

July 29, 1941.

A. D. MARTIN, JR., ET AL

2,251,064

AUTOMATIC DEVICE FOR ADJUSTING TUNED CIRCUITS

Filed Dec. 16, 1939

2 Sheets-Sheet 1

OSCILLATOR PERIODICALLY
VARYING IN FREQUENCY

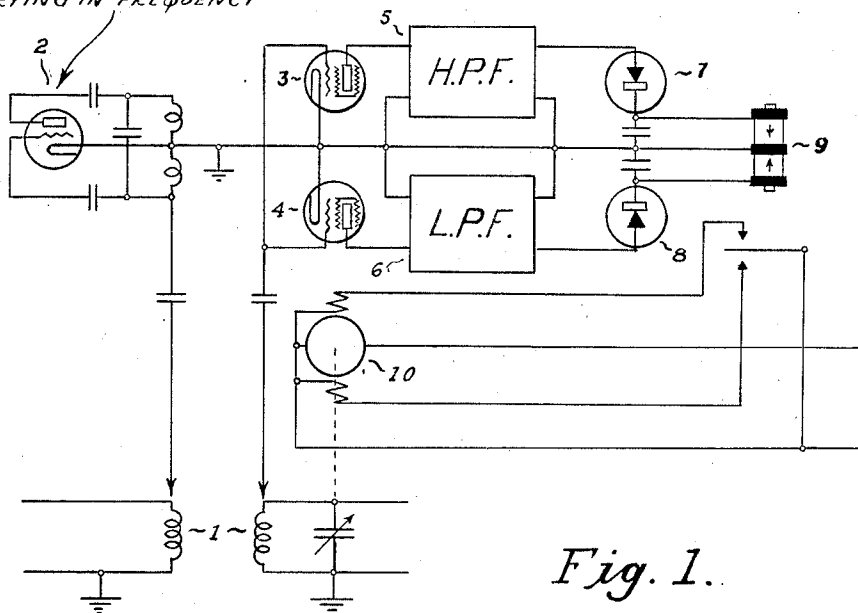


Fig. 1.

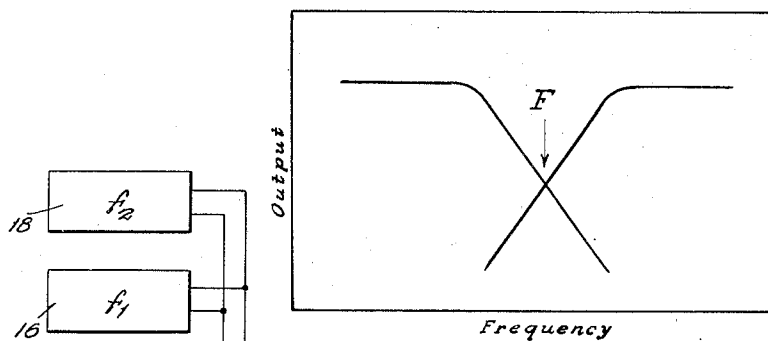


Fig. 2.

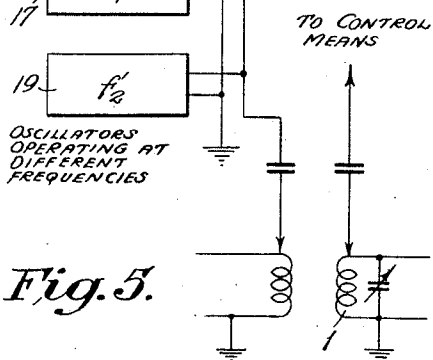


Fig. 5.

Albert D. Martin Jr.
Frank J. Houghton Inventors

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2 Sheets-Sheet 2

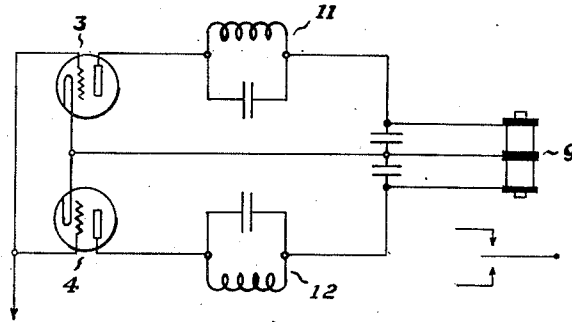


Fig. 3.

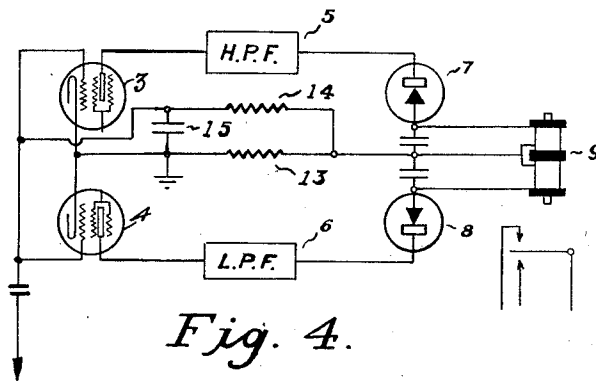


Fig. 4.

Albert D. Martin Jr.
Frank J. Houghton Inventors

UNITED STATES PATENT OFFICE

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AUTOMATIC DEVICE FOR ADJUSTING
TUNED CIRCUITSAlbert Dow Martin, Jr., Arlington, Va., and Frank
Theodore Houghton, Philadelphia, Pa.

Application December 16, 1939, Serial No. 309,520

8 Claims. (Cl. 250—40)

This invention relates to an automatic tuning device for the automatic adjustment of tuned circuits in radio receivers to resonance at a predetermined frequency in order to obtain the coordination and alignment of the several circuits necessary for ganged operation of the controls.

Heretofore, the initial alignment of the radio frequency and intermediate frequency circuits in a superheterodyne or tuned radio frequency receiver in factory production has been accomplished manually. The obvious disadvantages of such a system are, the factor of time involved and the chances for error due to negligence or inefficiency of the workman.

This invention overcomes the disadvantages referred to above by accomplishing the desired adjustments automatically with an accuracy and speed dependent only upon the excellence of the mechanical and electrical design.

The principles of the invention are illustrated in the attached drawings. Figure 1 is a schematic diagram of the basic electrical circuits involved. Figure 2 is a graph of the attenuation curves of the filter system employed. Figure 3 illustrates a differential detector which may replace the rectifiers in Figure 1. Figure 4 illustrates a convenient method of application of automatic gain control to the amplifier circuits of Figure 1. Figure 5 is a diagram of a modified form of oscillator means which may be employed in lieu of the oscillator of periodically varying frequency shown in Figure 1. For purposes of simplicity, the sources of DC voltages for the vacuum tubes in these drawings have been omitted, the customary arrangements of which are evident.

In Figure 1, item 1 is a tuned circuit which is to be adjusted to a given frequency F . Item 2 is a source of radio frequency voltage which varies periodically in frequency between limits which are equally spaced above and below F . Items 3 and 4 are isolating amplifiers having essentially flat frequency characteristics. Items 5 and 6 are high and low pass filters respectively whose characteristics are illustrated in Figure 2. Items 7 and 8 are rectifier elements. Item 9 is a differentially polarized relay whose contacts serve to control the direction of rotation of item 10, a reversible motor. The latter is mechanically coupled to the frequency control of item 1.

Assume that the initial adjustment of item 1 is such that the resonant frequency is higher than F . This circuit will then pass the higher frequencies of item 2 with less attenuation than

the lower frequencies and the voltage impressed on rectifier 7 through filter 5 will exceed that impressed on rectifier 8 through filter 6. Relay 9 will be actuated in one direction which by pre-arrangement will cause the motor 10 to lower the resonant frequency of item 1. Conversely, if 1 is initially adjusted to a frequency below F , it will offer less attenuation to the lower frequencies of 2 and the relay 9 and motor 10 will be actuated in the opposite direction, raising the resonant frequency of 1. When the above action has continued until frequencies equally spaced above and below F are passed by 1 with equal attenuation, the differential in output of the two rectifiers 7 and 8 becomes zero and the relay 9 stops in mid-position thus stopping the motor 10. Assuming that the sides of the frequency response curve of 1 are essentially symmetrical, the resonant frequency of 1 will coincide with the desired frequency F .

The several elements of the above system are individually subject to considerable variation in design and operating principle. These elements are discussed in greater detail hereafter.

The motor 10 is of conventional design and of a size consistent with the load requirements of the system.

The relay 9 should be sufficiently sensitive to operate on a small margin of differential in the rectifier outputs and yet avoid hunting of the motor. In practice the relay contacts would preferably control the motor through additional power relays rather than carry the motor current directly.

The rectifiers 7 and 8 may be of the familiar oxide type, or they may be diodes or multi-element tubes operating on the principles of grid or plate rectification. Still another arrangement is illustrated in Figure 3. Items 3 and 4 are the same as in Figure 1 except that the grid bias is so adjusted that plate current will flow in each tube only on the positive half cycle of the grid excitation voltage. Items 11 and 12 are impedances resonant respectively at frequencies equally spaced above and below F . Their impedances therefore vary in opposite directions with frequency in the vicinity of F . These impedances serve to limit the average plate currents of tubes 3 and 4 in opposite relations with the predominant frequency of the applied grid voltage. The differential in plate current "dip" will serve to actuate the relay 9 in the desired manner. The high and low pass filters are not required in this arrangement.

The amplifiers 3 and 4 are not necessarily lim-

ited to one stage. Sufficient amplification should be employed at this point so that a very small degree of coupling to circuit 1 is required, thus effecting a minimum of detuning of the latter when the connections are removed. The sensitivity of the relay operation may be increased by the addition of direct current amplification between the rectifiers and the relay windings.

The oscillator means may deliver, instead of a varying frequency, two, four or any even number of fixed frequencies symmetrically spaced above and below F . The action of the remaining circuits will be essentially the same. In Figure 5, we have shown diagrammatically an arrangement of four oscillators operating at different frequencies and connected to feed oscillations simultaneously to the tuning device 1. Oscillators 16 and 17 operate at frequencies f_1 and f_1' , equally differentiated from the desired frequency F , whereas oscillators 18 and 19 operate at frequencies f_2 and f_2' , likewise equally differentiated from the desired frequency F but by a greater differential frequency, frequencies f_1 and f_2 being greater, for example, than F while frequencies f_1' and f_2' are less than F . The tuning device 1 will thus discriminate among the oscillations supplied and transmit predominantly energy at the frequency nearest its resonant frequency for effecting adjustment of the device to the frequency F .

An automatic control of the sensitivity of the frequency discrimination circuits and of the output voltage of the frequency source will facilitate the overall operation and prevent overloading. Figure 4 illustrates one method of accomplishing this by inserting a resistance in the common return circuit from the rectifiers through the relay windings and utilizing the voltage drop across the same to bias the grids of amplifiers 3 and 4 and possibly an amplifier inserted in the output of the frequency generator 2.

In Fig. 4, bias resistor 13 is connected in the common return circuit from rectifiers 7 and 8. Connection is made then from a suitable point relative to resistor 13 to the grids of the amplifiers 3 and 4 whereby automatic control of the amplification is effected through variation of the grid bias potential. Ballast resistor 14 is included in this latter connection and a bypass condenser 15 is provided in shunt to resistors 13 and 14 for avoiding high frequency fluctuating potentials at the grids of the amplifiers 3 and 4.

The device described herein is applicable to the alignment of both intermediate frequency and radio frequency amplifiers in a radio receiver. It is important however, that the alignment process either be applied to one stage at a time, or that it proceed from the last stage to the first in order to avoid the effects of frequency discrimination by circuits which have not been properly aligned.

The possibilities of mechanical design of a tuning device embodying the above principles of operation are almost unlimited. For example, the tuning elements could be assembled in a case or cabinet and mounted over a bench or table in such a manner that it could be raised or lowered by an operator. A receiver to be aligned would be placed on the bench and the tuning unit lowered until the necessary electrical and mechanical connections were made through prods and shafts. By moving the receiver or the tuning device laterally the adjustment of various stages in succession could be

accomplished. In a more elaborate arrangement, the tuning unit could be made to adjust the several stages in sequence without manual guidance. This would require a number of sets of prods and tuning shafts electrically actuated in the proper order by a master control.

We claim:

1. Apparatus for automatically adjusting tuning means in a device operable as a tuned element at a predetermined resonant frequency, comprising, in combination with said device and the tuning means therefor, electric motor means engaged with said tuning means and operative for changing the resonant frequency of said device, oscillator means operative to supply energy to said device at different frequencies for frequency discrimination by said device, and automatic control means for said motor means energized from said device and operative in accordance with the frequency discrimination of said device with respect to the energy supplied thereto at said different frequencies, said oscillator means having a middle frequency equal to the desired resonant frequency of said device.

2. Apparatus for automatically adjusting tuning means in a device operable as a tuned element at a predetermined resonant frequency, comprising electric motor means, means for engaging said motor means with said tuning means, oscillator means for providing oscillations of different frequencies and subject to frequency discrimination, means for applying energy from said oscillator means to said device for frequency discrimination by said device, automatic control means for said motor means, and means for energizing said control means from said device for operation in accordance with the frequency discrimination of said device with respect to energy at said different frequencies, said oscillator means having a middle frequency equal to the desired resonant frequency of said device.

3. Apparatus for automatically adjusting tuning means in an electrical circuit operable as a tuned circuit at a predetermined resonant frequency, comprising electric motor means, means for engaging said motor means with said tuning means, oscillator means for providing electrical oscillations of different frequencies and subject to frequency discrimination, means for coupling said oscillator means with the input of said circuit for frequency discrimination by said circuit with respect to said oscillations of different frequencies, automatic control means for said motor means, and means for coupling said control means with the output of said circuit for operation in accordance with the frequency discrimination of said circuit with respect to said oscillations of different frequencies, said oscillator means having a middle frequency equal to the desired resonant frequency of said circuit.

4. Apparatus as set forth in claim 3 wherein said oscillator means comprises a source of oscillations variable in frequency between limits equally greater and less than the desired resonant frequency of said circuit, the rate of frequency variation being sufficiently rapid to provide said oscillations of different frequencies substantially instantaneously, for the frequency discrimination.

5. Apparatus as set forth in claim 3 wherein said oscillator means comprises means for producing an even number of component oscillations symmetrically spaced in frequency in pairs of equal amplitude between limits equally greater and less than the desired resonant frequency of

said circuit, for providing said oscillations of different frequencies substantially simultaneously, for the frequency discrimination.

6. Apparatus as set forth in claim 3 wherein said motor means is reversible, and said automatic control means includes separate high pass and low pass filters, individual rectifier elements connected therewith, and a differential polarized relay energized from said rectifier elements; the differential in rectifier outputs, resulting from frequency discrimination of said circuit, being effective to actuate said relay for operating said motor means in the proper direction to adjust said tuning means to counteract such discrimination.

7. Apparatus as set forth in claim 3 wherein said motor means is reversible, and said auto-

matic control means includes two electron tubes having output impedances which vary in opposite directions with the frequency of the oscillations from said oscillator means, and a differential polarized relay energized from said electron tubes; the differential in the average output currents of said tubes, resulting from frequency discrimination of said circuit, being effective to actuate said relay for operating said motor means in the proper direction to adjust said tuning means to counteract such discrimination.

8. Apparatus as set forth in claim 3 wherein said automatic control means includes amplifier means having automatic gain control circuits connected therewith.

ALBERT DOW MARTIN, JR.

FRANK THEODORE HOUGHTON.