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LOW REACTANCE SHUNT

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FIG. 1

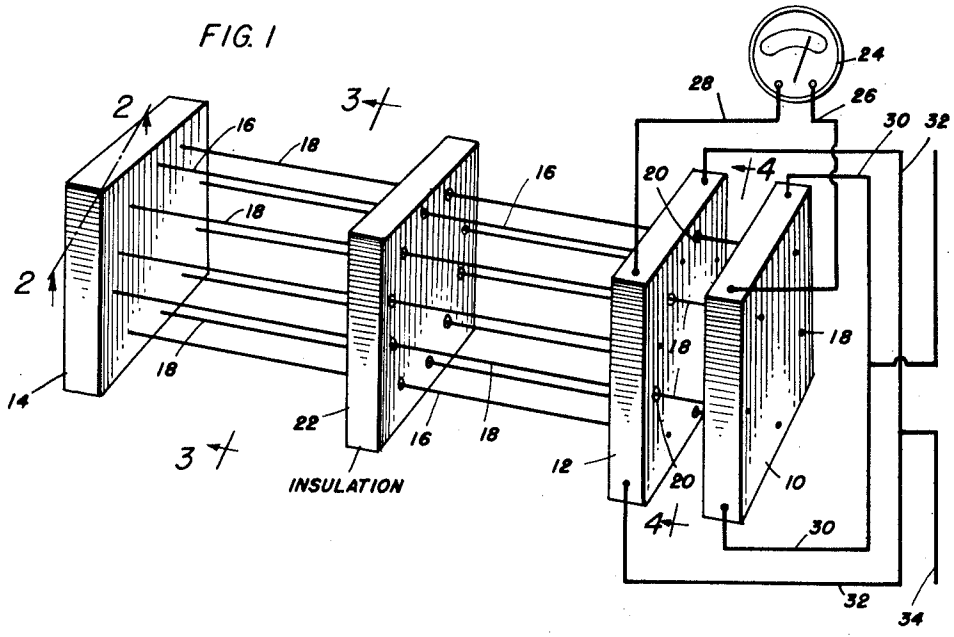


FIG. 2

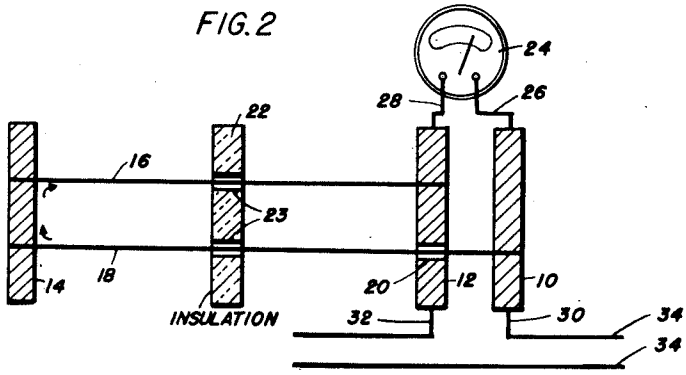


FIG. 3

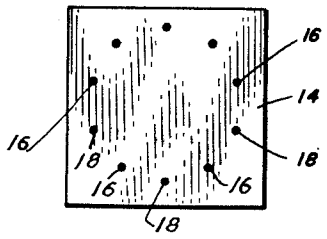
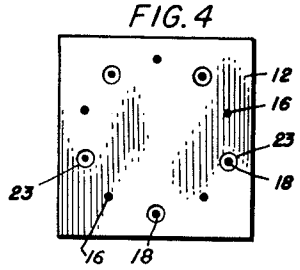


FIG. 4



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LOW REACTANCE SHUNT

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6 Claims. (Cl. 171—95)

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This invention relates in general to a high current, low reactance shunt of a type for use with electrical indicating and recording instruments, such as ammeters and the like.

A usual method for obtaining low reactance is to wind the shunt in bifilar form. For very high currents, of the order of hundreds of amperes, and if the resistance is to be made very small, the conductor required must be large in diameter and a bifilar winding is impractical, as the required small spacing between current elements cannot be obtained. The present invention provides an arrangement in which the current flow in adjacent conductors is in opposite directions, and the conductors are in short lengths, reducing mutual inductance and minimizing the reactive effect.

An important object of the invention is to provide a shunt for a high current, which has a low reactance.

A further object of the invention is to provide a shunt for electrical instruments which has a low reactance, to enable direct current measurements to be made when the rate of change frequency varies between zero and a few kilocycles per second.

A still further object of the invention is to provide contact means for circuit connections on opposite sides of the terminal blocks to insure equal currents in the conductor wires.

A further object of the invention is to produce a construction which is easy to make and to assemble, without the necessity of close tolerances, and in which the shunt is easily cooled.

Other objects of the invention will appear in the specification and will be apparent from the accompanying drawings, in which—

Fig. 1 is a perspective view of a shunt in accordance with this invention and a diagrammatic showing of its connections to a conductor and a meter;

Fig. 2 is a sectional view on the line 2—2 of Fig. 1, showing the direction of current in adjacent conductors, and the connections of the shunt.

Fig. 3 is a sectional view taken on the line 3—3 of Fig. 1, and

Fig. 4 is a sectional view taken on the line 4—4 of Fig. 1.

To reduce the reactance at high frequencies, the self inductance of the shunt must be reduced. This is done by interlacing or alternating the current carrying conductors in opposite directions. By this method, the flux linkages set up by a current flowing in one direction are in part neutralized by the effects of currents on both sides flowing in the opposite direction.

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Referring now more particularly to the drawings, three electrical conductor terminal blocks 10, 12, and 14, of any suitable conducting metal, are connected by two sets of conductors 16 and 18 in the form of straight rods or wires. Both sets of wires are firmly connected to one block 14 to extend at right angles therefrom, being arranged in a loop having the form of a circle, the wires of the two sets alternating around the circle.

One set of conductors 16 extends to the block 12 and are firmly connected to the block at spaced points in a circle. Between these points are holes 20 through which the wires 18 of the other set extend freely, so that wires are insulated from the block, and the projecting ends are firmly secured in the block 10 at spaced points in a circle. An insulating material may be inserted in the holes 20 through which the wires project.

The blocks 10 and 12 are located relatively close together and the block 14 is at a distance therefrom. Between the inner block 12 and the block 14, the conductors may become bent or displaced and a supporting and protecting insulating block 22 is interposed through which all of the wires 16 and 18 of both sets are inserted for holding them in place. Preferably, the wires fit closely in suitable holes 23 through the insulating block, or sleeves on the wires fit tightly in the holes to prevent the wires from wobbling loosely therein.

With this construction and arrangement, each adjacent pair of wires 16 and 18 has current moving relatively in opposite directions through wires of approximately equal lengths, depending somewhat upon the nearness of the terminal blocks 10 and 12. An electrical instrument 24 is connected by conductors 26 and 28 to the terminal blocks 10 and 12. To more nearly equalize the current distribution, conductors 30 and 32 are connected to opposite points of the terminal blocks 10 and 12 respectively. A main conductor 34 of a pair of main conductors 34—34' is represented as having a portion which is connected in series with the shunt and meter by the conductors 30 and 32.

For direct current observations, a low resistance, placed across the ammeter works satisfactorily. For alternating current, a current transformer is used for a similar purpose. The usual direct current shunt has such a high reactance that instead of obtaining a recording of the actual current, it is a recording of the current plus the time rate of change of current.

A transformer can give a recording proportional to the time rate of change of current, but cannot respond to the direct component of the current. This shunt reduces the reactive effect and hence gives a recording proportional to the actual current.

If a particular conductor 16 is examined, the conductors 18 on either side carry currents in the opposite direction. Hence, the magnetic flux set-up by conductor 16 will produce an induced voltage in conductor 16 which is opposite that produced in conductor 16 by the currents in the two adjacent conductors 18. This same condition is true of each of the other conductors. Summarizing the effects upon the conductors, and assuming currents in all conductors to be identical, it has been theoretically calculated that the self inductance of this shunt is twenty-eight times ten to the minus nine (28×10^{-9}) henrys. If the highest frequency at which recording is required is 1,000 cycles per second, then the reactance of the shunt becomes 176×10^{-6} ohms. The resistance of the shunt circuit is $2{,}000\times10^{-6}$ ohms. Therefore, the ratio of resistance to reactance is 0.088 at this frequency.

It is well known that if the ratio between the reactance and the resistance is 0.1 (frequently called the Q of the circuit), the impedance of the circuit differs from the resistanec by 0.05 per cent, and the voltage drop across the circuit is 5.8° out of phase with the current. Hence, this shunt is accurate to a higher degree than ½ per cent and 6° of phase. If this is contrasted with the usual shunt with a Q of 1 (one) or larger, at 1,000 cycles, the advantage of this shunt is apparent.

A larger number of wires could be used which would reduce the Q still further; they may be arranged within the circle or in some other geometrical figure. Any arrangement is a compromise between complexity of manufacture and the accuracy desired. In the present form, the parts are easy to make and assemble, and close tolerances are not a factor. When actually operated, the entire shunt is immersed in transformer oil to main constant temperature.

While a particular form of shunt having a low reactance is thus described in some detail, it should be regarded as an illustration or example, rather than a restriction or limitation of the invention, as many changes can be made in the construction, combination, and arrangement of the parts without departing from the spirit and scope of the invention.

We claim:

1. A low reactance shunt comprising a conductor block having a plurality of conductors each connected at one end thereto and arranged in a circle, the conductors being alternately of two different lengths, an electric terminal block to which the other ends of the shorter conductors are connected, this terminal block having perforations between the connected ends of the shorter conductors through which the longer conductors extend without contacting this block, another electric terminal block to which the ends of the longer conductors are connected, and insulating means between the conductor block and the first terminal block for engaging all of the conductors and holding them in relative spaced relation.

2. A low reactance shunt comprising three relatively thin conductor blocks, two adjacent and one spaced therefrom, but all in alignment along a line extending at right angles to the thin dimension thereof, a plurality of parallel conductors extending in pairs about a circle from the spaced block, the conductors of each pair extending separately to the two other blocks, and one conductor of each pair being longer than the other and extending through the other block to which it is not connected, the said other block having perforations through which the conductors extend without contacting the block, electrical contact means on opposite sides of each of the adjacent conductor blocks to equalize the current distribution therein, and means for connecting each of the adjacent conductor blocks to an electro-responsive instrument.

3. A low reactance shunt comprising a plurality of conductors arranged with respect to one another in a loop, means connecting all the conductors at one end, a first terminal providing a connection at the other end between certain alternate conductors constituting one-half of the said plurality at the other end, and a second terminal providing a connection at the other end between the remaining alternate conductors constituting the other half of the said plurality.

4. A shunt as specified in claim 3, the loop having the form of a circle.

5. A low reactance shunt comprising a number of relatively short conductors, an equal number of relatively long conductors, all the conductors being arranged with respect to one another in a loop with long ones alternating with short ones, a conductor block connected to all the conductors, a first terminal block spaced from the conductor block and connected only to the long conductors, and a second terminal block positioned between the conductor block and the first terminal block spaced from the conductor block and connected only to the short conductors, said second terminal block positioned between the conductor block and the first terminal block in spaced relation to both but nearer the latter and connected only to the short conductors, the long conductors passing through the second terminal block but insulated therefrom.

6. A shunt as specified in claim 5, the loop having the form of a circle.

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