May 3, 1938. N. M. RUST ET AL 2,115,882

ADJUSTABLE TUNING INDUCTOR

Filed Feb. 25, 1935 2 Sheets-Sheet 1

Fig. 1

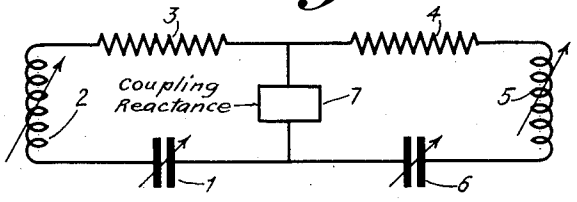


Fig. 2

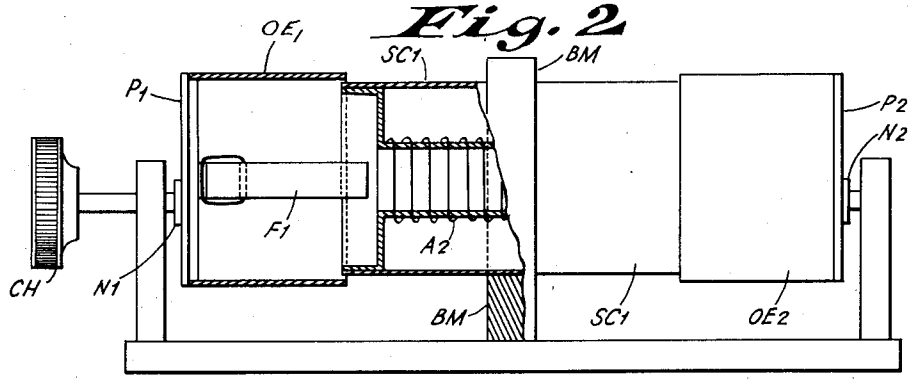
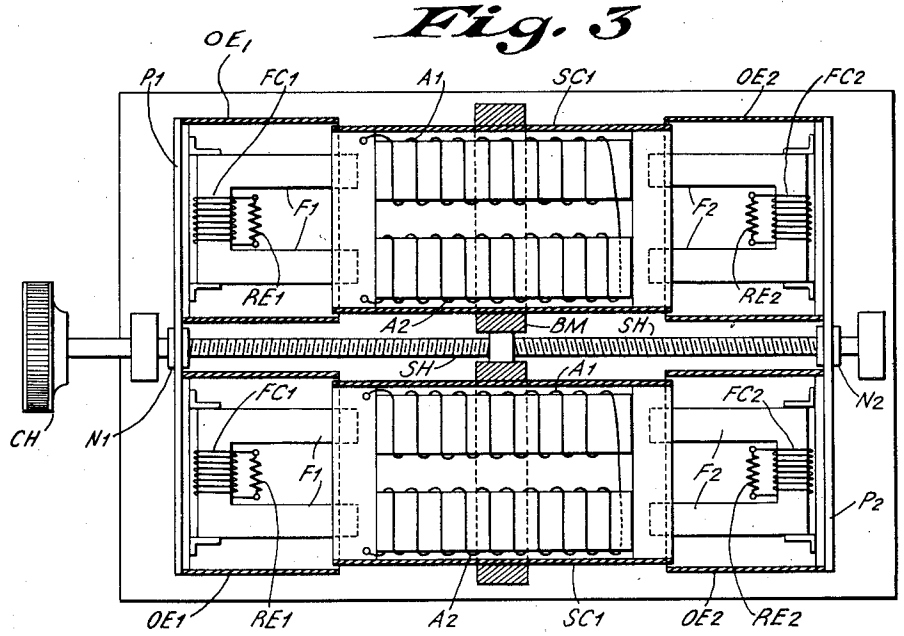


Fig. 3



INVENTORS
NOEL M. RUST
ROBERT F. O'NEILL

BY H. S. Grover

ATTORNEY.

May 3, 1938. N. M. RUST ET AL 2,115,882

ADJUSTABLE TUNING INDUCTOR

Filed Feb. 25, 1935 2 Sheets-Sheet 2

Fig. 4

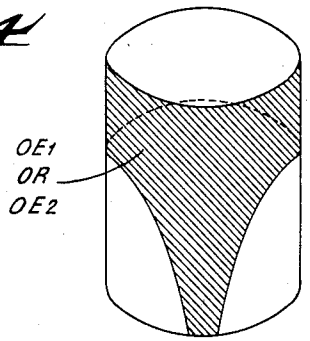


Fig. 5

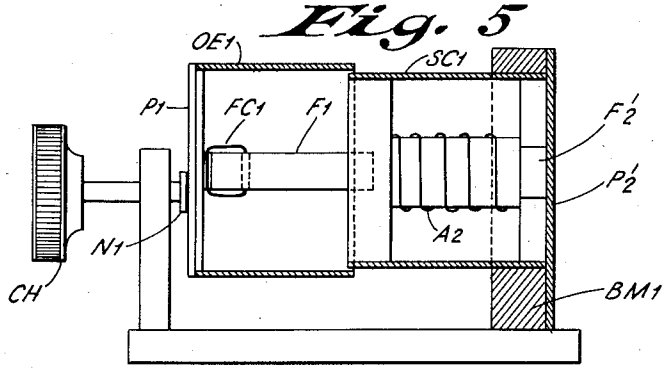
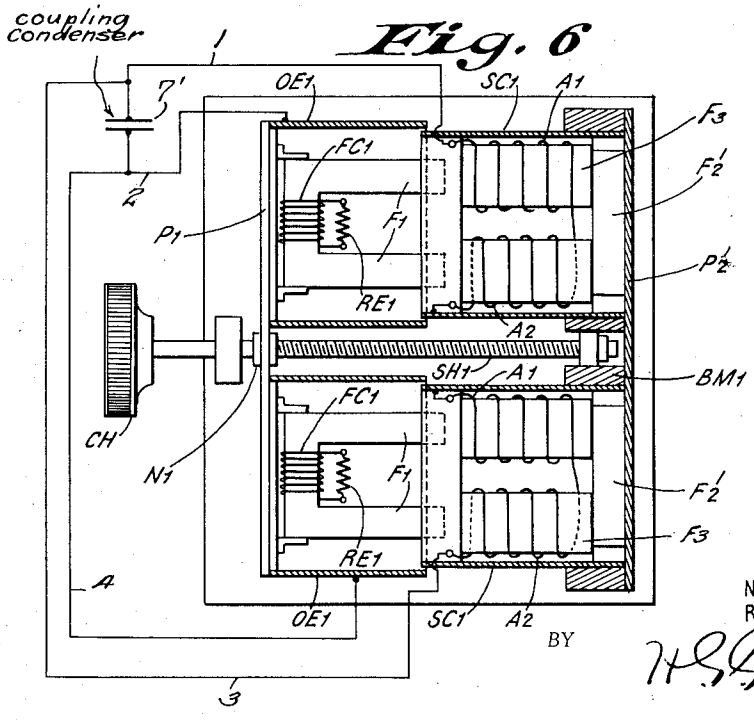


Fig. 6



INVENTORS
NOEL M. RUST
ROBERT F. O'NEILL

BY

ATTORNEY.

Patented May 3, 1938

2,115,882

UNITED STATES PATENT OFFICE

2,115,882

ADJUSTABLE TUNING INDUCTOR

Noël Meyer Rust and Robert Francis O'Neill, Chelmsford, England, assignors to Radio Corporation of America, a corporation of Delaware

Application February 25, 1935, Serial No. 8,068
In Great Britain April 6, 1934

5 Claims. (Cl. 178—44)

This invention relates to variably tunable electrical circuit arrangements, and more specifically to inductance devices for use in variable tuning circuit arrangements of the so-called band pass type suitable for use, for example in connection with the tuning of radio receivers.

Though not limited to its application thereto the invention may be utilized to provide a variably tunable electrical circuit arrangement which will maintain a substantially constant width of band pass over a desired relatively wide range of tuning. However, as will be seen later the invention may be utilized to provide electrical circuit arrangements in which the width of band pass is not constant but varies in a predetermined manner as the tuning is changed, i. e. as the band pass is moved up or down in the frequency spectrum.

In the drawings:

Fig. 1 shows the circuit elements of a tunable band pass circuit to which the present invention is applicable,

Figs. 2 and 3 are mutually perpendicular views of one form of the present invention which is adapted for connection in a circuit of the type shown in Fig. 1,

Fig. 4 is a detailed view of an element of a tuning condenser of the type shown in Figs. 2 and 3,

Figs. 5 and 6 are mutually perpendicular views of a modified form of the invention;

Fig. 6 including circuit connections.

A well known type of variably tunable band pass circuit arrangement is that which may be represented by a theoretical diagram as shown in Figure 1 consisting of a condenser **1** and an inductance **2**, two similar resistances **3**, **4**, a second inductance **5** similar to the first inductance, and a second condenser **6** similar to the first condenser, all those elements being connected in a series loop circuit in the order stated and there being provided a coupling reactance **7** which is connected between the junction point of the two condensers and the junction point of the two resistances. With such a band pass circuit arrangement a constant width of band pass is obtained if the ratio L/R (inductance/resistance) is constant and the value **X** of the coupling reactance **7** is proportional to the resistance R, i. e. X/R is constant.

Theoretically, therefore, constant band width may be obtained by making L and C (inductance and capacity) each proportional to the wave length and the ratio L/R constant. Thus, the coupling reactance **7** may be merely a fixed condenser and constant width of band pass obtained by so arranging matters that L, C and R are all varied for tuning purposes so that each is proportional to the working wave length, the width of band obtained being determined by the value C_1 of the condenser constituting the coupling reactance **7**.

The present invention provides a simple inductive device for use in a circuit arrangement of the band pass type.

According to this invention a variable inductive device suitable for use in a variably tunable band pass circuit arrangement comprises two bodies of magnetic material arranged with respect to one another in such manner as to provide a magnetic circuit consisting of the two said bodies and two air gaps in series, means for causing relative movement between said bodies in such manner as to diminish or increase said air gaps and astatically arranged windings upon the magnetic circuit which includes the two bodies and the two air gaps.

Preferably the bodies are made of the material known under the trade name "Ferrocart" or some similar material. These materials are essentially characterized by low eddy current losses at high frequencies. Either or both of said bodies may be made movable.

Referring to Figs. 2, 3 and 4 the device illustrated by these figures includes two variable inductive devices each comprising two bodies F_1, F_2 of the material known as "Ferrocart" each body being of rectangular U-shape, the bodies being placed with their limbs facing one another so as together to provide a rectangular magnetic circuit including two series air gaps symmetrically arranged in said circuit, said air gaps being each between the end of one limb of one body and the end of the corresponding limb of the other. Two coils A_1, A_2 astatically arranged and connected in series with one another are positioned in association with the magnetic system thus constituted, each coil embracing one of the air gaps and an amount of the limb on either side of that air gap, the amount embraced at any time depending upon the momentary positions to which the bodies are adjusted. The bodies are arranged to be moved by a suitable control handle CH so as to approach towards or recede from one another, the movement being such that for all positions of adjustment the magnetic circuit arrangement and the series connected astatically arranged coils are symmetrical so that as the air gaps are varied in length, each coil remains centrally positioned with respect to its associated air gap.

Thus movement of the control handle will cause similar variations of the inductances of the two coils. The arrangement illustrated is adapted for circuit connection in a band pass variably tunable circuit of the well known general type hereinbefore set forth and is more specifically shown in Fig. 6, and it is for this reason that two similar inductive devices in accordance with this invention are embodied therein, the astatically arranged windings A_1, A_2 of each device being utilized as one of the inductances (2 or 5—see Fig. 1) of the circuit.

The handle CH is a common control handle for moving the bodies F_1, F_2 of both inductive devices and it also serves to vary the capacities (1, 6—see Fig. 1) of the two tunable condensers which are included in the band pass circuit, the said variable condensers being constructed (as will be explained later) to have the same law of variation as the variable inductance devices so that when the control handle is operated proportional variations of inductance and capacity will occur.

In the embodiment shown the control handle CH drives a right and left handed screwed shaft SH running in a fixed bearing member BM and co-operating with right and left handed nuts N_1, N_2 fixed to frame plates P_1, P_2. The plate P_1 carries the two members F_1 and the plate P_2 carries the two members F_2 so that when the shaft SH is rotated in one direction the cores F_1 and F_2 move at like speeds towards one another while when the shaft is rotated in the other direction the cores move away from one another. Surrounding the coils A_1, A_2 of each variable inductive device is a screening can or cylinder SC_1 which constitutes the common electrode of the condensers 1, 6 (see Fig. 1), the screens SC_1 being carried by the fixed member BM and co-operating electrostatically with shaped electrodes OE_1 and OE_2 to constitute therewith the said condensers 1, 6. The electrodes OE_1 and OE_2 are carried by the plates P_1 and P_2 respectively and are shaped approximately as shown in Fig. 4 to give the required law of capacity variation. Fig. 4 in which the cross hatched part represents metal and the remainder insulation is not intended to be an accurate disclosure of shape but is merely illustrative.

Two further coils FC_1, FC_2 each wound upon one of the magnetic bodies F_1 or F_2 (preferably as shown on the bottom limbs of the U's) are shown provided in each inductance device, in the arrangement illustrated each of these further coils being shunted by a resistance element RE_1 or RE_2. In this way the series resistances 3, 4, for the band pass circuit of Fig. 1 are provided. In many cases the further coils FC_1, FC_2 may be so proportioned that the resistances in shunt therewith may be fixed, for it will be seen that as the magnetic bodies of an inductance device as above described and illustrated are moved towards one another, increase both of effective resistance and of inductance will occur and in practice it will commonly be quite feasible so to arrange matters that with fixed shunt resistances RE_1, RE_2 across the added coils FC_1, FC_2 the rate of change of effective resistance with movement of the bodies is, to a sufficient degree of approximation, equal to the rate of change of inductance.

In some cases, however, it may be necessary or desirable to arrange for the two resistances also to be variable. In such cases these resistances may be controlled by the same control handle CH. If the arrangement is such that the total inductance and the total capacity are always proportional to one another whatever the position of the control handle and the law of variation of the resistances is such that the ratio L/R remains constant irrespective of the position of the control handle substantially constant width of band pass will be obtained. The usual coupling condenser 7 as ordinarily employed in a band pass tunable circuit, as hereinbefore described, is provided, and as before this condenser will determine by its magnitude the width of band passed. This condenser is not shown in Figs. 2, 3 and 4.

The invention is not limited to embodiments such as that illustrated in Figs. 2 and 3 wherein variation of inductance is obtained by simultaneous and opposite movement of two magnetic bodies, for what may be termed "single end" adjustment may be resorted to. For example the construction of Figs. 2 and 3 may be modified as shown in Figs. 5 and 6 wherein parts corresponding to those of Figs. 2 and 3 are marked with the same references. It is thought that the constructional details of Figs. 5 and 6 will be fairly obvious from inspection of these drawings, so that little further description is necessary. As will be seen the movable U-shaped cores F_2 of Figs. 2 and 3 are replaced by fixed Ferrocart "keepers" F_3 carried on the fixed plate F_2' which also carries the bearing member BM_1 for the control shaft SH_1 which is now a simple single threaded shaft upon which runs the nut N_1 carrying the moving plate P_1 with its condenser plates OE_1 and U-shaped cores F_1.

In Fig. 6 there is shown the manner of connecting the device in a circuit of the type generally denoted in Fig. 1. The coupling reactance, condenser 7', has one side thereof connected through lead 1 to the terminal of coil A_1, and the other side of the condenser is connected through lead 2 to the condenser element OE_1. The terminal of coil A_2 is connected to the condenser element SC_1. The terminal of the other coil A_1 is directly connected to the condenser element SC_1 associated therewith, and the terminal of coil A_2 is connected through lead 3 to that side of coupling condenser 7' to which the lead 1 is connected. The lead 4 connects the opposite side of the coupling condenser to the adjustable condenser element OE_1. As explained heretofore the series resistances 3 and 4 in Fig. 1 is provided by the auxiliary windings FC_1 having shunt resistors RE_1. The same circuit connections are employed in connection with the device shown in Figs. 2 and 3. In the latter case it is only necessary to additionally connect lead 2 to the corresponding condenser element SC_1, and lead 4 to the corresponding movable condenser element OE_2.

In some cases, for example where apparatus in accordance with this invention is employed to couple thermionic valves in cascade, it may be desirable so to arrange matters that the ratio L/R decreases, for example in accordance with a rectilinear law, with increase in wave length, and this may easily be effected in carrying out this invention by suitably proportioning and arranging the variable resistances. Such a variation of the ratio L/R may be required, for example, to compensate for the characteristics of other apparatus provided in a radio receiver or other device incorporating apparatus in accordance with this invention.

While we have indicated and described a system for carrying our invention into effect, it will

be apparent to one skilled in the art that our invention is by no means limited to the particular organization shown and described, but that many modifications may be made without departing from the scope of our invention, as set forth in the appended claims.

What we claim is:

1. A resonant network comprising at least two spaced bodies of magnetic material constructed and arranged to provide a closed magnetic circuit, said material being characterized by its low eddy current losses at high frequencies, a coil operatively associated with the magnetic circuit, a metallic cylindrical screen member surrounding the coil, a second metallic cylindrical screen member surrounding one of said bodies, said two screens being co-axially disposed, means connecting one terminal of the coil to the first screen member, means connecting the other terminal of the coil to the second member, the capacity between the two screen members cooperating with the inductance of said coil to tune the network.

2. A resonant network comprising at least two spaced bodies of magnetic material constructed and arranged to provide a closed magnetic circuit, said material being characterized by its low eddy current losses at high frequencies, a coil operatively associated with the magnetic circuit, a metallic cylindrical screen member surrounding the coil, a second metallic cylindrical screen member surrounding one of said bodies, said two screens being co-axially disposed, means connecting one terminal of the coil to the first screen member, means connecting the other terminal of the coil to the second member, the capacity between the two screen members cooperating with the inductance of said coil to tune the network, and means for simultaneously varying the spacing between said bodies and the spacing between said screen members thereby to adjust the resonant frequency of the network.

3. A resonant network comprising at least two spaced bodies of magnetic material constructed and arranged to provide a closed magnetic circuit, said material being characterized by its low eddy current losses at high frequencies, a coil operatively associated with the magnetic circuit, a metallic cylindrical screen member surrounding the coil, a second metallic cylindrical screen member surrounding one of said bodies, said two screens being co-axially disposed, means connecting one terminal of the coil to the first screen member, means connecting the other terminal of the coil to the second member, the capacity between the two screen members cooperating with the inductance of said coil to tune the network, and means electrically associated with at least one of the magnetic bodies for providing resistance in said network in series with the coil and said capacity.

4. A resonant network comprising at least two spaced bodies of magnetic material constructed and arranged to provide a closed magnetic circuit, said material being characterized by its low eddy current losses at high frequencies, a coil operatively associated with the magnetic circuit, a metallic cylindrical screen member surrounding the coil, a second metallic cylindrical screen member surrounding one of said bodies, said two screens being co-axially disposed, means connecting one terminal of the coil to the first screen member, means connecting the other terminal of the coil to the second member, the capacity between the two screen members cooperating with the inductance of said coil to tune the network, a coil wound on one of the magnetic bodies, and a resistor being in shunt with the coil, said last coil and resistor introducing series resistance in said network.

5. A resonant network comprising at least two spaced bodies of magnetic material constructed and arranged to provide a closed magnetic circuit, said material being characterized by its low eddy current losses at high frequencies, a coil operatively associated with the magnetic circuit, a metallic cylindrical screen member surrounding the coil, a second metallic cylindrical screen member surrounding one of said bodies, said two screens being co-axially disposed, means connecting one terminal of the coil to the first screen member, means connecting the other terminal of the coil to the second member, the capacity between the two screen members cooperating with the inductance of said coil to tune the network, at least one of the bodies having a substantially U-shaped configuration, and an auxiliary coil wound on said one body.

NOËL MEYER RUST.
ROBERT FRANCIS O'NEILL.