Feb. 21, 1939. E. O. THOMPSON 2,148,328

ELECTRICAL SIGNAL APPARATUS

Filed June 29, 1936 2 Sheets-Sheet 1

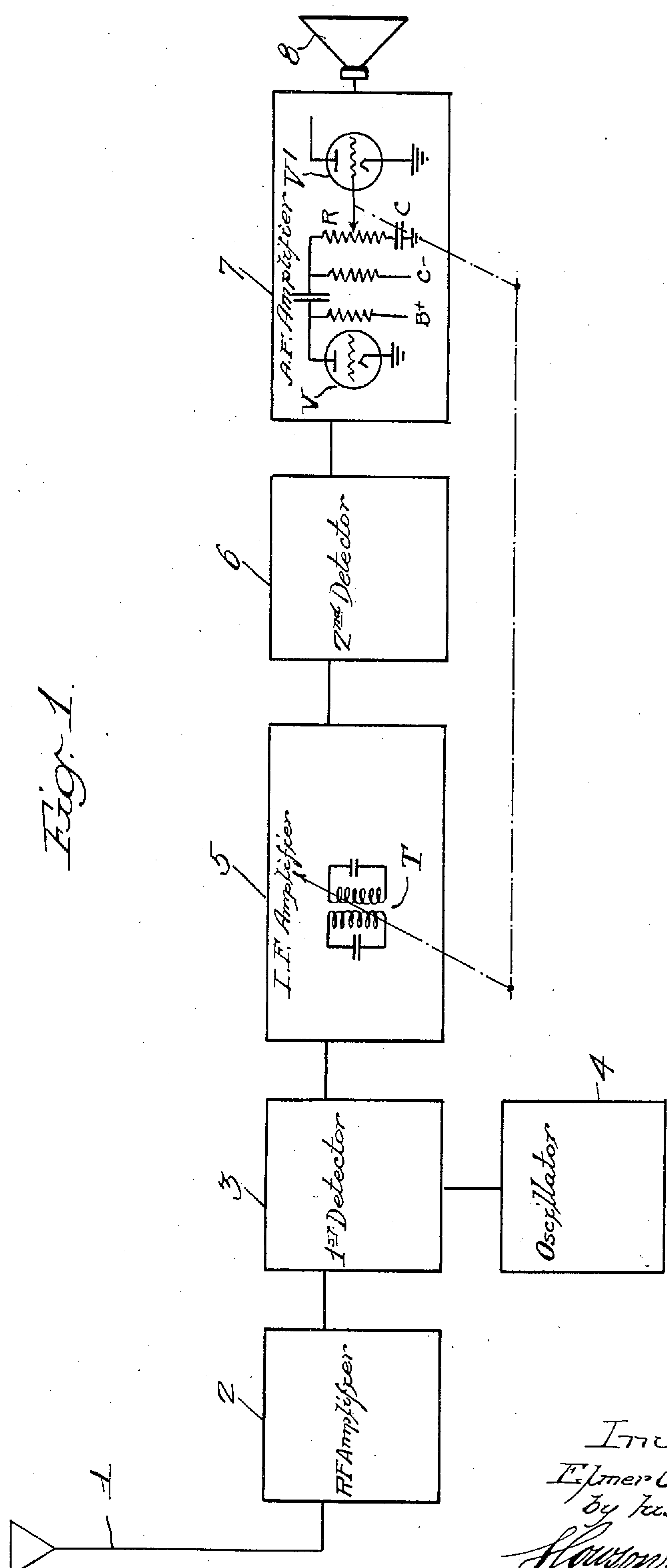

Fig. 1.

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Fig. 2

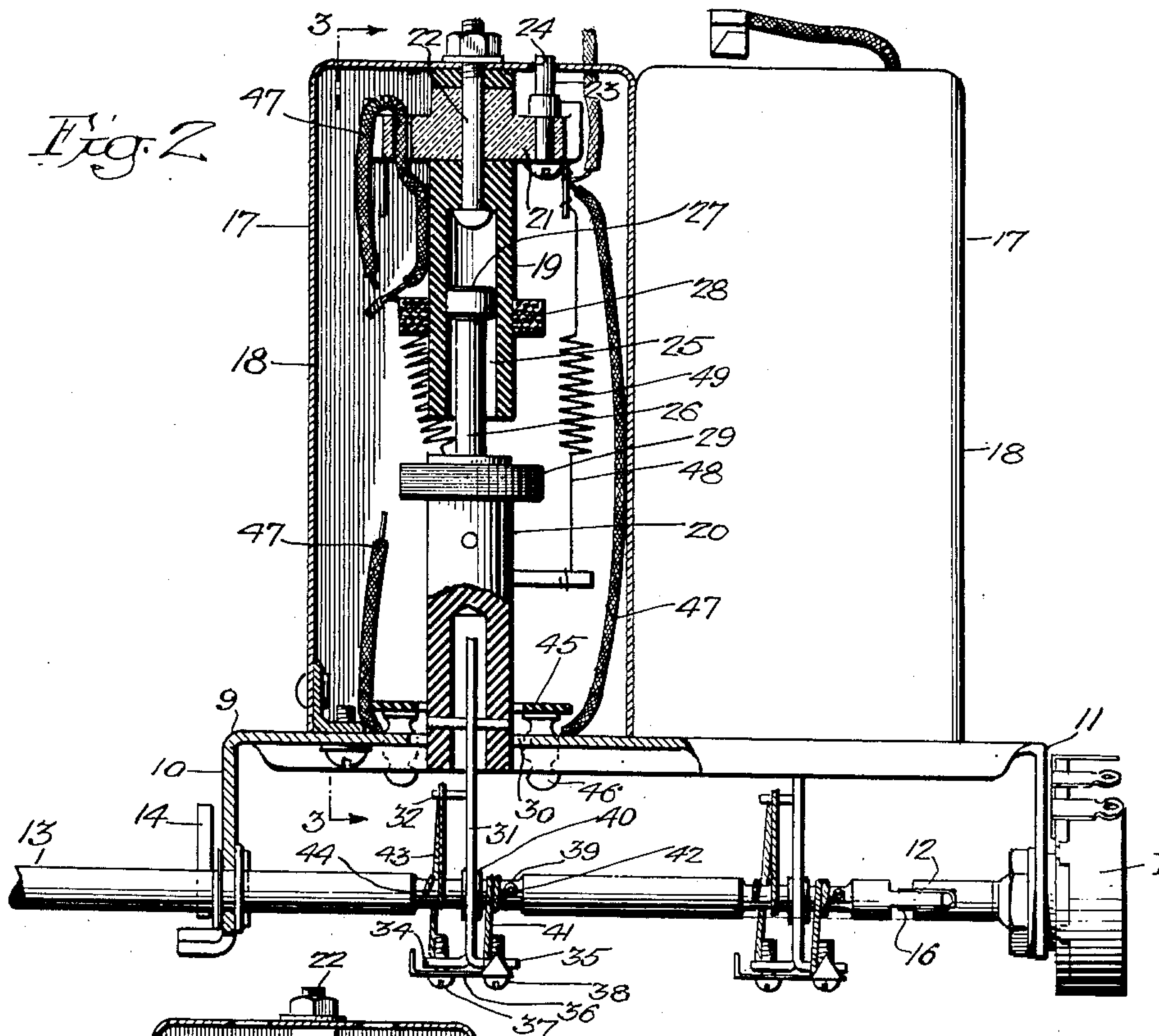


Fig. 3

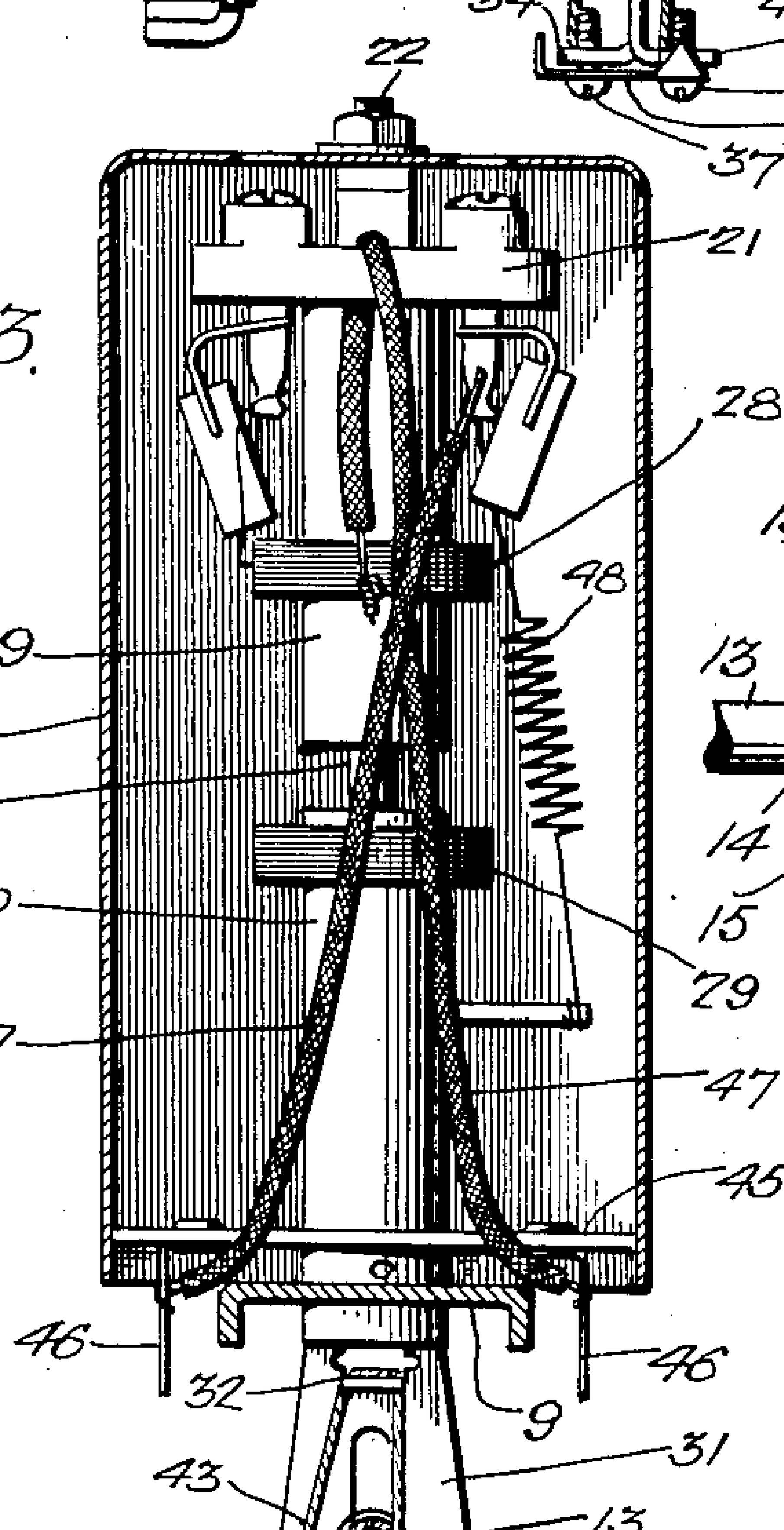


Fig. 4

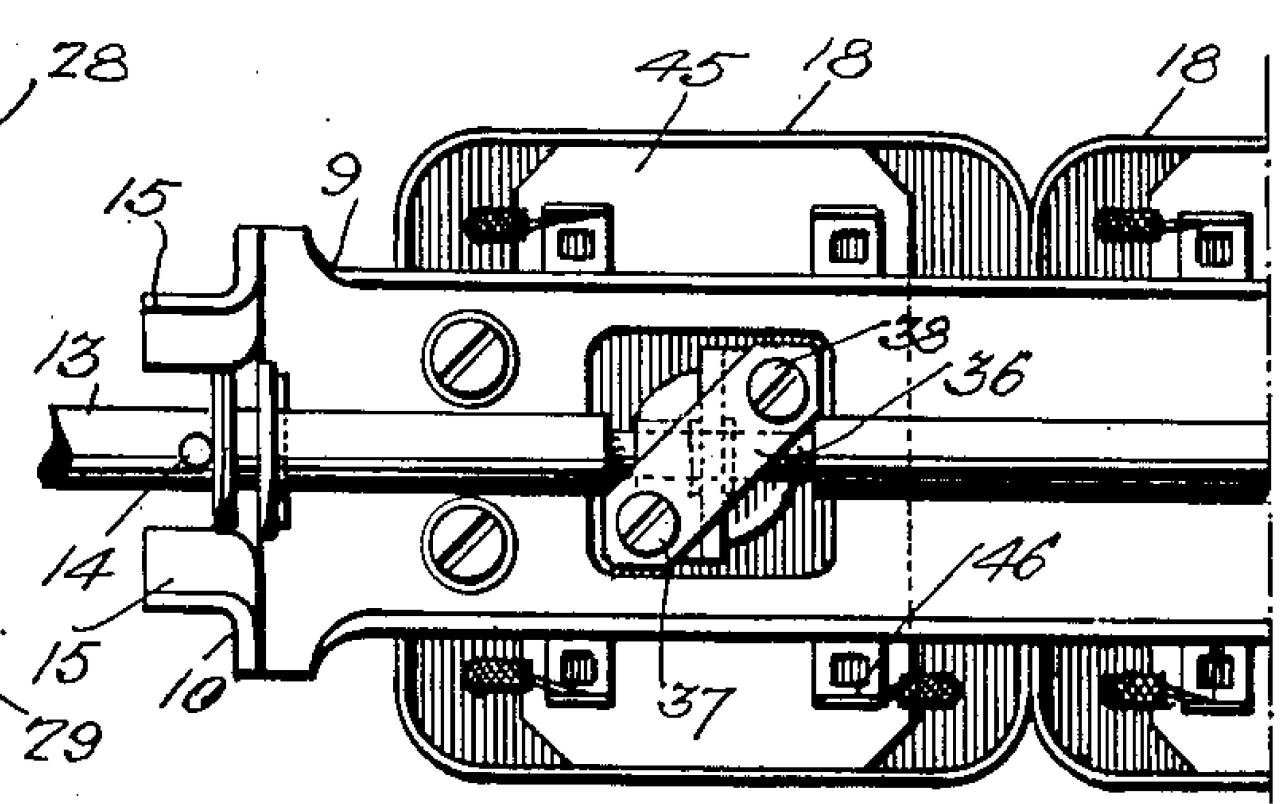
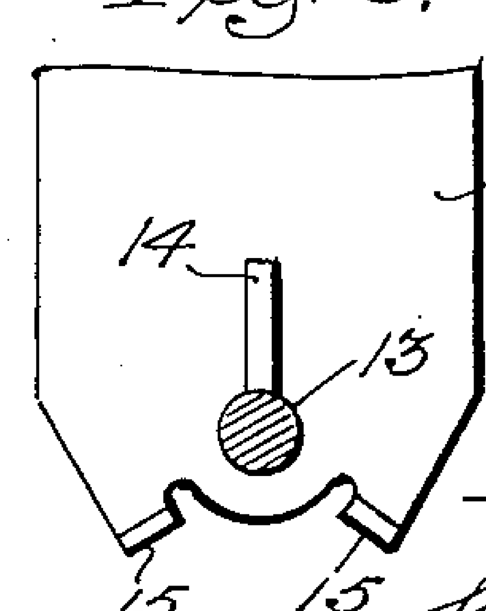


Fig. 5.



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Patented Feb. 21, 1939

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UNITED STATES PATENT OFFICE

2,148,328

ELECTRICAL SIGNAL APPARATUS

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Application June 29, 1936, Serial No. 88,016

10 Claims. (Cl. 171—119)

This invention relates to electrical signaling apparatus and more particularly to novel means for varying simultaneously the frequency response of different portions of a signaling system, such as a radio receiver. More specifically, the invention provides novel means for varying the coupling between the primary and secondary windings of the intermediate frequency transformers in a high fidelity superheterodyne radio receiver and for simultaneously and cooperatively actuating a frequency control device in the audio frequency portion of the receiver, thus greatly improving the selectivity of the receiver and avoiding certain objectionable characteristics, as hereinafter set forth.

One object of the invention, therefore, is to provide an improved selectivity or frequency response control in a signaling system such as a radio receiver, particularly a receiver of the superheterodyne type, so as to increase materially the fidelity of reception of the receiver.

Another object of the invention is to provide a novel mechanical structure by which the desired control may be accomplished in an economical and efficient manner.

A further object of the invention is to provide a mechanical structure of this nature embodying units which may be easily manufactured and assembled, thereby facilitating the manufacture of the device and maintaining the cost of production as low as possible.

Other objects and features of the invention will appear hereinafter as the description proceeds.

In the accompanying drawings:

Fig. 1 is a diagrammatic illustration of a superheterodyne radio receiver embodying the invention;

Fig. 2 is a side elevational view of the control apparatus provided by the invention with one of the units shown in section for the purpose of illustration;

Fig. 3 is a sectional view of one of the units taken along line 3—3 of Fig. 2;

Fig. 4 is a bottom face view of a portion of the device; and

Fig. 5 is a front face view of the lower portion of the apparatus showing clearly the stop mechanism.

Referring first to Fig. 1 of the drawings, there is illustrated a conventional superheterodyne radio receiving system comprising the usual antenna 1, the radio frequency amplifier 2, the first detector 3, the oscillator 4, the intermediate frequency amplifier 5, the second detector 6, the audio frequency amplifier 7, and the sound reproducer or loud speaker 8. Such a system is now so well known in the art that it requires no detailed description. As is well known, the intermediate frequency amplifier of such a system comprises one or more transformers which serve to couple the successive vacuum tube amplifiers, one to another. In accordance with the present invention, these intermediate frequency transformers are made variable, as indicated diagrammatically at T. More specifically, each of the intermediate frequency transformers comprises a movable winding, the position of which may be varied relative to the other winding of the transformer so as to vary the coupling between the two windings and thereby vary the frequency response of the transformer. While a single variable transformer is illustrated diagrammatically in Fig. 1, it will be understood that this is merely indicative of the variability of the several intermediate frequency transformers. While the invention is not limited to any particular range of variation of the coupling between the windings of the intermediate frequency transformers, in general, it will be preferable to vary the coupling within a range from about a half to one and a half or twice critical coupling.

By thus controlling the selectivity or transmission characteristic of the intermediate frequency amplifier, that portion of the radio receiver may be adjusted, when desired, to attenuate disturbing signals. In other words, when no disturbing signals are present, the selectivity control may be adjusted to give broad response throughout the entire signal channel, but when disturbing signals are present, the control may be adjusted to decrease the high frequency response of the receiver so as to attenuate the disturbance signals. It is found, however, that the control of the selectivity or frequency response of the intermediate frequency amplifier does not entirely eliminate the disturbing signals, since there is a certain amount of distortion introduced by the second detector which causes disturbing signals to be transmitted through the audio frequency amplifier to the sound reproducing device or loud speaker. For example, a certain amount of cross modulation takes place in the second detector which causes the formation of undesired signals that are supplied to the audio frequency amplifier. In further accordance with the invention, therefore, there is provided means for controlling the frequency response or transmission characteristic of the audio amplifier in order to attenuate these undesired signals. Furthermore, the frequency control provided in the audio frequency amplifier is correlated with the control of the intermediate frequency amplifier so that the two function cooperatively to vary the frequency response of the system. Thus by controlling the frequency response of both the I. F. and A. F. amplifiers, undesired signals picked up by the receiver and cross modulation products of the second detector may be attenuated, while still permitting the maximum usable fidelity to be obtained.

The frequency control circuit in the audio amplifier may comprise a potentiometer R and a condenser C serially connected together and in shunt with the signal channel, as is shown in Fig. 1. In this particular instance, the potentiometer and condenser are connected across the output circuit of the amplifier tube V and the input circuit for the tube V_1 is connected to the variable arm of the potentiometer. Thus, variable portions of the resistor R may be included in the input circuit of the tube V_1. Grid bias for V_1 is supplied through the grid-leak resistor and part of the potentiometer resistance, as will be apparent from the figure. The attenuation of higher frequencies is determined by the position of the variable contact on the potentiometer and obtains from the fact that for low frequencies, the impedance of the condenser will be considerably greater than that of the resistance of the potentiometer. The signal transfer to the tube V_1 will be the signal developed across the condenser and that portion of the resistance between the condenser and the variable contact. For signals of low frequency, the impedance of the condenser will be so much greater than that of the potentiometer that the amplitude of the signal transferred will be independent of the position of the variable contact. However, for higher frequency, the impedance of the condenser will be less, since its impedance varies inversely with frequency and thus at higher frequencies, the impedance of the potentiometer may become an appreciable portion of the total impedance of the unit and at these frequencies, moving the variable arm towards the condenser will decrease the amplitude of the higher frequency signal supplied to the tube V_1. Preferably, the circuits should be so adjusted that the impedance of the condenser for the highest frequency which it is desired to transmit in the most selective position should be somewhat less than the total resistance of the potentiometer. The variable transformer or transformers T and the adjustable potentiometer R are simultaneously operable as indicated by the broken-line representation in Fig. 1. This joint operation or control of these devices is obtained in a novel manner by means of the mechanical structure to be described later.

Referring now to Figs. 2 to 5 illustrating the mechanical structure of the control device, there is provided a base or support 9 having depending end portions 10 and 11 which may be considered, respectively, as front and rear end portions. The rear depending portion 11 carries the resistor R which may take the form of a conventional device of this type. This resistor is provided with a relatively short control shaft 12, rotation of which causes adjustment of a rotary arm (not visible) corresponding to the adjustable arm shown in Fig. 1. The front depending portion 10 of the base serves to rotatably support a control shaft 13 upon the front end of which there may be provided a control knob (not shown). The shaft 13 carries a pin 14 which is adapted to engage stops 15 (see Fig. 5) provided on the portion 10, thus limiting the rotation of the shaft to a desired range. The opposite end of shaft 13 is formed cooperatively with the free end of shaft 12 and is flexibly coupled thereto by means of coupling 16 which preferably takes the form of the flexible coupling described and claimed in the copending application of Gerald J. Barry, Serial No. 80,630, filed May 19, 1936. It will be understood, of course, that any other suitable coupling may be used. It will be seen that the shaft 12 of the resistor R serves to support the rear end of the control shaft 13, thus eliminating the necessity of providing a second bearing or support for that shaft. Furthermore, the flexible coupling 16 compensates for any slight misalignment of parts that may occur in manufacture and it also enables easy assembly of the parts notwithstanding any such misalignment. It will be understood, of course, that rotation of the control shaft 13 causes corresponding rotation of shaft 12 and, consequently, adjustment of the resistor R.

The shaft 13 also serves to vary the coupling of the transformers T in proper relation to the variation of resistor R. To this end, there are mounted on the base or support 9 one or more units 17 depending upon the number of variable transformers and stages employed in the intermediate frequency amplifier. In the specific illustration of Fig. 2, two such units are shown, but it will be understood that any desired number may be used. These units 17 are identical one with another and it is only necessary, therefore, to illustrate and describe one of the units in detail. Each unit comprises a shielding housing or casing 18 within which the other parts are disposed, as shown clearly in Figs. 2 and 3. Where more than one unit is employed, the housings or casings 18 may be placed adjacent one another and may be spot welded together. The transformer T comprises a stationary coil unit 19 and a movable coil unit 20. The coil unit 19 may be attached to a padding condenser 21 by means of a central bolt 22 which also serves to secure the assembly to the top of the housing 18 as clearly illustrated. To facilitate assembly of the parts as described in further detail hereinafter, there is provided on the padding condenser 21 an extending stud 23 which serves cooperatively with an opening 24 in the top of the casing 18 to properly position the parts within the casing. The padding condenser 21 serves as a convenient support for the coil unit 19 and the particular assembly of these units is advantageous in that it uses available space to the best advantage and provides for very short leads between each coil and its associated condenser.

The stationary coil unit 19 is provided with a longitudinal recess 25, while the movable coil unit 20 is provided with a cooperating projection 26, which preferably takes the form of an extending shank and plunger-like head 27 adapted to slide within the recess 25. Thus, there is provided a guide for the movable coil unit which serves to maintain the two coil units substantially in axial alignment, while permitting axial movement of the coil unit 20 relative to the coil unit 19. By this construction, exact axial alignment is not necessary which facilitates the commercial manufacture of the units. The windings or coils 28 and 29, respectively, of the two coil units are so disposed on the coil supports of the units that when the inner ends of the coil supports abut one against the other, the coils are spaced apart a predetermined distance and a predetermined degree of coupling exists between them. When, however, the movable coil unit **20** is moved to some position such as that illustrated, a lesser degree of coupling exists between the two coils and by properly adjusting the movable coil unit, any desired degree of coupling between the coils may be obtained within the range for which the device is adapted.

The coil support of the movable coil unit **20** extends through an aperture **30** provided in the base **9** and this coil support is attached to and is carried by a support or carrier **31** having a transverse lug **32** extending therefrom and having also a longitudinal slot **33** (see Fig. 3). The bifurcated lower portion of support **31** which is thus provided has oppositely extending feet or lugs **34** and **35** between which a strip or plate **36** is attached by means of screws **37** and **38**. The portion **39** of shaft **13** is of diminished diameter and extends transversely through the slot **33**. Preferably, this portion of the shaft is provided with flanges **40** forming a circumferential groove therebetween in which the edges of the slot **33** are seated. At the rear of the carrier **31** there is provided a flexible member **41** which may take the form of a cord having one end fastened to the shaft **13** at **42** and having its other end secured by the screw **38**. This member **41** is so arranged that rotation of the shaft **13** counterclockwise, as viewed in Fig. 3, causes the member **41** to wind up on the portion **39** of the shaft, thus drawing the carrier **31** upward to move the coil unit **20** toward the coil unit **19**. When the shaft **13** is rotated in the opposite direction, however, the member **41** merely unwinds from the shaft portion **39** and allows the coil unit **20** to be drawn downward away from the coil unit **19** by the flexible member **43** which has one end attached to shaft **13** at **44** and its other end secured by screw **37**. This flexible member passes over the lug **32** and is seated in retaining recesses thereof, and it (member **43**) is so arranged that rotation of shaft **13** in a clockwise direction, as viewed in Fig. 3, causes the member **43** to wind upon the shaft portion **39**, thus exerting a pull upon the lug **32**, as will be obvious from Figs. 2 and 3. In this manner, the movable coil unit **20** is moved downward away from the coil unit **19**. During the movement of the carrier **31**, the slot **33**, together with the flanges **40**, maintain the carrier in proper position and prevent lateral movement thereof.

Within the casing **18**, there is provided an apertured insulating plate **45** which carries terminals **46** that project outside the casing on opposite sides of the base **9**, as clearly shown in Fig. 3. Electrical connections designated generally by reference character **47** are connected between the terminals **46** and the electrical elements within the casing. Electrical connection to the movable coil **29** from the terminals of the padding condenser **21** are made by means of fine wires **48** having coiled or helical portions **49** to permit the wires to expand and contract as the coil unit **20** is moved. The wires **49** should be sufficiently self-supporting to maintain their positions as the device is operated.

It will be seen from the illustration and the above description that the control shaft **13** serves to actuate the variable resistor R and each of the variable transformers simultaneously and, as above stated, the device is so designed that these elements are actuated in predetermined relation to one another. The mechanical structure which enables the desired control comprises simple parts which may be manufactured easily and economically and the structure is such that the parts may be easily assembled. Assuming that the parts of the device are in disassembled condition, the assembly of the device may be easily performed as follows.

The upper coil unit **19** is first attached to the padding condenser **21** by means of the bolt **22**. The lower coil unit **20** with its carrier **31** attached thereto is then inserted in cooperative relation with the coil unit **19** as illustrated and the wires **48** are connected between the terminals of the padding condenser **21** and the movable coil. The insulating plate **45** is then placed over the movable coil unit and the electrical connections **47** are made between the elements. Each of the transformer units when thus assembled is inserted in its shielding casing **18**, the shank **23** being inserted through the opening **24** in the top of the casing. Initially the shank **23** is longer than shown so that it may be grasped at the outside of the casing to draw the assembly into place. The assembly is then secured in place by means of bolt **22** and the shank **23** is cut off substantially flush with the top surface of the casing, as shown. The shielding casing is then mounted upon the base or support **9**.

With the resistor R also mounted upon the support **9**, the control mechanism is assembled, the control shaft **13** being inserted through the end portion **10** and cooperatively associated with each of the carriers **31** and the rear end of the shaft being flexibly coupled to the control shaft **12** of the resistor. With the cords **41** and **43** attached to the shaft **13**, the shaft is rotated counterclockwise as viewed in Fig. 3 until the pin **14** abuts against the left hand stop **15**, as viewed in Fig. 5. The movable coil unit **20** is moved toward the coil unit **19** and is held thereagainst, while the cord **43** passing about the lug **32** is pulled tightly and is secured by screw **37**. The pulling of this cord maintains the shaft **13** in position with the pin **14** engaging the left hand stop **15** and also tends to hold the coil units together. The cord **41** which is looped about the shaft portion **13** is then secured taut by means of screw **38**. With the device thus assembled, rotation of the shaft **13** in a counterclockwise direction causes the cord **41** to draw the carrier **31** upward until the coil unit **20** abuts against the coil unit **19**, and the coil displacement and control shaft position will be properly orientated with respect to each other.

In one practical embodiment of the invention, the primary and secondary windings of the I. F. transformers each comprised 190 turns of #7–41 Litzendraht wire wound on a one-half inch coil form using a winding of the universal type. The width of the coils in each case was .18 of an inch and in the position of minimum spacing, which corresponds to maximum coupling, the coils were spaced $\frac{3}{32}$ of an inch apart. The device of the invention provided for variably increasing this spacing ⅜ of an inch. In this particular case, the total resistance of the potentiometer R was 500,000 ohms, while the capacity of condenser C was 300 micro-micro-farads. The impedance of this unit was considerably higher than that of the output or load circuit for the previous tube. With this particular arrangement, the total band width of the complete I. F. amplifier, measured at the point at which signal attenuation of 6 decibels occurred, amounted to 5½ kilo-cycles in the minimum position and 14½ kilo-cycles in the maximum position. The I. F. unit was thus adapted to transmit a signal of 2¾ kilo-cycles and 7¼ kilocycles, respectively. The corresponding cut-off frequency for the audio system in the minimum position amounted to approximately 3 kilo-cycles.

Although the invention has been illustrated and described with reference to a specific preferred embodiment, it will be understood, of course, that various modifications are possible without departing from the scope of the invention. For example, the details of the mechanical structure may be modified while still retaining the principal features of the invention. Other modifications or changes will occur to persons skilled in the art.

I claim:

1. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units comprising a hollow cylindrical coil form and the other unit comprising a coil form axially adjacent said hollow form, an axially projecting shank or stem on said second coil form of smaller diameter than the internal diameter of said hollow form and extending freely into the latter, a cylindrical head on the end of said stem slidably seated in said hollow form, whereby axial movement and some radial movement of one unit relative to the other is permitted, a rotatable shaft, and means operable by said shaft for moving said movable unit relative to the other unit to vary the coupling between the coils thereof.

2. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units each comprising a cylindrical coil form, one of said units being movable axially relative to the other unit, a carrier for said movable unit extending axially from an end of the coil form of the movable unit and having a guide portion, a rotatable shaft extending transversely of said carrier and having a portion seated in said guide portion, and means operable by said shaft for moving said carrier to thereby move said movable unit relative to the other unit to vary the coupling between the coils thereof.

3. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units each comprising a cylindrical coil form, one of said units being movable axially relative to the other unit, a carrier for said movable unit extending axially from an end of the coil form of the movable unit and having a guide slot therein, a rotatable shaft extending transversely of said carrier and having a portion seated in said slot, and flexible connections between said carrier and said shaft adapted to move said carrier when said shaft is rotated, to thereby move said movable unit relative to the other unit to vary the coupling between the coils thereof.

4. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units being movable axially relative to the other unit, a carrier for said movable unit having a lug thereon and a guide slot therein, a rotatable shaft having a portion seated in said slot, a flexible connection between said carrier and said shaft for moving said carrier in one direction, and another flexible connection engaging said lug and fastened between said carrier and said shaft for moving said carrier in the opposite direction, whereby said movable unit may be moved relative to the other unit.

5. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units being movable axially relative to the other unit, a carrier for said movable unit having a lug thereon, a rotatable shaft arranged cooperatively with said carrier, a flexible connection between said carrier and said shaft for moving said carrier in one direction, and another flexible connection engaging said lug and fastened between said carrier and said shaft for moving said carrier in the opposite direction, whereby said movable unit may be moved relatively to the other unit.

6. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units being movable axially relative to the other unit, a carrier for said movable unit having a lug thereon and transverse extensions spaced from said lug, a rotatable shaft arranged cooperatively with said carrier, a flexible connection between one of said extensions and said shaft for moving said carrier in one direction, and another flexible connection engaging said lug and fastened between another of said extensions and said shaft for moving said carrier in the opposite direction, whereby said movable unit may be moved relative to the other unit.

7. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units being movable axially relative to the other unit, a slotted carrier for said movable unit having a lug thereon and transverse extensions spaced from said lug, a rotatable shaft having a portion seated in said slot between said lug and said extensions, a flexible connection between one of said extensions and said shaft for moving said carrier in one direction, and another flexible connection engaging said lug and fastened between another of said extensions and said shaft for moving said carrier in the opposite direction, whereby said movable unit may be moved relative to the other unit.

8. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of adjacent axially aligned coil units, one of said units being movable axially relative to the other unit, a carrier for said movable unit having a guide slot therein, a rotatable shaft having a portion seated in said slot, a flexible connection between said shaft and a part of the carrier adjacent one end of said slot for moving said carrier in one direction, an element on said carrier adjacent the other end of said slot, and another flexible connection engaging said element and fastened between said shaft and the said part of the carrier for moving said carrier in the opposite direction, to thereby vary the coupling between the coils of said units.

9. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of axially aligned coil units, one of said

units being movable axially relative to the other unit, a carrier for said movable unit, a rotatable shaft arranged cooperatively with said carrier, a flexible member extending between said carrier and said shaft and arranged to wind about the shaft when the shaft is rotated in one direction so as to move the carrier in one direction, and another flexible member extending between said carrier and said shaft and arranged to wind about the shaft when the shaft is rotated in the opposite direction so as to move the carrier in the opposite direction.

10. A device for varying the frequency response of a portion of a radio receiver or the like, comprising at least one variable transformer including a pair of axially aligned coil units, one of said units being movable axially relative to the other unit, a carrier for said movable unit, a rotatable shaft arranged cooperatively with said carrier, a flexible member operatively engaging a portion of said carrier on one side of said shaft and connected to the shaft so as to wind thereabout when the shaft is rotated in one direction and thus move the carrier in one direction, and another flexible member operatively engaging a portion of the carrier on the other side of said shaft and connected to the shaft so as to wind thereabout when the shaft is rotated in the opposite direction so as to move the carrier in the opposite direction.

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