetic iron. The core section 13, however, is composed of a magnetic material having a reluctance which is much less than that of iron or silicon steel for small magnetizing forces but is much greater than that of iron or silicon steel for comparatively large magnetizing forces.

A magnetic material which fulfills these requirements, and which may therefore be used for the core section 13, is permalloy. 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 these alloys in order to obtain the desired properties is described in detail in a patent to G. W. Elmen, No. 1,586,884, issued June 1, 1926. While 78½% and 21½% have been mentioned as giving the proportion of the ingredients of nickel and iron to be employed in preparing the magnetic material for the core section 13, it will be understood that the proportion may deviate from these figures and that other ingredients may be added to vary the characteristics of the alloy.

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 obtainable whereas the corresponding value for the best grades of iron is only about 300. The value of the permeability at zero force is obtained by determining a series of values for exceedingly low forces, say of the order of .01 to .05 gauss. The results plot linearly and may be extrapolated back to the value for $H=0$.

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 several core sections are illustrated as comprising a plurality of plates or laminations, though any other suitable core construction may be employed. The joint between the plates comprising the core sections 11 and 13 is preferably interleaved in order to reduce the effect of the gap in the magnetic circuit where the silicon steel or iron meets the permalloy. In the particular construction illustrated the plates comprising the core section 12 are not interleaved with the plates of the other core sections, but are stacked in a bundle which may be secured in position by means of clamping plates 14 and bolts 15 which also serve to clamp the core sections 11 and 13 together. However, either type of joint may be employed, depending upon the particular requirements of the transformer.

The primary winding 16 on the core section 11 is connected directly across the terminals of the telephone receiver 6. The constants of this winding will depend upon the particular requirements imposed upon the transformer, its impedance in any case being such that its normal shunting effect across the circuit is negligible. The winding 16 is inductively related to a very low impedance short-circuited secondary winding 17, which may be in the form of a copper sleeve, disposed on the core section 12. The coupling between the windings 16 and 17 will be determined by the particular design of the magnetic circuit and in general should be reasonably good.

The construction of the magnetic protecting device having been described, the principle of action which enables the benefits of the invention to be secured will now be explained.

An alternating current flowing through the primary winding 16 produces a varying magnetizing force which, in turn, sets up varying lines of magnetic induction in the transformer core. From the above description of the magnetic characteristics of permalloy, it will be evident that the reluctance of the permalloy core section 13 will be much less than that of core section 12 composed of silicon steel or iron for voltages at which the telephone circuit is normally operated, and hence that under such conditions practically all of the magnetic flux caused by the current in the winding 16 will pass through core sections 11 and 13.

As the voltage across the terminals of the primary winding 16 rises, the magnetizing force applied to core sections 11 and 13 increases and the permeability of core section 13 rises rapidly. The permeability of the magnetic material of core section 13 reaches its maximum at a magnetizing force at which the permeability of core section 12 has not nearly reached its maximum. Thus, as the voltage across the circuit increases, the reluctance of core section 13 increases rapidly causing a corresponding increase in the flux passing through core section 12.

Since the core section 12 is provided with a short-circuited winding 17 this increase in the flux which flows through core section 12 will produce an increase in the current in the short-circuited winding. The increased current which is thus produced in the short-circuited winding 17 produces an increase in the flux which flows through the primary winding 16 and thus tends to lower the impedance of this winding, thereby allowing a high current to be shunted through this winding. This high current will in turn produce a greater magnetizing force in the magnetic core, increase the reluctance of core section 13, still further and cause more flux to flow through the core section 12 which will produce larger short-circuited currents and thereby still further lower the impedance of the primary winding 16. At some point a balance will be reached beyond which it will be impossible to increase the voltage across the circuit. The magnetic circuit of the transformer may be so designed that this maximum voltage is that beyond which it is desired that the voltage shall not rise.

For each particular application of the invention a special transformer may be designed to insure the proper protecting action with a minimum shunting effect on the circuit. In general the cross-sectional area of the high permeability section of the transformer will be much less than that of the other sections.

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. In combination, a line, an electro-responsive device connected thereto, and means for protecting said device from excessive potentials in said line, comprising an electromagnetic device in shunt to said electro-responsive device across said line, and having a magnetic circuit, the reluctance of which is responsive to increases in the potentials impressed on said electromagnetic device above a predetermined value to effectively lower the impedance of said electromagnetic device whereby said electro-responsive device is effectively short-circuited for line potentials in excess of said predetermined value.

2. In combination, a line, an electro-responsive device connected thereto, and electromagnetic means for protecting said device from excessive potentials in said line, said protecting means comprising an inductive winding in shunt to said electro-responsive device across said line, a magnetic circuit therefor, said magnetic circuit being such as to have increased reluctance for potentials exceeding a predetermined value impressed on said winding so as to effectively reduce the impedance of said winding for the increased potentials, whereby said electro-responsive device is effectively short-circuited for line potentials in excess of said predetermined value.

3. The combination with a circuit and a responsive device connected thereto, of a protective transformer having a primary winding connected in shunt to said circuit, a magnetic core section having a short-circuited secondary winding inductively related to said primary winding, and means for bypassing the flux produced by the current in said primary winding around said core section, said means being inoperative to carry additional flux when the magnetizing force produced by the current in said primary winding exceeds a predetermined value.

4. The combination with a circuit and a responsive device connected thereto, of a protective transformer having a primary winding connected in shunt to said circuit, a core section having a short-circuited secondary winding inductively related to said primary winding, and a second core section forming a shunt path for the flux produced by the current in said primary winding at a predetermined magnetizing force.

5. The combination with a circuit and a responsive device connected thereto, of a protective transformer having a primary winding connected in shunt to said circuit, a magnetic core section including a short-circuited secondary winding inductively related to said primary winding, and a second core section in shunt to said first-mentioned core section and comprising a magnetic material the reluctance of which is much less than that of the material of said first-mentioned core section for comparatively small magnetizing forces and is much greater for comparatively large magnetizing forces.

6. The combination with a circuit and a responsive device connected thereto, of a protective transformer having a primary winding connected in shunt to said circuit, a magnetic circuit for said transformer comprising two parallel core sections forming paths for the flux produced by the current in said primary winding, and a short-circuited secondary winding on one of said core sections and inductively related to said primary winding, the other of said core sections comprising a magnetic material having a reluctance which is much less than that of the material of said first-mentioned core section for comparatively small magnetizing forces and is much greater for comparatively large magnetizing forces.

7. In a protective device, a magnetic core member comprising two core sections forming a closed magnetic circuit, a primary winding on one of said core sections adapted to be connected across a circuit to be protected from excess voltages, a short-circuited secondary winding on the second core section, and a third core section connected in shunt to said second core section and comprising a magnetic material, the reluctance of which is much less than that of the material of said second core section for comparatively small magnetizing forces and is much greater for comparatively large magnetizing forces.

8. In a protective device, a magnetic core section including a primary winding adapted to be connected across a circuit to be protected from excess voltages, a second magnetic core section including a short-circuited secondary winding inductively related to said primary winding, and a magnetic core section in shunt to said second core section and comprising an alloy consisting chiefly of iron and nickel having a higher permeability than that of the material of said second core section at low magnetizing forces.

9. In a protective device, a magnetic core member comprising two core sections of

silicon steel forming a closed magnetic circuit, a primary winding on one of said core sections adapted to be connected across a circuit to be protected from excess voltages, a short-circuited secondary winding on the second core section, and a third core section in shunt to said second core section and comprising an alloy of iron and nickel in which the nickel is substantially 78½% of the whole.

In witness whereof, I hereunto subscribe my name this 8th day of February, A. D., 1926.

FRANK E. FIELD.