July 2, 1946. W. K. CAUGHEY ET AL 2,402,985

MAGNETIC RECORDER

Filed July 7, 1942

FIG. 1

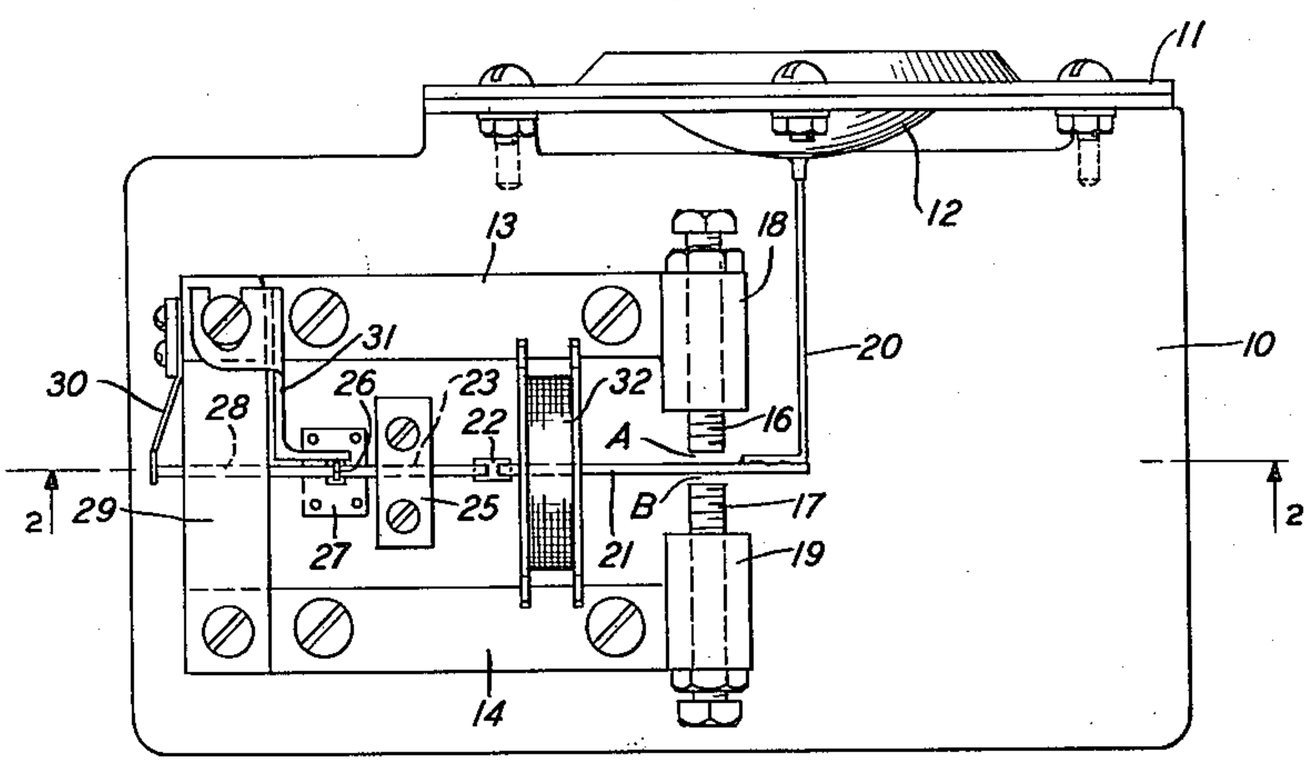


FIG. 2

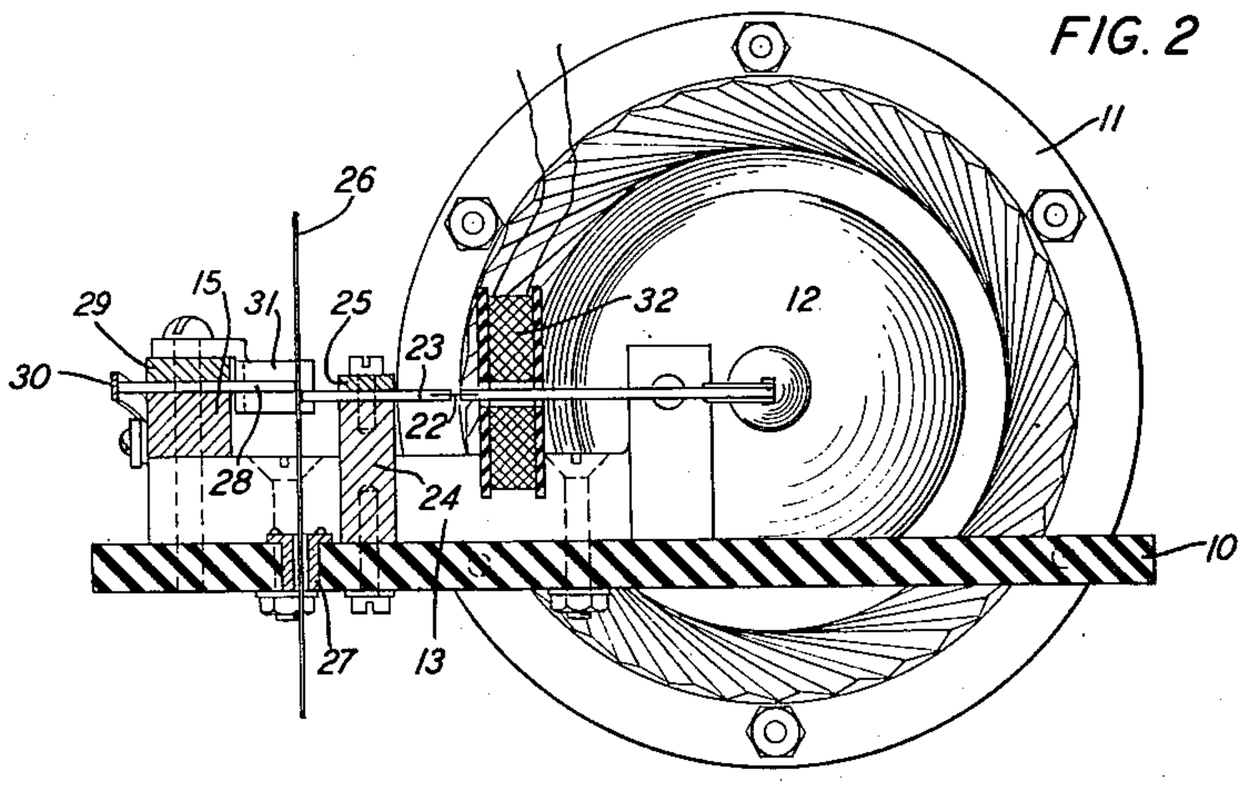
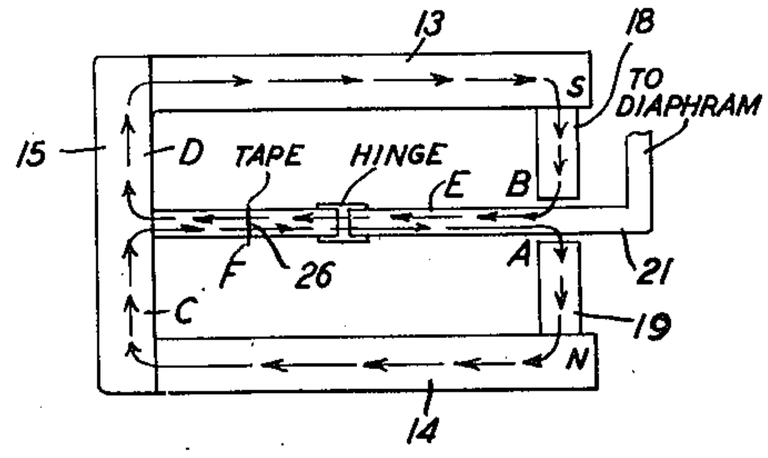


FIG. 3



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MAGNETIC RECORDER

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17 Claims. (Cl. 274—4)

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This application relates to magnetic circuits and more specifically to magnetic circuits used in the recording of signals.

One very well known magnetic tape recorder is that known generally by the name of "Telegraphone." In the telegraphone, a voice current to be recorded must first be amplified and then applied to the coil of the recording electromagnet, the core of which forms a part of a magnetic circuit containing a recording tape, wire or disc. The present invention constitutes an improvement over the usual telegraphone arrangement to the extent that an amplifier is not necessary.

It is an object of the present invention to provide an improved magnetic recorder in which amplifying means is not required.

In accordance with the present invention, magnetic energy which is used to record the message on a tape or similar device is derived from an independent source, which may be either a permanent magnet or an electromagnet, and this independent energy is controlled so as to affect the recording tape by the mechanical movement of a portion of the magnetic circuit with respect to another portion thereof. This movement may be caused by the vibration of a diaphragm by sound waves or by other means. Since the permanent magnet or electromagnet may be a strong one, very large recording energy can be made available. While a prior art arrangement employing this general principle is disclosed in Patent 901,397, issued October 20, 1908, to Stuart, the structure in accordance with the present invention is much simpler to construct and has many fewer parts, thus making it less likely to get out of order and easier to adjust than the Stuart arrangement.

It is accordingly another object of this invention to provide an improved magnetic recorder in which the energy used to energize the recording tape is derived from permanent magnets or electromagnets, the magnetic flux provided thereby being controlled by external means.

In accordance with one embodiment of the invention, chosen by way of example to illustrate the principles thereof, there is provided a magnetic tape recorder which does not require an amplifier and which comprises a magnetic bridge circuit and a diaphragm which, under the influence of sound waves, moves one end of an armature of magnetic material common to the two magnetic paths in the bridge circuit, thus setting up through the armature an alternating field which magnetizes a recording tape which is caused to pass between two pole-pieces included

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in the common magnetic path. A U-shaped permanent magnet or its equivalent is preferably used which, with the common path including the armature and the recording tape, forms the magnetic bridge circuit. An electromagnet may replace the permanent magnet, if desired. A coil may be placed around the armature and the coil actuated with either direct current or alternating current to supplement or "bias" the flux in the middle or common path.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawing forming a part thereof in which:

Fig. 1 is a plan view of one form of the invention;

Fig. 2 is an elevation view of the arrangement shown in Fig. 1, portions thereof being shown in cross section; and

Fig. 3 is a diagram showing the flux paths in the magnetic circuit of the arrangement of Fig. 1.

Referring more specifically to the drawing, Figs. 1 and 2 show a magnetic recorder for translating mechanical movements of a member thereof to an alternating flux to magnetize a recorder member. This recorder comprises a base member 10, preferably of insulating material, supporting a ring 11 on which is mounted a diaphragm 12. Also mounted on the base member 10 is a U-shaped yoke of magnetic material which may be a one-piece permanent magnet but the magnetic circuit has been shown for convenience in the drawing as made up of side members 13 and 14, an end piece 15, and adjustable pole-pieces 16 and 17. The adjustable pole-pieces are preferably screwed into supporting members 18 and 19. All of these pieces except members 13 and 14 are of magnetic material which offers a low reluctance path to magnetic flux. The side members 13 and 14 are preferably permanent magnets but, if desired, they may be replaced by electromagnets.

The diaphragm 12 is joined by any convenient means to a connecting member 20 which is fastened to an armature 21 of magnetic material in such a way that a movement of the diaphragm 12 in response to sound oscillates the armature 21 within the gap between the pole-pieces 16 and 17. The armature 21 is connected by means of a member 22, which may be a hinge, to a pole-piece 23 which is held in position between supporting members 24 and 25. If desired, the pole-piece 23, the hinge 22 and the armature 21 may be of one piece, if sufficiently flexible. The supporting member 24 is screwed or otherwise se-

cured to the insulating base 10 and the supporting member 25 preferably constitutes a strap having a groove therein adapted to fit the pole-piece 23. Strap 25 is secured to the supporting member 24 by any suitable means, such as by screws. The pole-piece 23 is adapted to make contact with a recording member 26, such as a movable magnetic tape, which is caused to be passed by any suitable means (not shown) through a groove in a guide member 27. On the opposite side of the tape 26 from the pole-piece 23 is a second pole-piece 28 which is held in position between the magnetic member 15 and a strap 29 of metallic material. Preferably the pole-piece 28 makes contact with the recording member 26 at a spot which is not exactly opposite that at which the pole-piece 23 contacts the tape 26, for reasons which are well known to the art. The advantages of offset recording are too well known to require a detailed discussion at this point. A spring member 30 which may be fastened to the member 15 exerts a compressive force on the pole-piece 28 causing it to make contact with the recording member 26. A strap member 31, fastened to the strap 29, may be used to help align the pole-pieces 28 and 23 with the recording member 26.

While the device just described is operative without any electromagnetic "biasing" means, still, if desired, such a bias may be provided by mounting a coil 32 around the armature 21, which coil may have either direct or alternating current passed therethrough for reasons which will be hereinafter pointed out. Magnetic bias can be produced by adjusting the pole-pieces 16 and 17 as hereinafter described.

The operation of the magnetic recorder of this invention is as follows: Assume for the moment that no current is flowing through the coil 32. The pole-pieces 16 and 17 are adjusted to produce an air-gap of desired size within which the armature 21 is adapted to vibrate in accordance with the vibrations of the diaphragm 12, when sound waves strike the latter, for example. When the diaphragm 12 is not moving, the member 21 is preferably mid-way between the pole-pieces 16 and 17, although, if desired, the armature 21 may be mechanically "biased" to make it a little nearer one of the pole-pieces 16 or 17 than it is the other in the neutral or "rest" position. The magnetic bias referred to above is controlled by this adjustment.

Reference will now be made to Fig. 3 which is a diagrammatic representation to aid in explaining the operation of the magnetic recorder of this invention. This figure shows the flux paths through the magnetic circuit of the recorder. One half of the end piece 15 of magnetic material is represented in the diagram of Fig. 3 by the member C while the other half of the member 15 is represented by the member D. The air-gap between the pole-piece 16 and the armature 21 is indicated by the reference character A while the air-gap between the pole-piece 17 and the armature 21 is indicated by the reference character B. The permanent magnets 14 and 13 are placed between C and A and between B and D, respectively. The armature 21 is represented in Fig. 3 by the reference character E and the tape is represented by the reference character F. If there is an exact balance in the two halves of the bridge, the flux tending to pass in one direction through the armature E and the tape F is balanced by that tending to pass through these members in the opposite direction and hence

there is no resultant magnetic flux flowing through the tape. If, however, the armature 21 is moved from one side to the other of the "rest" position, the reluctances of the members A and B are altered, the flux balance is disturbed, and an alternating flux flows through the central path including the armature E and the tape F. Similarly an alternating flux flows through the magnetic path including the magnetic tape 26 in Fig. 1, and magnetizes the latter in accordance with the vibrations of the diaphragm 12 which, as pointed out above, are preferably in response to sound waves.

By using strong permanent magnets 13 and 14 or equivalent electromagnets, even a weak signal causing the vibrations of the diaphragm 12 may be reproduced as a strong signal on the tape as the number of flux lines flowing through the magnetic circuit is dependent upon the strength of the magnetic field produced by the members 13 and 14. Thus no amplifier is necessary.

In accordance with principles of direct current recording well known to the art, a direct biasing flux can be used. Prior to recording, the tape is conditioned by passing it through a suitable magnetic field, as well known in the art, to remove any signals previously recorded. As pointed out in Patent 1,886,616, issued November 8, 1932, to James G. Alverson, it has been common practice to saturate the wire with magnetic flux and then to return the magnetization of the wire either to a mid-point on the B—H curve or else to a neutral state by a direct polarizing flux. Such a direct polarizing flux may be applied in the present invention by passing a direct current through the wires of the coil 32 surrounding the armature 21. This armature then carries an alternating flux produced by the vibrations of the diaphragm 12 and a direct current biasing flux due to the current flowing through the coil 32. It is a feature of the present invention that the requisite biasing flux may be obtained without recourse to a coil by mechanically biasing the position of the armature 21 so that it is nearer the pole-piece 16 than the pole-piece 17, or vice versa, in the neutral or undeflected position of the armature. As a modification a magnetic equivalent of a mechanical bias of the armature 21 may be obtained by making one of the magnets 13 and 14 stronger than the other.

The structure shown in Figs. 1 and 2 is also suitable for the alternating current recording technique which is well known to the art. In this case also the tape is preconditioned by removing any signals previously recorded and causing the tape to be magnetically neutral. The pole-pieces 16 and 17 are adjusted for substantially zero flux through the gap 26 caused by the magnets 13 and 14, and an alternating current of suitable strength and of frequency higher than the highest oscillations of the diaphragm 12 is passed through the coil 32. The results are as if the magnetization curve of the tape were made substantially straight through the origin and somewhat steeper than before. An arrangement wherein high frequency waves are applied to a telegraphone is shown in Patent 1,640,881 to Carlson et al., issued August 20, 1927. It has been found that records made under such conditions may have a lower noise level than direct current recordings.

Various changes may be made in the embodiment above disclosed without departing from the spirit of the invention, the scope of which is indicated in the appended claims. For example, in a modification, the element 21 may be held sta-

tionary and the pole-pieces 16 and 17 moved with respect thereto. Moreover, the "record" produced by the device of the invention may be a record of speech or other sounds. The shape of the record is not material. It may, for example, be a wire, a ribbon, or a disc.

The signals on the tape may be reproduced either by a standard telegraphone reproducer or by any other suitable means.

What is claimed is:

1. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, at least one terminal portion of each of said gaps being oscillatable to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, means for passing a magnetic record element through said last-mentioned gap, and energy transfer means coupled to said oscillatable terminal portion.

2. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, means including apparatus to vibrate the portion of said member near said end portions to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, and means for passing a magnetic record element through said last-mentioned gap.

3. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, means including a sound actuated diaphragm to cause the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, and means for passing a magnetic record element through said last-mentioned gap.

4. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, at least one terminal portion of each of said gaps being oscillatable to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, means for passing a magnetic record element through said last-mentioned gap, energy transfer means coupled to said oscillatable terminal portion, and electro-magnetic means for setting up a flux in said flux-shunting member.

5. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, at least one terminal portion of each of said gaps being oscillatable to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, means for passing a magnetic record element through said last-mentioned gap, energy transfer means coupled to said oscillatable terminal portion, said oscillations of said terminal portions acting to set up an alternating flux in said flux-shunting member, and electromagnetic means for setting up a biasing unidirectional flux in said flux-shunting member.

6. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, at least one terminal portion of each of said gaps being oscillatable to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, means for passing a magnetic record element through said last-mentioned gap, energy transfer means coupled to said oscillatable terminal portion, said oscillations of said terminal portions acting to set up an alternating flux in said flux-shunting member, and electromagnetic means for setting up a flux which alternates at a frequency which is high compared to the frequency of said oscillations.

7. In combination, a U-shaped element of magnetic material terminating in a pair of pole-pieces, an armature of magnetic material arranged to vibrate between said pole-pieces, an element of magnetic material forming a flux path between said armature and the mid-portion of said U-shaped element, said last-mentioned element having a gap therein, means for passing a magnetic record element through said gap, and means for vibrating said armature.

8. In combination, a U-shaped element of magnetic material terminating in a pair of pole-pieces, an armature of magnetic material arranged to vibrate between said pole-pieces, an element of magnetic material forming a flux path between said armature and the mid-portion of said U-shaped element, said last-mentioned element having a gap therein, means for passing a magnetic record element through said gap, and means for vibrating said armature in response to sound waves.

9. In combination, magnetic material arranged to have three substantially parallel legs, the two outer legs being stationary and the inner leg

adapted to have a limited vibratory movement, said inner leg having a gap therein adapted to receive a record member, and means for vibrating at least a portion of said middle leg to set up a flux therein.

10. In combination, magnetic material arranged to have three substantially parallel legs, the two outer legs being stationary and the inner leg adapted to have a limited vibratory movement, said inner leg having a gap therein adapted to receive a record member, and means for vibrating at least a portion of said middle leg to set up a flux in said middle leg, said means comprising a sound-actuated diaphragm.

11. In combination, a U-shaped permanent magnet terminating in a pair of pole-pieces, an armature of magnetic material arranged to vibrate between said pole-pieces, said armature being connected by a magnetic flux path to a portion of said magnet intermediate the pole-pieces, said flux path including a gap adapted to receive a record member, and means for mechanically vibrating at least a portion of said armature to set up a flux in said gap.

12. In combination, a U-shaped permanent magnet terminating in a pair of pole-pieces, an armature of magnetic material arranged to vibrate between said pole-pieces, said armature being connected by a magnetic flux path to a portion of said magnet intermediate the pole-pieces, said flux path including a gap adapted to receive a record member, means for mechanically vibrating at least a portion of said armature to set up a flux in said gap, and means for setting up an additional flux in said gap, said last-mentioned means comprising an electromagnetic coil.

13. A magnetic tape recorder comprising a magnetic tape, a yoke of magnetic material terminating in a pair of oppositely polarized pole-pieces separated by a gap, means for forming a magnetic path from an intermediate portion of said yoke to the region of said gap, said means comprising two pole-pieces spaced apart by a distance corresponding to the thickness of said magnetic tape which is adapted to pass between them, a member of magnetic material pivotally connected to one of said last-mentioned pole-pieces and extending to the region of said gap, a diaphragm, and means for connecting said diaphragm to said member whereby sound waves actuating said diaphragm cause movement of said member with respect to said first-mentioned pole-

pieces and thereby set up an alternating flux in said member which magnetizes said tape.

14. The combination with a series magnetic flux path the terminals of which are aligned with each other and spaced apart to form a gap therebetween, of a flux-shunting member extending from within said gap to said series path at a region thereof such that the reluctances of said series path on the two sides of said region are equal, the part of said member lying within said gap being out of contact with said terminals whereby two gaps between said part of said member and each of said terminals, respectively, are formed, said terminals and said part being relatively oscillatable to increase the width of one of said two gaps and to decrease that of the other when the movement is in one direction and to oppositely vary said widths when the movement is in the reverse direction, said shunting member having a gap therein across which the shunted flux passes, and means for passing a magnetic record element through said last-mentioned gap.

15. The combination of elements as in claim 9 in which one of said two outer legs is a stronger magnet than the other.

16. The combination of elements as in claim 9 in which said inner leg is mechanically biased so that, in the absence of vibrations, it is nearer one of said two outer legs than the other.

17. The combination with a series magnetic flux path of low reluctance with its end portions adjacent each other, of a flux-shunting member extending from the region of said end portions to an intermediate portion of said path, said member being out of contact with said end portions and so positioned that two gaps are formed each having a portion of said member as one terminal and one of said end portions of said series path as the other terminal, at least one terminal portion of each of said gaps being oscillatable to permit the widths of said two gaps to be simultaneously varied while maintaining their sum substantially constant, said flux-shunting member having a gap therein, driving means for oscillating at least one terminal portion of each of said gaps, and means for passing through said last-mentioned gap a medium sensitive to magnetic flux variations for utilizing the flux variations in said flux-shunting member resulting from the action of said driving means.

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