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2,054,097

HARMONIC COMPRESSOR

Filed May 31, 1932

2 Sheets-Sheet 1

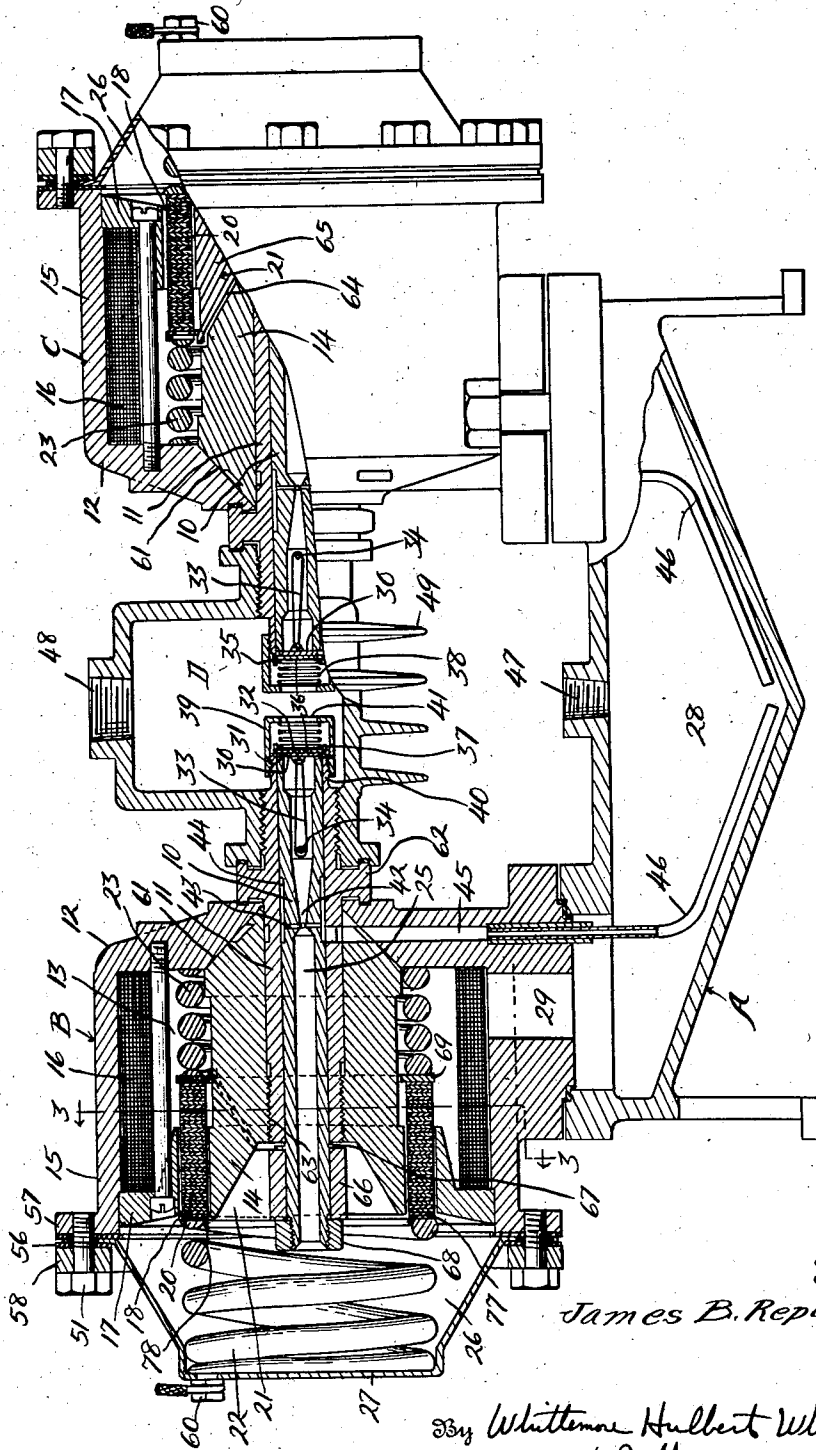


FIG. 1.

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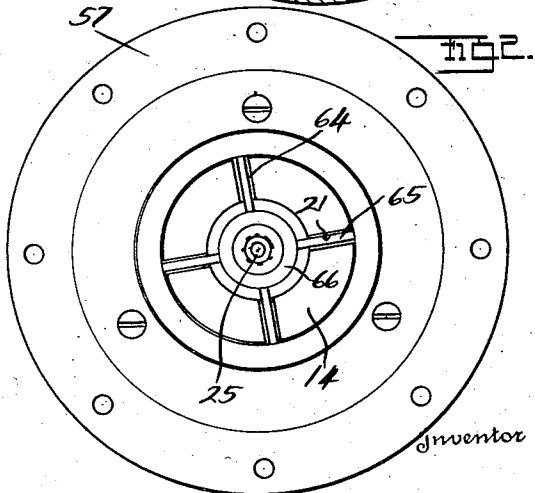
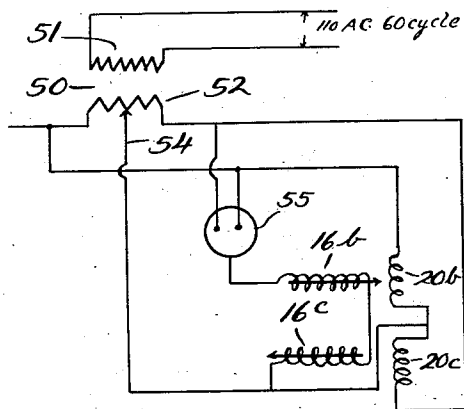
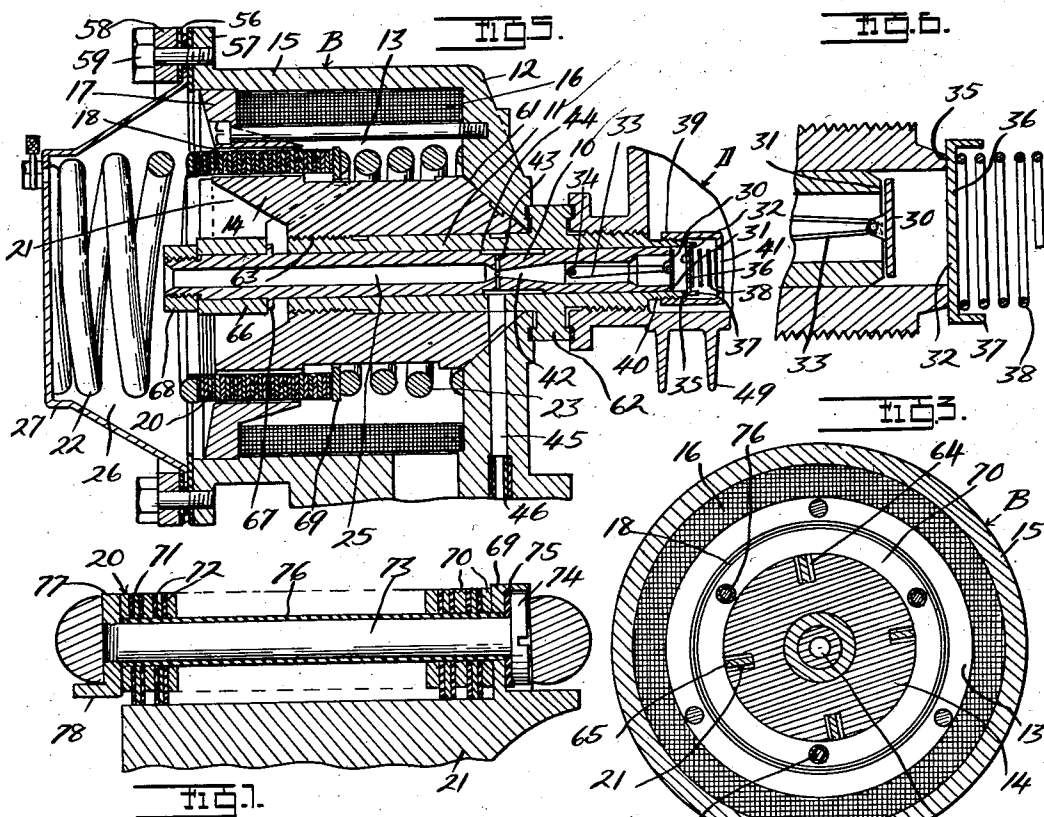
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UNITED STATES PATENT OFFICE

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HARMONIC COMPRESSOR

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Application May 31, 1932, Serial No. 614,591

12 Claims. (Cl. 230—55)

The invention relates to electrically driven reciprocating apparatus and more particularly to compressors such, for example, as are adapted for the refrigeration industry.

One of the primary objects of the invention is to produce an electrically operated reciprocating device free from rotating parts in which the electrical energy is converted directly into the energy of mechanical reciprocation.

Another important object of the invention is to obtain a compressor of simple design adapted to be produced at low initial cost and to operate at high efficiency.

Other objects will be more apparent upon the consideration of the details of construction hereinafter set forth and illustrated in the accompanying drawings, wherein

Figure 1 is a side elevation partly in section of an electrical compressor in which the piston of each power unit is shown at the end of its compression stroke;

Figure 2 is an end view of a power unit with the cap 27 and spring 22 removed;

Figure 3 is a transverse section through a power unit on the line 3—3 of Figure 1;

Figure 4 is an electrical diagram;

Figure 5 is a sectional elevation of one unit showing the piston starting on the backward or intake stroke;

Figure 6 is an enlarged view of a portion of the cylinder and piston shown in Figure 5;

Figure 7 is an enlarged longitudinal section through the electric vibrator 20.

The apparatus comprises a base A on which are symmetrically mounted two power units B and C, respectively, connected by an intermediate compressor chamber D. Each of the power units B and C contains a reciprocable element, and the arrangement is such that the movements of the elements are always equal and in opposite directions. The reciprocable element in the particular construction illustrated is a cylindrical piston 10 adapted for horizontal movements in a surrounding cylinder 11. The cylinder is arranged centrally of a magnetic housing 12 which has an annular slot 13 therein arranged between the central core 14 and the surrounding wall 15. Within the annular recess is arranged a magnetizing coil 16 which when energized induces a magnetic field in the housing 12. At the open end of the housing there is preferably arranged an annular pole piece 17 projecting inwardly from the outer wall 15 and forming an annular passage 18 in which the magnetic field is concentrated.

The motive power for the device is obtained by placing in the annular space 18 an electric vibrator 20 consisting of a coiled conductor through which alternating current is caused to flow. This vibrator is secured to the reciprocable piston 10 through the medium of a spider member 21. The vibrator is also disposed between two coiled springs 22 and 23 adapted to normally maintain the vibrator in a central position within the magnetic field.

With the arrangement thus far described, whenever an alternating current of predetermined frequency is passed through the coil of the vibrator 20 forces are set up in the vibrator tending to move the vibrator relative to the housing alternately in opposite directions for each alternation of the electric current. It is an essential feature of my invention that the resiliency of the springs 22 and 23 be so proportioned to the mass of the vibrating element that the natural period of vibration of this element corresponds to the frequency of the alternating current. In other words, assuming that a 60 cycle alternating current is impressed on the coil of the vibrator, it is necessary then that the vibration period of the vibrator 20, the piston 10 and the parts connected thereto be exactly 60 cycles per second. With this condition of tuning between the mechanical vibration period of the vibrator and the electrical frequency of the current, the amplitude of vibration of the vibrator will be built up to an appreciable value determined by the electrical characteristics of the vibrator and the device becomes a reciprocating electric motor vibrating with true harmonic motion.

As heretofore set forth, there are two power units B and C and each of these units contains identical parts, the arrangement being such that the electric current in any given instant flows oppositely through the vibrators with respect to the magnetism in the respective units. Thus the mechanical movements of the vibrating elements are always in opposite directions and by having identical units B and C the power impulses are exactly equal in the opposite directions. This arrangement places the device in balance and eliminates vibration of the machine as a whole.

My invention may be embodied in various specific constructions depending upon the character of the work to be performed by the device, but I will now describe more in detail a preferred construction as illustrated in the drawings.

The piston 10 has a longitudinal passageway 25 extending completely through the same commu-

nicating at the outer end with the chamber 26 formed within the cap 27. The chamber 26 is in open communication with the sump 28 in the base A, there being a radial port opening 29 in the housing 12 for this purpose. At the inner end of the hollow piston 10 there is a disk valve 30 which seats against the end face 31 of the piston. The disk 30 is preferably of polygonal shape and of a size to fit within the cylinder 11 and be guided thereby. The flat portions 32 of the disk provide the necessary clearance for permitting the escape of fluid past the valve. The valve is assembled to the piston by means of a link 33 fastened at one end to the center of the disk valve and at the other end to a pin 34 in the piston. The link forms a lost motion connection which, as shown, is due to the looping of the link over the pin with a slight clearance. The cylinder 11 is formed with an end shoulder 35 against which a disk valve 36 normally rests. This valve as shown has an out-turned annular flange 37 for guiding the valve spring 38 which in turn is held in position by the cap 39 threaded to the projecting portion 40 of the cylinder 11. The cap is provided with a central aperture 41 and is arranged in its entirety within the compression chamber D.

The central passage 25 in the piston is provided with a Venturi portion 42. The piston also has radial bores 43 leading outwardly from the throat of the venturi to an annular recess 44 on the outer surfaces of the piston. This recess is at all times in communication with the downwardly extending passage 45 in the housing from which a tube 46 leads to the bottom of the sump 28. 47 represents the inlet port to the sump and 48 represents the outlet from the compression chamber D. As shown, this chamber has radial flanges 49 for dissipating the heat of compression.

The compressor may be used with any suitable medium but where it is to be used for a refrigerating apparatus a desirable refrigerant is methyl chloride. The inlet 47 is connected to the low pressure side of the refrigerating apparatus and the outlet 48 to the high pressure side. The methyl chloride and lubricant are returned to the sump 28 through the inlet 47 and the lubricant settles to the bottom of the sump while the methyl chloride gas fills the balance of the sump and circulates into each of the units B and C through the radial passages 29, annular recesses 13 and outer chambers 26. During the reciprocation of the piston 10 the gas in the cylinder 11 between the valves 30 and 36 is compressed by the inward movement of the piston and escapes into the compression chamber D. In the outward stroke of the piston the gas is drawn through the central passage 25 and venturi 42 past the valve 30 into the space between said valve and the check valve 36. The aspirating effect of the venturi causes lubricant to be drawn into the venturi from the sump 28 and mix with the refrigerant. Thus the reciprocation of the piston 10 builds up a pressure within the chamber D.

Figure 4 shows an electrical diagram of the preferred circuits in which 50 represents a transformer having a primary 51 adapted to operate on the ordinary line voltage such, for example, as 110 volts 60 cycle A. C. The secondary 52 of the transformer is adapted to deliver the desired voltage for any particular construction and in the example illustrated is wound to deliver $6\frac{2}{3}$ volts. The vibrator coils 20b and 20c are connected in series with the secondary 52 while the center tap 54 of the transformer is grounded and connected

intermediate the coils 20b and 20c. In order to obtain a constant magnetic field for the field coils 16b and 16c a rectifier 55 is connected to the secondary and this in turn is connected through the coils 16b and 16c to the grounded center tap 54 in such a way as to produce opposite magnetic effects.

For convenience in passing the current through the coils 20 of the apparatus illustrated in Figure 1 the cap 27 of each power unit is connected to but insulated from the housing 15. This is accomplished by inserting insulation 56 between the flanges 57 and 58 which in turn are secured together by the bolts 59. Each cap 27 is provided with a suitable binding post 60. The coil spring 22 thus serves to connect the cap 27 to one end of the coil 20 while the opposite end of the coil 20 is connected to the spider 21, which in turn is grounded on the housing 12 by the coiled spring 23.

Referring now more particularly to the specific construction of the power units, it will be noted that the outer casing 12 has a conical inner surface 61 in which is seated the correspondingly shaped end of the core 14. The cylinder 11 has an annular flange 62 thereon adapted to abut the outer face of the housing 12 and has a threaded portion 63 for engaging the core 14, thus clamping the core and housing together and forming a composite structure. The outer end of the core 14 is provided with a series of slots 64 for receiving the arms 65 of the spider 21. This spider has a hub 66 secured to the outer end of the piston 25 and clamped against a shoulder 67 by the clamping nut 68 threaded on the piston. The spider arms are connected by a continuous ring 69 forming an abutment for the inward end of the conducting coil 70. This coil preferably consists of a continuous helix of copper or other suitable conductor, the leaves of which are substantially rectangular in cross section. Between the adjacent convolutions of the helical conductor are inserted steel washers 71 split on one radius to permit following the contour of the helix. These washers are insulated from the copper helix by identical washers 72 made of insulating material, the steel and insulating washers having an inner diameter such as to bear on the edges of the spider arms. In order to secure the helix and intermediate washers in one compact unit a series of bolts 73 (preferably three in number as shown) are inserted through coincident perforations in the convolutions. Each bolt is insulated from the convolutions by an insulating tube 76. The head 74 of the bolt is inserted in a recess in the flange 69 and insulated therefrom by a suitable washer 75. 77 is a clamping ring to which the bolts 73 are threadedly secured, thereby clamping the helix and intermediate washers into a compact unit. The ring has an annular flange 78 projecting into the inner end of the coil spring 22. It will be observed that the helical coil has one end thereof electrically contacting with the clamping ring 77 and the other electrically contacting with the flange 69 of the spider member. The electric circuit is from the cap 27 through coil spring 22, clamping ring 77, helical coil 70, flange 69 and coil spring 23 to the housing 12 which acts as a ground and is suitably connected to the grounded center tap of the secondary coil of the transformer. Thus the coil springs serve not only to introduce the required resiliency to mechanically tune the apparatus to the frequency of the alternations but also serve to conduct the alternating current to the reciprocating helical

coil 70. The springs 22 and 23 are always under compression so as to be always held by continuous compression against the insulated surface 27 and the grounded surface of the frame 12 so as to have sufficient pressure to complete the electric circuit through the springs 22 and 23 and the helical conductor 70 at all times. These springs therefore always have non-reversible stresses. In other words, these springs are never subjected to a reverse stress when the device is in operation.

From the foregoing description it will be observed that I have provided an improved form of harmonic compressor which is entirely free from rotating parts and is operable from an ordinary alternating current supply line. While I have described the apparatus in considerable detail, it is to be understood that the invention is capable of being embodied in various other forms.

What I claim as my invention is:

1. The combination of a magnetic field element, an element in the field for carrying alternating current, one of said elements being fixed and the other being movable with respect thereto, an oppositely acting alternating current supply of predetermined frequency connected to the second element and constituting the sole actuating current of the device and resilient means interposed between said movable and fixed elements at separated points and having a predetermined resiliency adapted to impart to said movable element a natural period of vibration corresponding to the frequency of the alternating current.

2. The combination of a magnetic field element, an element in the field for carrying alternating current, one of said elements being fixed and the other being movable with respect thereto, an oppositely acting alternating current supply of predetermined frequency connected to the second element and resilient means interposed between said movable and fixed elements at separated points and having a predetermined resiliency adapted to impart to said movable element a natural period of vibration corresponding to the frequency of the alternating current and a compressor mechanically connected to said movable element.

3. An alternating current electrically operated pumping apparatus comprising a cylinder, a piston reciprocable therein, valves for feeding fluid to said cylinder, a helical coil coaxial with said piston, means for passing an alternating current of predetermined frequency through said coil, means for producing a substantially constant magnetic field around said coil and means mechanically connected to said coil for producing a predetermined resiliency adapted to impart to said movable element a natural period of vibration corresponding to the frequency of the alternating current.

4. An alternating current electrically operated pumping apparatus comprising a magnetic housing having an annular gap, a helical coil mounted for reciprocation within said annular gap, means for energizing said coil with alternating current of predetermined frequency, a coaxial piston connected to said coil to reciprocate therewith, a cylinder for said piston, springs on opposite sides of said coil, the mass of said reciprocating parts being so proportioned with respect to the resiliency of said springs as to impart a natural period of vibration corresponding to the frequency of the alternating current.

5. Electrically operated pumping apparatus

comprising a pair of coaxial reciprocating compressors, and separate means for electrically reciprocating the respective compressors always in opposite directions.

6. Electrically operated pumping apparatus comprising a pair of coaxial reciprocating compressors, resilient means connected to each of said compressors adapted to impart thereto a predetermined natural vibration period, and electrical means for urging the respective compressors always in opposite directions in synchronism with said natural vibration period.

7. In an apparatus of the class described, outer and inner magnetic pole pieces having an annular gap therebetween, a vibrator mounted for reciprocation in said annular gap comprising a helical conductor, and magnetic members interposed between the adjacent convolutions of said helical conductor.

8. Electrically operated pumping apparatus comprising a compression chamber, a pair of coaxial cylinders communicating with said compression chamber, pistons in each of said cylinders, an annular vibrator connected to each of said pistons, a magnetic housing surrounding each cylinder and having an annular gap embracing said vibrator, a magnetizing coil for the magnetic housing, resilient means connected to opposite ends of said vibrator and adapted to impart a natural vibration period to said vibrator corresponding to the frequency of alternating current, an electric coil in said vibrator and means for passing alternating current through said coil, the helical coil being so disposed with respect to the magnetic field in the corresponding magnetic housing that each of said vibrators is urged always in the opposite direction from the other vibrator.

9. Electrically operated pumping apparatus, comprising two coaxially reciprocating compressor members of substantially equal mass, separate means for simultaneously reciprocating them in opposite directions at substantially the same speed.

10. Electrically operated pumping apparatus comprising two coaxially reciprocating compressor members, separate actuating means for reciprocating them in opposite directions at substantially the same speed, and a compression chamber located intermediate the compressor members' actuating means into which the material acted upon is discharged by the compressor members.

11. Electrically operated pumping apparatus comprising a reciprocating pumping element, electric means for reciprocating said pumping element, a spring associated with said reciprocating pumping element for elastically resisting the reciprocating movement of said element, said spring being under compression at all times during the reciprocation of said pumping element, so that it is never subjected to reverse stress when the apparatus is in operation.

12. Electrically operated pumping apparatus comprising a reciprocating pumping element, electric means for reciprocating said pumping element, a spring associated with said reciprocating pumping element for elastically resisting the reciprocating movement of said element, means for preventing a reversal of stress in said spring when the apparatus is in operation.

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