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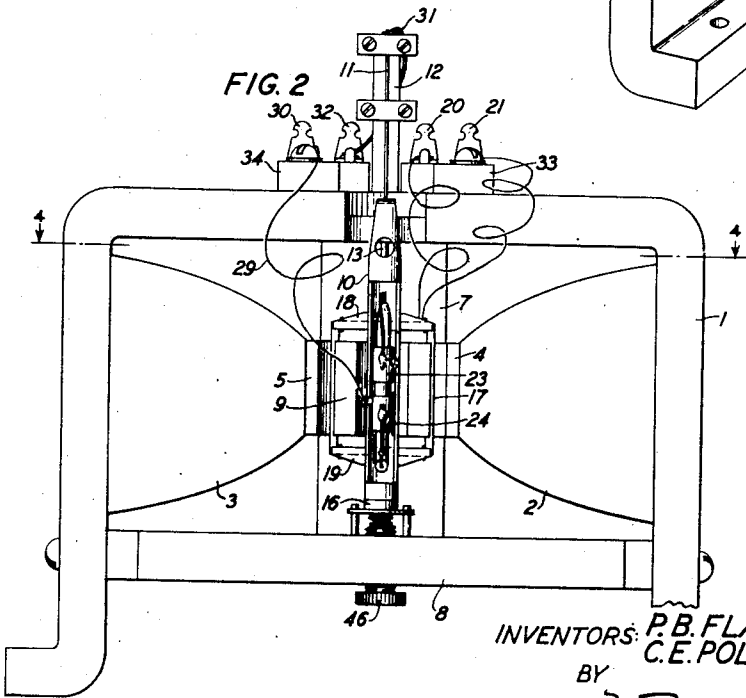
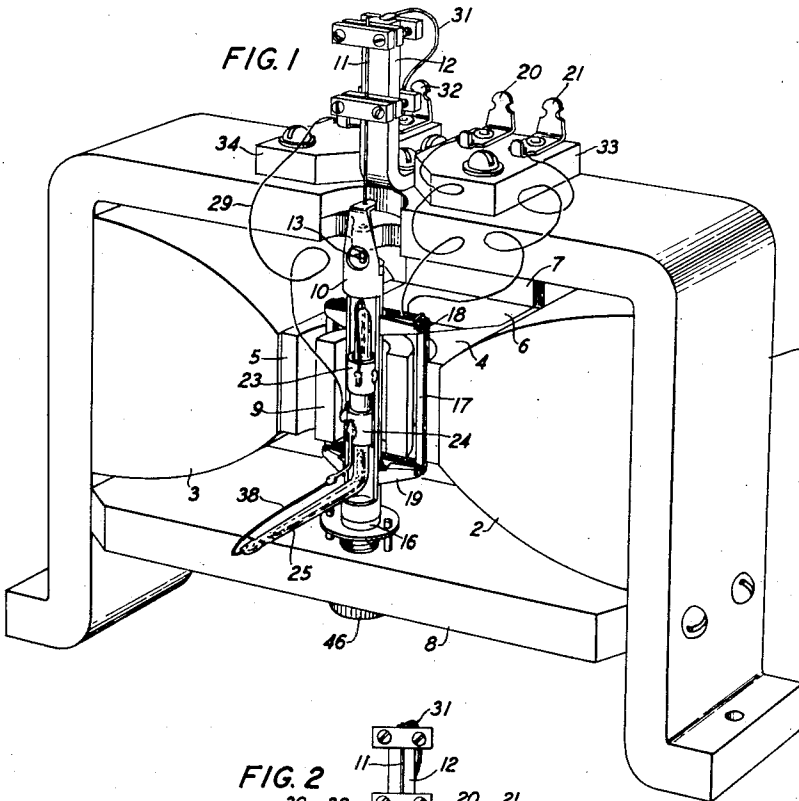
P. B. FLANDERS ET AL.

2,259,953

SWITCHING DEVICE

Filed June 15, 1940

3 Sheets-Sheet 1



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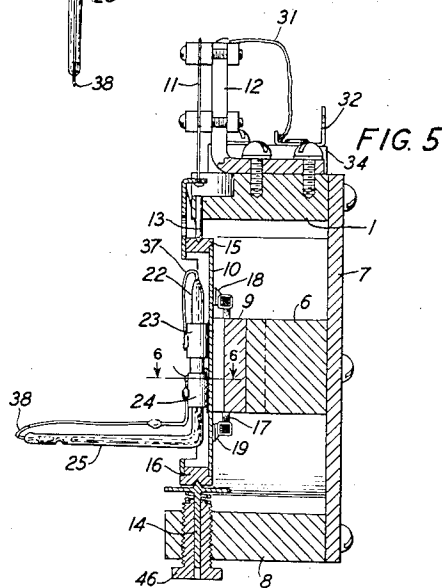
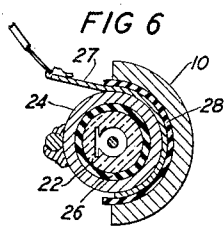
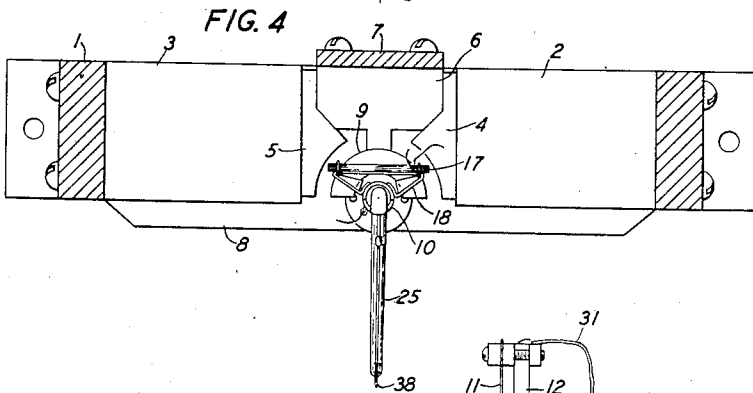
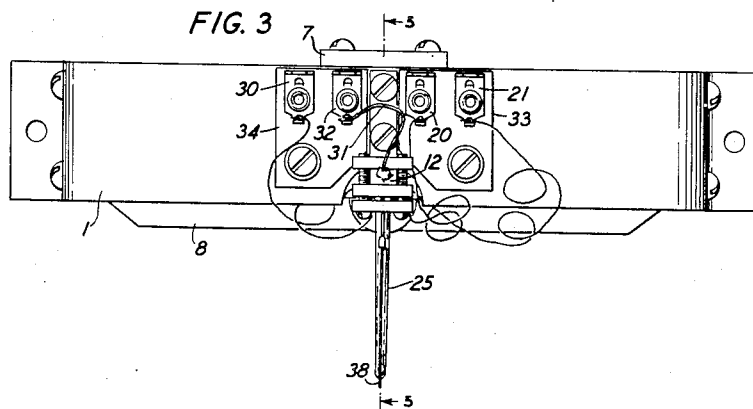
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3 Sheets-Sheet 2



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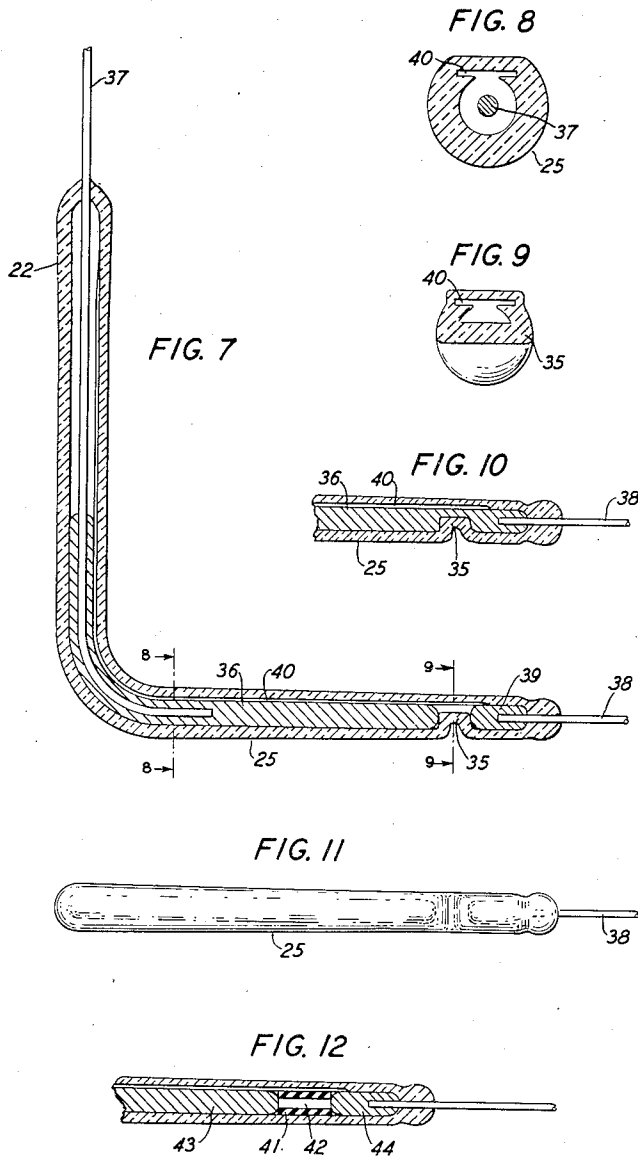
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SWITCHING DEVICE

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

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SWITCHING DEVICE

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Application June 15, 1940, Serial No. 340,664

7 Claims. (Cl. 200—80)

This invention relates to switching devices and particularly to relay switches for controlling electrical circuits.

The objects of the invention are to obtain a positive and steady closure of the electrical contacts of a relay in response to pulsating or alternating current; to obtain good electrical connections between the contact-making elements; to insure a positive opening of the contact elements when actuating current ceases to flow; to simplify the construction; and otherwise to improve these devices.

According to the present invention these objects are attained by means of a relay in which a tube, containing a mass of mercury and a pair of metallic terminals sealed therein, is arranged to be oscillated in such a way as to produce a centrifugal force tending to move the mercury mass toward one end of the tube. A baffle or barrier near the end of the tube separates the interior into a main chamber and a small auxiliary chamber at the extreme end of the tube. The mass of mercury normally rests in the main chamber where it constantly engages one of the metallic terminals. The auxiliary chamber also holds a small globule of mercury which it retains at all times, and the second metallic electrode of the pair projects through the end of the tube into the auxiliary chamber where it is immersed in the small mercury globule. The electrical connection between the two metallic terminals is made by vibrating the tube to force the main mass of mercury, through the constriction formed by the barrier, into the auxiliary chamber where it meets and merges with the globule therein. When the tube ceases to vibrate, the forces of surface tension, acting on the masses on each side of the barrier, produce a separation within the auxiliary chamber, and the main mass returns to its normal position in the main chamber. In so doing it withdraws from the auxiliary chamber substantially the same amount that entered under the centrifugal force of vibration, thus dividing the total into the main mass in the main chamber and the small globule that remains in the auxiliary chamber. With this provision the electrical connection between the metallic terminals is always made on the one hand by the merging of two masses of mercury and on the other hand is always broken by the division of a single mass into two separate parts.

A feature of the invention is a mercury relay switch of the kind above described in which the tube has a right-angle bend, forming a hori-

zontal section, which contains the auxiliary chamber and the major portion of the main chamber, and a vertical section, which contains an upper chamber or reservoir filled with any suitable gas. This reservoir communicates with the auxiliary chamber by means of a shallow duct or channel which is too small for the mercury to enter. The purpose of this duct is to enable the gas to pass the mercury mass in either direction between the gas reservoir and main and auxiliary mercury chambers. This maintains a uniform pressure on the mercury mass, thus preserving the normal forces of surface tension which serve to cause the separation and withdrawal of the main mass of mercury from the auxiliary chamber.

Another feature is a device of this character in which the movable element may be tuned to respond selectively to desired frequencies, and in which the centrifugal force that urges the mercury into the auxiliary chamber is so proportioned with respect to the forces that causes it to withdraw therefrom that the electrical connection is maintained uninterrupted as long as the tube is vibrated. The advantage of this arrangement is that a steady circuit closure may be obtained in response to a pulsating or alternating current of desired frequencies or frequency bands.

The foregoing and other features of the invention will be described more fully in the following specification.

In the drawings accompanying the specification:

Fig. 1 is a front perspective view of an alternating current relay embodying the features of the present invention;

Fig. 2 is a front plan view of the relay;

Fig. 3 is a top plan view of the relay;

Fig. 4 is a sectional view taken along line 4—4 in Fig. 2;

Fig. 5 is a sectional view taken along line 5—5 in Fig. 3;

Fig. 6 is an enlarged sectional view taken along line 6—6 of Fig. 5;

Figs. 7 to 11, inclusive, are enlarged views of the vibratory tube containing the mercury for performing circuit controlling operations, Figs. 7 and 10, respectively, showing the normal and operative conditions of the tube, Fig. 8 being a section taken along line 8—8, and Fig. 9 a section along line 9—9, of Fig. 7; and

Fig. 12 shows a modified form of the vibratory tube.

For the purpose of the present disclosure the

vibratory mercury-contact tube has been incorporated in a magnetic structure of the type similar to those used in galvanometers. It should be understood, however, that the invention is not limited to any particular form of magnetic structure. Numerous variations in the magnetic operating mechanism may be employed, the essential requirement being that the tube containing the mercury is acted upon in response to alternating or pulsating current to produce forces that move the mercury from its normal position into its contact-making position. Also the invention is not to be limited to the tube illustrated herein. For example, variations may be made in the size and shape of the gas duct, in the shape and location of the baffle or barrier separating the tube into its different chambers and in other details.

The relay illustrated in the drawings comprises a combined mounting frame and permanent magnet 1 having inwardly extending poles 2 and 3. The pole-pieces 4 and 5 are secured to the inner ends of the poles 2 and 3, respectively, and engage the non-magnetic spacing member 6. The member 6 is secured by screws to the back plate 7. The plate 7 is secured to the frame 1 and to the horizontal plate 8, which in turn is secured to the side members of the frame 1. A semicylindrical magnetic piece 9 is secured to the non-magnetic spacing member 6 and forms air-gaps with the arcuate faces of the pole-pieces 4 and 5.

The movable element of the relay includes a skeletonized hollow cylinder 10 supported by the pivot pins 13 and 14. The cylinder 10 is arranged to oscillate about the pivot pins 13 and 14, which engage conical recesses in the heads 15 and 16, respectively, of the cylinder. The lower pin 14 is adjustable by means of a thumbscrew 46 to facilitate removal and replacement of the unit. The movable element also includes a rectangular operating coil 17 which is wound on the coil supports 18 and 19. These supports are welded or otherwise secured to the cylinder 10 so that the vertical sections of the coil are free to oscillate in the air-gaps formed between the stationary pole faces 4 and 5 and the stationary magnetic member 9. The coil 17 is connected by flexible wires to the terminals 20 and 21, which are mounted on the insulating block 33, as shown in Figs. 1 and 2.

The switching tube, which has a vertical section 22 and a horizontal section 25, also forms a part of the movable unit of the relay. The vertical section of the tube is secured to the skeletonized cylinder 10, in substantially axial alignment therewith, by means of collars 23 and 24. These collars are attached to the cylinder 10, and the tube is secured within the collars in any suitable manner. Since it is desirable to insulate the collar 24 from the cylinder 10, which is preferably made from non-magnetic material, the attachment of the collars to the cylinder may be made by the use of non-conducting cement. This construction is more clearly disclosed in the enlarged cross-sectional view of Fig. 6. In this figure a layer of cement 26 is shown holding the tube 22 to the collar 24. Partially surrounding the collar 24 is a connecting strip 27 of any suitable conducting material. The connecting strip is welded to the surface of the metallic collar 24, and a layer of insulating cement 28 secures the tube 22 and collar 24 firmly to the cylinder 10. The collar 23, however, is welded or otherwise attached in conductive relation to the cylinder

10. The terminal lead 38 projecting from the horizontal section 25 of the tube is welded to the collar 23, and the connection is further extended by way of the connector 27 and a flexible lead wire 29 to the terminal 30, which is mounted on the insulating block 34. The lead wire 37 projecting from the end of the vertical section 22 is welded to the collar 23, from whence the electrical circuit extends through the cylinder 10, wire 11 and conductor 31 to the terminal 32.

The frequency at which the movable unit oscillates may be adjusted by means of the tuning wire 11. One end of this wire is attached to the cylinder 10, and the other end is clamped to the bracket 12. By varying the tension of this wire the movement of the unit may be tuned to desired frequency ranges.

The switching tube, which is shown more clearly in Figs. 7 to 11, inclusive, is formed with a constriction near the end of the horizontal section to provide a barrier or baffle 35 separating the interior of the horizontal section into a main chamber and a small auxiliary chamber. The main chamber is substantially filled with a mass of mercury 36, which is normally held by the barrier 35 from entering the restricted passage inter-connecting the main and auxiliary chambers. The mercury mass 36 is at all times in engagement with the terminal wire 37, which enters the upper end of the section 22. The other terminal 38 is sealed into the closed end of the horizontal section 25 and projects into the auxiliary chamber. A small globule of mercury 39 rests in the auxiliary chamber at all times and surrounds the end of the terminal 38. The vertical section 22 of the tube serves as a reservoir and is filled with any suitable gas. The interior surface of the tube is formed with an open duct or channel 40, which extends from the gas reservoir chamber down the vertical section, around the bend in the tube and along the horizontal section to a point beyond the baffle 35 and within the auxiliary chamber. Although the duct 40 opens directly into the interior chambers of the tube, it is sufficiently shallow to prevent the mercury from entering. Hence there is at all times a passageway for the movement of the gas in either direction between the horizontal and vertical sections of the tube. This free passage of the gas from one part of the tube to another serves to maintain an equalized pressure on the mercury mass, so that the movement of the mercury is controlled by the forces applied to it by the operating mechanism of the relay and by the forces of gravity and surface tension.

The operation of the relay will now be described. Assume that it is desired to obtain a permanent circuit closure between the terminals 30 and 32 in response to an alternating current signal. This may be accomplished with the present relay structure by connecting the alternating current signal circuit to the terminals 20 and 21. The alternating current flowing through the movable coil 17 causes the coil to oscillate in the air-gap between the pole-pieces 4 and 5. The oscillating coil drives the movable unit including the cylinder 10 and the switching tube in a similar oscillatory movement about the pivot pins 13 and 14. As soon as the section 25 of the tube begins to oscillate in a horizontal plane centrifugal force is applied to the mercury mass 36 urging it against the baffle 35 and through the restricted passage until it merges with the globule 39 in the auxiliary chamber as seen in Fig. 10. This merging of the mercury bodies closes the

desired electrical circuit, and the continued vibration of the tube maintains the circuit in a closed condition as long as the alternating current signal flows through the operating coil 17. When, however, the signal ceases to flow in the coil, the centrifugal force is removed, and the forces of surface tension, acting on the mass of mercury, severs it at a point within the auxiliary chamber, whereupon the main mass 36 withdraws to its normal position within the main chamber of the tube. This severance is facilitated by the movement of the gas from the reservoir through the duct to the auxiliary chamber to establish there the same pressure that is applied to the opposite end of the mercury mass. As the main body of mercury 36 withdraws itself over the baffle 35 and back to its normal position in the main chamber the residual globule 39 is retained in the auxiliary chamber.

The modification shown in Fig. 12 is similar to the form above described. Instead of using the baffle, however, an insulating cylindrical barrier 41 is provided having a central opening 42 therein. The size of the opening is such that the mercury mass 43 normally does not enter. When, however, the centrifugal force is applied, the mercury passes through the opening and merges with the residual globule 44 in the auxiliary chamber.

Thus it is possible to obtain circuit closures by bringing two masses of mercury together and to obtain circuit openings by severing the merged mass. The closures are obtained by applying a simple vibratory movement to the tube, and the openings are obtained by removing the vibratory force. One of the advantages of this method of operation is that all circuit closures and openings are made with mercury, which is free from the usual corrosion and contamination which exists when solid contacts are used.

By tuning the movable element of the relay it is possible to limit its responsive oscillation to a desired narrow band of frequencies. Hence the relay may be used to select the desired band of frequencies and to give steady circuit closures in response to energizing currents of these frequencies. In practice a relay of this type may be used for many purposes; it could serve as a band-pass filter, as a rectifier, and also as a sensitive device responsive to direct current.

What is claimed is:

1. The combination in a switch of a closed tube, a partition within said tube dividing the interior thereof into two chambers with a restricted passage between said chambers, a mass of fluid conducting material normally resting in one of said chambers, an electrical terminal in said one of said chambers, an electrical terminal extending into the second of said chambers, and means for oscillating said tube to force said fluid material through said restricted passage and into electrical connection with the terminal in said second chamber.

2. The combination in a switch of a tube, a baffle within said tube dividing the interior thereof into a small chamber and a large chamber with a restricted passage interconnecting said chambers, a relatively large mass of mercury normally resting in the large chamber, an electrical terminal in said large chamber, an electrical terminal extending into the small chamber, a relatively small mass of mercury resting in said small chamber in engagement with said terminal, and means for vibrating said tube to force said large mass of mercury centrifugally through said pas-

sage to merge with said small mass of mercury in said small chamber.

3. The combination in a switch of a closed vessel, a barrier within said vessel dividing the interior thereof into a main chamber and a small auxiliary chamber with a restricted passage interconnecting said chambers, a main mass of mercury resting within said main chamber, an electrical terminal extending into said main chamber and into engagement with the mercury mass therein, a second electrical terminal extending into said auxiliary chamber, a small residue of mercury resting in said auxiliary chamber in engagement with said second terminal, and means for oscillating said vessel to force said main mass of mercury through said passage to merge with the small mass of mercury within said auxiliary chamber, the force of surface tension serving to divide the main mass from the residual mass when said vessel ceases to oscillate.

4. The combination in a tuned relay of a closed tube, a partition within said tube dividing the interior thereof into a main space and an auxiliary space with a reduced passageway interconnecting said spaces, a main mass of mercury normally resting within said main space, an electrical terminal in said main space, an electrical terminal extending into said auxiliary space, a residual globule of mercury resting in said auxiliary space in engagement with said terminal, and means for oscillating said tube to force said main mass of mercury centrifugally through said reduced passage to merge with said globule of mercury in said auxiliary space, the forces of surface tension acting to divide the main mass from the residual mass and to withdraw the main mass back through said passage into the main space when said tube ceases to vibrate.

5. The combination in a relay of a closed tube, a barrier within said tube dividing the interior thereof into a main chamber and an auxiliary chamber, with a restricted passage interconnecting said chambers, a mass of mercury normally resting wholly within said main chamber, an electrical terminal engaging the mercury mass in said main chamber, a second electrical terminal extending into said auxiliary chamber, a relatively small mass of mercury resting wholly within said auxiliary chamber and in engagement with said second terminal, said tube having a gas-filled reservoir communicating with said main chamber and a duct for the passage of gas between said reservoir and said auxiliary chamber, and means for oscillating said tube to force said main mass of mercury through said restricted passage to merge with the small mass of mercury within the auxiliary chamber, the forces of surface tension serving to divide the merged mass of mercury within said auxiliary chamber and to withdraw the main mass back through the restricted passage into said main chamber when the tube ceases to vibrate.

6. The combination in a relay of a closed tube having a horizontal section, a partition within said horizontal section dividing the interior thereof into a main chamber and an auxiliary chamber with a restricted passage between said chambers, an electrical terminal within said main chamber, a main mass of mercury normally resting within said main chamber, an electrical terminal extending into said auxiliary chamber, a small mass of mercury within said auxiliary chamber, said tube having a vertical section containing a gas-filled reservoir communicating with said main chamber, said tube having an open

duct communicating in common with said reservoir and said main and auxiliary chambers, said duct being shaped to prevent the entrance of the mercury and to permit the free passage of gas between the reservoir and said chambers, and means for oscillating said tube to force said main mass of mercury centrifugally through the restricted passage and into merging engagement with the small mass of mercury in said auxiliary chamber, the forces of surface tension aided by the passage of gas through said duct serving to divide the merged mass of mercury when the tube ceases to vibrate and to withdraw the main mass thereof back into the main chamber.

7. The combination in a relay of a tube having a mass of mercury therein, an electrical terminal engaging said mass, a second electrical terminal normally out of engagement with said mass, means responsive to alternating currents for oscillating said tube to move said mercury mass into engagement and to hold it in engagement with said second terminal, and means for tuning said tube to respond selectively to currents of desired frequencies.

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