Oct. 30, 1945. R. W. KEISER 2,387,797

REACTANCE

Original Filed Dec. 4, 1941

FIG. 1.

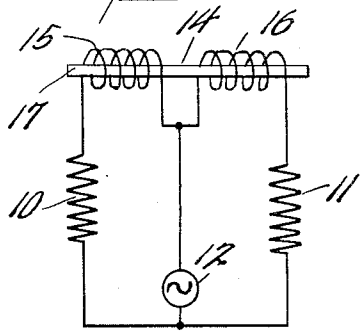


FIG. 2.

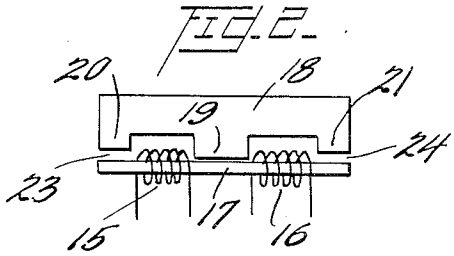


FIG. 3.

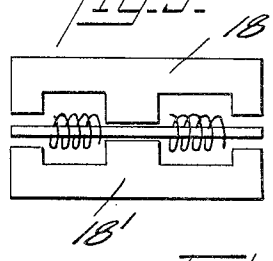


FIG. 4.

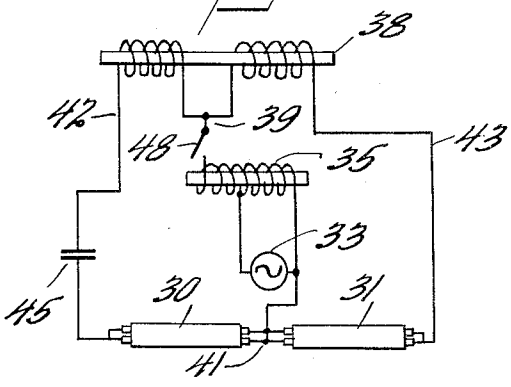


FIG. 5.

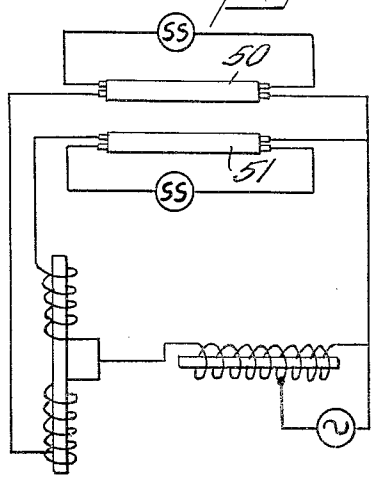


FIG. 6.

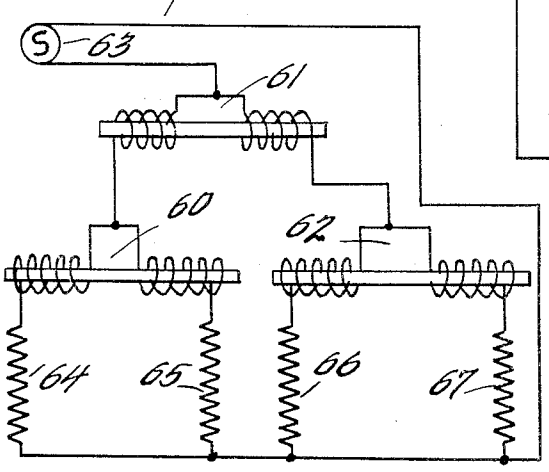
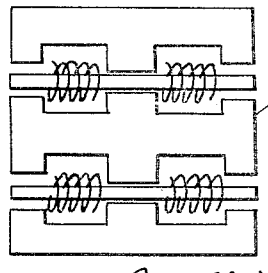


FIG. 7.



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UNITED STATES PATENT OFFICE

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REACTANCE

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Original application December 4, 1941, Serial No. 421,700. Divided and this application May 29, 1942, Serial No. 445,047

1 Claim. (Cl. 171—242)

This invention relates to reactances and more particularly to plural reactances intended primarily for the division of and limitation of current from a single source for application to a plurality of negative resistances.

It is a general object of the present invention to provide novel and improved forms of plural reactances.

More particularly it is an object of the invention to provide a plurality of reactance coils arranged on a common core together with means for providing flux interlinkage between the several coils.

An important object of the invention resides in the provision of a plurality of reactance coils on a common core so that in normal operation each acts on one portion of a divided electric circuit to control the current flow therein entirely independently of the other, but under certain abnormal conditions the flow of current in one coil induces a current in the other which is superimposed on that normally impressed on this second coil to increase its potential.

A further important object of the invention consists in the provision of a reactance unit for negative resistance loads adapted to divide the current from a single source for independent operation of a plurality of loads, for regulating the current flow to each of the same, and for supplying operating current at normal load potential with a minimum of loss.

Yet another object of the invention consists in the provision of a dual reactor for use with such loads as fluorescent lamps to adapt the same for starting by ionic bombardment at higher voltage and operation at normal voltage, the whole control being entirely automatic and inherent in the reactances.

As an important feature of the invention may be mentioned the construction of the reactor to provide for the division of alternating current into two components either equal or unequal for the operation of electrical apparatus having negative load characteristics.

Another feature of the invention relates to the construction of the reactance to provide independent operation of each load of a plurality so that the failure of one will not prevent the operation of the others nor substantially alter the potential or current supplied to the same.

Other and further features and objects of the invention will be more apparent to those skilled in the art upon a consideration of the accompanying drawing and following specification wherein are disclosed several exemplary embodiments of the invention with the understanding that various modifications and combinations of the same may be made such as fall within the scope of the appended claim without departing from the spirit of the invention.

In said drawing:

Figure 1 is a schematic wiring diagram of a pair of negative resistances supplied from a source of alternating current through a dual reactance in accordance with the present invention;

Figure 2 is a schematic showing of the structural features of the type of reactance suitable for the circuit of Figure 1;

Figure 3 is a view similar to Figure 2 showing a shell type core;

Figure 4 is a diagram similar to Figure 1 illustrating the invention used with fluorescent lamps, a dual inductance, and a step-up auto transformer for providing operating voltages sufficiently high for cold starting;

Figure 5 is a view similar to Figure 4 but illustrating the use of the conventional automatic starters in conjunction with the fluorescent lamps;

Figure 6 is a view illustrating the use of a plurality of dual reactances for the operation of a number of negative resistances: and

Figure 7 illustrates schematically the arrangement of a multi-reactor.

In the operation of negative resistance loads from alternating current sources some means must be provided for restricting the flow of current to an amount which is not harmful to the apparatus constituting this resistance. By a negative resistance is meant one in which the voltage drop continually decreases in value with increased flow of current. An excellent example of a negative resistance and one which will be used, illustratively only, hereinafter in this specification is the so-called fluorescent lamp now popularly used for lighting purposes and comprising an elongated evacuated glass tube, the inner walls of which are coated with some material adapted to fluoresce when activated by an ionized gas. A quantity of suitable gas is incorporated within the tube along with some metallic vapor if necessary, and each end of the tube is provided with at least one electrode.

The conventional fluorescent lamp has, instead of a single electrode at each end of the tube, a filament thereat adapted to be temporarily heated to provide the necessary ionization for a breakdown of the cold resistance of the tube by the potential applied between the two ends to start it in operation. These filaments are short-liver

if not continuously operated and because they are arranged to be heated only momentarily when the lamp is started and during ordinary operation are not heated but constitute the main terminals between which the voltage for operating the lamp is applied, their life is short and determines the life of the lamp.

The starting equipment is preferably automatic so that when the current is switched on the filaments are first lighted and subsequently extinguished when the arc strikes through the tube and the lamp is in normal operation. The automatic equipment for the purpose is extremely unreliable and constitutes the source of perhaps 90% of the difficulties experienced with fluorescent lamps.

In accordance with the present invention means is provided to eliminate this automatic starting equipment cooperating with the filaments and to start the lamps by ionic bombardment resulting from a sufficiently high potential applied between the terminals at the opposite ends of the lamps. Since the lamp in operation under all conditions requires some current limiting means, convenient use is made of this requirement to provide for automatic ionic bombardment starting and current control by the arrangement of a suitable reactance in the circuit between the lamp and the source of alternating current.

In the normal operation of fluorescent lamps there occurs a certain amount of flicker at the frequency of the alternating current because of the absence of any metal or solid material for holding heat during the passage of the current through the zero point. A single lamp is therefore often unsatisfactory because of the stroboscopic effects obtained in the presence of rotating of moving parts operating from the same source of current and hence in synchronism in multiples or sub-multiples of the current frequency. The lamps are therefore almost always operated in pairs with some means to provide current advance for one of the tubes to break up these difficulties by having the lamps extinguished at different times in the current cycle. The current to these lamps normally lags the voltage providing a relatively low power factor. The device of the present invention therefore incorporates means for operating at least two lamps and includes means for dividing the current from a single alternating current source into several equal or unequal parts feeding several lamps. Conventional power factor correction may be used for one lamp of a pair or group.

The invention is illustrated in several embodiments which are only illustrative of structures and systems incorporating the same. Referring particularly to Figure 1 there is depicted schematically a simple system in accordance with the present invention where two negative resistances 10 and 11 are shown as supplied from a single source of alternating current 12 through the agency of a dual reactor 14 which serves the purpose of dividing the current from the source into two parts, limited in accordance with the respective reactances of the coils 15 and 16 forming parts of the reactor and mounted on a suitable iron core 17 serving not only to increase the amount of reactance available from a predetermined quantity of winding but providing a certain interlinkage of flux between the magnetic circuits of the two windings so that under stipulated conditions the reactances do not act entirely independently.

The reactance of each winding 14 or 15 is the sum of its direct current resistance and its inductance and in the circuit illustrated acts to limit the quantity of current which can flow through the resistances 10 and 11 which are considered to be negative resistances, that is, the voltage drop across them decreases as the current increases. This distinguishes from the customary resistance in which the voltage drop increases in proportion to the current in the resistance in accordance with the recognized formula E=RI. A negative resistance if directly connected across a source of current of unlimited capacity will be destroyed because of this peculiar property. A reactance such as illustrated in Figure 1 serves to prevent this and can be proportioned to provide any desired potential drop across the negative resistance and hence the requisite current therein.

When the negative resistances of Figure 1 are fluorescent lamps they are commonly of like capacity when operated in pairs so that the two parts of the reactance are identical, but this is not a requirement for proper operation of the dual reactances of the present invention.

From a structural standpoint the dual reactances are constructed as schematically illustrated in Figure 2, where the straight core portion 17 is of rectangular cross section and forms only a portion of the whole core which is completed by the E-shaped section 18 having the central arm 19 longer than the end arms 20 and 21 so that it may closely engage the center section of the straight portion 17 of the core, between the windings 15 and 16 as shown, while air gaps 23 and 24 are provided between the arms 20 and 21 and the ends of the core bar 17. This construction and the disposition of the coils provides for two substantially closed magnetic paths one for each coil, each of which paths has therein a small air gap. The two paths have a common portion in the central arm 19 so that there is an interlinkage of magnetic flux resulting from the currents passing through the two windings. In the event that current passes through but one winding, as sometimes happens, particularly when two fluorescent lamps are operated together and one starts before the other, these air gaps serve to force a portion of the flux from the coil carrying substantially normal current through the companion magnetic circuit to provide an induced potential in the companion winding. The purpose of this will appear in a subsequent description of the manner of operating the reactor for starting and lighting fluorescent lamps.

In Figure 3 a dual reactance is shown with a so-called shell type of core as often used in transformers. The advantages of this as compared with the so-called core type of Figure 2 are the same as in connection with alternating current transformers. The structural difference involves only the addition of a second E-shaped member 18' to the straight core portion opposite the first one to provide more complete iron paths for the magnetic flux so that there is less leakage through the air except in the purposely provided air gaps.

Figure 4 illustrates a circuit involving two fluorescent lamps 30 and 31 adapted to be operated from a commercial source of alternating current 33. Since these sources are usually of one of the well-known potentials 110, 220, or 440 volts and since the lamps operate on different potentials from these in accordance with their length and/or diameter, it is conventional to provide some form of transformer to step up the voltage

to that required by the lamp or the lamp and its ballast. The voltage may be lowered in some cases by ballast resistances or the like. A step-up auto transformer **35** is illustrated, and since it is of conventional construction and operation needs no description here. In this arrangement the source of current **33** plus the transformer **35** becomes the source of total voltage supply for the lamps and reactors and may be substituted for the source shown at **12** in Figure 1.

The dual reactance of the present invention is illustrated schematically at **38** and may take the form of Figure 2 or 3. One end of each of the windings is connected at **39** to the output from the transformer while the wire connecting the two lamps together is associated at **41** with the opposite end of the source of supply. The remaining ends of the reactance coils are connected respectively by wires **42** and **43** with the outside ends of the two lamps, a suitable condenser **45** being inserted in one but not both of these lines. In normal operation of a fluorescent lamp the power factor is reduced by the lag in current. This condenser **45** as is well known serves to cause a leading current and improves the power factor in the circuit of the lamp with which it is associated, whereby the two lamps operate out of phase to eliminate the stroboscopic effects earlier referred to.

The lamps will be seen to be connected by only a single wire at each end, the filaments being used only as terminals, if present, as in lamps now available.

The voltage supplied from the source is such that in the absence of current flow in the reactance coils the potential across each of the lamps is substantially higher than the normal operating voltage of the same, but since the lamps are cold when the switch **48** is first closed there is no rush of current. The relatively high potential existing between the terminals at the two ends of the lamp results in an ionic bombardment of the same thereby slightly heating them and causing the emission of electrons which break down the high resistance path throughout the length of the tube and allow what may be considered an arc to strike through the same which provides the source of activation for the fluorescent material with which the inside of the tube is coated. Now the lamp becomes a negative resistance but at the same time it draws substantial current, which, flowing in the coils of the reactor, produces a voltage drop across the same which will increase with any tendency to increased current. The current is thereby stabilized to a value determined by the characteristics built into the reactor which must be adjusted for each size of lamp in accordance with its desired potential and current.

The above method of cold starting fluorescent lamps does away with the trouble-making starters referred to in the early portion of this specification and it will be seen that starting is effected merely by closing the switch supplying current to the lamps, the operation being entirely automatic and inherent in the structure of the reactor. Some lamps, however, either because of age, initial high resistance, or other characteristics, do not start so readily as others, perhaps requiring a slightly higher voltage for starting. One of the important features of the reactor of the present invention is that it assists in starting lamps which are normally difficult to place in operation, for the operating current flowing through the winding of the reactor of the easy starting lamp acts by mutual induction, because of the interlinked magnetic flux of the two core sections, to build up a voltage in the winding of the companion reactance which is superimposed on the voltage existing across the same from the source and therefore the sum of these two voltages is available for starting, ensuring a quick and ready start of even the most refractory lamp. The air gaps in the interlinked magnetic circuits come into play in this operation of starting one lamp after the other has been started, for if the active and energized coil had a 100% complete iron magnetic circuit there would be no tendency to magnetize the circuit of the other winding, but with this air gap in its circuit the flux tends to follow the line of least resistance and some of its travels in the interlinked magnetic circuit thereby energizing the second coil to provide the additional starting voltage.

It will be noted that there is substantially no current required in the starting operation so that the reactance does not reduce the available potential except by its low direct current resistance. Therefore, the lamp which may be burning does not have its voltage reduced below the critical value and does not tend to be extinguished by the operation of starting the other lamp. The critical value of voltage is that necessary to keep the lamp in operation under normal conditions.

In normal operation the reactors act substantially independently and serve only to provide the necessary current limiting facilities such as are required in the operation of all fluorescent lamps. A reactance is superior to a ballast resistance since there is less current loss in the same by heating. If one lamp should go out because of some defect preventing it from operating, the other lamp can carry on with its normal potential and current supplied with the assistance of its portion of the reactance.

In case it is not desired to make use of the cold starting characteristics of the reactance of the present invention the circuit may be wired as shown in Figure 5 which is substantially identical with Figure 4 except for the addition of the starting switches SS each arranged in a circuit between opposite terminals of each of the lamps **50** and **51**. When these switches are momentarily closed a circuit is completed through the filament windings at both ends of the lamps to heat the same and provide the necessary electron emission for starting. This starting current is provided through the reactances which serve to limit it to a usable amount. Note that under these conditions the high potential available for starting in accordance with the circuit of Figure 4 is not available because of the current flow in the inductances which produces a voltage drop across the same. The reactor in this case serves only as a current divider and limiter.

Figure 6 shows the combination of three dual reactors **60**, **61**, and **62** used to divide current from the single source **63** into four branches for operating the four negative resistances **64**, **65**, **66** and **67**, each pair of which is supplied in the manner above described by one of the dual reactances **60** or **62**. The current is divided to supply these two dual reactances by the single dual reactance **61** connected to one end of the source, the other end being connected to the lower terminals of the four resistances.

The pair of dual reactances **60**, **62** may be combined into a single unit in accordance with the structure of Figure 7 which merely comprises two of the units of Figure 3 with the central core

member 70 in the form of two E's arranged back to back.

In the several structural arrangements of the reactors it will be appreciated that the core forms may be of different shape and arrangement and that the air gaps need not be provided in the manner illustrated. For instance, in Figure 2 the end air gaps may be substituted by tight magnetic joints and a single central air gap provided between 17 and 19. The effect will not be substantially different.

It will be appreciated that reactors may be constructed to divide current from a single source into any desired number of circuits by suitably arranging reactance coils on a common core as illustrated in several of the figures of the drawing. Furthermore the reactors may be constructed with unbalanced windings, i. e., more turns on one section of a two section reactor (for instance) than on the other. Such a reactor has two uses, first with a power factor correcting condenser which is used in conjunction with the reactor section of fewer turns, and second, to provide the proper current distribution to two lamps of unlike capacity such as one 20 watt and one 40 watt lamp.

The present application is a division of my copending application Serial No. 421,700, filed December 4, 1941.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

A multiple reactor comprising a pair of straight core sections positioned parallel to each other, two inductance coils wound and spaced on each of said sections, an intermediate core section engaging each of the parallel sections intermediate their coils, said intermediate section having portions extending to close the magnetic circuit for each coil except for a small air gap.

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