Nov. 28, 1961 J. J. ANTALEK 3,011,138

TRANSFORMER

Filed Dec. 20, 1957 2 Sheets-Sheet 1

Fig. 1

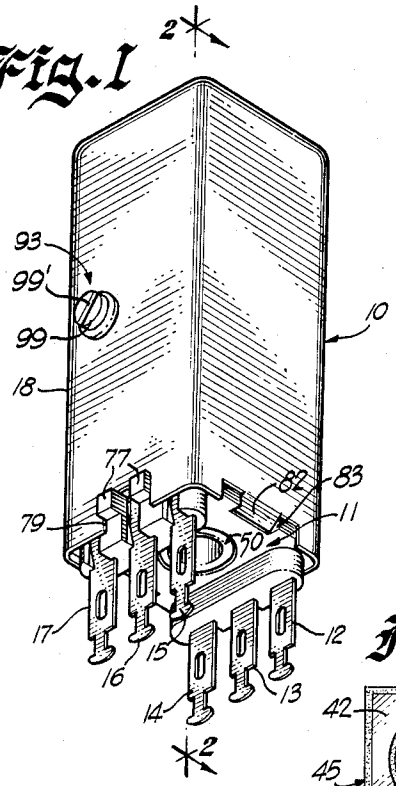


Fig. 2

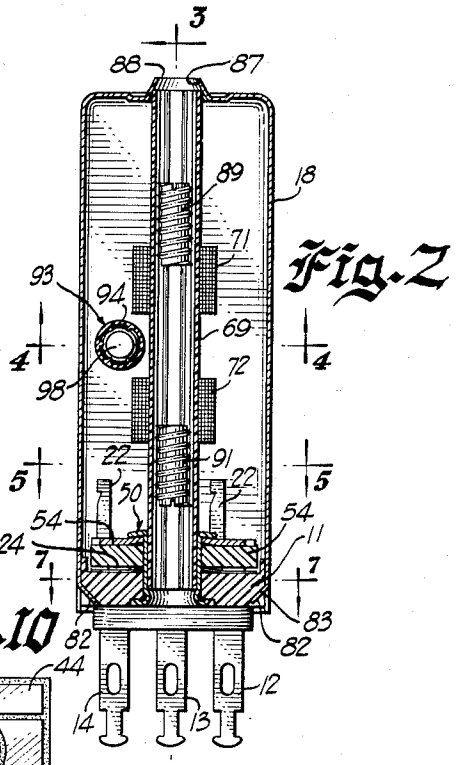


Fig. 10

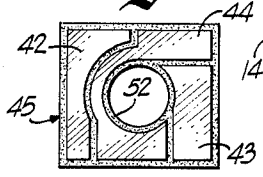


Fig. 11

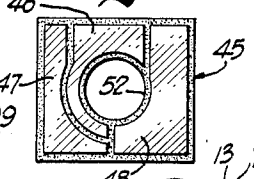


Fig. 3

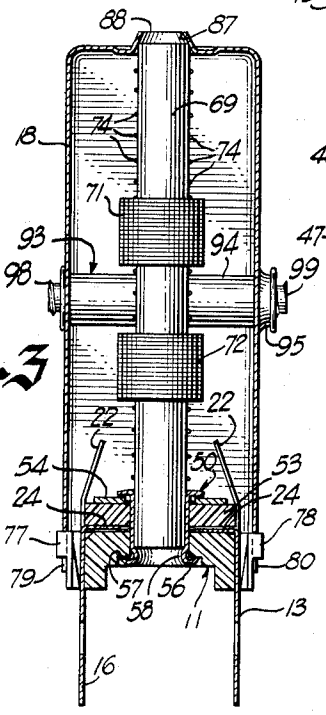


Fig. 4

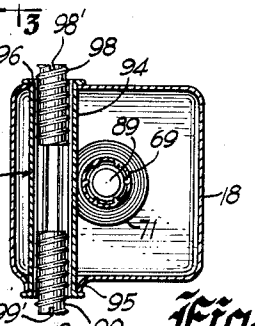
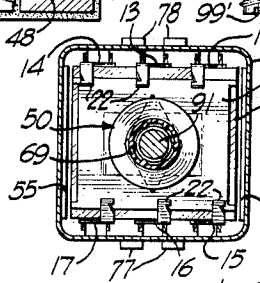


Fig. 5



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TRANSFORMER

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Fig. 5

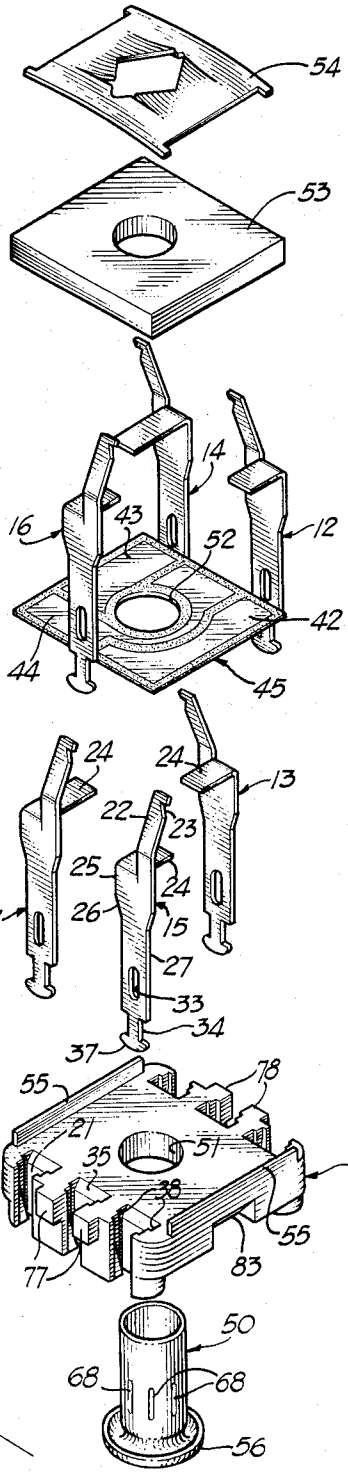
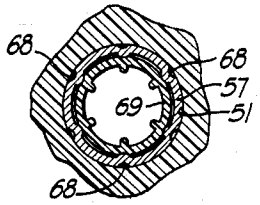


Fig. 7



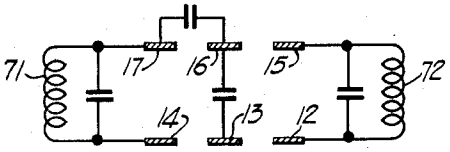


Fig. 12

Fig. 8

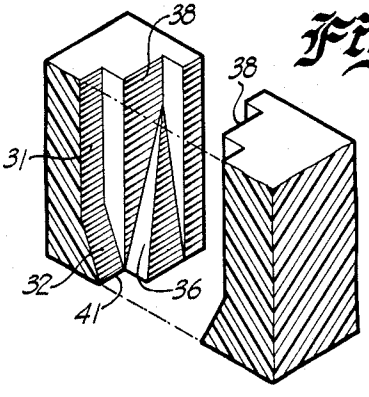
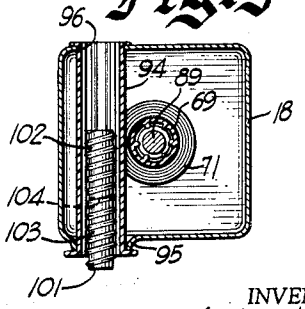


Fig. 9



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United States Patent Office 3,011,138 Patented Nov. 28, 1961

3,011,138

TRANSFORMER

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Filed Dec. 20, 1957, Ser. No. 704,119
1 Claim. (Cl. 336—87)

The present invention relates to transformers and more particularly to IF transformers having adjustable coupling between the primary and secondary windings thereof.

There are many applications, including the output IF stage of a signal seeking receiver, which require the use of high frequency transformers having between the primary and secondary windings thereof a mutual coupling which is adjustable with a high degree of precision. In such applications it is usually important that the adjustment of the mutual coupling of the transformer have a negligible effect on the respective inductance values of the windings and thus on the center frequencies of the primary and secondary windings and their associated tuned circuit components.

Therefore, a principal object of the present invention is to provide a new and improved high frequency transformer having a mutual coupling which is adjustable to precise values within a relatively wide range, and which may be manufactured at a relatively low cost.

Another object of the present invention is to provide a new and improved high frequency transformer including means for adjusting the mutual coupling between a primary and a secondary winding thereof without appreciably changing the center frequency of either the input or output tuned circuits of the transformer.

A further object of the present invention is to provide a new and improved means for adjusting the mutual coupling between the primary and secondary windings of a high frequency transformer.

Still another object of the present invention is to provide a new and improved high frequency transformer including means for adjusting the bandwidth of the transformer throughout a relatively wide range.

Another object of the present invention is to provide new and improved means for adjusting the gain of a high frequency transformer without appreciably changing the Q thereof.

Another object of the present invention is to provide means for adjusting the Q of a transformer without appreciably affecting the gain thereof.

Another object of the present invention is to provide a new and improved high frequency transformer construction.

Very briefly, the above and further objects are realized in accordance with the present invention by providing a high frequency transformer which includes primary and secondary windings spatially wound on a common coil form in which a pair of tuning cores are threadedly supported for respectively adjusting the inductances of the windings. The coil form is disposed within a conductive shielding can and mounted on an insulating base to which the can is attached, and a mutual coupling adjusting means is mounted in the can for transverse movement between the transformer windings.

The invention, both as to its organization and operation, together with further objects and advantages thereof, will best be understood by reference to the following detailed description taken in connection with the accompanying drawings, in which:

FIG. 1 is an isometric view of a high frequency transformer embodying certain features of the present invention;

FIG. 2 is a sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a sectional view of the transformer of FIG. 2 taken along the line 3—3 thereof, assuming the entire structure to be shown therein;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 2, assuming the entire structure to be shown therein;

FIG. 5 is a sectional view taken along the line 5—5 of FIG. 2, assuming the entire structure to be shown therein;

FIG. 6 is an exploded isometric view of the base portion of the transformer of FIG. 1;

FIG. 7 is a fragmentary sectional view taken along the line 7—7 of FIG. 2, assuming the entire structure to be shown therein;

FIG. 8 is a fragmentary exploded perspective view showing the arrangement used for mounting terminal members in the support base of the transformer of FIG. 1;

FIG. 9 is a cross sectional view similar to FIG. 4 showing another feature of the present invention;

FIGS. 10 and 11 are respective top and bottom views of a multiple capacitance device employed in the transformer illustrated in FIG. 1; and

FIG. 12 is a circuit diagram of the transformer of FIG. 1.

Referring now to the drawings and particularly to FIGS. 1–5, there is shown an IF type high frequency transformer **10** comprising a generally rectangular insulating base **11** on which are mounted a plurality of terminal members **12**, **13**, **14**, **15**, **16** and **17**, and a rectangular shielding can or housing **18**.

As best shown in FIG. 6, the base **11** is substantially square in cross section and includes a plurality of terminal mounting receptacles **21** arranged along opposite side edges thereof. The receptacles **21** are arranged in two sets of three and, therefore, the terminals **12–17** are similarly arranged in two sets of three. The terminals **12–17**, which are substantially identical, are punched and stamped from a sheet of suitable conductive metal and each comprises an upstanding slightly angulated connector portion **22** having a notch **23** provided near the upper end thereof for facilitating connection thereto of one of the leads from the transformer windings. A perpendicularly disposed offset tab **24** is provided adjacent to and directly beneath the upstanding portion **22** for operative engagement with the upper surface of the base **11** to prevent withdrawal of the terminal through the receptacle from the bottom of the base **11** and to provide an electrical connection between the terminal and a capacitor element mounted on the base **11** and described in greater detail hereinafter. The portion of each terminal which extends into the receptacle **21** includes a tapered or necked-down portion **26** which connects an upper rectangular portion **25** disposed immediately beneath the tab **24** with a lower rectangular portion **27** which depends from the base **11**. The receptacles **21** each include an upper rectangular portion **31** (best shown in FIG. 8) having a width substantially equal to the corresponding width of the upper terminal portion **25** and a tapered shoulder **32** connecting the portion **31** with the walls of an aperture **41** at the bottom of the receptacle.

In order to enable a rapid and facile assembly of the terminals **12–17** to the base member **11**, the receptacles **21** are provided with an upper or mouth portion which is appreciably larger than the corresponding dimensions of the lower portions **27** of the terminals. Moreover, certain ones of the walls defining the receptacles **21** are tapered to lead the upper portions **25** of the terminals **12–17** into those portions of the receptacles which correspond in configuration to the upper portions **25** of the terminals. Considering the shape of the receptacles **21** in greater detail, each receptacle has an outer auxiliary portion partially defined by the walls **38** (FIG. 8) which lies adjacent to the terminal receiving portion defined in

part by the walls 31. The receptacle walls 38 are spaced apart by a distance slightly exceeding the width of the lower terminal portion 27 so that the lower convex end 37 of the terminals may fit in either the auxiliary or principal portions of the receptacle. Should the terminal end 37 initially move into the auxiliary portion of the receptacle it rides down a sloping cam surface 36 which leads into an aperture 41 at the bottom of the principal receptacle portion thereby to move the terminal inwardly toward the main terminal portion. In addition, the principal receptacle portion is provided with a bevel 35 at the inner upper end to further simplify insertion of the terminals into the receptacles.

The depending portions 27 of the terminals each include an elongated aperture or slot 33 for facilitating connection of the transformer 10 to the circuits of the associated equipment, and the portions 27 also comprise an undercut portion 34 which may be used for facilitating the physical wiring of the transformer in associated equipment.

In order to provide a self-contained IF transformer including the necessary capacitances for tuning the primary and secondary windings thereof, a plurality of capacitors are mounted internally of the unit between appropriate ones of the terminals 12–17. As best shown in FIGS. 10 and 11, these capacitances are established between a plurality of conductive layers 42, 43 and 44 disposed on the upper surface of a thin insulating member 45 and a plurality of conductive layers 46, 47 and 48 disposed on the opposite and lower surface of the member 42. The lower layers or capacitor plates 46, 47 and 48 are respectively engaged by the tabs 24 on the terminals 13, 15 and 17 and the upper plates 42, 43 and 44 are engaged by the tabs 24 on the terminals 12, 14 and 16. The latter terminals thus hold the member 45 in place on the base 11 above the tabs 24 on the terminals 13, 15 and 17. Capacitances are thus respectively provided between the terminals 12 and 15, 14 and 17, 16 and 17, and 13 and 16, the electric circuit of the transformer 10 being illustrated in schematic form in FIG. 12. It will be understood that different configurations of the conductive layers on the sheet 45 may be used to provide different capacitive circuit arrangements between the terminals 12–17.

The terminals 12–17 and the member 45 are secured to the base 11 by an eyelet 50 which extends through respective apertures 51 and 52 in the base 11 and in the member 45. In order to insure a tight fit and thus good electrical connections between the terminals 12–17 and the member 45, the eyelet 50 extends through an apertured insulating block 53 and an apertured spring 54. Assembly of the base assembly is facilitated by a pair of upstanding flanges 55 on the base member 11 which insures alignment of the apertures in the members 11, 45, 53 and 54 prior to the insertion therethrough of the eyelet 50. As shown, the eyelet 50 comprises a head 56 in the form of an external flange which is received in a counterbore 57 at the bottom of the base 11, and the upper end of the eyelet 50 is peened over to at least partially compress the spring 54 and to fasten the base assembly together.

As best shown in FIGS. 2 and 3, the head 56 of the eyelet is formed by a partial toroidal portion including the outwardly extending flange which seats in the counterbore 57 and an inwardly directed portion which provides a seat 58 against which the lower end of a cylindrical coil form 69 abuts. A pair of coils or transformer windings 71 and 72 are wound around the form 69 at spaced apart locations and the ends of these windings are respectively connected to the terminals 12, 14, 15 and 17. The wire from which the coils 71 and 72 are wound is very thin and frangible, and breaking of the connections between these terminals and the windings 71 and 72 by rotation of the coil form 69 in the base member 11 is prevented by means of a plurality of knurls 68 in the eyelet 50 which grip the form 69. The coil form 69 is formed of a resilient plastic so that as it is forced into the eyelet 50 against the seat 58, the knurls 68 press into the form 69 thereby to prevent relative rotation between the coil form 69 and the base member 11.

As best shown in FIGS. 2 and 3, the transformer windings 71 and 72 are wound at spaced apart locations on the coil form 69 and are prevented from moving along the form by a plurality of small protuberances 74 which are integral with the form 69.

The shielding can 18, which is rectangular in cross section, fits snugly over the base member 11. Two sets of ears 77 and 78 on the base member 11 seat in notches 79 and 80 in the bottom of the can 18, and a pair of struck-out tabs 82 on the can 18 are bent into a pair of notches 83 on the lower surface of the base member 11 to force the ears 77, 78 into the bottoms of the notches 79 and 80. The shielding can is thus attached to the base member 11.

In order to fixedly mount the coil form 69 centrally of the shielding can 18, a frusto-conical upstanding sleeve 87 is provided at the center of the can 18 at the upper end thereof, and the coil form 69 extends partially into this sleeve. The external diameter of the coil form 69 has a dimension which is intermediate that of the internal diameters of the top and bottom of the sleeve 87, and since the coil form 69 is resilient, as the can 18 is pressed over the base member 11, the coil form 69 is press fitted into the sleeve 87. Accordingly, the coil form 69 is tightly held at the top and bottom to prevent relative movement between it and the shielding can 18.

The aperture 88 permits the use of a screw driver for adjusting a tuning slug or core 89 which is threadedly received in the upper portion of the coil form 69 for adjustable movement into the winding 71. A similar core 91 is disposed in the bottom of the core form 69 in proximity to the winding 72 and may be adjusted by means of a suitable tool such as a screw driver insertable through the eyelet 50. The manner in which the tuning cores 89 and 91 are mounted within the coil form 69 is described in detail in my copending application, Serial No. 520,332, filed July 6, 1955.

In order to enable adjustment of the mutual coupling between the transformer windings 71 and 72 without appreciably affecting the respective inductances of these windings, there is provided in accordance with the present invention an adjustable tuning mechanism 93 mounted in the shielding can 18 transversely of the principal axis of the coil form 69. In the embodiment of the invention illustrated in FIG. 4, the adjustable tuning mechanism 93 comprises a non-magnetic tube or sleeve 94 which is secured by suitable means in apertures 95 and 96 at opposite sides of the can 18. Preferably, the sleeve 94 is formed of plastic and the ends thereof are turned over so as to stake the sleeve 94 in place. As best shown in FIGS. 2 and 3, the apertures 95 and 96 are positioned in the shield 18 so that when the transformer 10 is assembled, the tube 94 is approximately midway between the transformer windings 71 and 72 and extends partially within an imaginary cylindrical envelope defined by the outer turns of the windings 71 and 72. In the embodiment of the invention illustrated in FIG. 4, a pair of tuning slugs or cores 98 and 99 are respectively threaded into the tube 94 from the opposite ends thereof and screw driver slots 98′ and 99′ in the outer ends of the slugs 98 and 99 enable separate adjustment of the cores 98 and 99 to adjust the mutual coupling between the windings 71 and 72 by movement of the cores into and out of the space directly between the windings 71 and 72 thereby to alter the magnetic field which couples the windings 71 and 72 together. The cores 98 and 99 are preferably mounted in the sleeve 94 in the same manner as the cores 89 and 91 are mounted in the coil form 69.

Although two tuning cores **98** and **99** are employed in the device of FIG. 4 for purposes more fully explained below, it will be apparent to those skilled in the art that a single core may be used to adjust the mutual coupling of the transformer. However, if but one core is used, the range of adjustment is less than where two cores of different magnetic characteristics are used, and the types of material chosen for the cores **98** and **99** depend upon the desirability of having other characteristics of the transformer affected by the adjustment of the mutual coupling thereof.

The data listed in Table I shows the changes in gain, Q, and bandwidth which were provided between the fully in and fully out positions of tuning cores of different materials when a transformer embodying the present invention was driven with a 265 kc. signal. In all cases, the variation in center frequency was less than 0.15 kc.

Table I

	Gain	Q	B./W. of transformer at 2X down in kc.	Core position
R.F. powdered iron core	89	101	7.75	Fully in.
	100	100	8.25	Fully out.
Brass core	100	93	8.75	Fully in.
	100	100	8.25	Fully out.
Steel core	84	88	8.45	Fully in.
	100	100	8.25	Fully out.
Copper core	104	96	8.75	Fully in.
	100	100	8.25	Fully out.

From Table I it will be apparent that a maximum change in bandwidth with a constant transformer gain is provided when a brass core is used. However, where a much greater change in bandwidth is required, and a small change in gain throughout the range of adjustment can be tolerated, the use of two tuning cores, one of brass and one of RF powdered iron may be employed, thereby doubling the change in bandwidth of the transformer. Accordingly, where a maximum adjustability of bandwidth is desired the core **98** may be formed of brass and the core **99** may be formed of RF powdered iron.

Referring to FIG. 9, there is shown a preferred embodiment of the invention employing a single core **101** threadedly mounted in the tube **94**. The core **101** is a composite member having end portions **102** and **103** secured together end to end along a line **104**. The portion **102** may be brass and the portion **103** may be RF powdered iron so as to provide a transformer having a maximum degree of bandwidth adjustability. Since the end portions **102** and **103** are bonded together, as the core **101** is moved through the tube **94** to move one portion thereof into the space between the transformer windings **71** and **72**, the other portion of the core **101** is moved out of this space. Reference to Table I shows that the composite core **101** in the transformer of FIG. 9 provides a bandwidth adjustment of 1 kc. with a change in gain of slightly more than 10 percent. Consequently,

only a single adjustable element is provided to control the bandwidth of the transformer throughout a wide range.

The characteristics of a transformer built in accordance with the embodiment of the invention illustrated in FIG. 9 are listed in Table II.

Table II

	Gain	Q	B./W. of transformer at 2X down in kc.	Core position
5/16 brass & 5/16 R.F. iron core end to end.	89	101	7.75	R.F. core fully in.
	100	93	8.75	Brass core fully in.

While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto, since many modifications may be made, and it is therefore contemplated by the appended claim to cover any such modifications as fall within the true spirit and scope of the invention.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

A transformer construction comprising an insulating base, an elongated shield mounted on said base, a generally tubular coil form mounted on said base and extending upwardly therefrom into said shield, first and second coils mounted on said coil form with their axes extending generally parallel to the axes of said tubular coil form, said first and second coils being spaced from each other along the axis of said form, first and second magnetic cores movably mounted in said coil form and each positioned adjacent one of said first and second coils, said base and said housing each having an opening aligned with said coil form to permit adjustment of said first and second cores, a nonmagnetic sleeve extending transverse to the axis of said coil form and located adjacent said coil form in a position between said first and second coils, said shield having a pair of aligned openings and said sleeve being disposed within said shield and mounted in said openings, and magnetic means movably mounted in said sleeve and adjustable through said sleeve to vary the field coupling between said first and second coils.

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