Sept. 4, 1928. F. A. KOLSTER 1,683,081

VARIABLE COUPLING TRANSFORMER

Filed March 23, 1926

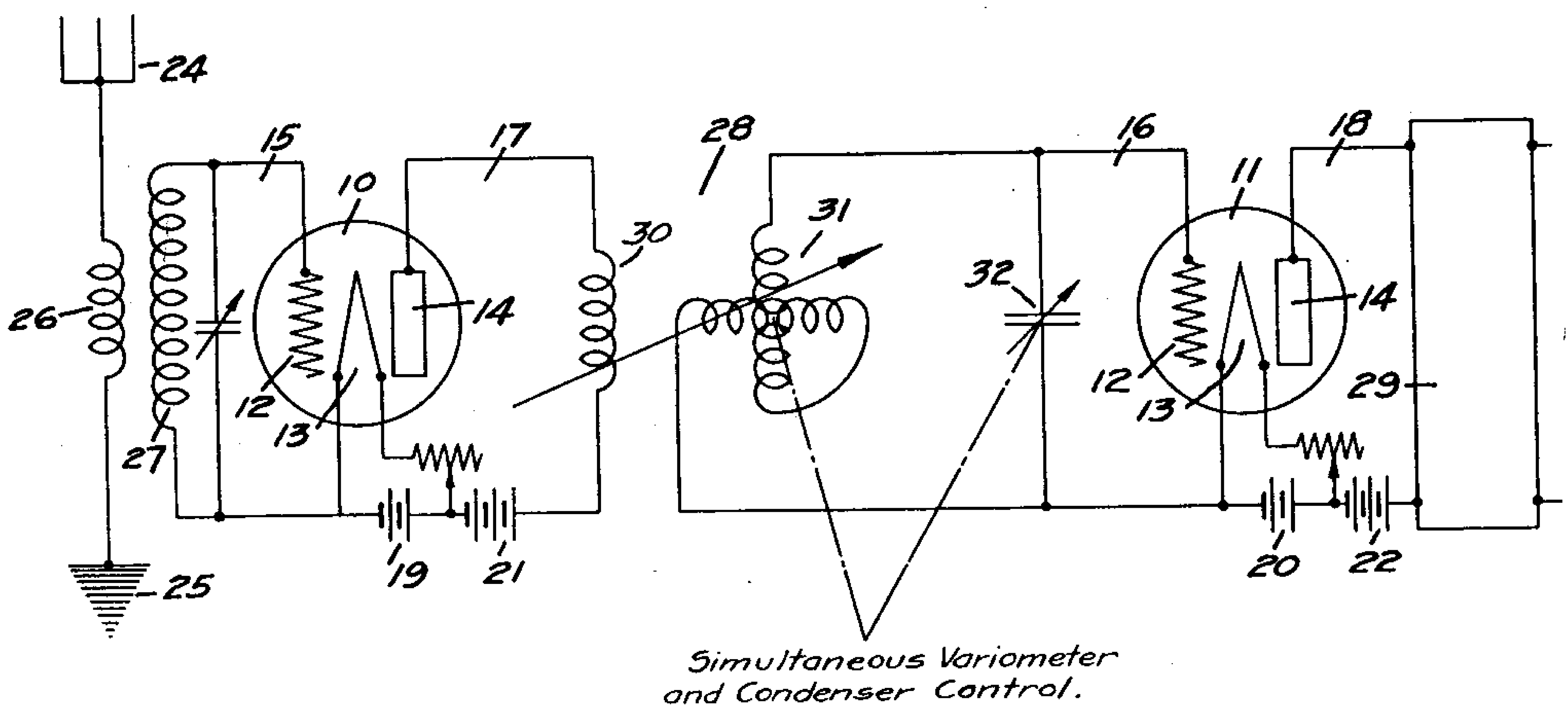

FIG. 1.

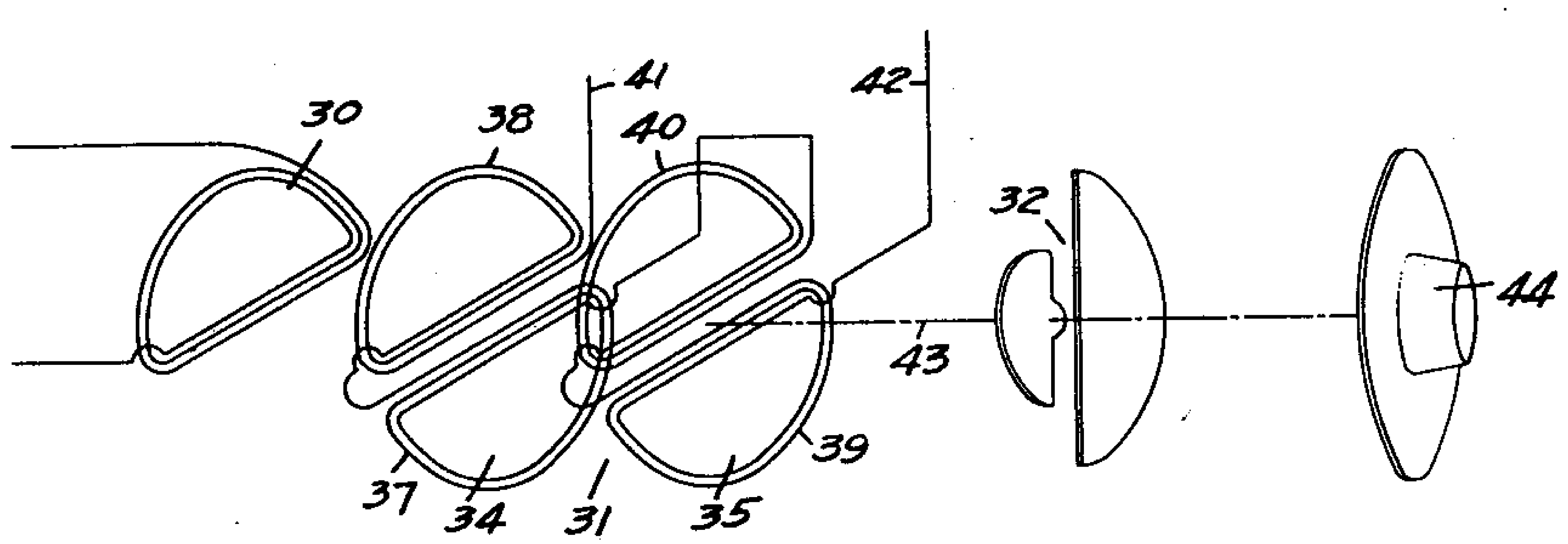

FIG. 2.

INVENTOR
Frederick A. Kolster
BY White & Prost
his ATTORNEYS

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FREDERICK A. KOLSTER, OF PALO ALTO, CALIFORNIA, ASSIGNOR TO FEDERAL TELEGRAPH COMPANY, OF SAN FRANCISCO, CALIFORNIA, A CORPORATION OF CALIFORNIA.

VARIABLE-COUPLING TRANSFORMER.

Application filed March 23, 1926. Serial No. 96,689.

This invention relates generally to a coupling device for coupling together two electrical circuits for the transfer of radio frequency energy. It has particular application in coupling together the stages of a radio frequency amplifier system such as employed in the radio art.

It is an object of this invention to devise a coupling device which will effect a substantially constant energy transfer ratio for all frequencies.

It is a further object of this invention to construct a cascade amplifier system having selectively tunable coupling devices in which automatic coupling adjustments are effected upon tuning the system for different frequencies.

It is a further object of this invention to devise a coupling arrangement for an amplifier system which will efficiently cover a relatively broad range of radio frequencies without causing the amplifier tubes to oscillate locally.

Further objects of this invention will appear from the following description in which the preferred embodiment of the invention has been set forth.

Referring to the drawings:

Figure 1 is a circuit diagram of a radio frequency amplifier incorporating this invention.

Fig. 2 is a detail showing diagrammatically the elements of the variable coupling transformer.

The most common form of coupling device for coupling together the stages of a radio frequency amplifier comprises simply a transformer having primary and secondary coils in fixed physical relationship to each other, the secondary coil being tuned to the desired frequency by means of a variable condenser. Since the value of an inductance varies in proportion to the frequency of the electrical energy, such a coupling device will transfer a proportionally greater amount of energy for relatively high fequencies than for lower frequencies, thus resulting in unequal performance over the frequency range for which the system is adapted to be used. Also if the primary and secondary coils are placed sufficiently close to effect efficient transfer of energy for low frequencies than for the higher frequencies reactive and feedback effects will cause the amplifier tubes to oscillate locally. It is therefore desirable to employ a different degree of coupling for different selected frequencies so that the system will amplify with substantially constant efficiency throughout the frequency range. There is an added disadvantage in the above type of transformer in that relatively large variable condensers must be shunted across the secondary coil in order to cover a substantial frequency range. In this invention it is proposed to employ a transformer having a variable secondary inductance, which by its variations will effect the desired variations in coupling between the primary and secondary coils. The secondary is shunted by a variable condenser which is controlled simultaneously with the variable secondary so that coupling adjustments are effected simultaneously with variations in tuning. Because the secondary is a variable inductance the variable condenser may have a higher minimum and a lower maximum capacitance to cover the same or even a greater frequency range than with the ordinary form of coupling transformer.

The invention is shown in Fig. 1 as incorporated with a radio frequency amplifier comprising electron emission tubes 10 and 11 which are preferably of the three element type, each comprising a grid or control element 12, electron emission element 13 and plate or anode 14. The grid and electron emission elements of each tube are associated in the usual manner with input circuits 15 and 16 respectively while the anodes 14 of each tube are associated with the output circuits 17 and 18 respectively. The specific connections for the circuits are well known in the art and will not be described in detail. It is sufficient to state that the electron emission elements are energized from a suitable source of current such as "A" batteries 19 and 20, while the output circuits 17 and 18 are energized from another source such as "B" batteries 21 and 22. The input circuit 15 is suitably coupled to a convenient source of radio frequency energy such as an antenna 24 and ground 25, the antenna and ground being inductively coupled to the input circuit by means of an antenna inductance 26 placed in inductive relation to a tuned secondary inductance 27. The output circuit 17 is coupled to the input 16 by a novel form of coupling device 28 later to be described, while the output circuit 18 for the tube 11 supplies a suitable translating device 29.

The variable coupling device 28 preferably comprises a primary inductance 30 which is included in the output circuit 17 and is in inductive relation to a variable secondary inductance 31 included in the input circuit 16. The variable secondary 31 is shunted by a variable condenser 32 which is preferably varied simultaneously with the secondary 31. As shown in Fig. 2 the variable inductance 31 is preferably in the form of a variometer having stationary and movable coils 34 and 35 respectively. This variometer illustrated is of the D coil type, coil 34 comprising a pair of oppositely wound D shaped sections 37 and 38 which are mounted side by side in a common plane, and coil 35 comprising similar sections 39 and 40. The two coils 34 and 35 are connected in series with each other and to the conductors 41 and 42 of the input circuit 16. The coil 35 is adapted to be rotated in a plane parallel to and adjacent that of the coil 34 by suitable means such as a shaft illustrated diagrammatically at 43. This shaft is actuated by a suitable manual control device such as a dial 44 which also simultaneously controls the variable condenser 32.

Preferably the rotor plates of the condenser 32 are mounted upon the same shaft as the shaft 35 of the variometer so that upon rotation of the shaft the capacitance is varied from a maximum to a minimum. The coils 34 and 35 are wound in such a manner that upon rotation of the coil 35 through 180 degrees the coil sections move from a position in which they are in inductive opposition to a position in which their fields are additive, thus effecting a variation in the total inductance of the variometer from a minimum to a maximum value. The primary inductance 30 may consist of a single D wound section which is placed in inductive relation with one of the D sections of the coil 34. Preferably the primary coil is positioned closer to the stationary coil of the variometer than to the rotary coil.

The operation of this coupling device is as follows:—For comparatively long wave lengths or low frequencies, the variometer coils are moved in such position that the D sections act additively so that the inductance value of the secondary will be relatively high. At the same time since the condenser 32 is controlled simultaneously with the variometer 31 the capacitance of the condenser is made relatively high. The primary coil 30 will then also be in inductive relation with both the D sections 38 and 39 so that relatively close coupling will be effected for this frequency. However, for a low wave length or comparatively high frequency the dial 44 is turned so that the total inductance of the variometer and the capacitance of the condenser 32 are relatively low. In this position the sections 38 and 40 will be acting in opposition and as the primary coil 30 is in inductive relation with these sections, the mutual inductance between the primary and secondary 31 will be decreased so that compensation is made for the higher frequencies. The result is somewhat the same as if the distance between the primary and secondary coils were made greater for the higher frequencies than for the lower frequencies, although the variometer arrangement effects this result in a much more convenient manner.

The arrangement of the variable secondary together with the simultaneously controlled variable condenser makes it possible for this coupling device to cover a very broad range of radio frequencies. This broad range is not obtained at any sacrifice of efficiency as the capacitance of the condenser 32 need not be large for even the longest wave lengths and therefore its losses will be negligible. It is also a simple matter with this system to obtain a straight line frequency characteristic for angular movements of the shaft 43 as the plates of the condenser may deviate greatly in shape from those of the ordinary straight line capacity condenser.

I claim:

1. A device of the class described comprising a primary inductance, a variometer secondary inductance including a pair of coils relatively rotatable with respect to each other for varying their total inductance between a maximum and minimum, said primary inductance positioned in fixed inductive relation to one of said coils whereby the coupling between the primary and secondary will vary upon variation of said secondary, a variable capacitance shunted across said secondary, and a common control means simultaneously increasing said secondary from a minimum to a maximum inductance upon variation of the capacitance from a minimum to a maximum value without effecting a substantial change in the primary inductance.

2. In an amplifying system, an electron emission tube amplifier having an output circuit, means for selectively coupling said output circuit to another circuit comprising a primary inductance included in the output, a variometer secondary inductance included in the other circuit, said variometer comprising two relatively movable coils, one of which is in fixed inductive relation with said primary inductance, a variable condenser shunted across said secondary inductance, and common control means for simultaneously varying said variometer and condenser whereby closer coupling is effected for long wave lengths than for short, movement of said control means having substantially no effect upon the value of the primary inductance.

3. In an amplifying sytsem, an electron emission tube amplifier having an output circuit, and means for inductively coupling said output circuit to another circuit, said means including a fixed primary inductance in said output circuit, a variable secondary inductance in inductive relation to said primary inductance and included in said other circuit, a variable condenser shunted across said variable inductance, and a common mechanical control means for simultaneously increasing said secondary inductance upon an increase in the capacitance of said condenser and vice versa, without substantially changing the primary inductance.

In testimony whereof, I have hereunto set my hand.

FREDERICK A. KOLSTER.