July 10, 1928. 1,676,973

R. D. AMSDEN

VIBRATORY CONVERTER

Filed Aug. 24, 1922

Fig. 1.

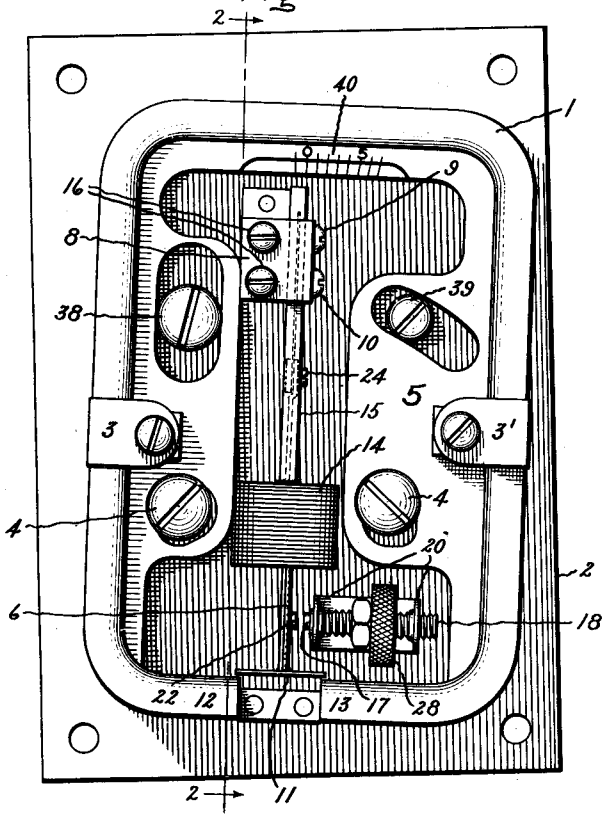


Fig. 2.

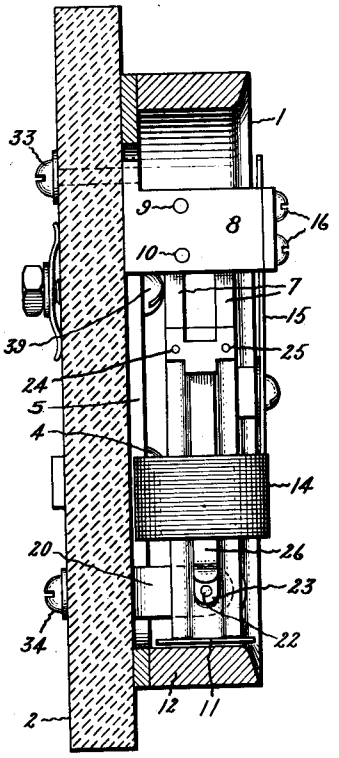


Fig. 6.

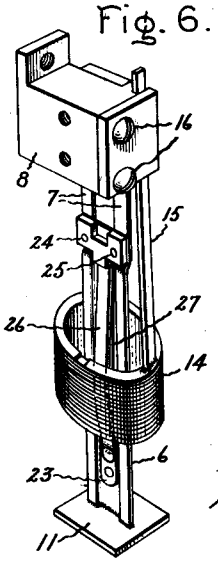


Fig. 3.

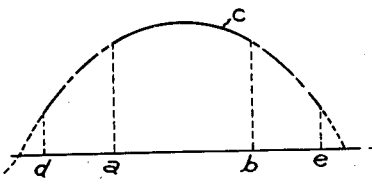


Fig. 4.

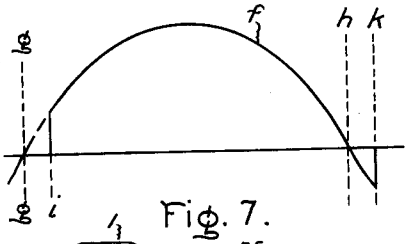


Fig. 5.

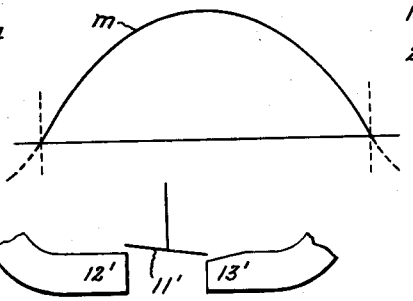


Fig. 7.

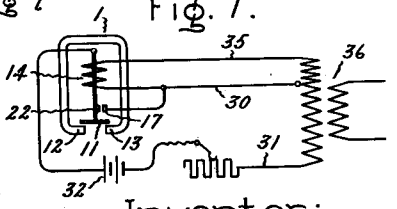


Fig. 8.

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by Albert G. Davis
His Attorney.

Patented July 10, 1928. 1,676,973

UNITED STATES PATENT OFFICE.

RALPH D. AMSDEN, OF LYNN, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

VIBRATORY CONVERTER.

Application filed August 24, 1922. Serial No. 583,981.

This invention relates to electric make and break apparatus containing a vibrating reed which is caused to oscillate by the interaction of magnetic forces, the invention being embodied in a rectifier for converting alternating current to unidirectional current.

It is the object of my invention to improve the reliability of this apparatus, to make the same automatically responsive to changes in frequency or voltage of the operating circuit; to provide mechanical means for timing the operation of the make and break contacts, and to automatically compensate for variations in gap between the contacts.

My present invention comprises an improvement in a current converter containing a vibrating element held under magnetic tension as described and claimed in a copending application filed by Ralph T. Cheeseman concurrently herewith, Serial No. 583,986.

My invention consists in certain new features in a converter having a vibrating element or reed with means for inducing therein an alternating magnetic flux to cause the reed to oscillate in synchronism with the cyclic changes of this magnetic flux, thereby bring the make and break contacts into engagement during desired time intervals.

In accordance with one feature of my invention I have provided a construction whereby the relation of the make and break of the vibratory contacts with respect to the phase of the current being converted may be varied at will by simple mechanical adjustments which magnetically vary the periodicity of the vibrator.

In accordance with another feature of my invention I have provided mechanical means for varying the length of time the electric contacts in the converting device remain in contact during each cycle of operation.

Another feature of my invention relates to the mechanical construction of the vibrating element whereby it is made non-periodic.

In the accompanying drawings, Figs. 1 and 2 show respectively in plan and longitudinal section a rectifier for alternating current embodying my invention; Figs. 3, 4 and 5 are graphs of current waves illustrating novel features of my invention; Fig. 6 is a perspective view of the vibrator and actuating coils; Fig. 7 is a diagram of circuit connections; and Fig. 8 is a fragmental outline view of a modified structure of magnetic poles.

Referring to Figs. 1 and 2, the device illustrated comprises a looped permanent magnet 1 of substantially rectangular shape mounted on a base 2 consisting of slate, or other suitable insulating material by the clamps 3, 3', which are mounted on a non-magnetic support. The screws 4, in the support 5 when loosened permit of a tilting adjustment of the magnet 1 for reasons hereinafter explained.

A T-shaped magnetic armature 6 and the light spring support 7, constitute the vibrating element. The spring 7 is mounted on a pedestal 8 within the confines of the magnet 1 by the screws 9, 10. The resiliency of the spring 7 and the weight of the vibrating element are so chosen that the period of vibration apart from the magnetic effects would differ materially from the periodicity of the current to be rectified. The rectangular head 11 of the armature 6 is located closely adjacent to a gap in the magnet 1 and slightly laps the gap. This position places the vibrator under magnetic tension as any movement of the head 11 past the poles 12, 13 in either direction laterally will vary the relative magnetic reluctance of the gaps between the armature 6 and the poles of the unidirectional magnet 1. This magnetic tension substantially determines the periodicity of the vibrator.

Surrounding the armature 6 is a solenoid or winding 14, carried by a stem 15, which in turn is adjustably mounted on a pedestal 8 by the screws 16. When the coil 14 is traversed by an alternating current, corresponding alternating magnetic fluxes are induced in the armature 6, causing the head 11 to be attracted alternately toward one pole and repelled from the opposite pole of the magnet 1.

A stationary electric contact 17 is carried by a threaded pin 18 passing through holes in the upwardly bent ends of the support 20, mounted upon the base 2. A cooperating contact 22 is mounted on a yielding leaf spring 23, which is attached to the armature 6 by the screws 24, 25, the head of one of which appears in Fig. 1 and the opposite ends of which are shown in Fig. 2. As shown in Fig. 2 the contact 22 projects through a hole in the stem 6 of the vibrator. A long leaf spring 26 and an intermediate

short leaf spring 27, (see Fig. 6) both bear against the spring 23 to make the contact carrier non-periodic and prevent chattering of the contacts.

The distance between the contacts 17, 22 may be adjusted by turning the knurled thumb nut 28 which is fixedly attached to the threaded contact-carrying pin 18. The width of the gap between the make and break contacts 17, 22, preferably is made about 0.025″, a variation of 50% above and below this width being permissible. The pin 18 preferably is provided with forty threads to the inch, so that a single turn of the screw when the contacts have been brought together separates the contacts the proper distance for the most favorable operation. Sticking, or welding of the make and break contacts is entirely avoided because of the relatively wide gap, and also because of the magnetic tension which acts to hold the vibrator in the off position, that is, with the contacts open. The contacts preferably consist of platinum-iridium alloy. Practically no sparking is observable at the contacts during the operation of the device, there is no tendency for the contacts to become pitted or corroded, and hence the original adjustment is maintained over a long period of time.

Assume, as shown in Fig. 7, an alternating current circuit 30, 31, containing a direct current load device, such as a battery 32, to be connected to the rectifier terminals 33, 34 (Fig. 2) leading respectively to the vibrating contact 22 and the stationary contact 17. The magnetizing coil 14 is connected by the conductors 30, 35 to end turns of the secondary of a transformer 36. Vibrations of the armature 6 will occur in synchronism with the alternating current, causing the circuit 30, 31 to be closed during selected intervals, thereby delivering unidirectional impulses of current to the load device 32.

The duration of closure of the contacts 17, 22 can be varied by varying the relative magnetic reluctance of the gaps between the head 11 and the respective poles 12, 13, and hence the relative effectiveness of the constant magnetic poles. For example, if it is desired to increase the length of the selected wave portions from the interval included between the lines marked *a*—*b*, Fig. 3, in which *c* represents a current wave, to the interval between the lines *d*, *e* then the magnet 1 is tilted to bring the pole 13 closer and in more overlapping relation with the armature head 11. This decreases the reluctance of the gap between 13 and 11, and correspondingly decreases the reluctance between 12 and 11. In order to make this biasing adjustment the screws 4 are loosened and the magnet 1 is rocked by turning the screw 38, the stem of which acts as a cam. The magnet 1 may be moved longitudinally by means of the screw 39 which is also constructed to act as a cam, when it is desired to time the vibrations of the make and break contact or to tune the device for a different range of frequencies. For higher frequencies the head 11 is brought nearer to the poles 12, 13. Markings may be provided on the magnet, as indicated at 40, whereby in conjunction with a mark on the slate base 2 (not shown) the setting of the gaps may be indicated.

The timing of the instants of make and break of the work circuit with respect to the phase of alternating current in the supply circuit can be carried out either by a longitudinal displacement of the coil 14 upon the vibrator, or by an adjustment of the air gap between the stationary magnet and the vibrator. Either adjustment alters the natural periodicity of the vibrator under the influence of magnetic forces. Although both of these displacements effect both the instants of make and break of the circuit, the movement of the coil 14 longitudinally with respect to the vibrator is most effective in varying the instant of break of the circuit and the movement of the magnet toward or away from the armature is most effective in altering the establishment or make of the work circuit.

When the screws 16 are loosened, the coil 14 may be moved toward or away from the head 11 and the phase relation of the oscillations of the vibrator with respect to the alternating current is altered. A movement of the coil 14 forward, that is, toward the head 11, causes both the make and break of the work circuit to occur later with respect to the current and voltage in the supply circuit, but effects particularly the break of the work circuit. Assuming, as shown in Fig. 4, that in one position of the coil 14, the make and break of the work circuit occurs at such a point as to give a symmetrical current wave *f* between the lines *g*, *h*. If the coil 14 is moved forward the break of the circuit will occur at *k* instead of *h*, that is, at a later point upon the current wave after the supply current has passed through zero. For the sake of simplicity it will be assumed that current and voltage are in phase with each other. The make of the circuit will be somewhat retarded by this displacement of the coil 14, but the adjustment of the make of the circuit is most effectively brought about by an alteration of the air gap between the stationary magnet 1 and the head 11 of the vibrator. For example, should the magnet 1 be moved away from the vibrator, increasing the air gap, then the moment of circuit closing will be retarded, say, from a point *g* to a point *i*. As a result of both of these changes an unsymmetrical current wave will be obtained,

as indicated by the full line of Fig. 4. Conversely, a movement of the coil 14 back and away from the head 11 advances the break of the contact and the movement of the magnet 1 toward the vibrator, advances the make of the contact. The full line curve *m* of Fig. 5, shows the rectified current obtained when adjustments are made to cause both the make and break of the work circuit to occur near the zero point of the current and voltage. If a battery is being charged the make and break of the work circuit preferably should occur at about the time at which the voltage of the charging current is equal to the battery voltage. For example, at the point *d* and *e* of Fig. 3.

In some cases a bias of the stationary magnetic poles with respect to the vibrating armature to secure a predetermined period of contact may be secured by inclining the vibrating armature head with respect to the path of lowest reluctance between the poles of the stationary magnet, as shown, for example, in Fig. 8. The armature head 11′ is inclined with respect to the pole 13′, the edge of which is cut away to maintain a desired relative reluctance value between it and the armature 11′. As shown in Fig. 8, the magnetic reluctance of the gap between the head of the vibrator and the pole 13′ is less than the reluctance of the gap between the vibrator head and the pole 12′, hence prolonging the periods of engagement of the contacts, assuming the same arrangement of parts as in Fig. 1. In fact, any construction or mode of regulation may be employed whereby the relative effectiveness of the magnetic poles may be properly adjusted.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. An electric converting device comprising a reed consisting in part at least of magnetic material, a magnet of unidirectional flux having poles arranged to hold said reed under magnetic tension and a winding surrounding said reed for inducing a cyclically varying magnetic flux therein, said winding being longitudinally adjustable with respect to said reed to time the phase relation of the vibrations of the contacts with respect to a cyclic current to be converted.

2. A vibrating rectifier comprising the combination of a vibrating reed hving an armature consisting in part at least of magnetic material, a magnet having poles arranged at right angles to said reed and separated by a gap lapped by said armature so that the vibrations of said reed alter the magnetic reluctance between said reed and said magnet poles, a magnetic winding arranged about said reed to induce a cyclically varying magnetic field in said reed and supporting means for said winding permitting longitudinal adjustments to time the vibrations of said reed.

3. A vibrating rectifier comprising the combination of an alternating current supply circuit, a work circuit vibrating reed consisting in part at least of magnetic material, a magnet having poles arranged to hold said reed under magnetic tension, a magnetic winding surrounding said reed, electric contacts operatively related with said reed and connecting when closed said supply circuit to said work circuit and a cam support cooperating with said magnet for varying the magnetic relation of said magnet to said reed to time the operation of said contacts with respect to voltage changes in said supply circuit.

4. A vibrating rectifier comprising the combination of a magnetic means of constant polarity providing oppositely placed poles separated by a gap, a magnetic armature located adjacent said gap and arranged to vibrate past said gap, a mounting permitting vibrations of said armature, a solenoid surrounding said mounting and in magnetic relation to said armature for magnetizing the same with a cyclically varying magnetic flux, switching contacts operating by the resulting vibrations of said armature and means for biasing the magnetic relation of said armature with respect to said poles.

5. In a vibrating electrical make and break device comprising an alternating current supply circuit, a work circuit, a stationary magnet, a movable magnet one of said magnets being fixed in polarity, electric contacts brought in and out of engagement by said movable member for connecting said supply circuit to said work circuit, a winding for inducing an alternating magnetic flux causing said movable member to vibrate, said winding being longitudinally adjustable with respect to said vibrating member whereby the vibration of said contacts may be timed, connections for energizing said winding from said supply circuit, and means for biasing the movable member with respect to one of the poles of the fixed magnet to predetermine the duration of the periods of closure of said contacts.

6. An electric apparatus comprising the combination of a magnet of constant polarity having oppositely disposed poles, a vibrating reed having a head of magnetic material and a support therefor permitting vibrations of the head past said poles and outside of the gap between said poles, means for superimposing an alternating magnetic flux upon said reed to cause vibrations thereof accompanied by cyclic changes of magnetic reluctance of the gaps between said head and said poles and electric contacts arranged to be brought into operative relation by said vibrations, the magnet of constant polarity and the reed being arranged with respect to each other to cause the magnetic

reluctance of the paths from the reed to said respective poles to be unequal, thereby correspondingly controlling the relative duration of the periods of make and break of said contacts.

7. An electric vibrating rectifier comprising the combination of a magnet of constant polarity having poles arranged opposite one another and separated by a gap, an armature having a stem extending substantially at right angles to the axis of said poles and a head of substantially the width of said gap inclined at a small angle with respect to the path of lowest magnetic reluctance between said poles, the edge of the pole toward which said head is inclined being cut away to bias the magnetic effect of said pole, and make and break terminals operated by said armature, the relative length of the period of contact of said terminals being largely controlled by the bias of said armature.

8. A vibrating rectifier comprising the combination of a looped magnet of constant polarity, having oppositely disposed poles separated by a gap, a vibratory reed supported within the confines of said magnet and having an armature head arranged opposite said poles just outside of the path of lowest magnet reluctance and being supported to permit vibrations across said poles, a solenoid surrounding said reed whereby an alternating magnetic field may be induced therein, and make-and-break contacts located to be brought into operative relation by said reed when vibrating.

9. A vibrating contact-making device comprising the combination of magnetic means affording poles of opposite polarity spaced apart, a magnetic armature located adjacent the gap between said poles, lapping the same, and slightly inclined relatively to one of said poles, a mounting for said armature extending substantially at right angles to a line joining said poles and permitting vibrations of said armature across said gap, means for vibrating said armature and make and break contacts operated by said vibrations.

10. A vibrating rectifier comprising the combination of a looped permanent magnet which is provided with a gap, a vibratory T-shaped armature, the latter being located closely adjacent to said gap and angularly inclined thereto, a resilient support for said head arranged substantially at right angles to the axis of said gap, a solenoid surrounding said armature at a point remote from said gap, and make and break contacts operatively associated with said armature.

In witness whereof, I have hereunto set my hand this 16th day of August, 1922.

RALPH D. AMSDEN.