INVERTER FOR SMALL VOLTAGES

Knud J. Knudsen, Woodbury, Conn., assignor to The Lewis Engineering Company, Naugatuck, Conn., a corporation of Connecticut

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This invention relates to a switching device having a movable contact for make-and-break engagement with a fixed contact, and more particularly to a device for converting small D. C. voltages into pulsating voltages of substantially the same strength and magnitude.

An object of this invention is to provide an inverter which is capable of converting a small D. C. voltage, on the order of between 10 millivolts and 5 microvolts, without introduction of any significant spurious voltages which would alter the voltage, and without any decrease in the potential of the D. C. voltage, into a pulsating voltage of the same potential.

Another object of this invention is to provide an inverter of the above-disclosed type which will provide for stable operation and extremely long life, even with large deviations from an ambient temperature and even with substantially the same strength and magnitude.

Still another object of this invention is to provide an inverter of the above type capable of being used under extremely violent vibration conditions such as are encountered in an airplane, for example, and in which the components of the inverter are so arranged and constructed as to make the unit substantially unaffected by the vibration.

A still further object of this invention is to provide an inverter which is capable of producing a substantially undistorted output wave and in which there is eliminated chattering between the contacts resulting from their impact with each other.

Another object of this invention is to provide a switching device of the above-stated type in which the position of the movable contact member is determined by the direction of flow of the alternating current employed for actuating the movable member, in order to synchronize the position of the contact member with the direction of flow of the alternating current.

A further object of this invention is to provide an inverter which is small, lightweight, economical to manufacture and durable, and is specifically adapted for use in airplanes where it is desired to convert the D. C. potential difference between a compensating bridge and a thermocouple into an alternating voltage capable of amplification, for operating electrical mechanisms.

In accomplishing these objects there is provided, according to my invention, a cylindrical tubular coil connectable with a source of alternating current and having a pivoted armature actuated thereby; the armature in turn actuates an elongate, current-carrying, movable contact. Any significant spurious voltage created by the magnetic field in the iron vibrating member is not transmitted to the current-carrying contact member because of electrical insulation interposed between the contact and the vibrating member. To eliminate the magnetic field of the coil from creating any spurious voltage, the coil is enclosed by material having high magnetic permeability and the current-carrying contact member is formed from non-magnetic material. Moreover, to prevent any contact potential from occurring between the contact elements, the contacts are formed from similar material, for example, in the specific embodiment illustrated herein, from fine silver. It is to be noted that spurious voltages on the order of a hundred times the minimum voltage to be converted are capable of being created in an inverter, but in the embodiment of my invention set forth herein, I have reduced these spurious voltages to such values that they fail to annul the pulsating D. C. voltage and are consequently considered to be insignificant. For example, my inverter as described herein is capable of converting a 5 microvolt D. C. current into a pulsating D. C. voltage without the introduction of any spurious voltage which would overpower the 5 microvolt pulsating D. C. signal voltage and render the same imperceptible.

Other features and advantages will hereinafter appear. In the accompanying drawings:

Figure 1 is an elevation of my inverter.

Figure 2 is a sectional view taken along line 2—2 of Fig. 1.

Figure 3 is a plan view of my inverter, partly in section.

Figure 4 is a view taken along line 4—4 of Fig. 3.

Figure 5 is a view of the inverter mounted in the case with portions of the case broken away.

Figure 6 is a sectional view taken on the line 6—6 of Fig. 2.

The improved converter of my invention is indicated generally by the reference numeral 10 and has a flat base member 11 which is somewhat T-shaped. Positioned above the cross of the T of the base member 11 is a cylindrical tubular actuating coil 13, while the switching mechanism generally indicated by the reference numeral 14 is located above the leg of the T-shaped base member.

For securing the coil 13 in position, uprights 15 are secured to the ends of the cross of the base member are used. While these uprights may be secured to the base member by welding, soldering, etc., screws 16, as shown, provide the attaching means. An elongate soft iron tube 17 encompasses the coil and is secured to the uprights 15 by any suitable means but, in the embodiment shown, soldering 18 is employed. Located within the tube 17 is a spool 19 formed of insulating material upon which the coil 13 is wound. The leads 20 to the coil project from a slot 21 formed in the tube 17, and these leads are connectable to a source of alternating current (such as 115 volts, 400 cycles).

Mounted on the top of the leg portion of the base member 11 is an angle 22 formed from magnetic material such as iron and having an L-shaped section providing a vertical leg 23 and a horizontal leg 24. While the angle 22 may be secured to the base 11 by soldering, etc., in the preferred embodiment illustrated herein countersunk screws 25 are used. One side of the vertical leg 23 acts as an abutment to maintain the coil in position and is mounted to be in contact with the tube 17, while on the other side of this vertical leg a V-shaped groove 26 is formed. Positioned within the groove is an arbor or pivot pin 27 which carries an elongated armature 28. As shown the armature has a U-shaped cross-section throughout and is formed of iron material having a high magnetic permeability. One portion of the armature 28 extends through a cylindrical aperture 29 formed in the spool 19, while the other end portion is crimped as at 30 to maintain in position a strip 31 of resilient, electrical insulating tape, such as "Teflon," which conforms to the lateral shape of the armature.

Switching mechanism 14 is maintained in position by vertical supports 32. While these supports may be soldered, welded, bolted, etc., to the base 11, in the embodiment shown they are secured in position by bars 33 and screws 34. Above the base 11, these supports carry the
The contacts 35, the contacts 35 are preferably silver-tipped brass screws which are threaded into the support member and locked in position by lock nuts 36.

A flat piece 37 bridges the space between the supports 32 and is secured to their side ends. The front portion of the piece 37 is provided with a V-shaped groove 38 which forms a bearing surface for an arbor or pivot pin 39. The arbor 39 has attached thereto the current-carrying element member 40, preferably formed of fine silver. While the member 40 may be attached to the arbor 39 by a slot-and-groove, crimping, etc., in the preferred embodiment illustrated herein, soldering 41 is employed. The other end of the current-carrying member 40 is positioned within the right portion of the U-shaped armature 28 and is electrically insulated therefrom by the tape 31. By virtue of having both the armature 28 and the current-carrying movable contact member 40 pivotally mounted in the same plane, vibrations angular to this plane do not affect movement of these members.

It will be apparent that the contacts 35 are spaced on opposite sides of the member 40 and are closely positioned with respect thereto so that only a slight movement (on the order of .002") of the member 40 is needed to change from electrical engagement from one contact to the other. To obviate excessive chattering occurring when the member 40 comes into engagement with the contacts, and which would cause output wave distortion and instability in operation if allowed, self-damping means are employed. These consist of a flat spring 42 which bears against portions of the pivot pin 27 and a flat spring 43 which bears against portions of the pivot pin 39. These springs are provided with square apertures 43 and 46 respectively, in order to control the amount of frictional surfaces between the pins and the spring. These apertures 43 also permit, in the case of the spring 42, the passage therethrough of the armature, and in spring 45, the wire connection to the contact member 40. Moreover, these springs serve to maintain pivot pads in their respective grooves. While the spring may be attached to the adjacent support elements by rivets, etc., screws 44 and 47 are provided.

To facilitate manufacture by decreasing the required tolerance and improve the output wave form, and stability of the inverter, apertures 48 are formed in the bridge piece 37 and in the vertical leg 23 adjacent the pivot element. As has been found, the stiffness between the pivot pin and its corresponding groove caused the armature to wobble, which resulted in a poor wave form and a tendency of instability in output. These apertures reduce the bearing surface between the groove and pin and, as will be noted, the bearing surfaces are closely adjacent the armature and the member 40, so that fine pins may be advantageously employed. The ends of the pins sub the ends of the apertures to prohibit relative movement therebetween in the longitudinal plane of the pivot.

By virtue of providing permanent magnets 49, 49, synchronization and positive action of movement of the armature are created. These magnets have opposite poles adjacent each other (and indicated as N and S, for example in Fig. 1) to form a strong magnetic field in the air gap separating them. The end of the armature is positioned within the air gap. It will be apparent that a closed magnetic field is created, and that current in the armature 40, by means of the magnetic passing through the iron cylinder 17 and the vertical leg 23 of the iron angle.

To insulate the contacts 35 in the current-carrying member 40 from any spurious voltage which may be present in the base member 11, insulating strips 50 are interposed between the bar 33 and the member 40, and insulating strips 51 are interposed between the base 11 and the supports 32. To insulate the current-carrying member 40 from the contacts, insulating strips 52 are positioned between the flat piece 37 and the supports 32.

A stabilizer 53 formed of aluminum is interposed between the supports 32 in order to maintain the contacts separated in the desired amount when the inverter is subjected to extreme temperature variations. As shown, the stabilizer 53 is a cylindrical rod having threaded apertures 54 on each end portion. Engaging in these threaded apertures are screws 55 which pass through holes 56 in the supports 32, advantageously employing a material having a greater coefficient of expansion for the stabilizer, such as aluminum, than the material used for the contacts (silver tipped brass). Thus, with a rise in temperature, the contacts 35 will elongate, tending to decrease spacing, but the stabilizer elongates even more spreading the free ends of the support 32, which increases the spacing between the contacts thus compensating for temperature variations. It will thus be seen that not only does the stabilizer maintain the desired spacing between the contacts, but also prevents separation of the contacts with changes in dimensions caused by temperature variations. In order to insulate the stabilizer, insulation 57 is provided.

Upon applying an alternating current, which may be a 400 cycle, 150 volts to the coil 13, the armature is caused to vibrate. By reason of the permanent magnetic field maintained by the magnets 49, when the current in the coil is flowing in one direction, the end of the armature in the air gap will, for example, be magnetically polarized as a south pole. This causes the north pole of the magnet 49 ("N" as shown in Fig. 1) to attract and the south pole ("S" as shown in Fig. 1) to repel the end of the armature. Upon reversal of current in the coil, the armature end will then be polarized north and, since the armature is nearest the north pole of the permanent magnet 49, it will be repelled and also attracted by the south pole, which causes the armature to move to adjacent the south pole. This, of course, causes the current-carrying contact member 40 to shift from one contact to the other. It will thus be observed that for the duration in which current is flowing in one direction in the coil, the armature which becomes magnetically polarized will have its end portion adjacent the pole of the permanent magnet which is opposite, and that only a slight amount of power is needed to shift it from one position to the other. Movement of the armature causes a pivoting of the member 40 about its pivot 39 and this would tend to cause a slight distortion or bending of the member 40. In the absence of any damping, the member 40 will move between the faces of the contact 35, the armature 28, and the pivot 39. This manner of construction, in which there is no bending of the flexible member, greatly enhances and makes possible the long life of my inverter.

Threaded apertures 58 are provided in the base member 11 for mounting the inverter in a case 59 as shown in Fig. 5. It will be appreciated that another feature of my invention is the provision in an inverter of damping means for restraining movement of the armature except in response to excitation by said coil in order to produce a substantially non-distorted output wave. The damping means moreover prevent any chattering between the contacts when they first come into engagement. The initial impact between the movable contact 40 and a fixed contact 35 creates a force tending to separate the contacts which would cause chattering of the contacts, but my damping means effectively prevent such chattering. This is accomplished by the construction of pivotally mounting the armature 28 and contact 40 on the supporting structure, and by exerting frictional forces on the pivots 27 and 39 by means of springs 42 in the manner previously described. The successful movement of the pivots is hampered.

The production of a non-distorted output wave and synchronization between the direction of flow of the alternating exciting current is facilitated and accomplished
by the provision of means for creating a permanent magnetic field in which the armature operates and by causing a changing magnetic field in the armature, which armature field reacts with the permanent field to cause movement of the armature. This permanent magnetic field serves also to maintain the armature and hence the movable contact in engagement with one of the fixed contacts until the current in the coil changes the field of the armature and causes the movable contact to move to the other fixed contact with a "snap" action. More specifically, in the embodiment shown herein, I have disclosed a pair of permanent magnets 49 having adjacent opposite poles on opposite sides of the armature 28 which create a magnetic field which tends to hold the armature adjacent the magnet, having a pole dissimilar to the armature pole. The armature is positioned within the hollow core of the coil spool 19 and upon changes in the direction of the alternating current in the coil, the armature's magnetic polarization is reversed, which causes it to be repelled by the nearest permanent magnet and attracted by the other.

From the foregoing description, it will be seen that the provision of mounting the movable elements, namely the armature 28 and the movable contact 40, so that they are dynamically balanced about the mounting or pivot 27, in order to substantially eliminate interference with the movement of the contact by extraneous violent vibrations. The elongate armature 28 is pivoted intermediate its length and has one portion extending into the coil 13, while the other end portion slidably receives the one end of the movable contact member. The armature is U-shaped in cross-section with the movable contact 40 positioned in the bight portion but insulated therefrom by a strip 31 of resilient insulating tape. The other end portion of the contact member is pivoted on the support 35, which structure. This results in the pivotal movement of the armature causing pivotal movement of the movable contact and a slight compression of the insulating tape when the movable contact vibrates between the fixed contacts. It will be appreciated that this construction not only provides a resistance to movement when the inverter is vibrated, but also provides for the extremely long life of the device since the movable contact member does not flex. In the specific embodiment shown herein, the contacts 35 are spaced a distance in the neighborhood of only .002 more than the thickness of the movable contact 40, and consequently the insulating tape 31 is capable of absorbing the side deflection of the movable contact.

As set forth above, the provision of a stabilizer or temperature compensator separating the two contacts 35 maintains them in the desired spaced relation for operation under extreme temperature conditions. This stabilizer 53 is formed from aluminum and is positioned between the vertical supports 32 containing the two contacts 35. This prevents the contacts from coming closer, while the manner of mounting the stabilizer prevents the contacts from expanding due to the normal changes in dimension of the supporting structure caused by temperature changes.

Variations and modifications may be made within the scope of the claims and portions of the improvements may be used without others.

I claim:

1. A device for changing small D. C. voltages on the order of 5 microvolts into pulsating voltage of the same magnitude, said device comprising: a fixed contact and a movable contact, a coil connected to a source of alternating current, a pivoted mounted armature oscillated by said coil, a pivotally mounted current-carrying contact arm connected to said armature for movement from and into electrical engagement with a fixed contact, said pivotally mounted contact being a grove in which the mid-point of the path of movement of the contact, and means insulating both of said contacts from said armature and coil to eliminate introduction of any significant spurious voltages during operation of the inverter.

2. An inverter for converting small D. C. voltages into a pulsating voltage of the same magnitude comprising support means, a member pivotally mounted on said support means on a pivot pin, a coil connectable to a source of alternating current for moving said member, and clamping means for restraining excess movement of said member, said clamping means including resilient means mounted on said support means and bearing on the pivot pin of said member.

3. The invention as defined in claim 2 in which there is provided a fixed contact in the path of the movable member, the support means includes a groove in which is disposed a portion of the pivot pin, and the resilient means acts to maintain said pin in the groove and prevent chattering upon initial engagement of the movable member with the fixed contact.

4. A switching device comprising a support, an elongate armature, means pivotally mounting said armature intermediate its length, an elongate movable contact inter-connected to said armature, and means pivotally mounting said contact, both of said means being in the same plane perpendicular to the path of movement of the armature and contact, said armature mounting means being so located intermediate the length of the armature that the armature is balanced about its pivotal mounting thereby enabling the device to be substantially unaffected by extraneous vibrations.

5. An inverter for converting a D. C. voltage into a pulsating voltage comprising support means; a fixed contact on the support means; a movable contact movable into and out of engagement with said fixed contact, said movable contact being an elongate strip having one end pivotally mounted on the support; a tubular solenoid having input terminals connectable to a source of A. C.; and an elongate armature pivotally intermediate its length and having one end portion extending within the tubular solenoid; a resilient connection between the other end portion of the armature and the other end of the movable contact to absorb side movement of the strip to prevent flexing of the strip whereby when A. C. is introduced into the coil the armature oscillates the movable contact into and out of engagement with the fixed contact.

6. The invention as defined in claim 5 in which the connection between the moving armature and the movable contact includes a resilient element of electrical insulating material for electrically insulating the contact from the armature.

7. The invention as defined in claim 2 in which the movable member includes an elongate movable contact supported at one end by a pivot pin and an armature supported intermediate its length by a pivot pin, said armature and contact having interconnected end portions and in which the damping means includes resilient elements bearing on both of the pivot pins.

8. A switching device comprising a support, an elongate armature, means pivotally mounting said armature intermediate its length, an elongate movable contact interconnected to said armature, and means pivotally mounting said contact, both of said means being in the same plane perpendicular to the path of movement of the armature and contact, said armature mounting means being so located intermediate the length of the armature that the armature is balanced about its pivotal mounting, thereby enabling the device to be substantially unaffected by extraneous vibrations, and in which the armature when moving in one rotative direction moves the contact in the other rotative direction, in which the interconnection provides for telescoping movement and in which there is a resilient element in the interconnection between the armature and the movable contact which prevents flexing of the contact member.

9. The invention as defined in claim 1 in which there
is a second fixed contact; the support means includes a pair of spaced support members fastened to a base, a fixed contact being carried by a support member; and means positioned between the support members for maintaining the desired spacing between the contacts with variations in ambient temperature.

10. The invention as defined in claim 9 in which the base and support members are formed of brass and the contact spacing maintaining means is an aluminum rod.

11. An inverter for converting a D. C. voltage into a pulsating voltage comprising support means; a fixed contact on the support means; a movable contact movable into and out of engagement with said fixed contact, said movable contact being an elongate strip having one end pivotally mounted on the support; a tubular solenoid having input terminals connectible to a source of A. C.; an elongate armature pivoted intermediate its length and having one end portion extending within the tubular solenoid and its other end portion connected to the other end of the movable contact whereby when A. C. is introduced into the coil the armature oscillates the movable contact into and out of engagement with the fixed contact, in which the armature has a U-shape cross section with the end of the movable contacts positioned within the bight of the "U" and in which a strip of electrically insulating resilient material is disposed between the movable contact and the bight portion.

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