

April 26, 1949.

L. COUILLARD

2,468,041

RADIO RECEIVER

Filed Feb. 12, 1943

2 Sheets-Sheet 1

FIG. 1.

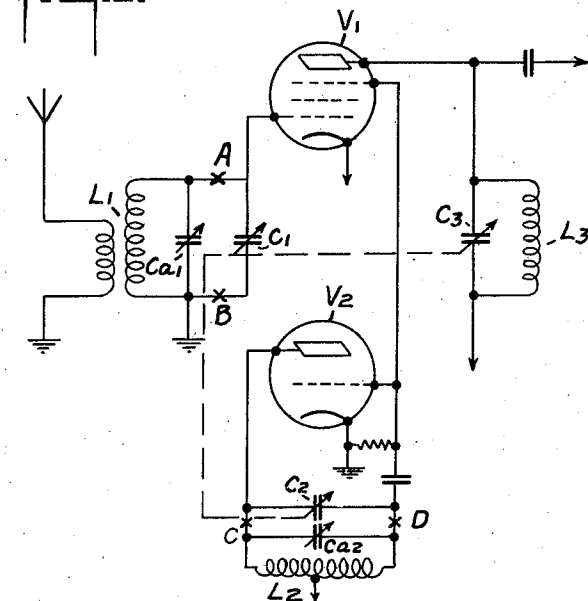
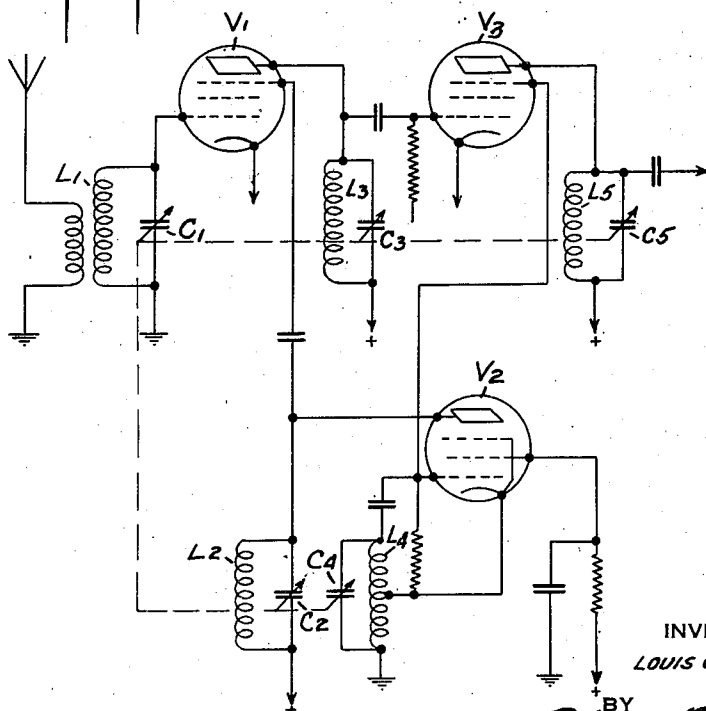


FIG. 2.



INVENTOR
LOUIS COUILLARD

BY
Edward J. Whalley
ATTORNEY

April 26, 1949.

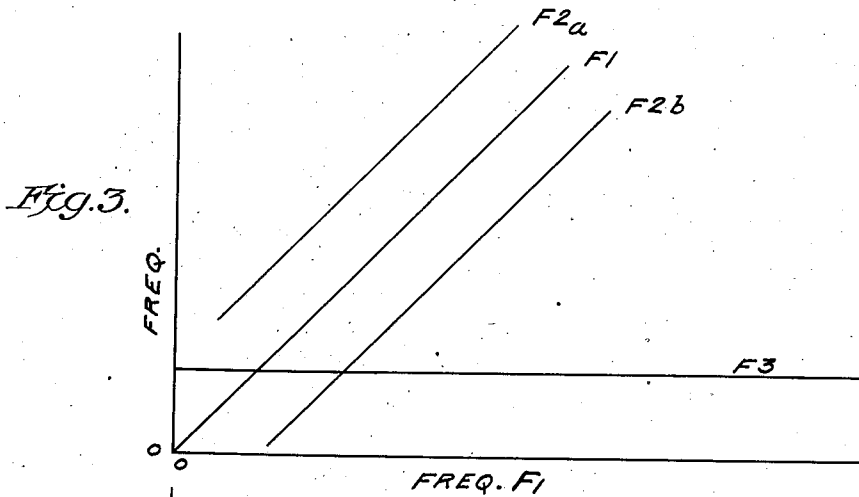
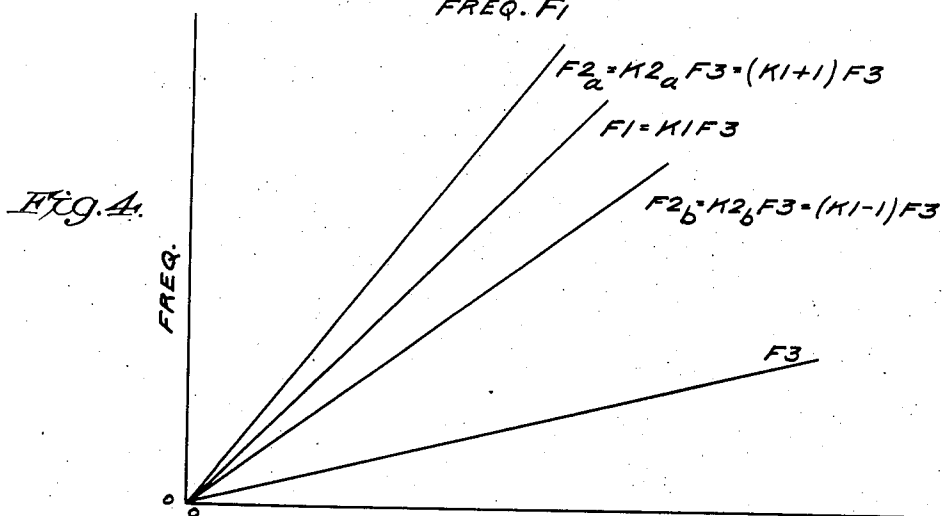
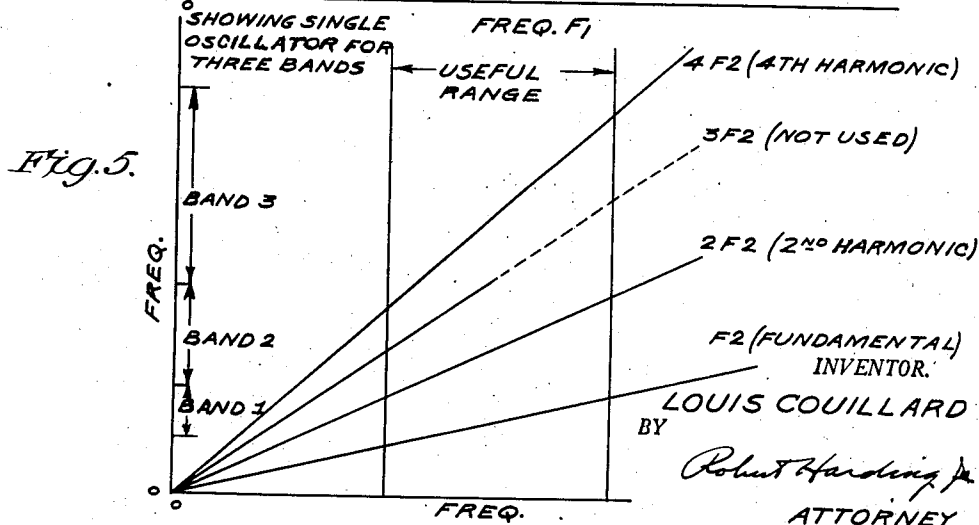
L. COUILLARD

2,468,041

RADIO RECEIVER

Filed Feb. 12, 1943

2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE

2,468,041

RADIO RECEIVER

Louis Couillard, Boulogne-Billancourt, France,
 assignor to International Standard Electric
 Corporation, New York, N. Y., a corporation of
 Delaware

Application February 12, 1943, Serial No. 475,685
 In France March 9, 1942

6 Claims. (Cl. 250—20)

1

The present invention relates to radio receivers employing frequency conversion.

The arrangement of several variable frequency circuits, present in the usual heterodyne radio-electric receivers, has the following principal disadvantages:

Since the difference between the frequency of the signal to be received and the frequency of the local oscillator must be constant, the arrangement of a single control usually renders it necessary to use a condenser with plates of a special shape. The use of a specially shaped condenser for each wave band to be received in order to maintain a predetermined constant intermediate frequency, is particularly undesirable. Exact alignment of the circuits of the conventional heterodyne receiver is usually difficult. Harmonics of the intermediate frequency which occur in the wave band of reception or harmonics of the local oscillator may cause unwanted heat frequencies with the carrier.

Moreover, if the intermediate frequency is constant the signal frequency approaches the intermediate frequency, and the circuits may start to oscillate spontaneously thus impairing the reception of a signal carrier, the frequency of which is in the neighborhood of the intermediate frequency. For this reason, frequencies in the neighborhood of the intermediate frequency cannot be included in the reception bands.

The principal object of the invention is a heterodyne receiver in which any received signal carrier regardless of frequency may never approach the intermediate frequency, nor the local oscillator frequency, nor their harmonics or sub harmonics.

It is a further object of the invention to eliminate all disadvantages mentioned above and to provide a receiver construction with a single control for all the variable circuits, in which an exact alignment of the tuned circuits and a perfect reception over an extended range of signal frequencies are obtained.

The objects of the invention are accomplished by means of the arrangement and combination of elements set forth in the specification, defined and illustratively exemplified in the accompanying drawings, in which

Fig. 1 is a wiring diagram of the high and medium frequency stages of a receiver with simple frequency conversion, that is, a receiver having a single intermediate frequency;

Fig. 2 is a wiring diagram of the high and medium frequency stages of a receiver with a double frequency conversion;

Fig. 3 is a set of curves illustrating the frequency changes in ordinary superheterodyne receivers;

Fig. 4 is a set of curves illustrating the fre-

2

quency changes in a receiver of the present invention; and

Fig. 5 is a set of curves illustrating the positions of the harmonics of the local oscillator frequency with respect to bands of signal frequencies.

In Figs. 1 and 2 of the drawings, only the elements of the receivers are shown which are necessary for an understanding of the invention.

Referring now to the drawings, and particularly to Fig. 1, L1, C1 denote the input circuit which is tuned to the frequency F1 of the signal carrier wave. V1 is a frequency converter tube. The local oscillation for the tube V1 is furnished by the tube V2 having an oscillating circuit L2, C2 tuned to the local frequency F2. The circuit L3, C3, which is the plate circuit of the tube V1, is tuned to the intermediate frequency F3.

Obviously, any number of R. F. or I. F. amplifiers circuits may be tuned respectively to the frequencies F1 and F3 without departing from the spirit and scope of the present invention.

The relation between the three frequencies F1, F2 and F3 is predetermined in accordance with the well known equations:

$$F2 = F1 \pm F3 \text{ when } F3 \text{ is less than } F1.$$

$$F2 = F3 \pm F1 \text{ when } F3 \text{ is greater than } F1.$$

According to the invention, the three condensers C1, C2 and C3 are keyed to a common control shaft and have identical variation characteristics, and, furthermore, the proportion between their end values (inclusive of the residual capacity of the circuits) is the same. In Fig. 4 the relation of the various frequencies for the case when the intermediate frequency F3 is less than the signal frequency F1 has been illustrated. The curves have been plotted with frequency as the ordinate against signal frequency, F1 as the abscissa. The two possible local oscillator frequencies have been represented as curves F2a and F2b, these being the upper and lower frequencies, respectively. This figure may be compared to Fig. 3 which shows the relation of the same frequencies in an ordinary superheterodyne receiver where the intermediate frequency is maintained constant.

Because of the arrangement of the condensers in the present invention the proportion between F1 and F3 is a constant, and we can write:

$$K1 = \sqrt{\frac{C3}{C1}} = \frac{F1}{F3}$$

Therefore

$$F1 = K1 \times F3$$

and by substituting in the first equation above, we obtain

$$F2 = (K1 \pm 1) F3$$

3

The proportion between F_2 and F_3 is also a constant, and we can thus write:

$$K_2 = \sqrt{\frac{C_3}{C_2}} = \frac{F_2}{F_3}$$

and

$$F_2 = K_2 \times F_3$$

then, since $F_2 = (K_1 \pm 1) F_3$,

$$K_2 = K_1 \pm 1$$

In order to obtain an exact alignment of the circuits it is, therefore, sufficient to establish the tuned circuits in such a manner that

$$K_2 = K_1 \pm 1$$

or

$$\sqrt{\frac{C_3}{C_2}} = \sqrt{\frac{C_3}{C_1}} \pm 1$$

The harmonics of the intermediate frequency F_3 can, then, not interfere with the signal frequency F_1 unless K_1 is an integer. In practice it is sufficient that this condition is fulfilled for only one point of the wave band in order to be correct for all its points. Likewise, interferences due to the harmonics of the local oscillator are avoided, because the oscillator is tuned by means of a variable condenser keyed to the same control shaft as the condensers of the other circuits, and its frequency is accurately located at a point away from any harmonic of the intermediate frequency. For example, a harmonic of the range n will differ by about n kc./s. from the harmonic of the intermediate frequency of the same range. Thus, it is easy to eliminate all interferences between this harmonic and the signal.

In the case of a receiver having several wave bands, different self-inductance coils L_1 may be inserted between the points A and B and corresponding self-inductance coils L_2 inserted between the points C and D for each wave band (see Fig. 1). In order to maintain an exact alignment of the circuits, it is sufficient to adjust the value of the residual capacity for each wave band, for instance by means of the small adjustable condensers Ca_1 and Ca_2 shown, in such a manner that a constant proportion is maintained for the capacities corresponding to the two end positions of the variable condensers for the circuits L_1, C_1, Ca_1 — L_2, C_2, Ca_2 —and L_3, C_3 .

The reception bands can be easily so chosen that the signal frequency never approaches the intermediate frequency to a point where the reception could be disturbed. Moreover, the frequency range occupied by the intermediate frequency may even be included in the reception band.

Assuming, for instance, that the intermediate frequency varies between 500 kc./s. and 1500 kc./s., the two next adjacent subdivisions of the reception band could be from 333 kc./s. to 1000 kc./s. and from 1000 kc./s. to 3000 kc./s., the former band being a case where F_3 is greater than F_1 . The values of the intermediate frequency corresponding to the extreme frequencies of said sub-bands are given in the following table:

	First band		Second band	
Signal frequency (F_1)	333	1,000	1,000	3,000
Intermediate frequency (F_3)	500	1,500	500	1,500

It will be seen that the frequency range occupied by the intermediate frequency overlaps

4

or passes through the signal frequency range without causing any disturbance.

A receiving system according to the invention is particularly suitable for the construction of a receiver with several successive frequency changes, each subsequent converter frequency being lower than the preceding one. In this case it is advantageous to select the different frequencies so that each higher local frequency is a multiple of the lowest local frequency. This makes it possible to use a single oscillator and to utilize the fundamental frequency and the harmonics of said oscillator for the different frequency changes. Curves illustrating this feature are shown in Fig. 5.

Fig. 2 illustrates diagrammatically a receiver of this type. A high frequency input circuit L_1, C_1 , tuned to the frequency F_1 of the signal, excites the first frequency converter tube V_1 . The local oscillation for the tube V_1 is furnished by an oscillator tube V_2 through an oscillating circuit tuned to the first local frequency F_2 . The circuit L_3, C_3 for the first intermediate frequency F_3 feeds the oscillations coming from the stage V_1 to a second frequency converter stage V_3 . The local oscillation for the stage V_3 is furnished by the circuit L_4, C_4 tuned to the second local frequency F_4 . The circuit L_5, C_5 is tuned to the second intermediate frequency F_5 . In the example given, the circuit L_2, C_2 serves to filter the harmonic nF_4 of the oscillator V_2 . Thus:

$$F_2 = nF_4$$

Adopting the same relations between the frequencies F_1, F_2 and F_3 as in Fig. 1:

$$F_4 = F_3 \pm F_5$$

$$F_3 = K_3 \times F_5$$

$$F_4 = K_4 \times F_5 = (K_3 \pm 1) F_5$$

$$K_3 = \sqrt{\frac{C_5}{C_3}}$$

$$K_4 = \sqrt{\frac{C_5}{C_4}}$$

The conditions for an exact alignment of the circuit are, then, expressed by the following equations:

$$K_2 = K_1 \pm 1$$

$$K_4 = K_3 \pm 1$$

Substituting for F_4 in the equation $F_2 = nF_4$ we get

$$F_2 = K_4 n F_5$$

Now

$$F_3 = K_3 \times F_5 \text{ and } F_3 = \frac{F_2}{K_2}$$

Therefore

$$\frac{F_2}{K_2} = K_3 \times F_5$$

and

$$F_2 = K_2 \times K_3 \times F_5$$

and

$$K_2 \times K_3 = n K_4$$

$$K_2 = n \pm \frac{n}{K_3}$$

These equations permit the determination of the characteristics of the essential circuit elements in devices according to the present invention.

Instead of using harmonic frequencies as local frequencies, it is possible to construct receivers

5

with multiple frequency change and exact circuit alignment by keying all the variable condensers to the same control shaft; however, this arrangement involves certain material difficulties.

In a communication receiver with double frequency change, the amplifier for the second intermediate frequency comprises generally a certain number of circuits which operate on a relatively low frequency. Therefore, the process according to the invention requires a considerable number of variable condensers of large capacity. On the other hand, the number of circuits for the first intermediate frequency is relatively small, because their function is practically limited to the elimination of the frequency image. The tuning of these first intermediate frequency circuits by means of variable condensers keyed to the same control shaft as those of the high frequency circuits, as provided according to the invention, will thus easily permit an exact alignment of the latter.

Carefully shaping the variable tuning condensers of the second intermediate frequency circuit to obtain alignment over the tuning range, permits the omission of the so-called "padding" condensers from the oscillator circuits of all the sub-bands. The suppression of all interferences between the signal and the harmonics of the local oscillations and of the first intermediate frequency is insured. As far as the second intermediate frequency is concerned, it can be chosen sufficiently remote from the first one to render its harmonics harmless. As shown in detail with respect to the receivers with simple frequency conversion, it is also possible to have reception over a continuous frequency band which may include the first and the second intermediate frequency without any inconveniences due to the closeness of the signal frequency and the intermediate frequency.

It will be understood that the invention is not limited to the embodiments shown and described, but may be carried into effect by numerous other arrangements or modifications.

I claim:

1. Radio receiver with multiple frequency conversion comprising a plurality of converter tubes, each tube having an input circuit, a local oscillator circuit, and an intermediate frequency circuit, each of said circuits including a separate variable tuning condenser, all said tuning condensers having identical variation characteristics and the same proportions between their end values inclusive of the residual capacities of the circuits, a common control shaft to which all said variable tuning condensers are keyed, and an oscillator, said oscillator being coupled to the local oscillator circuits of each of said converter tubes, said local oscillator circuits being resonant to different frequencies so that each subsequent conversion frequency is lower than the preceding one.

2. Radio receiver, as claimed in claim 1, in which the resonant frequency of the oscillator circuits are multiples of one another.

3. Radio receiver, as claimed in claim 1, wherein, the resonant frequencies of said oscillator circuit are, respectively, the fundamental frequency and the harmonics of said oscillator.

4. Radio receiver with multiple frequency conversion comprising a plurality of converter tubes coupled in cascade, each tube having an input circuit, a local oscillator circuit, and an intermediate frequency output circuit, each of said

6

circuits including a separate variable tuning condenser, all said tuning condensers having identical variation characteristics and the same proportions between their end values inclusive of the residual capacities of the circuits, a common control shaft to which all said variable tuning condensers are keyed, a single oscillator, the local oscillator circuit of one converter tube being resonant to the fundamental frequency of said oscillator and the local oscillator circuit of a succeeding converter tube being resonant to a harmonic of said oscillator.

5. Radio receiver as claimed in claim 4, in which, for the reception of a given signal frequency, the capacities of said variable tuning condensers are defined by the following equations:

$$\sqrt{\frac{C_3}{C_2}} = \sqrt{\frac{C_3}{C_1}} \pm 1$$

$$\sqrt{\frac{C_5}{C_4}} = \sqrt{\frac{C_5}{C_3}} \pm 1$$

$$\sqrt{\frac{C_3}{C_2}} \sqrt{\frac{C_5}{C_3}} = n \sqrt{\frac{C_5}{C_4}}$$

$$\sqrt{\frac{C_3}{C_2}} = n \pm \frac{n}{\sqrt{\frac{C_5}{C_3}}}$$

where C1 is the capacity of the variable condenser in the first input circuit, C2 and C3, respectively, are the capacities of the variable condensers in the first local oscillator circuit and in the first intermediate frequency circuit, C4 and C5, respectively, are the capacities of the variable condensers in the second local oscillator circuit and in the second intermediate frequency circuit, and n is the range of the oscillator harmonic used in said second oscillator circuit.

6. A superheterodyne radio receiver comprising a first frequency converter stage with an input circuit and an output circuit, a second frequency converter stage with an input circuit and an output circuit, the output of the first stage being coupled to the input circuit of the second stage, an oscillator, said oscillator having at least two resonant circuits, one oscillator circuit being resonant to a harmonic frequency of the other oscillator circuit, said resonant circuits being coupled, respectively, to the first and to the second converter stages, separate means for tuning said input and output circuits of the converter stages and the oscillator resonant circuits, and mechanical interlocking means between the separate tuning means for adjusting the tuning means in unison.

LOUIS COUILLARD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,342,885	Armstrong	June 8, 1920
1,742,773	Loewe	Jan. 7, 1930
1,933,778	West	Nov. 7, 1933
2,020,832	Grimes	Nov. 12, 1935
2,086,331	Holmes	July 6, 1937
2,151,810	Siemens	Mar. 28, 1939
2,186,980	Lowell	Jan. 16, 1940
2,239,756	Riddle	Apr. 29, 1941
2,282,092	Roberts	May 5, 1942