May 9, 1950 J. A. MAS 2,506,727

VIBRATOR DEVICE

Filed Nov. 27, 1944 5 Sheets-Sheet 1

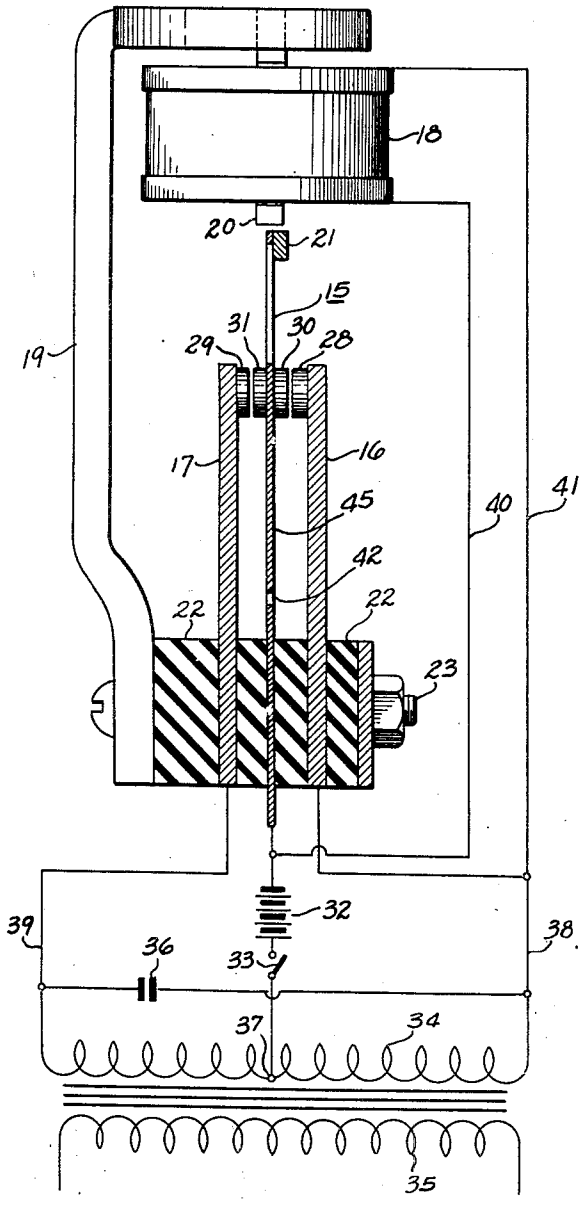


Fig. 1

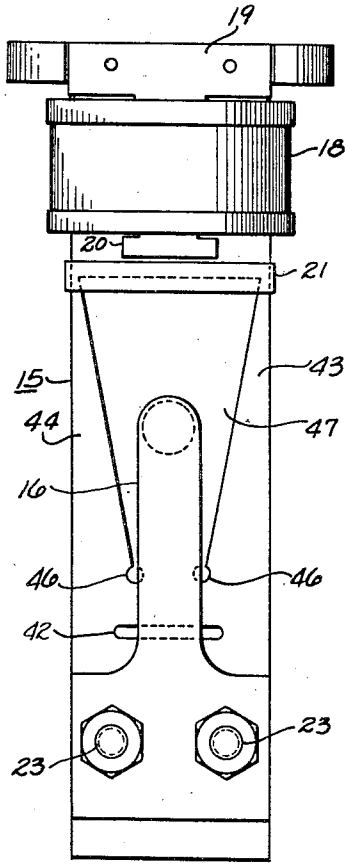


Fig. 2

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May 9, 1950 J. A. MAS 2,506,727

VIBRATOR DEVICE

Filed Nov. 27, 1944 5 Sheets-Sheet 2

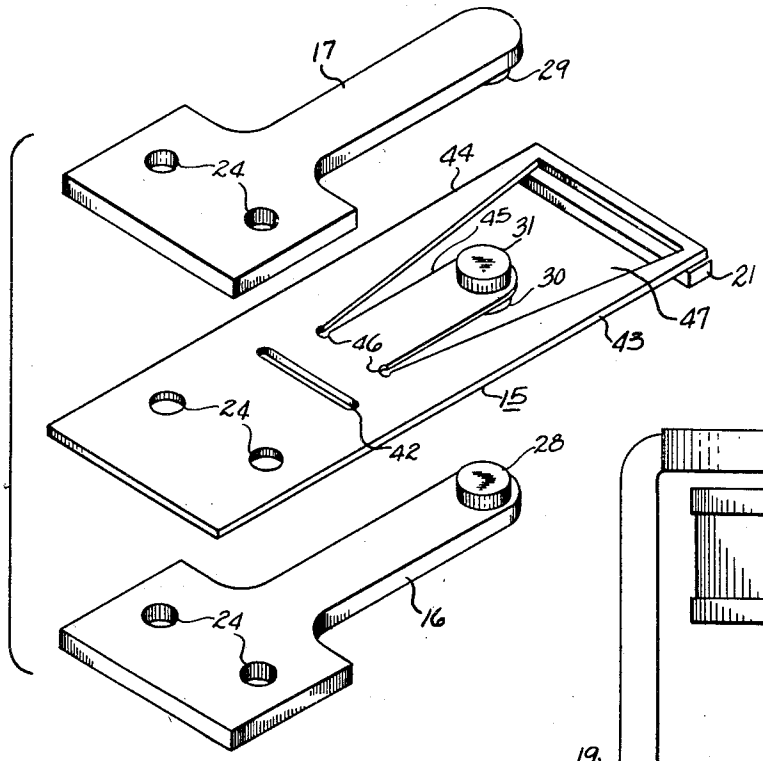


Fig. 3

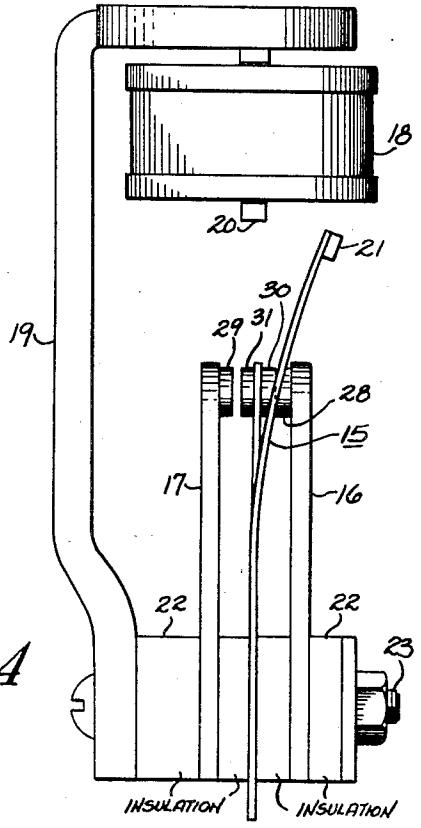


Fig. 4

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May 9, 1950 J. A. MAS 2,506,727

VIBRATOR DEVICE

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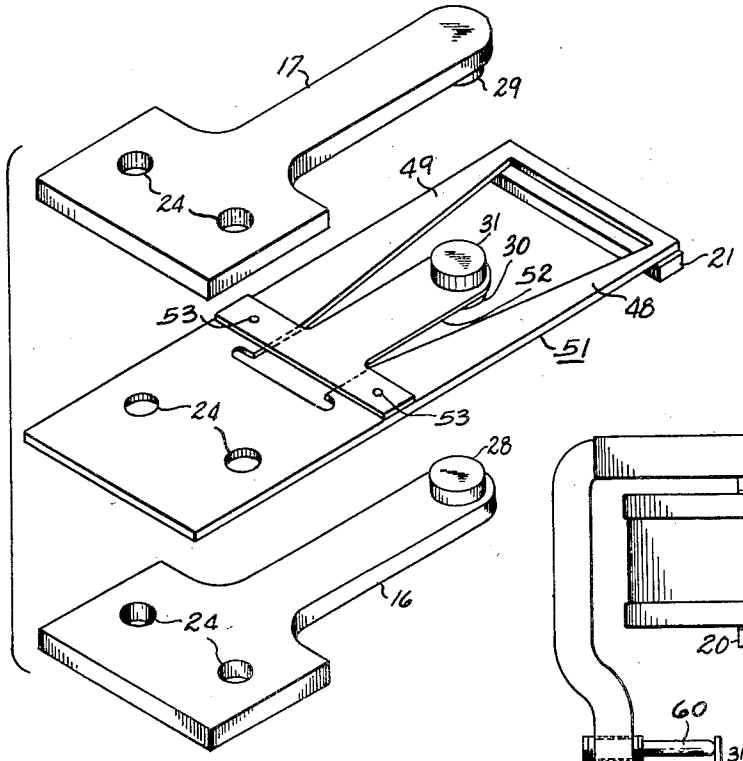


Fig. 5

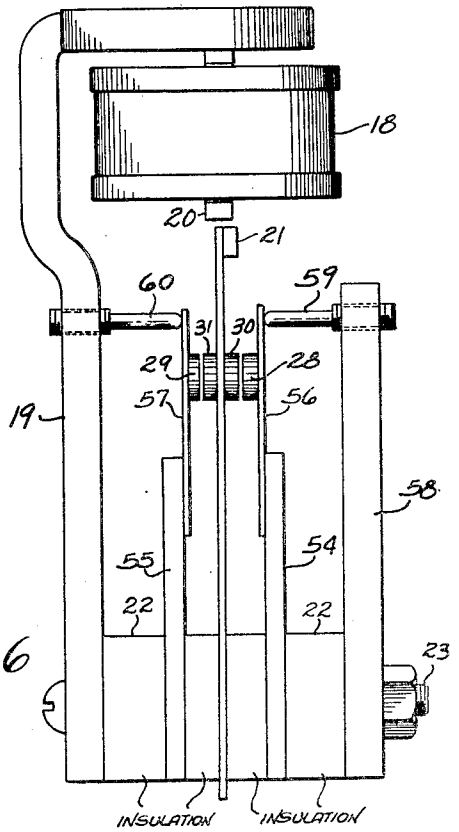


Fig. 6

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May 9, 1950 J. A. MAS 2,506,727

VIBRATOR DEVICE

Filed Nov. 27, 1944 5 Sheets-Sheet 4

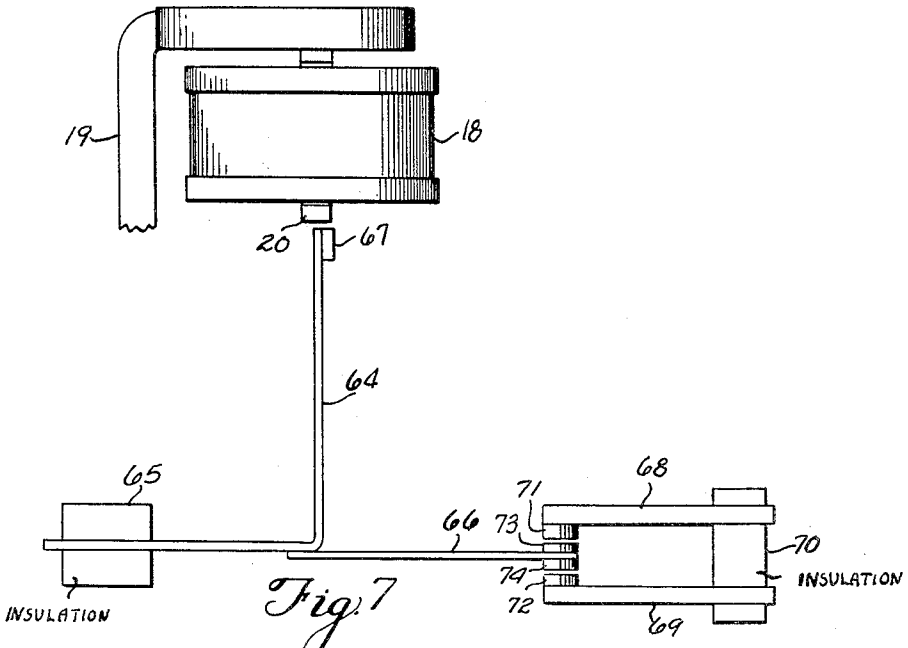


Fig. 7

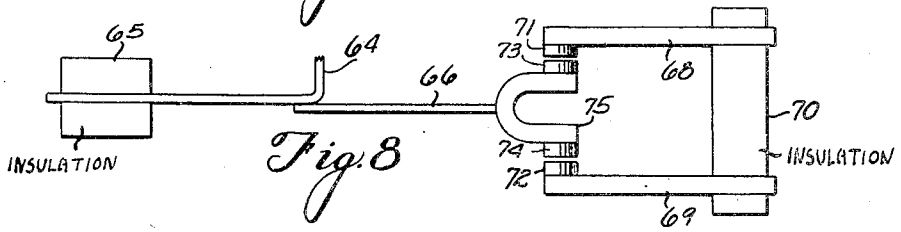


Fig. 8

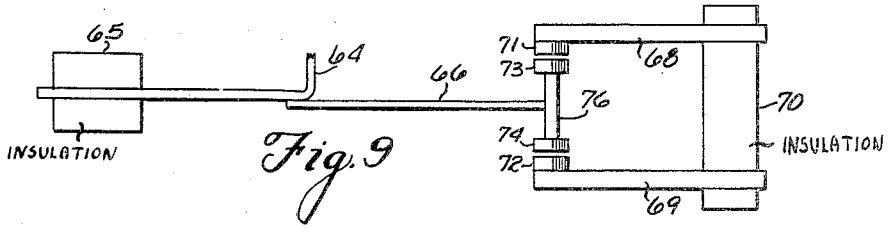


Fig. 9

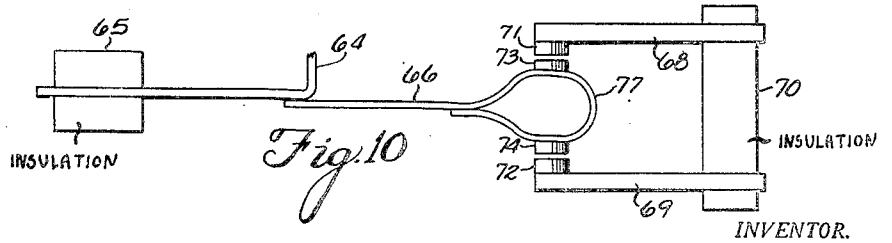


Fig. 10

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May 9, 1950 J. A. MAS 2,506,727

VIBRATOR DEVICE

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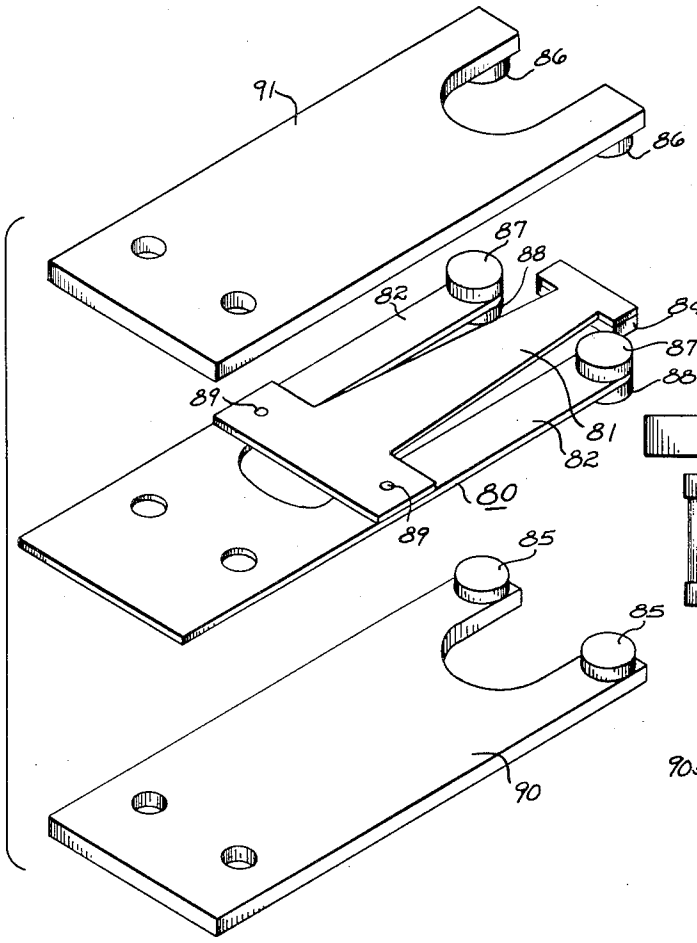


Fig. 11

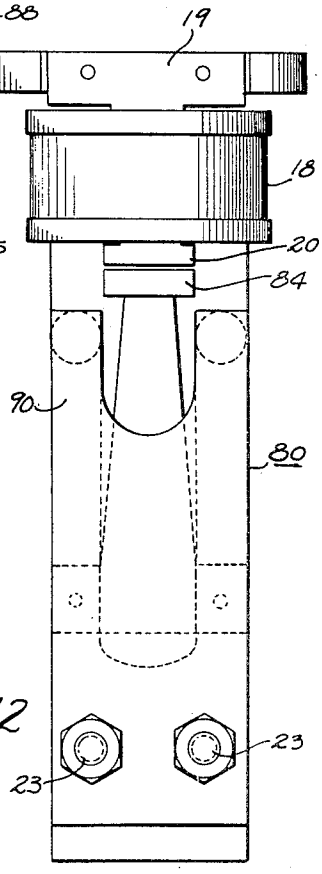


Fig. 12

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Patented May 9, 1950

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UNITED STATES PATENT OFFICE

2,506,727

VIBRATOR DEVICE

Joseph A. Mas, Indianapolis, Ind., assignor, by mesne assignments, to Cornell-Dubilier Electric Corporation, South Plainfield, N. J., a corporation of Delaware

Application November 27, 1944, Serial No. 565,297

13 Claims. (Cl. 200—90)

1

My invention relates in general to vibrator devices and more particularly to vibrator devices adapted to interrupt electric current.

In the operation of vibrator devices and particularly those employed for supplying an interrupted direct current to a transformer for producing alternating current, it is highly important that the amplitude and frequency of the vibrator be maintained practically constant even under conditions of varying voltage of the direct current source. It has been found that it is substantially impossible to convert the present vibrator design for relatively low frequency operation into a high frequency structure by selecting and choosing component parts of different sizes and proportion. Thus, for example, a vibrator design for a frequency of 100 cycles per second cannot be converted into a vibrator for 300 cycles per second by merely changing or selecting the component parts to have different constants to meet the higher frequency requirements.

Desirable characteristics for a successful high frequency vibrator device are as follows:

(1) Low loss per cycle
(2) Contact pressures no higher than those employed at medium or low frequency operation
(3) The use of good sized contacts
(4) High stability of frequency
(5) High speed of make and break of contact
(6) No selection of component parts
(7) High controlled time-constant
(8) Mechanical simplicity and easy and low cost of manufacture

An object of my invention is the provision of a vibrator device which accomplishes the above mentioned desirable characteristics.

Another object of my invention is the provision in a vibrator device of attaching a contact system to a driver oscillating member in such a manner as to draw as little energy as possible from the driver oscillating member while at the same time maintaining the desirable characteristics mentioned above.

Another object of my invention is the provision of having a light coupling between the driver oscillating member and the contact system.

Another object of my invention is the provision of a primary oscillating system for driving a secondary oscillating system including contacts in which most of the energy in the secondary system is returned to the primary oscillating system.

Another object of my invention is the provision of a primary oscillating system for driving a secondary oscillating system including contacts in

2

which there is very little loss in the secondary oscillating system.

Another object of my invention is the provision of limiting the travel of the vibrating contact which is carried by the secondary oscillating system, whereby the secondary oscillating system is prevented from oscillating at its resonant frequency.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a side elevational view of a vibrator device embodying the features of my invention, parts being shown in section to illustrate the construction of the vibrating parts, the vibrator device being also connected in circuit relation with a transformer for producing alternating current;

Figure 2 is a front view of the device shown in Figure 1;

Figure 3 is an exploded perspective view of the parts which carry the current interrupting contacts;

Figure 4 is a side view of the device shown in Figure 1, with the vibrating element shown in one of its extreme vibrating positions;

Figure 5 is an exploded perspective view similar to Figure 3, but shows a modified form of the intermediate or vibrating element;

Figure 6 shows a modified form of my invention, in that the stationary contacts are carried by a compliant member which produces a shock absorber effect;

Figure 7 is a further modified form of my invention and shows generally in a diagrammatic manner the principle of operation;

Figure 8 is a modified showing of the invention in Figure 7, in that the movable contacts are mounted in a back-to-back manner upon a U-shaped support;

Figure 9 is a further modified form in that the vibrating contacts are mounted in a back-to-back position upon a cross-bar;

Figure 10 is a further modified showing of the mounting of the vibrating contacts, in that they are mounted upon a looped compliant member;

Figure 11 is an exploded perspective view of a further modified form of my vibrating element; and

Figure 12 is a view similar to Figure 2 and embodies my vibrating element shown in Figure 11.

With reference to Figure 1 of the drawing, my

vibrator device comprises generally a vibrating element 15, two oppositely disposed contact support members 16 and 17, a magnetizing coil 18 for driving the vibrating element 15, an insulating block assembly 22 for supporting the vibrating element 15 and the two oppositely disposed contact support members 16 and 17, and a frame support 19 for supporting the magnetizing coil 18. The insulating block assembly 22 may comprise a plurality of insulating spacer members which are held together by through-bolts 23. Provided upon the upper end of the vibrating element 15 is a cross-bar 21 constituting a mass which is magnetically driven by the pole 20 which is magnetized by the magnetizing coil 18. As shown in Figure 3, the lowermost ends of the vibrating element 15 and the two side contact support members 16 and 17 have holes 24 through which the bolts 23 extend for securely mounting the vibrating element 15 and the side contact support members 16 and 17 to the insulating block assembly. The upper ends of the contact support members 16 and 17 carry, respectively, contacts 28 and 29. Mounted between the two contacts 28 and 29 are two vibrating contacts 30 and 31 which are mounted in a back-to-back relationship with respect to each other upon the vibrating element 15.

The interrupting contacts are disposed to supply an interrupted current to a primary winding 34 of the transformer for developing alternating current in a secondary winding 35. In this circuit arrangement a battery 32, or any other source of direct current, is adapted to be connected between the vibrating element 15 through means of a switch 33 to a center tap 37 of the primary winding of the transformer. The opposite ends of the primary winding of the transformer are connected respectively to the oppositely disposed contact support members 16 and 17 through conductors 38 and 39. A condenser 36 is connected across the conductors 38 and 39. The magnetizing coil 18 is arranged to be energized through conductors 40 and 41.

With reference to Figure 3 of the drawing, the vibrating element 15 is constructed to have a primary vibrating portion consisting of the side portions 43 and 44 and a secondary vibrating portion consisting of the intermediate projecting portion 45. The side portions 43 and 44 carry the cross-bar mass 21 and may be arranged to vibrate at a predetermined frequency which is a function of the compliance of the side portions 43 and 44 and the mass 21.

As illustrated, the vibrating element 15 is provided with a transverse slot or aperture 42 to provide a hinge effect for the vibrating movement of the system. The intermediate projecting portion 45 is arranged to carry the vibrating contacts 30 and 31 which constitute a mass for the secondary vibrating system which has a resonant frequency separate from the resonant frequency of the primary vibrating system consisting of the side portions 43 and 44 and the mass 21. The resonant frequency of the secondary vibrating system including the intermediate projecting portion 45 and the contacts 30 and 31 is a function of the compliance of the projecting portion 45 and the mass of the contacts 30 and 31. In the construction shown in Figure 3, the resonant frequency of the secondary vibrating system consisting of the projecting portion 45 and the mass of the vibrating contacts 30 and 31, is higher than the resonant frequency of the primary vibrating system consisting of the side portions 43 and 44 and the mass 21. The projecting portion 45 is substantially in the same plane as the side portions 43 and 44 and vibrates in the cut-away portion or aperture 47 of the vibrating element 15. Stress relieving holes 46 may be provided in the vibrating element 15 in the region where the side edges of the projecting portion 45 meet with the inside edges of the side portions 43 and 44.

In operation, the vibrating element 15 is caused to vibrate under the influence of the pole which is energized by the magnetizing coil 18. The primary vibrating system consisting of the side portions 43 and 44 and the mass 21 is free to vibrate at its resonant frequency which is a function of the compliance of the side portions 43 and 44 and the mass 21. The vibrating movements of the primary vibrating system drive the secondary vibrating system which oscillates the vibrating contacts 30 and 31 between the stationary contacts 28 and 29. The travel of the vibrating movements of the secondary oscillating system is limited upon the vibrating contacts 30 and 31 engaging, respectively, the stationary contacts 28 and 29 which are rigidly supported since the contact supporting members 16 and 17 are substantially non-compliant. The vibrating contacts 30 and 31 are also substantially non-compliant since they are mounted in a back-to-back relationship with respect to each other upon the intermediate projecting portion 45. Accordingly, my invention comprises substantially non-compliant vibrating contact members operating between substantially non-compliant stationary contact members. The open circuit distance between one set of contacts, for example 28 and 30, when the other set of contacts 29 and 31 is closed, is less than the amplitude of a resonant frequency cycle of the vibrating projecting portion 45 under conditions of free vibration. In other words, the non-compliant oppositely disposed contact supporting members 16 and 17 and the non-compliant construction of the contacts limits the travel of the vibrating movement of the secondary vibrating system consisting of the intermediate projecting portion 45 and the contacts 30 and 31 to a distance less than the amplitude of a resonant frequency cycle of the secondary vibrating system under conditions of free vibration. In my vibrating element 15 the secondary vibrating system which carries the vibrating contacts 30 and 31 draws very little energy from the primary vibrating system because the projecting portion 45 is compliant and constitutes a light coupling between the two systems. Although the secondary vibrating system has a higher resonant frequency than the primary vibrating system, the compliance of the projecting portion 45 is much larger than the compliance of the side portions 43 and 44. Inasmuch as the distance of travel of the vibrating contacts 30 and 31 is very short, very little energy is stored in the secondary vibrating system so that the losses accompanying its travel are maintained to a minimum small value. Also, most of this energy is returned to the primary vibrating system. Since the compliance of the projecting portion 45 is large compared to the compliance of the side portions 43 and 44, the contact pressure is relatively low and is comparable to those at medium frequencies in devices heretofore manufactured. My system provides high speed make-and-break of the contacts because of the high resonant frequency of the secondary vibrating system. In other words, the vibrating contacts 30 and 31 move relative to the side portions 43 and 44 so that this relative speed is additive to the

actual speed of the side portions 43 and 44 with the result that the time required for the vibrating contacts 30 and 31 to move across the gap is greatly reduced. In Figure 3, since the transverse slot 42 is relatively close to the base of the intermediate projection portion 45, the time of travel of the vibrating contacts 30 and 31 between the stationary contacts 28 and 29 is determined principally by the resonant frequency of the projecting portion 45. However, any movement of the side portions 43 and 44 is additive to the movements of the projecting portion 45 to reduce the time for the vibrating contacts to move between the stationary contacts.

The stability of frequency of my vibrator device is high inasmuch as there is little drain of energy from the primary vibrating system to the secondary vibrating system. This is because of the light coupling afforded by the relatively large compliance of the projecting portion 45. The loss per cycle is also very low.

In the making of vibrators as found in the prior art, the selection of the component parts had to be made very carefully in order to insure a high stability of frequency. In fact, the construction of a vibrator is comparable to watch making. In my invention, the selection of the component parts is not nearly so critical, since the resonant frequency of the primary vibrating system is not materially affected by driving the secondary vibrating system since the drain of energy is very small. It has been found that my design takes the manufacture of high frequency vibrators out of the so-called watch making type of skill and requires a minimum of care in the selection of component parts. Consequently, the mechanical simplicity of this type of structure makes possible easy and low cost of manufacturing. In addition, because of the fact that my device has a high stability of frequency, its amplitude and frequency stays practically constant for wide ranges in the voltage of the direct current battery or other source. Summarizing briefly, the frequency of the interruptions is determined primarily by the product of the compliance of the side portions 43 and 44 and the mass 21 and the speed of the make-and-break is determined primarily by the product of the compliance of the projecting portion 45 and the mass of the vibrating contacts 30 and 31.

In Figure 5 of the drawing I show a modified form of the vibrating element which is designated generally by the reference character 51. In this modified form the intermediate projecting portion 52 is riveted or otherwise connected at 53 to the side portions 48 and 49. The vibrating intermediate portion 52 lies in a plane which is substantially parallel to the plane of the side portions 48 and 49. In this form of my invention I preferably make the compliance of the projecting portion 52 such that the secondary vibrating system which carries the vibrating contacts has a higher resonant frequency than that of the primary vibrating system. However, this arrangement provides a construction whereby the resonant frequency of the secondary vibrating system may be substantially the same as that of the primary vibrating system or the resonant frequency may be less than that of the primary vibrating system.

In Figure 6 I show a modified form of supporting the stationary contacts 28 and 29 in that they are mounted upon compliant support members 56 and 57, respectively, to give a shock absorber effect. The lower ends of the compliant support members 56 and 57 may be connected, respectively, to substantially non-compliant support members 54 and 55. The upper ends of the compliant support members 56 and 57 are arranged to be backed up by adjusting screws 59 and 60. The adjusting screw 60 may be threadably connected in the frame support 19 and the adjusting screw 59 may be threadably connected to an upright member 58 carried by the insulating block assembly. In this construction the stationary contacts 28 and 29 are disposed to give a little bit as they are engaged by the vibrating contacts, but the amount of the give is held within controlled limits.

In Figure 7 I illustrate diagrammatically a system which embodies the principle of my invention and comprises an L-shaped primary vibrating element 64 supported by a block 65 and is arranged to be actuated by the pole 20 of the magnetizing winding 18. The secondary vibrating element is indicated by the reference character 66 and carries vibrating contacts 73 and 74 which oscillate between stationary contacts 71 and 72, respectively. As illustrated, the stationary contacts 71 and 72 are carried respectively by substantially non-compliant support members 68 and 69 which are rigidly connected to the supporting block 70. A mass 67 is connected to the upper end of the primary vibrating element 64 and this mass in combination with the compliance of the vibrating element 64 determines the frequency of vibration. The speed of travel at which the vibrating contacts 73 and 74 move between the stationary contacts 71 and 72 is determined principally by the compliance of the secondary vibrating element 66 and the mass of the vibrating contacts 73 and 74.

In Figure 8 I show a modified form of Figure 7 in that the stationary contacts 73 and 74 are carried by a U-shaped member 75 which is substantially non-compliant. In other words, the U-shaped member 75 connects the vibrating contacts 73 and 74 in a back-to-back relationship having substantially no compliance therebetween. Because of the mass of the U-shaped member 75, together with the mass of the vibrating contacts 73 and 74 being relatively large, the resonant frequency of the secondary system is lower in Figure 7 than the resonant frequency of the primary vibrating system. In Figure 7, the resonant frequency of the secondary system is higher than that of the primary system.

In Figure 9 the stationary contacts 73 and 74 are connected in a back-to-back relationship by a cross bar carrier 76 and in this construction the resonant frequency of the secondary system may be made the same as the resonant frequency of the primary system.

In Figure 10 I show a modified form of supporting the vibrating contacts in that they are mounted upon opposite sides of a looped compliant member 77. In this construction, the vibrating contact members 73 and 74 are mounted in a back-to-back relationship with respect to each other and have a small compliance therebetween to absorb the shock.

In Figures 11 and 12, I have illustrated a further modified form of a vibrating element which is indicated by the reference character 80. In this element, the primary compliant portion is indicated by the reference character 81 and carries a mass member 84 and the secondary compliant portion is indicated by the reference char-

acter 82. The primary compliant portion 81 is disposed between the two side members which comprise the secondary compliant portion. In Figure 11, the primary compliant portion 81 is riveted at 89 to the base of the two side members, although it is to be understood that the vibrating element may be made in one piece. Two sets of contacts are provided in this modified form. The oppositely disposed contact members 85 and 86 of which there are two sets, are carried respectively by the supporting members 90 and 91 which are relatively stiff. The vibrating contacts 87 and 88, of which there are two sets, are carried respectively by the two side members comprising the secondary compliant portion. The operation of the vibrating element 80 in Figures 11 and 12 is substantially the same as that described for the previously described vibrating elements.

From the foregoing description, it is noted that I have produced a vibrating element having two modes of vibration for driving the vibrating contacts. One of the modes of vibration, namely, that produced by the primary vibrating means determines substantially the frequency of the vibrating contacts and the other mode of vibration, namely that produced by the secondary vibrating means, determines substantially the speed at which the vibrating contacts move between the oppositely disposed contacts. The second mode of vibration is limited in its travel between the two relatively closely spaced oppositely disposed contacts. Free oscillation is thus prevented, but during the period of the cycle that movement occurs the speed is substantially independent of that of the primary vibrating means which is free to oscillate. In my invention, by reason of the fact that I have substantially two independent modes of vibration, there is substantially no upper limit to the high frequency value to which my vibrator may be designed. This is true because I am able to keep the two modes of vibration substantially independent since the secondary vibrating means includes a compliant member and draws very little energy from the primary vibrating means. Also, in view of the fact that the speed at which the vibrating contacts move between the oppositely disposed contacts is primarily a function of the secondary vibrating means, I am able to make the speed at which the contacts move between the oppositely disposed contacts substantially independent of the speed at which the primary vibrating means moves. The speed of the vibrating contacts may be materially faster than the speed of the primary vibrating means, or the speed may be the same as or slower than the primary vibrating means. My invention contemplates all three conditions. Since the two modes of vibration are substantially divorced from each other substantially no critical selection of the parts is necessary since one vibrating system does not materially affect the other vibrating system and I am able to accomplish all of the desirable characteristics requisite for the design of a vibrator device for high frequency operation.

Although I have described my invention with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example and that numerous changes in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

I claim as my invention:

1. In a vibrator device, oppositely disposed contact means adapted to face each other, a vibrating element disposed between said oppositely disposed contact means, said vibrating element comprising a first compliant portion and a second compliant portion, a first mass carried by the first compliant portion, and intermediate contact means carried by the second compliant portion and constituting a second mass, said intermediate contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, said vibrating contact surfaces being substantially rigidly supported with reference to each other, the open circuit distance between adjacent contact surfaces being less than the amplitude of a resonant frequency cycle of the second compliant portion under condition of free vibration.

2. In a vibrator device, oppositely disposed contact means adapted to face each other, means for substantially rigidly supporting the oppositely disposed contact means, a vibrating element disposed between said oppositely disposed contact means, said vibrating element comprising a first compliant portion and a second compliant portion, a first mass carried by the first compliant portion, intermediate contact means carried by the second compliant portion and constituting a second mass, said intermediate contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, said intermediate contact surfaces being substantially rigidly supported with reference to each other, the product of the first compliant portion and the first mass being greater than the product of the second compliant portion and the second mass.

3. In a vibrator device, oppositely disposed contact means adapted to face each other, substantially non-compliant means for supporting the oppositely disposed contact means, vibrating contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, a compliant element supporting the vibrating contact means, and compliant vibrating driver means for vibrating the vibrating contact means, said vibrating contact means comprising at least two contact members substantially rigidly mounted back-to-back with respect to each other upon the said compliant element.

4. In a vibrator device, oppositely disposed contact means adapted to face each other, substantially non-compliant means for supporting the oppositely disposed contact means, vibrating contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, a compliant element supporting the vibrating contact means, compliant vibrating driver means for vibrating the vibrating contact means, said vibrating contact means comprising at least two contact members, and substantially non-compliant means for mounting the contact members back-to-back upon the compliant element.

5. In a vibrator device, a vibrating element comprising a thin strip of compliant material, said strip having a first end portion adapted to be rigidly supported and having a second end portion adapted to be vibrated, said strip having a first and a second aperture intermediate said end portions, said first aperture being disposed next adjacent to the first end portion and said second aperture being disposed next adjacent to

the second end portion, said strip having a projecting portion extending into the second aperture, and first and second contact means carried back to back only on the said projecting portion.

6. In a vibrator device, oppositely disposed contact means adapted to face each other, substantially non-compliant means for supporting the oppositely disposed contact means, vibrating contact means having contact surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, substantially non-compliant means for supporting the vibrating contact surfaces with respect to each other, and compliant vibrating driver means compliantly connected to said vibrating contact means.

7. In a vibrator device having vibrating contact means and oppositely disposed contact means between which the vibrating contact means oscillates, the improvement of a vibrating element having two periods of free vibration for driving the vibrating contacts, one of said periods of vibration determining substantially the frequency of the vibrating contact means and the other period of vibration determining substantially the speed at which the vibrating contact means moves between the oppositely disposed contact means.

8. A vibrator including first and second fixedly displaced oppositely disposed contact means, first and second vibrating members each having first and second ends and each having a first and a second compliance, respectively, vibrating contact means having a given mass and adapted to contact said first and second contact means, substantially non-compliant means for mounting said vibrating means on said second end of said second vibrating member in a position to contact said first and second contact means, compliant means for connecting said first end of said second vibrating member to said first vibrating member for vibration therewith, means for rigidly mounting said first end of said first vibrating member relative to said first and second contact means, power means for vibrating said second end of said first vibrating member, and a weight fastened to said second end of said first vibrating member and having a first mass sufficient to cause the product of said first mass and said first compliance to be different than the product of said given mass and said second compliance.

9. A vibrator including first and second fixedly displaced oppositely disposed contact means, first and second vibrating members each having first and second ends and each having a first and a second compliance, respectively, vibrating contact means having a given mass and adapted to contact said first and second contact means, non-compliant means for mounting said vibrating contact means on said second end of said second vibrating member in a position to contact said first and second contact means, compliant means for connecting said first end of said second vibrating member to said first vibrating member for vibration therewith, means for rigidly mounting said first end of said first vibrating member relative to said first and second contact means, power means for vibrating said second end of said first vibrating member, and a weight fastened to said second end of said first vibrating member and having a first mass sufficient to cause the product of said first mass and said first compliance to be greater than the product of said given mass and said second compliance.

10. In a vibrator device, oppositely disposed contact means adapted to face each other, a vibrating element disposed between said oppositely disposed contact means, said vibrating element comprising a first compliant portion and a second compliant portion angularly displaced relative to each other, a first mass carried by the first compliant portion, and intermediate contact means carried by the second compliant portion and constituting a second mass, said intermediate contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, said vibrating contact surfaces being substantially rigidly supported with reference to each other, the open circuit distance between adjacent contact surfaces being less than the amplitude of a resonant frequency cycle of the second compliant portion under condition of free vibration.

11. A vibrator including first and second fixedly displaced oppositely disposed contact means, first and second vibrating members disposed substantially mutually perpendicular and each having first and second ends and each having a first and a second compliance, respectively, vibrating contact means having a given mass and adapted to contact said first and second contact means, substantially non-compliant means for mounting said vibrating contact means on said second end of said second vibrating member in a position to contact said first and second contact means, compliant means for connecting said first end of said second vibrating member to said first vibrating member for vibration therewith, means for rigidly mounting said first end of said first vibrating member relative to said first and second contact means, power means for vibrating said second end of said first vibrating member, and a weight fastened to said second end of said first vibrating member and having a first mass sufficient to cause the product of said first mass and said first compliance to be different than the product of said given mass and said second compliance.

12. In a vibrator device, oppositely disposed contact means adapted to face each other, a vibrating element disposed between said oppositely disposed contact means, said vibrating element comprising a first compliant portion and a second compliant portion, a first mass carried by the first compliant portion, a substantially non-compliant mounting carried by said second compliant portion, and intermediate contact means mounted on said mounting in a spaced relationship greater than the thickness of said second compliant portion, said intermediate contact means and said mounting constituting a second mass, said intermediate contact means having surfaces adapted to oscillate between and respectively engage the oppositely disposed contact means, the open circuit distance between adjacent contact surfaces being less than the amplitude of a resonant frequency cycle of the second compliant portion under condition of free vibration.

13. A vibrator including first and second fixedly displaced oppositely disposed contact means, first and second vibrating members each having first and second ends and each having a first and a second compliance, respectively, vibrating contact means having a given mass and adapted to contact said first and second contact means, substantially non-compliant means for mounting said vibrating contact means on said second end of said second vibrating member in a spaced rela-

tionship greater than the thickness of the second end of the second vibrating member and in a position to contact said first and second contact means, compliant means for connecting said first end of said second vibrating member to said first vibrating member for vibration therewith, means for rigidly mounting said first end of said first vibrating member relative to said first and second contact means, power means for vibrating said second end of said first vibrating member, and a weight fastened to said second end of said first vibrating member and having a first mass sufficient to cause the product of said first mass and said first compliance to be different than the product of said given mass and said second compliance.

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