March 1, 1966 D. BLITZ ETAL 3,238,434

R F SUPPRESSION APPARATUS

Filed March 9, 1962 2 Sheets-Sheet 1

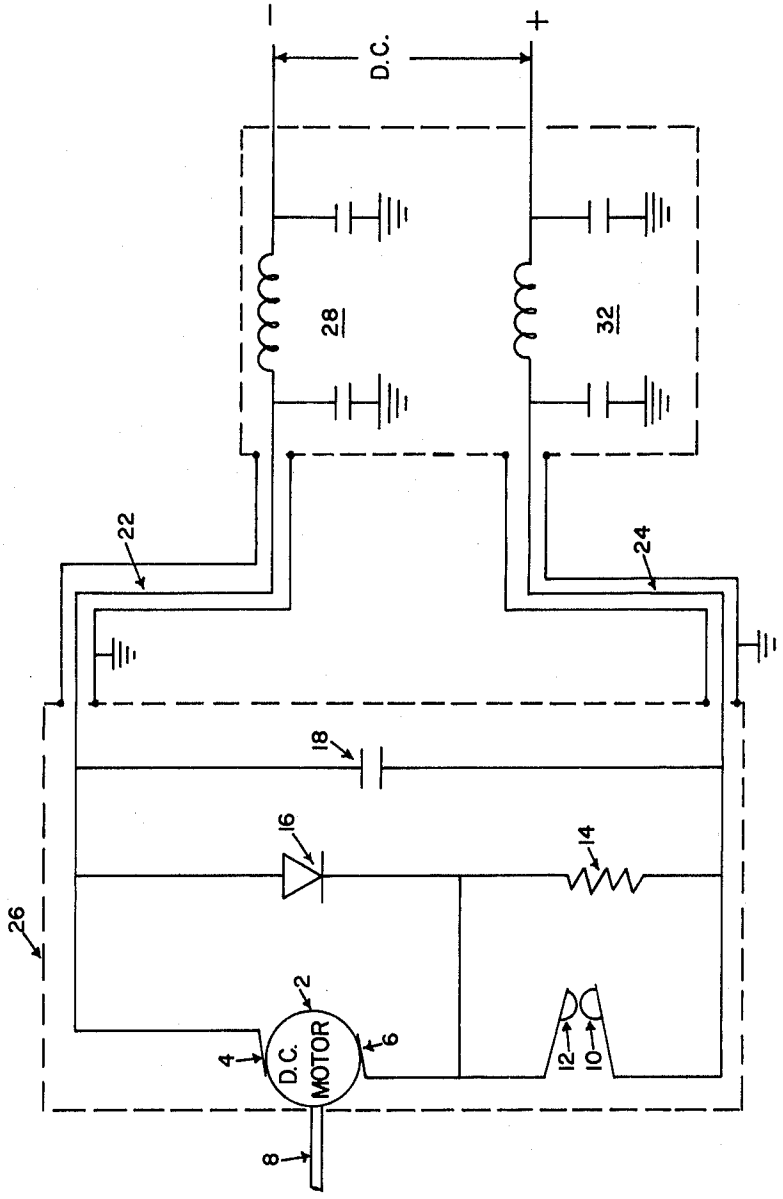


Fig. 1

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R F SUPPRESSION APPARATUS

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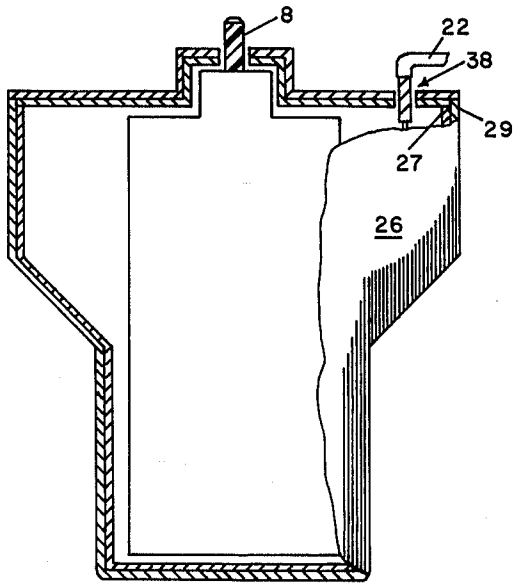


Fig.2

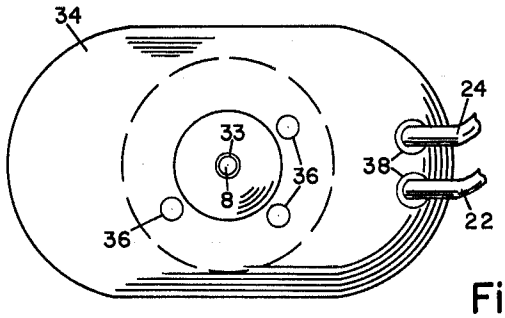


Fig.3

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RF SUPPRESSION APPARATUS

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8 Claims. (Cl. 318—325)

The invention relates in general to shielding techniques and more particularly to the prevention of radiation of radio frequency (RF) energy from a motor housing.

In the direct current (D.C.) motors used in aircraft, it is conventional to enclose the motor in a housing formed by shielding laminates to inhibit the radiation of spurious RF energy fields set up by the motor. In addition, it is conventional to provide RF filters in the power supply leads which enter the shielding member to prevent the leads from becoming a path to the exterior for the RF energy generated within the housing.

The primary object of the invention is to provide means for preventing RF energy generated by the D.C. motor and its associated circuitry from radiating beyond the shield enclosing the motor. The invention is particularly adaptable for use in aircraft where weight considerations are a necessary problem and where metallic shielding means for a motor should be kept to a minimum. Further, the invention reduces the radiation of RF energy to an extent where it does not interfere with the operation of equipment in the vicinity of the motor such as instruments or magnetic recording devices.

The invention resides in RF suppression apparatus used in conjunction with a D.C. motor having a governor employing a pair of contacts to prevent the motor from exceeding a preset speed. In accordance with the invention, a diode is placed in parallel with the windings of the motor's armature to provide a path for any current induced in the motor when the governor's contacts open. A resistor in parallel with the contacts of the governor prevents the current through the armature from going below a predetermined value when the contacts are open. In addition, the shaft of the motor which extends through an aperture in the housing of the motor is made of a material, such as epoxy fiberglass or nylon, which is a poor-conductor of RF energy and has sufficient strength to drive the load attached to the shaft.

Other objects and many of the attendant advantages of the present invention will be readily appreciated as the invention becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings, wherein:

FIG. 1 illustrates a schematic diagram of the invention;

FIG. 2 depicts a cutaway view of the preferred form of the invention; and

FIG. 3 illustrates a top view of the embodiment of FIG. 2.

Referring now to FIG. 1, there is depicted the general arrangement of the invention. A small D.C. motor **2** having a pair of permanent magnets (not shown) supplying a magnetic field, is shown having commutator brushes **4** and **6**. The motor has a drive shaft **8** which is connected to a load (not shown) driven by the motor. In order to keep the motor at a constant speed, a conventional centrifugal governor is provided having a pair of contacts **10** and **12** (only the contacts of the governor are shown) which open when the motor exceeds a predetermined speed. The contacts are arranged so that they are in series with the armature windings of motor **2**. Shunting the contacts **10**, **12** is a resistor **14** whose value is chosen to limit the minimum current through the armature of the D.C. motor **2**. A diode **16** is placed in parallel with the armature windings to dampen any reactive current induced in the armature when the switch contacts **10**, **12** open. In order to present a low impedance path-to-RF energy flowing in the lines **22**, **24**, a by-pass capacitor **18** is placed across the lines.

Current from the power source is supplied to the motor through a pair of leads **22**, **24**. The leads **22**, **24** are made of coaxial cable in order to prevent radiation of any RF energy which might escape from a shield housing **26** (shown as a dotted line in FIG. 1) surrounding the motor **2** and its associated circuitry. Finally, any RF energy on the coaxial cables is suppressed by low pass π filters **28** and **32**.

Before proceeding to a discussion of FIGS. 2 and 3, the manner in which RF energy is developed in the motor housing **26** and the precautions needed to prevent radiation of that energy are considered. As the motor **2** reaches its "constant" speed and begins to exceed it, the contact switches **10**, **12** open, interrupting the current flowing from the power supply through the motor's armature and causing thhe speed of the motor to drop. As the motor again reaches its "constant" speed, the switches close. In order to keep the motor at its "constant" speed, the switches close and open at a very fast rate, producing a pulsating D.C. current flow in the line. As is well known from Fourier analysis, each of the current pulses is resolvable into an infinite number of sinusoidal waves, each having a different frequency. Apparatus must be provided to suppress this energy to prevent it from adversely affecting equipment in the vicinity of the housing **26**.

One of the well-known methods of suppressing unwanted oscillations is by means of by-pass capacitor **18** and the line filters **28**, **32**. Despite the use of such suppressors, it was found that RF energy continued to be radiated. A plurality of telescoped shields were utilized to surround the motor housing and its associated circuitry. Four shields—two made of copper and two of Mu Metal—were alternately telescoped within each other. The copper shields were intended to short circuit the electric field while the Mu Metal shields were intended to provide a low reluctance path for short circuiting the magnetic field of the radiated energy.

Referring now to FIGS. 2 and 3, there is shown an oval-shaped motor laminated shield **26** consising of a layer of copper **27** and a layer of Mu Metal **29**. The non-conductive drive shaft **8** of the motor protrudes through an aperture **33** in an end plate **34** of the housing. The end plate **34** is of the same laminate construction as the housing **26** and is secured to the stationary portion of the motor **2** by screws **36**. Leads **22** and **24** are secured to the end plate **34** by means of eyelets **38**.

The device of FIGS. 2 and 3 constitutes an improvement over conventional motor housings. The non-conductive drive shaft **8**, because of its poor conductivity, prevents RF energy from leaking out the only physical opening in the shield **26** other than the opening for the leads **22** and **24**. The use of the non-conductive drive shaft permits the laminated shield to consist of two layers while keeping the amount of RF radiation lower than is encountered when the shaft is metallic and the housing has four laminated layers.

Obviously, many modifications and variations of the present invention are possible in the light of the above teachings. Thus, for example, other types of material may be used in place of the non-conductive drive shaft 8. However, such material must be both non-conductive and strong enough to drive a load.

Accordingly, it is to be understood that the invention is not limited in its application to the details of construction specifically described or illustrated and that within the scope of the appended claims, it may be practiced otherwise than as specifically described or illustrated.

What is claimed is:

1. A radio frequency suppression apparatus for an electric and magnetic field eminating direct current motor comprised of

an electric and magnetic field eminating direct current motor,

a housing,

said direct current motor mounted within said housing,

said housing having shielding laminates to prevent a portion of said electric and magnetic fields extending beyond said housing,

said motor having a driving shaft extending through an aperture in said housing,

said driving shaft being of an electrically non-conductive material which prevents any remaining portion of said electrical and magnetic eminated field from extending beyond said housing.

2. A radio frequency suppression apparatus for an electric and magnetic field eminating direct current motor comprised of

an electric and magnetic field eminating direct current motor,

a housing,

said direct current motor mounted within said housing,

said housing having shielding laminates to prevent a portion of said electric and magnetic fields from extending beyond said housing,

said motor having a driving shaft extending through an aperture in said housing,

said driving shaft being of an electrically non-conductive material which prevents any remaining portion of said electrical and magnetic eminated field from extending beyond said housing,

said electrically non-conductive driving shaft being a high strength epoxy fiberglass whereby said driving shaft can withstand heavy cross axial loading.

3. A radio frequency suppression apparatus for an electric and magnetic field eminating direct current motor comprised of

an electric and magnetic field eminating direct current motor,

a housing,

said direct current motor mounted within said housing,

said housing having shielding laminates to prevent a portion of said electric and magnetic fields from extending beyond said housing,

said shielding laminates having alternative layers of copper and Mu Metal whereby said copper layers short circuits a portion of said electrical fields and said Mu Metal layers provide a low reluctance path for short circuiting a portion of the eminated magnetic field,

said motor having a driving shaft extending through an aperture in said housing,

said driving shaft being of an electrically non-conductive material which prevents any remaining portion of said electrical and magnetic eminated field from extending beyond said housing.

4. A radio frequency suppression apparatus for an electric and magnetic field eminating direct current motor comprised of

an electric and magnetic field eminating direct current motor,

a housing,

said direct current motor mounted within said housing,

said housing having shielding laminates to prevent a portion of said electric and magnetic fields from extending beyond said housing,

said shielding laminates having alternative layers of copper and Mu Metal whereby said copper layers short circuits a portion of said electrical fields and said Mu Metal layers provide a low reluctance path for short circuiting a portion of the eminated magnetic field,

said motor having a driving shaft extending through an aperture in said housing,

said driving shaft being of an electrically non-conductive material which prevents any remaining portion of said electrical and magnetic eminated field from extending beyond said housing,

said electrically non-conductive driving shaft being a high strength epoxy fiberglass whereby said driving shaft can withstand heavy cross axial loading.

5. In combination with a D.C. motor enclosed in a housing having shielding laminates for preventing electric and magnetic fields from extending beyond the housing, the motor having a drive shaft extending through an aperture in the housing, and in which the speed of the motor is regulated by a governor of the type having a pair of contacts in the housing which intermittently open to interrupt the D.C. current supplied through the commutator brushes to the armature windings of the motor, the improvement comprising a diode connected across the communator brushes, the diode being arranged to provide a low impedance path for the reactive current generated in the armature windings when the contacts open, and a resistor connected across said governor contacts to limit current flow through said motor.

6. In combination with a D.C. motor enclosed in a housing having shielding laminates for preventing electric and magnetic fields from extending beyond the housing, the motor having a drive shaft extending through an aperture in the housing, and in which the speed of the motor is regulated by a governor of the type having a pair of contacts in the housing which intermittently open to interrupt the D.C. current applied through the commutator brushes to the armature windings of the motor, the improvement comprising a diode connected across the commutator brushes, the diode being arranged to provide a low impedance path for the reactive current generated in the armature windings when the contacts open, and a resistor connected across said governor to limit current flow through said motor, and wherein said drive shaft is made of a non-conductive material.

7. In combination with a D.C. motor enclosed in a housing having shielding laminates for preventing electric and magnetic fields from extending beyond the housing, the motor having a drive shaft extending through an aperture in the housing and in which the speed of the motor is regulated by a governor of the type having a pair of contacts in the housing which intermittently open to interrupt the D.C. current supplied through the commutator brushes to the armature windings of the motor, the improvement comprising a diode connected across the commutator, means for providing a low impedance path for the reatctive current generated in the armature windings when the contacts are open, comprising a diode connected in parallel with said motor and commutator brushes, and a resistor connected in parallel with said governor to limit current flow through said motor, and wherein said drive shaft is made of a non-conductive material.

8. A radio frequency noise-free motor drive unit comprised of,

an electric and magnetic field emanating direct current motor.

a housing,

said direct current motor mounted within said housing,

said housing having shielding laminates to prevent a

portion of said electric and magnetic fields from extending beyond said housing,

said motor having a driving shaft extending through an aperture in said housing,

said motor having armature windings and commutator brushes electrically connected thereto wherethrough electric current is delivered to said windings,

said motor having a governor of the type having a pair of moveable contacts in said housing which intermittently interrupts the current supplied to said commutator to control said motor speed and also producing an undesirable radio frequency energy.

a diode connected across the commutator means for providing a low impedance path for the reactive current generated in the armature windings when the contacts are open, comprising a diode connected in a parallel with said motor and commutator brushes,

and a resistor connected in parallel with said governor to limit current flow through said motor,

said driving shaft being of an electrically nonconductive material which allows a mechanical output while

preventing said electrical and magnetic emanated field from extending beyond said housing.

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