Aug. 19, 1958 K. J. KNUDSEN 2,848,578

INVERTER FOR SMALL VOLTAGES

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Fig. 1

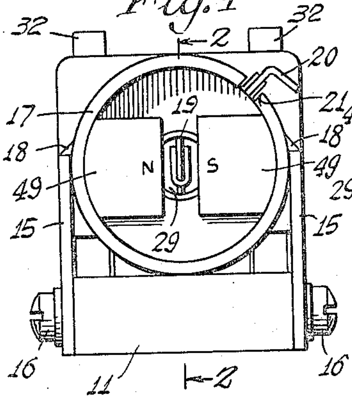


Fig. 2

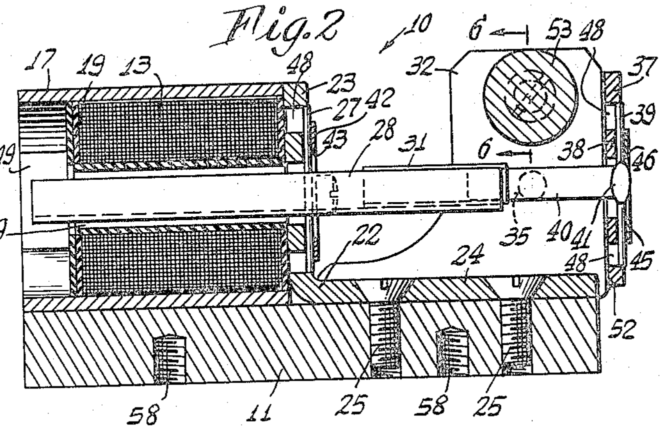


Fig. 4

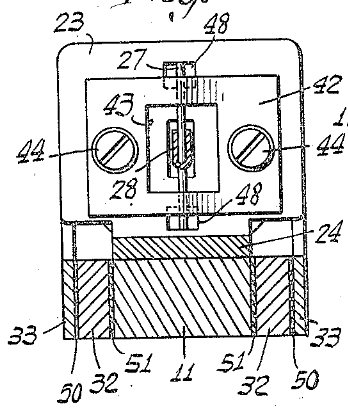


Fig. 3

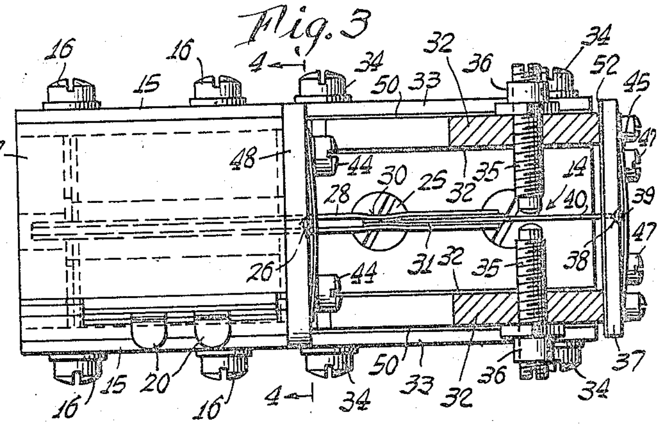


Fig. 5

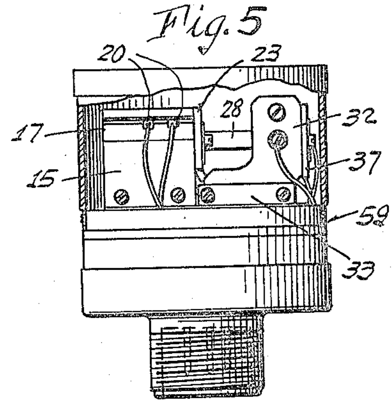
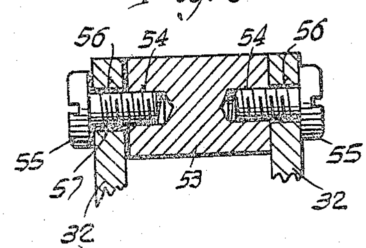


Fig. 6



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INVERTER FOR SMALL VOLTAGES

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11 Claims. (Cl. 200—90)

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 substantial variations in the frequency of the actuating voltage.

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 encounted 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 non-distorted 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 connectible 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 drawing:

Figure 1 is an elevation of my inverter.

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

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

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

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

Fig. 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** attached 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 slit **21** formed in the tube **17**, and these leads are connectible 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 interior 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 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 elongate contact 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 bight 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 **45** 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 surface 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 pins 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 pins. It has been found that any lack of straightness 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 abut 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, except for the air gap, by the flux lines of the magnet 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 upright **32** 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 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**. I advantageously employ 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, 115 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 in the member **40**. However, since the movement is small, on the order of .002, no flexing of the member **40** is caused because the resilient tape **31** compresses to absorb the slight distortion. 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 actuation 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, if uncontrolled, would cause chattering between the contacts, but my damping means also 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** and **45** whereby any excess rotatable 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 supporting 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 comprising a coil connectible to a source of alternating current, a pivotally 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 pivotal mounting of the contact and the armature each including a pivot pin with the pivot pins being in a plane which includes 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 connectible to a source of alternating current for moving said member, and damping means for restraining excess movement of said member, said damping 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 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.

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 connectible to a source of A. C.; an elongate armature pivoted 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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