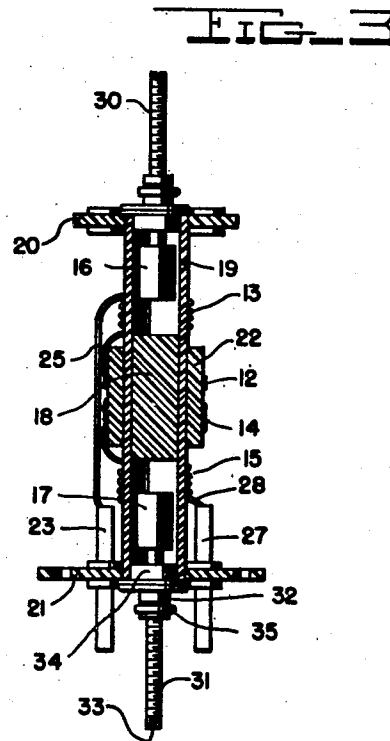
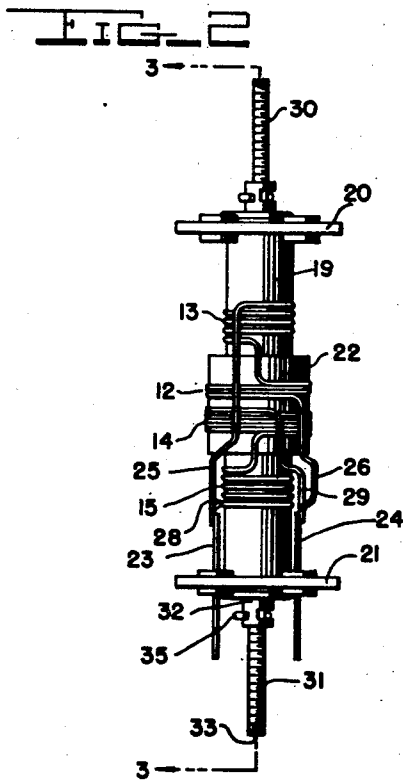
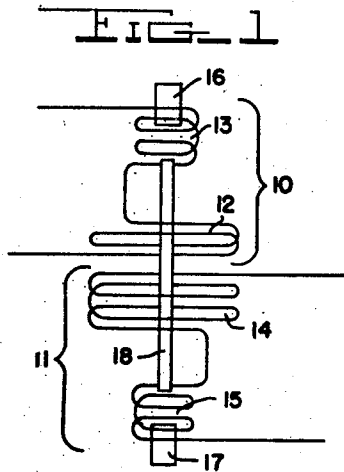


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PERMEABILITY TUNED INTERMEDIATE
FREQUENCY TRANSFORMER
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PERMEABILITY TUNED INTERMEDIATE
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The present invention relates to tunable inter-stage transformers and more particularly to intermediate-frequency permeability-tuned transformers.

According to the known practice, intermediate-frequency transformers in superheterodyne receivers are adjusted to give the desired L-C combination for the plate and grid circuits of the driving and driven tubes respectively, by varying the position of a coil core element of high permeability, such as an iron-dust core, in the primary and secondary windings. Such adjustments become necessary whenever any of the constants of the circuits are altered as upon insertion of a new tube, a condenser or resistor.

However, in such practice, it has been found that when the iron cores are moved relative to their respective transformer windings, the coupling coefficient of the transformer is altered, with consequent alteration of the over-all, amplification-characteristic of the amplifier in which the transformer coupling is used.

An object of the present invention is to provide a coupling transformer overcoming the above disadvantages of the known practice.

Another object is to provide a coupling transformer in which the inductance of either or both the primary and secondary circuits may be varied without undesirable variation in the coupling coefficient of the transformer.

A further object of the invention is the provision of a coupling transformer having coupling and tuning windings with minimum inductive coupling between a tuning winding and the coupling winding.

Other objects and advantages of the invention will become apparent upon a perusal of the following specification and the drawings accompanying the same.

In the drawings:

Fig. 1 is a schematic diagram of the arrangement of windings and core elements constituting the transformer.

Fig. 2 is a side elevation of a preferred embodiment of the invention.

Fig. 3 is a section on the line 3-3 of Fig. 2 with certain central portions in full.

Referring to the drawings more in detail, and first to Fig. 1, here is illustrated the principle of the invention which comprises in general a primary section 10 and secondary section 11, the primary section being comprised of a coupling portion 12 and a tuning portion 13, while the secondary section is similarly comprised of a coupling portion 14 and a tuning portion 15.

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The coupling portions 12 and 14 are relatively closely coupled while the tuning portions 13 and 15 are relatively loosely coupled and preferably very loosely coupled. To further avoid objectionable coupling between the tuning portion of one section of the transformer and the coupling portion of the other, say the portions 13 and 14, and to afford close coupling between the portions 12 and 14, and to give them a relatively large inductance without undue axial length, the coupling portions 14 and 12 are given a relatively large diameter. However, it is not essential that the portions 12 and 14 be of larger diameter than the tuning portions, and in fact may be of even slightly less diameter than the tuning coils without detriment to the operation of the device.

Each of the tuning portions 13 and 15 is provided with means 16 and 17 respectively for varying its inductance, the inductance varying means being preferably in the form of iron-dust cores movable toward and away from the centers of their respective tuning-coil portions. Thus movement of the core 17 toward and away from the center of the coil portion 15 will increase and decrease the effective inductance of the latter with consequent variation in the tuning of any circuit of which the latter forms a part, and this without substantial variation of the coefficient of coupling, due to the remoteness of the coil portion 15 from the primary coil-portions 12 and 13. Mutual inductance between coil-portions 14 and 15 is maintained low and practically ineffectual by suitable spacing between them and by avoidance of a movement of the core 17 too far into the space between the coil portions. Preferably, movement of the core into the tuning-coil portion beyond the center of the latter is to be avoided and to insure against further movement, suitable mechanical stop means 18 of substantially non-magnetic, non-conducting material may be provided.

Referring now to Figs. 2 and 3 which show one practical, physical embodiment of the invention, the main frame consists of a tube member 19 of electrical insulating material, such as polystyrene, mounted in a pair of end plates 20 and 21 of like material and having mounted on its central portion an enlarged coil support or form 22, in the form of a short section of tubing of electrical insulating material telescoped over the inner tube 19 and suitably secured thereto as by cement or other suitable securing means. This relatively large central core-form supports the two, closely coupled, coupling portions 12 and 14, while the inner tube 19 supports the tuning por-

tions 13 and 15, of the primary and secondary sections of the transformer. In the present embodiment, the large coils have a diameter of approximately one and one half times that of the small coils, the actual diameter being approximately one half of an inch for the outside diameter of the small tube 19 and three quarters of an inch for the outside diameter of the large tube. As pointed out above, this difference in diameter is not essential to satisfactory operation of the device, and the device may as well be formed with the coupling coils wound directly on the tube member 19 so long as the coil section 13 is spaced sufficiently distant from the coil section 14 to have only a relatively loose coupling therewith and the coil sections 12 and 15 are similarly spaced. The coupling coils 13 and 14 are formed with closely spaced turns, for example, contacting convolutions of enameled wire, while the small coils are formed with more widely spaced convolutions, approximately the diameter of the wire apart. This relatively large spacing of the tunable coil portion results in a more gradual variation of inductance for a given extent of movement of the iron-dust core element.

Terminal lugs such as 23, 24 secured in the lower end plate 21, serve as connecting terminals for the coils. As shown in Fig. 2, the lugs 23 and 24 serve as terminals for the primary section of the transformer through leads 25 and 26 while a similar pair of lugs, not shown in Fig. 2, situated in line with the first mentioned lugs as indicated for the lugs 23, 27 in Fig. 3, serve as terminals for the secondary portion through leads 28 and 29 respectively.

The inductance varying means for the tuning coil-portions 13 and 15 are here embodied in the form of iron-dust core elements 16 and 17 mounted for axial adjustment within the inner tube 19 to and away from the centers of their respective tunable coil elements by means of threaded supporting rods 30 and 31 respectively, each rod passing through an end cap such as the cap 32, in threaded engagement with the cap and terminating in a slotted end portion 33 outside the cap to facilitate adjustment with a screw driver. Each end cap such as the end cap of 32 is held fixed in the end of the inner tube in any suitable manner as by a driving fit of its rough-surfaced reduced portion 34 within the tube end. A spring clip 35 engages the rod 31 through a slot in the end cap to frictionally hold the rod in adjusted position. The stop element 18 is comprised of a cylindrical plug of electrical insulating material cemented or otherwise secured in the inner tube 19 with its ends extending to approximately the middle of the tuning coil-portions 13 and 15.

In operation, assuming for example that the transformer is used as a coupling transformer in an L-F. amplifier circuit, when some element of the circuit is altered as when a new tube is inserted, say in the circuit of the secondary section 11 of the transformer, to replace a poor one, the capacity of the new tube may not be the same as that of the original. To maintain the circuit tuned to the desired intermediate frequency, it will be necessary to increase or decrease the inductance of the secondary circuit, according as to whether the capacity of the new tube is less or greater than that of the original tube. This may be accomplished by moving the plug 17 toward or away from the center of the tuning coil-portion 15. It will be clear that this adjustment can take place with but an extremely slight change in the

mutual inductance between 11 and 13 because of their remoteness from each other, or in the mutual inductance between 17 and 12 because of their remoteness from each other. With various of these adjustments within wide limits, the coefficient of coupling between primary and secondary sections of the transformer will remain substantially constant, due to the fact that although movement of either inductance-varying core toward the center of the transformer structure increases very slightly the coupling between the coil-portion thus adjusted and the opposite side of the transformer, tending slightly to increase the mutual inductance between the two sides of the transformer as a whole, and consequently the coefficient of coupling, the increase in the inductance of the adjusted coil-portion tends to reduce the coefficient of coupling as between the two sides of the transformer. This will be further clarified upon reference to the formula for the coefficient of coupling K, where

$$K = \frac{M}{\sqrt{L_{10} \times L_{11}}}$$

in which M is the mutual inductance between the primary and secondary sections 10 and 11, and L_{10} and L_{11} the self inductance of the sections 10 and 11, respectively.

In the ordinary transformer in which one or both of the windings consisting of a single primary and a single secondary arranged end-to-end on a common tubular support, are permeability tuned by insertion of a core, the mutual inductance tends to increase when the magnetic cores are moved into the coils. Then the lower term of the equation also increases but their rates of change are different, consequently K will vary.

In the new transformer the effective mutual inductance M between the primary and secondary sides of the transformer taken as a whole consists of a constant part, that between the coupling portions 12 and 14 plus a variable part, that between 13—15, 13—14 and 12—15, small relative to the constant part. This variable part of the total mutual inductance M increases when the cores are moved in. Obviously the rate of change of M has been changed from what it was in the old arrangement, and by proper adjustment of the constant part of the mutual inductance relative to the variable part, the rate of increase in M may be made so small relative to that of L_{10} and L_{11} that it will just make up for the increase in the lower term of the right hand side of the equation and thus keep K, the coefficient of coupling, substantially constant over wide ranges of adjustment of the tuning.

It is apparent that where the mutual inductance between 12 and 14 is made large in comparison to the mutual inductance between 13 and 14, 15 and 12, and 15 and 13, and the change in inductance due to the cores being moved into 13 and 15 is small relative to the total inductance of the primary and secondary sections of the transformer as a whole, the effective M will be constant and the term, square root of $L_{10} \times L_{11}$, will also be relatively constant because the changes in L_{10} and L_{11} are assumed small. Therefore the coefficient of coupling will be constant as is also the mutual inductance.

It is to be noted here that in use, the effect of the distributed capacity between the coupling coils 12 and 14 may be rendered either aiding or opposing with reference to the coupling effect between these coils, in known manner as by re-

versal of the connection to the leads of one of the coils, and according as to what shape selectivity curve or frequency-response curve is desired.

While one specific embodiment of the invention has been described herein in detail for the sake of disclosure, it is to be understood that the invention is not limited to such specific embodiment but contemplates all such modifications and variants thereof as fall fairly within the scope and purview of the appended claims.

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

What is claimed is:

1. A tuned transformer comprising a pair of relatively closely coupled primary and secondary coil-portions, a third coil-portion having a looser coupling to said primary and secondary coil portions than the coupling between said primary and secondary coil-portions and connected in series with the nearer of said primary and secondary coil portions, and inductance varying means for said third coil portion.

2. A tuned transformer comprising a pair of relatively closely coupled primary and secondary coil-portions, a third coil-portion having a looser coupling to said primary and secondary coil portions than the coupling between said primary and secondary coil-portions and connected in series with the nearer of said primary and secondary coil-portions, and inductance varying means for said third coil-portion, all said coil-portions being spaced axially along a common axis and said closely coupled portions being of larger diameter than said third coil-portion.

3. A tuned transformer comprising a pair of relatively closely coupled primary and secondary coil-portions, a third coil-portion having a looser coupling to said primary and secondary coil portions than the coupling between said primary and secondary coil-portions and connected in series with the nearer of said primary and secondary coil-portions, all said coil-portions being spaced axially along a common axis and said closely cou-

pled portions being of larger diameter than said third coil-portion, inductance varying means for said third coil-portion movable along the common axis into different degrees of operative relation with said third coil-portion, and means for limiting the movement of said inductance varying means to a degree of movement insufficient to bring it into substantial cooperative relation with said nearer coil-portion.

4. A permeability tuned transformer comprising a tubular coil-form of electrical insulating material, a group of four coil sections spaced axially along the outside of said form, the two middle sections of said group being relatively closely coupled and the end sections each relatively loosely coupled with the nearer of the middle coil sections and connected in series with only the nearer of said middle sections and a pair of ferromagnetic high permeability core elements slidably mounted in the tubular coil-form, one from each end, toward and away from the center of a near-end coil-section.

5. A permeability tuned transformer comprising a coil-form of electrical insulating material, a group of four coil sections spaced axially along said form, a pair of inductance varying means one for each end coil of the group, each end coil being relatively closely coupled to its inductance varying means and relatively very loosely coupled to both middle coils of the group and the end coil and said middle coils being relatively closely coupled to each other, whereby the induction varying means has relatively very slight but substantially equal influence on both said middle coils.

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