March 6, 1951 D. MACKEY 2,544,508

SIGNAL TRANSFER APPARATUS

Filed March 26, 1948 2 Sheets-Sheet 1

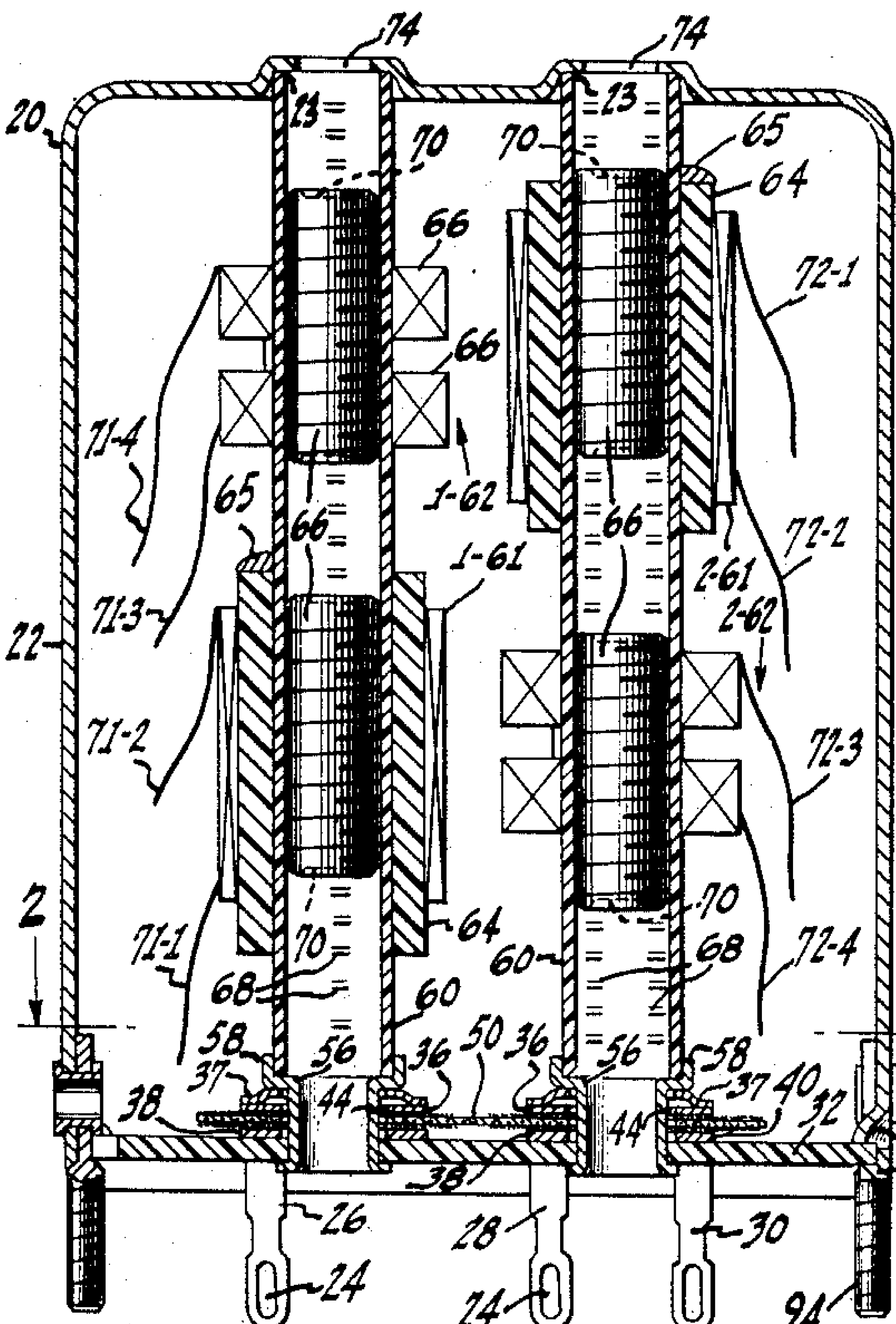

Fig. 1.

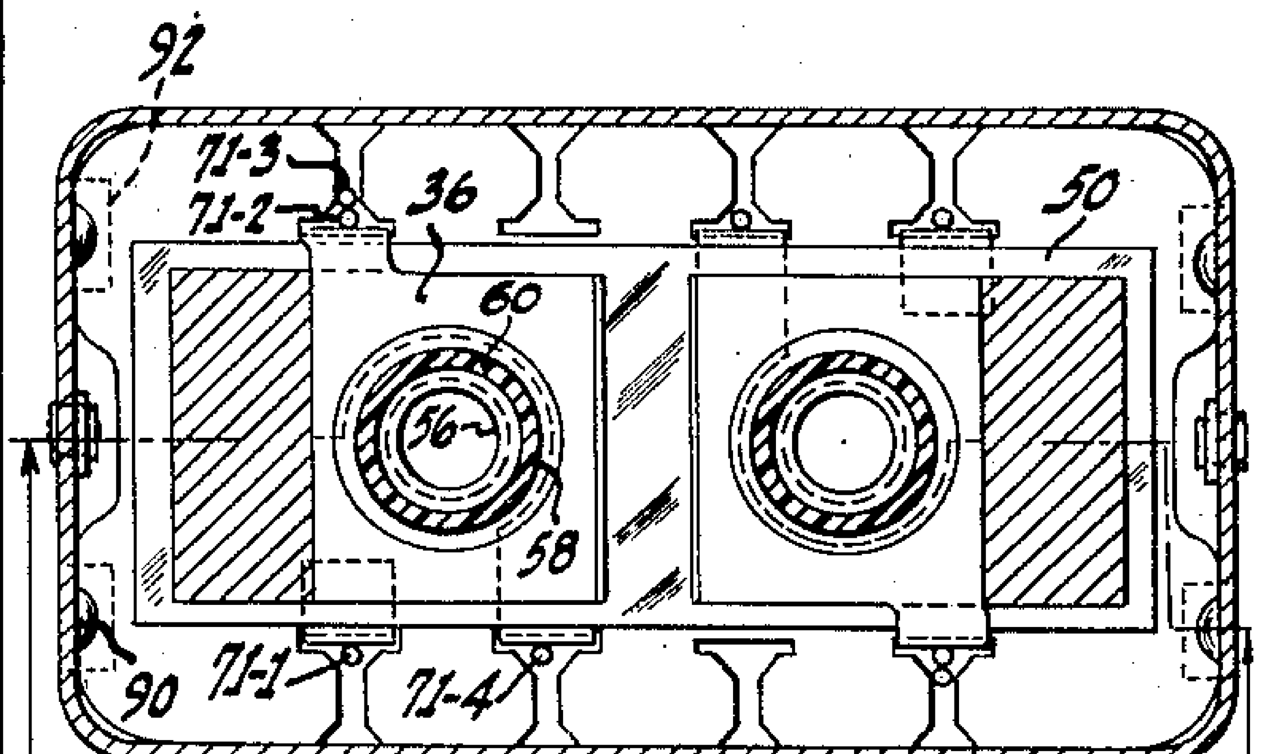

Fig. 2.

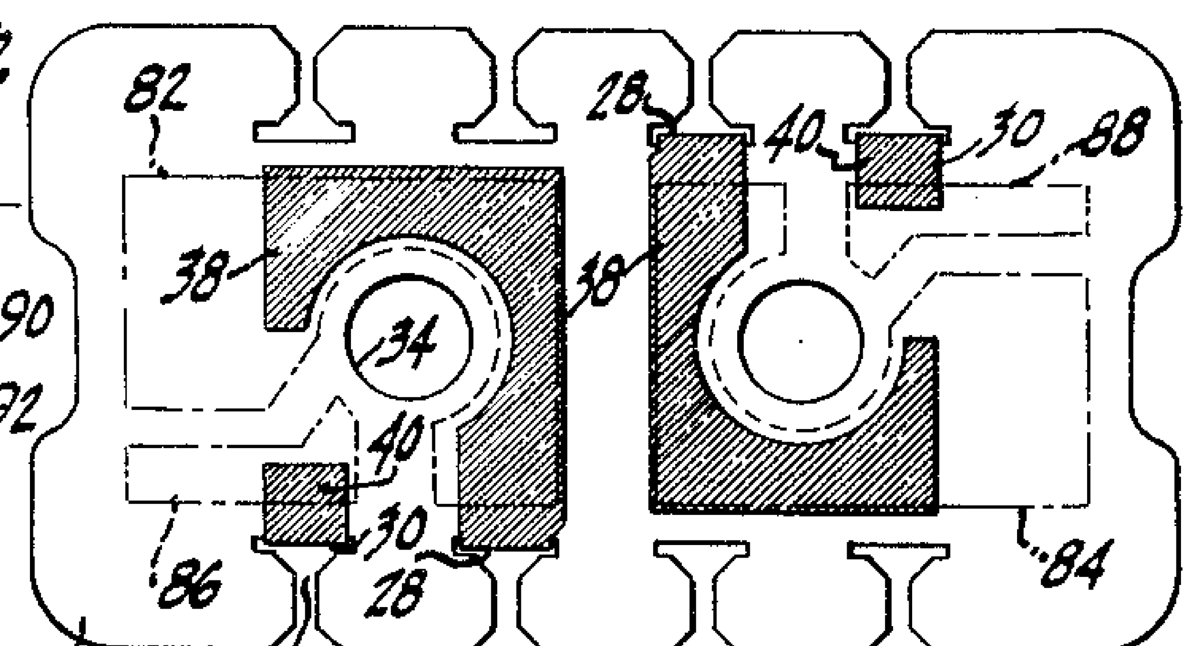

Fig. 3.

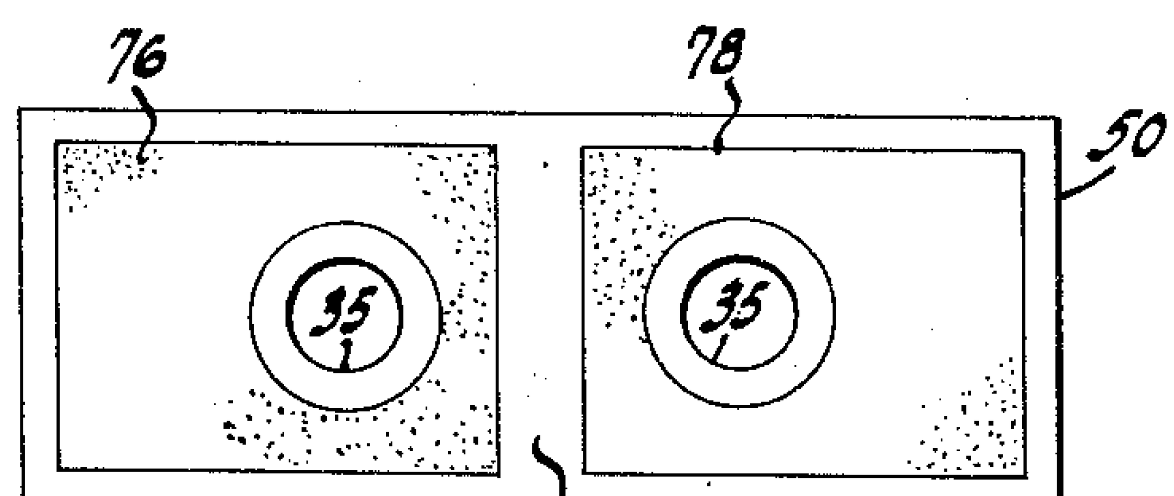

Fig. 4. 80

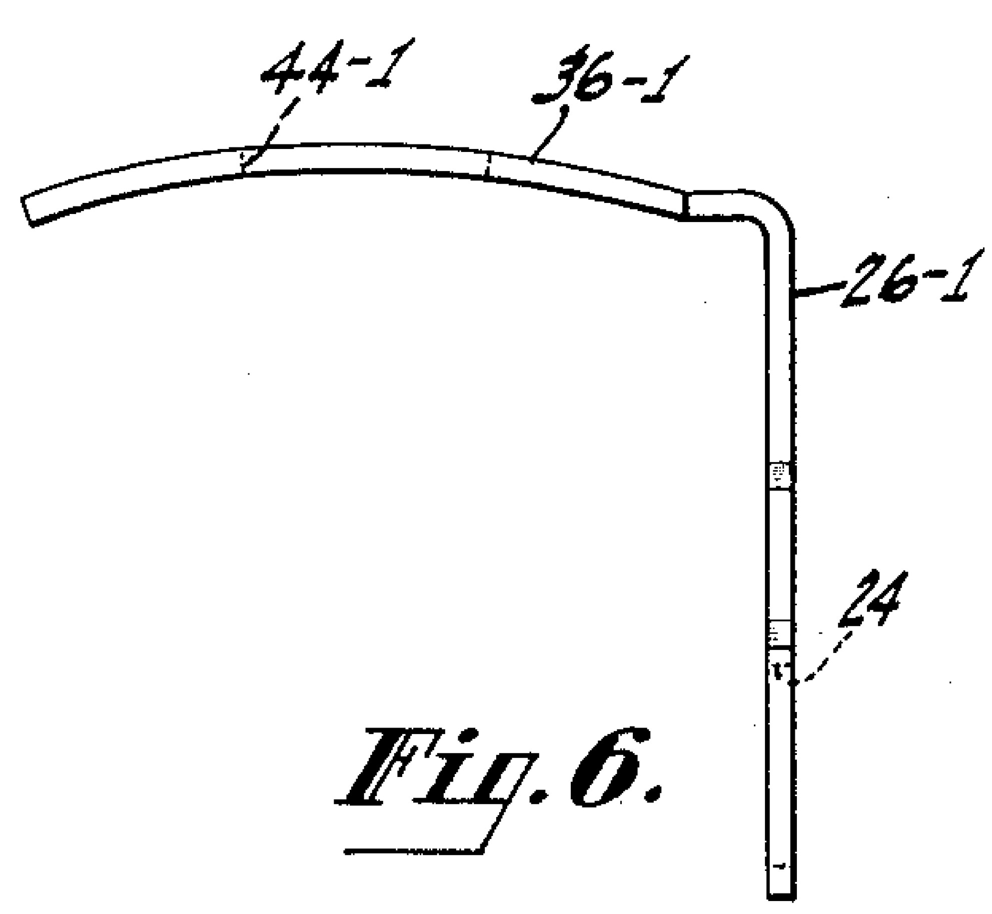

Fig. 6.

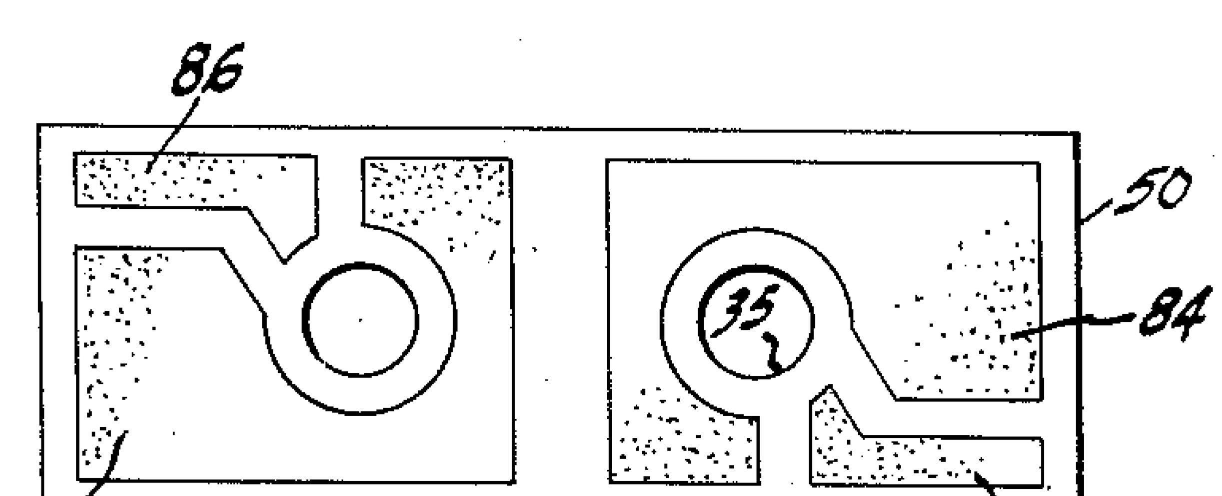

Fig. 7.

INVENTOR
DONALD MACKEY
BY Philip L. Cooper
ATTORNEY

March 6, 1951 D. MACKEY 2,544,508

SIGNAL TRANSFER APPARATUS

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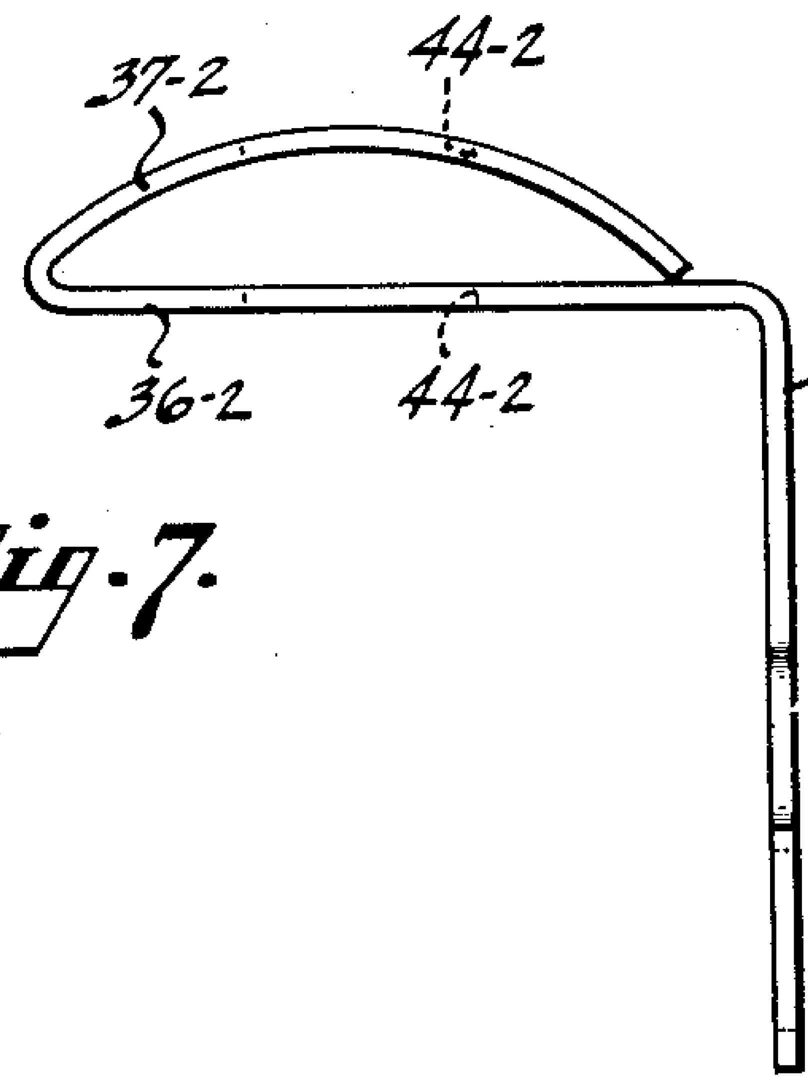

Fig. 7.

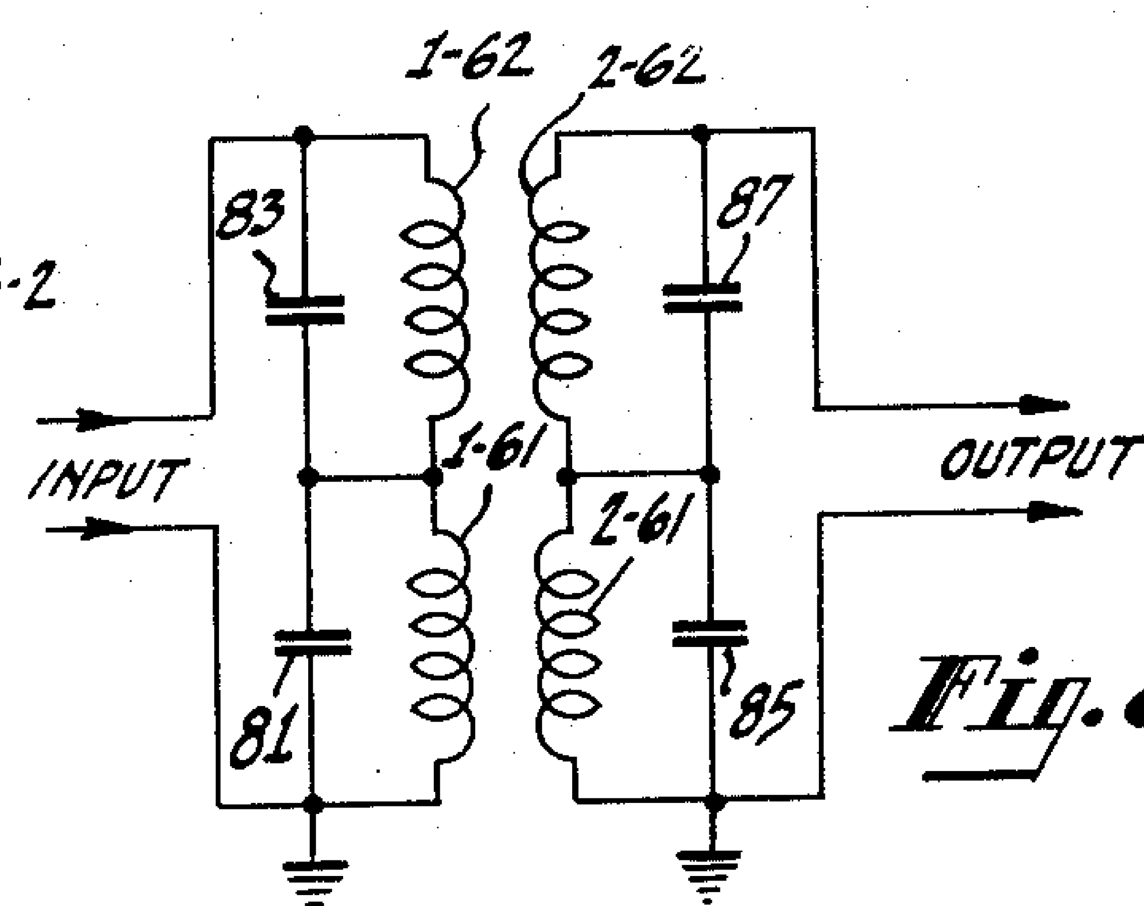

Fig. 8.

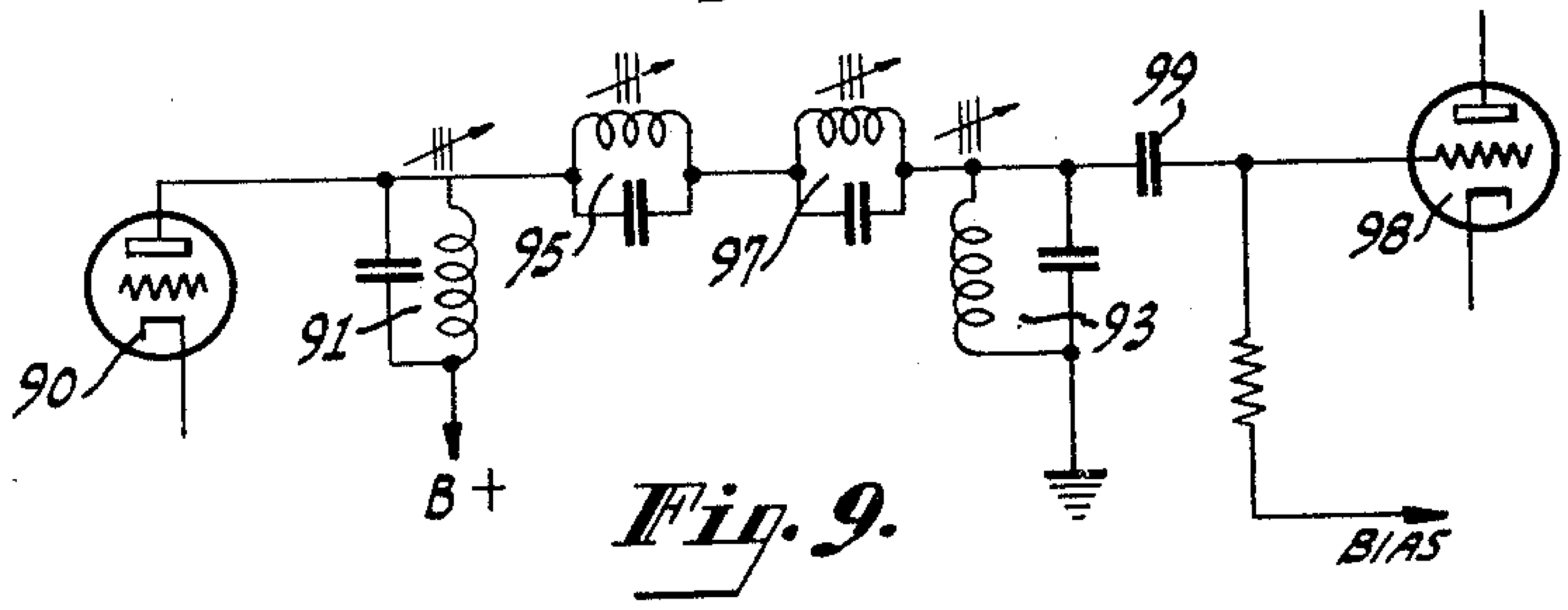

Fig. 9.

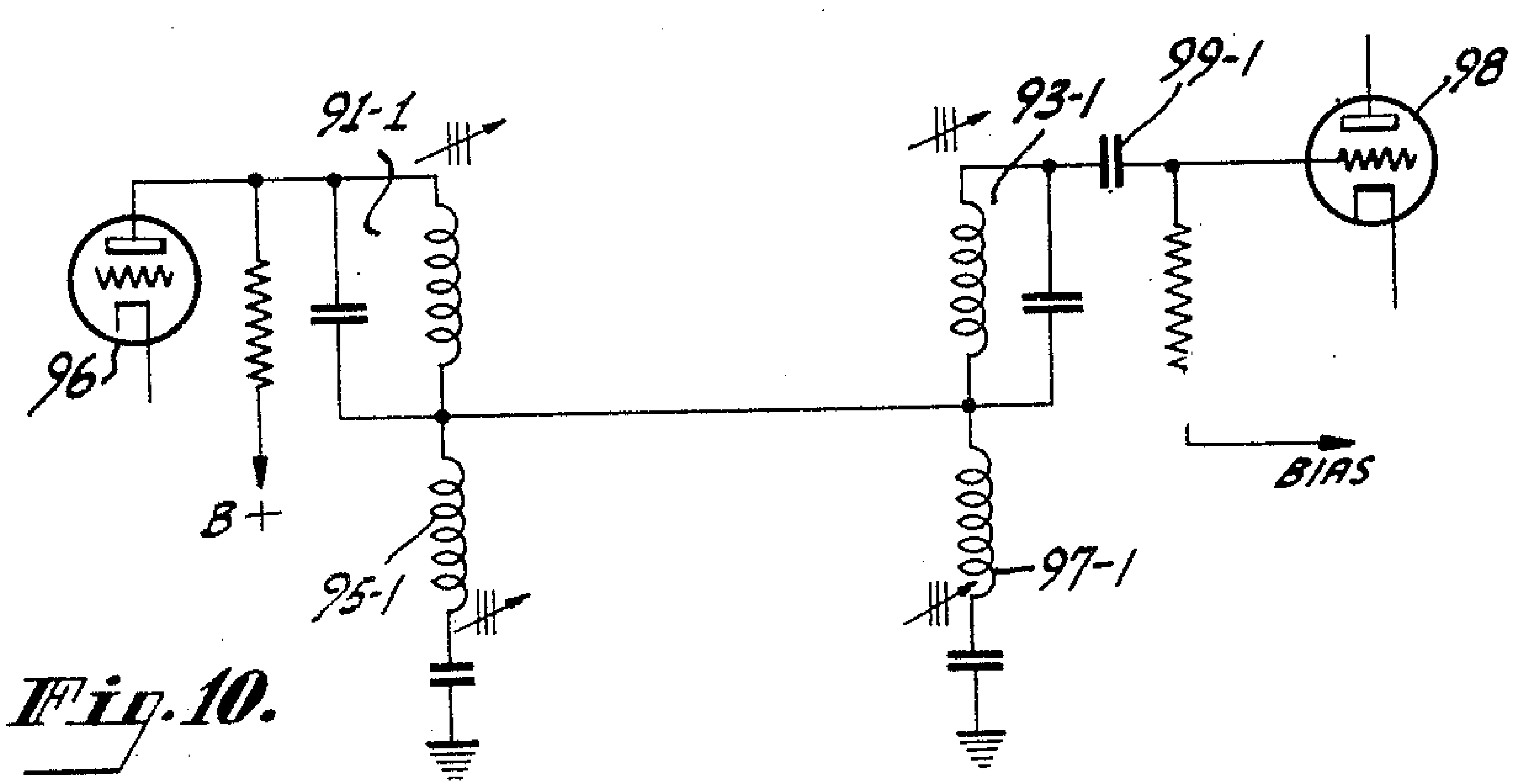

Fig. 10.

INVENTOR
DONALD MACKEY
BY Philip G. Cooper
ATTORNEY

Patented Mar. 6, 1951

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UNITED STATES PATENT OFFICE

2,544,508

SIGNAL TRANSFER APPARATUS

Donald Mackey, Haddon Heights, N. J., assignor to Radio Corporation of America, a corporation of Delaware

Application March 26, 1948, Serial No. 17,359

12 Claims. (Cl. 178—44)

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This invention relates to transducing apparatus for transferring alternating electric currents from one circuit network to another. More particularly the transducing apparatus of the invention include novel high frequency transformers having improved features.

Among the objects of the invention are novel transducers that are simple to assemble from component parts.

Additional objects of the invention include novel transducers having a small number of components.

Further objects of the invention are novel compactly constructed transformers for efficiently transferring high frequency electric currents of two different frequency bands from one circuit network to another.

The above as well as other objects of the invention will best be understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein:

Fig. 1 is a vertical sectional view of one form of transformer of the invention, taken along line 1—1 of Fig. 2;

Fig. 2 is a horizontal section of the transformer of Fig. 1, taken along line 2—2;

Fig. 3 is a view similar to Fig. 2 with some of the overlying structure removed to show the underlying elements;

Fig. 4 is a top view of the condenser dielectric of the transformer of Figs. 1 and 2;

Fig. 5 is a bottom view of the condenser dielectric of Fig. 4;

Fig. 6 is a side view of a modified contactor element for use with the transformer of Figs. 1 and 2;

Fig. 7 is a side view similar to Fig. 6 of a further modification of contactor element;

Fig. 8 is a circuit diagram showing one operating arrangement for the transducer apparatus of the invention; and

Figs. 9 and 10 are circuit diagrams showing different operating arrangements.

According to the invention the compactness of electric current transducers is provided by disposing the spaced components in a novel manner for conserving bulk and the simplicity of construction is contributed to by a novel capacitor arrangement.

Figs. 1 through 5 show the details of one practical form of transducer embodying the invention. This form is excellently suited for use as transformers in coupling high frequency amplifying stages in conventional radio receivers for example.

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The transformer of Fig. 1 has a hollow housing **20** in which is contained input and output circuits magnetically linked together and connected to terminal prongs **24** projecting out from the housing. The prongs **24** are shown as part of terminal lugs **26**, **28** and **30** held in place on an electrically non-conductive terminal board **32** which constitutes part of the housing **20**. As shown in Figs. 2 and 3, the terminal lugs are provided with upper contact ears **36**, **38** and **40** respectively, each extending generally parallel to the board and of different configuration. T-shaped slots **42** along both edges of the board permit the penetration of the lead wires and the prongs **24** of the terminal lugs out of the housing while the contact ears are carried internally. At the same time the walls of the slots support or help to support the lugs in place. The contact ears **36** of lugs **26**, as more clearly shown in Fig. 2, each extend over an appreciable area approximately from the slots on one side to those on the other, and are each provided with an intermediate opening by which they are secured in place. The contact ears **38** of lugs **28** are of generally similar shape differing in that a portion is cut away as indicated in Fig. 3. The contact ears **40** of lugs **30** are shown as of relatively small size for fitting in the cut away zone of ears **38**.

In assembled condition the lugs **28** and **30** are positioned on the terminal board **32** with their ears against the face of the board and their prongs projecting through the slots in the manner shown in Fig. 3. Over their ears is placed a dielectric sheet **50** and over this assembly the terminal lugs **26** are mounted so that the extended contact ears **36** cover the lower ears **38**, **40** and hold the dielectric sheet sandwiched between them. The terminal board **32** is also perforated at **34** in register with the perforations **44** of ears **36** and through each pair of aligned perforations securing means shown in Fig. 1 as a rivet **56** is passed and crimped over to securely hold the components in mounted relation. The dielectric sheet **50** which may be of low loss material such as mica has adherently united to both its faces electrically conductive coatings to form a self-contained capacitor assembly as more fully explained below.

In the form shown the securing rivets **56** are hollow and include extensions **58** forming supports cooperating with suitably shaped parts of the housing **20** to hold transformer windings in place. An electrically conductive box-like shell **22** against which the terminal board **32** is secured completes the housing **20** and forms an effective shield to prevent interference with the electrical signals being transduced within it. Opposite each support 58 the shield 22 is shown as dished out at 23 to provide a further supporting element and between the pair of supports 58 and 23 is mounted a pin 60. Although the supports 58 and 23 may be of any desired shape, they are illustrated as recessed to form sockets in which the ends of the pins are securely fitted.

The pins 60 which may be of dielectric composition, carry windings connected to the capacitors provided on dielectric sheet 50 and constituting, together with their connected capacitors, the input and output circuits of the transducer. In the construction of Fig. 1 the transformer of the invention has input windings formed in two portions shown at 1—61 and 1—62 respectively each separately tunable to different frequency bands. The output windings are also similarly divided into corresponding portions 2—61 and 2—62. Windings 1—61 and 2—61 are suitable for tuning to high frequency and may merely be a single layer of turns helically wound on a sleeve 64 held on the pin 60. The windings 1—62 and 2—62 are suitable for tuning to lower frequencies and may be in the form of one or more interconnected universal wound sections 66 directly held on pin 60 as shown.

A feature of the invention is the crossing of the windings on the respective pins so that the magnetic coupling between the high frequency portions 1—61 and 2—61 as well as the coupling between the low frequency portions 1—62 and 2—62 have the desired spacing for efficient transducing and at the same time fit into a relatively small volume. The amount of space occupied by the various components of a radio receiver or other complicated multi-component apparatus in which the individual components must be fitted and connected together to make a neat, not too bulky apparatus is of extreme importance. The saving of as little as a half-inch on one of the dimensions of a component simplifies the assembling, permits more compact packing of the components and mounting on smaller mounting members which need not be as stoutly built to adequately support them. This is especially marked where the apparatus includes more than one of the more compact components and the individual bulk saved is multiplied. Furthermore the resulting compact apparatus is more suitable for transportation and for certain practical forms of construction such as portable type radios and the like. In addition individual parts such as the housings of the more compact components may also be more simply and more inexpensively made.

According to the invention the respective high frequency and low frequency portions of the windings are held spaced from each other by an amount which imparts the desired transducing coupling relationship. High frequency input winding 1—61 is thus in magnetic coupling with the high frequency output winding 2—61 and the corresponding low frequency windings 1—62 and 2—62 are also magnetically coupled. In general very close coupling of input and output windings is avoided where the advantages of high "Q" and hence highly selective coupling circuits are to be realized. As is well known the tightness or proximity of coupling is roughly inversely proportional to the "Q" or so-called efficiency of the circuits. For proper band-pass characteristics with reasonably good efficiency, a relatively wide spacing between the linked primary and secondary windings is necessary. In the transducing

of recognizable signals, as where the electric currents are modulated by these signals, a wide-band transducer or transformer is especially desirable inasmuch as the fidelity of transducing depends on the width of the frequency band passed.

As shown in Fig. 1, the coupled windings are located at approximately the corners of a rectangle lying in the plane of the pins 60 so that they are linked diagonally of the rectangle. Accordingly a relatively small difference in level between the windings and spacing between the pins provides a large coupling path.

In use the windings are formed to resonate to the frequencies desired to be transduced. Tuning is accomplished by connecting a capacitance across the individual windings although in some cases all or part of this capacitance may merely be the distributed capacitance of the winding itself or of the circuit to which it is connected, especially where a high inductance-to-capacitance ratio of the tuned circuit is desired.

When capacitors are used for tuning the windings of the form of the invention shown in Fig. 1, considerable advantage results from the fact that the leads connecting the windings to the condensers may be so disposed as to nowhere approach each other or the other coupled winding very closely. A feature of this arrangement is the very small undesired coupling capacitance between the input and output circuits thereby enabling improved energy transfer. In the form of the invention having the primary or input windings on one winding form or pin 60 and the output windings on the other, as shown in Fig. 1, the desired condensers of the respective circuits are mounted adjacent an end of the pin holding the windings of that circuit. The connecting leads merely extend approximately directly downwardly from the ends of the windings to the corresponding condensers, as partially shown in Fig. 1 by the connectors 71—1, 71—2, 71—3, 71—4, and 72—1, 72—2, 72—3, 72—4. At no point is it necessary for the leads of one circuit to pass close to the leads or any other portion of the other circuit.

The condensers used in this embodiment of the invention may be of any type such as the conventional variable or "trimmer" type well known in the art, having one or more separate dielectric layers sandwiched between electrodes that are adjustably movable toward and away from each other. Such a condenser is shown in U. S. Patent No. 2,119,107, granted May 31, 1938 and may have its capacitance varied to tune the corresponding circuit to the desired frequency. Instead of varying the capacitance, the condensers may be fixed and tuning provided by arranging the windings so that their inductance may be varied. For example, as shown in Fig. 1, the coil forms or pin 60 may be hollow and receive high permeability tuning cores longitudinally movable with respect to the windings for changing their inductance in accordance with the amount of highly permeable material present in the magnetic field of a winding, as is well known. The cores 66 are generally a molded mixture of finely powdered ferro-magnetic material such as iron together with insulating resin or binder which gives it mechanical form and minimizes eddy current losses by electrically insulating the powder particles from each other. In the construction shown the cores 66 are externally threaded and threadedly engage corresponding thread-like separated indentations 68 extending inwardly of the inner surface of the pins 60. Ends of the cores are provided with screw-drivers slots 70 by which they can be rotated to screw themselves longitudinally along the indentations for suitable positioning as desired. The housing is shown as perforated at 74 for admission of a core rotating tool such as a screw driver blade. Access to the lower cores may be through the hollow interior of rivets 56.

An unexpected advantage of the permeable tuning arrangement shown in Fig. 1 is the fact that simple fixed tuning capacitors may be used and at the same time each winding portion is separately tunable. Thus when adjusting the inductance of the high frequency transformer windings 1—61, 2—61 by movement of their cores, the inductance of the low frequency windings 1—62, 2—62 remain substantially unaffected and vice versa. This is a very valuable characteristic inasmuch as it greatly simplifies tuning operations. If there were any appreciable cross-influence from either the high or low frequency circuits to the other circuit, tuning would necessitate a cumbersome series of alternate tuning steps first of one of the circuits, then the other, after which the first must be returned, then the other returned, etc. The shifting from one circuit to another would entail switching of the transformer operation, as for example when incorporated in an AM-FM radio receiver, changing from the AM band to the FM band or vice versa. In changing bands, the station selector mechanism of the radio would also have to be carefully reset to a suitable position for properly receiving a desired signal. The substantial absence of cross tuning between the circuits which eliminates these difficulties is apparently due to the crossed arrangement of the windings which establish diagonal linkage between the winding portions. The alignment between the winding portions and the opposed winding portion at the same level is such that the magnetic lines of force generated at one of them are directed substantially axially of the opposed winding. As a result axial movements of the core in one winding do not appreciably change the number of flux lines generated by the other, that pass through the core. The permeability of the overall field space of one winding portion is accordingly substantially unaffected by core adjustments of the winding at the same level on the other pin. With respect to the winding portions on the same pin 60, it appears that the flux lines establishing the diagonal linkage do not extend appreciably through the vertically spaced core.

In Fig. 1 most of the adjusting cores are shown as deeply penetrating into their coils although in actual use they do not extend to the innermost turns of the coils and occupy a position no deeper than the one shown for the core of coil 2—61. In this manner, the cores are used to vary the inductance of their surrounding winding portion without materially changing the coefficient of coupling between coupled windings. In the construction shown the coefficient of coupling depends on the inductance of the adjacent turns of the coupled windings to which the flux lines of the linking fields are essentially limited. Any change in inductance of the outer forms varies the individual inductance and the mutual coupling inductance in a manner that keeps the coefficient of coupling constant.

Another feature of the invention is the use of sleeves to hold the windings on the coil pins. Because of the varying characteristics of different types of windings, best results are obtained with windings of different form for different purposes. Thus, for example, low frequency coupling for use with the intermediate frequency amplification stages of standard broadcast AM (amplitude modulated) radio signal receivers, the coupled windings may be more economically formed of relatively small diameter coils having high permeability cores which increase their "Q" or circuit efficiency as much as desired. At intermediate coupling frequencies of the order of 450 kilocycles per second, an internal coil diameter of about 7 millimeters or less is quite satisfactory and not much core material is required. However, as the signals transferred increase in frequency, the ability of a core to increase the "Q" of the circuit drops off. Accordingly for such higher frequencies desirable characteristics depend on relying on the windings alone for high coil "Q," the core being used essentially for inductance adjustment only. Inasmuch as one of the coil form factors influencing coil "Q" is the diameter, the inherently higher "Q" of larger diameter high frequency coils lends itself readily to this invention.

The use of the thinner cores with the high frequency windings also limits any losses contributed by the core material at such high frequencies.

Another advantage of the sleeve construction is that the automatic winding of the coils is simplified. The different types of coils may each be wound on a corresponding form after which the separate coil containing forms are cut to individual sizes and assembled. It is unnecessary to wind the different types on the same form, a procedure which necessitates alternate shifting of the coil winding operation after at least every other coil. Assembly of the sleeves 64 on the pins 60 may be by merely sliding or threading them together and anchoring as by adhesive, as shown at 65.

According to another phase of the invention, the energy transducer or transformer includes condensers of novel construction having a small number of component elements and easily assembled in the completed apparatus. This feature is provided by coating a sheet of dielectric with electrically conductive strata arranged so that the strata form a plurality of different condensers with a single dielectric sheet. In the transformer of the invention shown in Fig. 1 four condensers are formed on the single dielectric sheet 50 and are connected for tuning the different windings 1—61, 1—62, 2—61 and 2—62.

Figs. 4 and 5 show the arrangement of the condensers according to one form of the invention. The sheet 50 has two separate electrically conductive coatings 76, 78 of extensive area on one surface. These coatings, 76, 78 are spaced from each other as indicated at 80 and may terminate some distance from perforations 35 which penetrate the sheet in approximate register with the corresponding terminal board perforations 34 for passage of the securing elements 56. On the other face of the dielectric sheet 50, generally similar conductive coatings are subdivided to provide a pair of extended layers 82, 84 and a pair of smaller layers 86, 88. One of the larger layers such as layer 82 and an adjoining small layer such as layer 86 are together approximately of the same shape as and overlie the layer 76 on the opposite face of the dielectric sheet. The individual layers 82, 84, 86, 88 are all separated from each other and cooperate with a corresponding portion of the opposite layer to form four individual capacitors.

For use with widely different frequency bands such as AM and FM frequency bands as presently allocated, the high and low frequency windings of the circuits although separately tuned may be connected together in series to form one continuous input and one continuous output circuit. When so connected, the capacitance of the tuned low frequency circuit forms a low impedance path for the high frequency currents and the inductance of the tuned high frequency circuit forms a low impedance path for the low frequency currents. The high and low frequency portions of the circuits accordingly function substantially independently of each other even though each sets acts as a connecting path for the currents passing through the other. In such an arrangement the condensers for the separate winding portions of the input and for output circuit may have one of their electrodes connected in common as for example by not dividing the coatings **76** or **78** into individual condenser electrodes corresponding to the electrodes on the opposite face of the dielectric sheet **50**.

The coated dielectric is shown as sandwiched between the contact ears **38**, **40** of the terminal lugs **28**, **30** and the overlying contact ears **36** of the terminal lugs **26**. As more clearly seen in Fig. 3, where the terminal board assembly is shown with the upper lugs removed and the lower conductive coatings **82**, **84**, **86**, and **88** on the sheet **50** shown in dash-dot lines, these subdivided layers are so shaped as to separately contact the larger contact ears **38**, **38**, and the smaller contact ears **40**, **40** respectively when the sheet is held in place over the terminal board with the sheet perforations **35**, **35**, aligned over the board perforations **34**, **34**. The terminal lugs, **30**, **40** are between the sheet and the board. With the sheet so held in place, the upper lugs are then mounted by passing their prong ends **24** through the proper slots **42** so that their contact ears **36** cover the sheet **50** as shown in Fig. 2. The securing rivets **56** are then passed through apertures **44** in the contact ears **36**, as well as through the sheet **50** and board **32**, and crimped over to hold the capacitor assembly in place. The contact ears are arranged for maintaining resilient and positive electrical contact throughout the life of the transducer in spite of variations in terminal board thickness, as by providing them with metallic spring backing such as the washers **37**. These spring washers **37** are arranged to be normally arched and are deformed or flattened when clamped in place as shown. By such an arrangement the electrical connections will be preserved regardless of any tendency for the terminal board to shrink or exhibit cold flow during its useful life. The use of a metallic clamping engagement as direct as possible greatly simplifies the construction inasmuch as metallic members are less subject to shrinkage or cold flow. In the form shown the minimum number of non-metallic clamping members, viz: only the terminal board **32**, is included.

If desired, the metallic springy means is included as an integral portion of the inner or outer contactor elements. In this way the number of component elements may be reduced.

Fig. 6 shows an outer contact lug **26—1**, according to the invention, having a contact ear **36—1** of springy metal and arched to provide the desired resiliency. The arch also includes a clamp receiving passageway **44—1**.

Fig. 7 shows a different form of outer contact lug **26—2** for use with the invention. In this construction the metallic resiliency is provided by an arched extension **37—2** formed integral with the ear **36—2** and folded back over it. Passageways **44—2** may penetrate both ear and extension for use with centrally applied holding clamps.

After the windings and winding pins have been fitted in the sockets **58**, the coil ends may be connected to the condensers by merely uniting them to the corresponding connector prongs of the terminal lugs, in the manner shown in Fig. 2 for example, these leads as well as the external circuit leads may be soldered in place on the prongs. Dummy prongs may also be inserted in unused terminal board slots **42**, as when some of the condenser electrodes are internally connected, and utilized for convenient wiring connection posts.

The condensers and windings so assembled on the board **32** are then inserted into the shield or can portion **22** of the housing which may contain punched positioning detents **90** against which the board is supported and held by deforming outer lip portions of the can as shown at **92**. Attaching means may be provided in the form of conventional threaded lugs **94** secured to the housing as by being riveted to the can in the manner shown in Fig. 1 so that the threaded ends project through a cut away portion at the sides of the terminal board **32**.

An additional feature of the invention is the fact that the condenser arrangement described in connection with Figs. 3, 4, and 5 is not only simple to assemble, requiring no separate securing elements, but can be built without careful grading and sorting of dielectric sheets **50**. Inasmuch as only a small number of such sheets are used it is simpler to adjust the capacitances of the individual condensers after their formation rather than go through the laborious and expensive dielectric sheet thickness measuring and classifying operations. Dielectric sheets such as mica are quite expensive and rather fragile and each sheet even though small, may vary appreciably in thickness over its extent. The saving of material permitted by wider thickness tolerances and the reduction of breakage during handling, together with the more exact adjustment of the final capacitance values make an important and unexpected contribution to the art.

Final capacitance trimming of the apparatus of the invention may be made by adjusting the area of the conductive layers forming the capacitors, as by removing from or adding to these layers. One highly practical technique is to burn off the coating as by arcing. The conductive coating itself may be a stratum of silver deposited as by painting on a layer of finely divided silver powder mixed with a flux and binder that can be burnt away. The coatings are applied through masks or stencils such as by the conventional silk-screening techniques and the coating dried and fired to fuse and unify the powder particles of a stratum while the binder is burnt off. The details of the coating application and composition form no part of the present invention and are described in the National Bureau of Standlards circular 468 entitled Printed Circuit Techniques.

When the coatings are completed, each condenser may be adjusted as by securely contacting the layer 76 with one terminal of a low voltage electric current supply and bringing the other terminal into arcing contact with the portion of the coating to be removed. Arcing contact is easily established by the use of a wire arcing terminal which is brought into loose contact with the coating. Thus a six volt current supply using a tungsten tantalum or iron wire arcing electrode brought against a conventional silver layer or mica will cause sparking and removal of the silver at the points contacted. The arcing electrode may be moved across the surface of coating 76 opposite the layers 82 and 86 until the desired capacitance values are reached. The coating areas may be so shaped that with the thickest sheet of dielectric likely to be encountered, substantially all of the coating areas will be needed and the amount of removal may be automatically controlled by a capacitance measuring circuit connected to the electrodes of the condenser being adjusted. The dielectric sheet is preferably mounted in a suitable jig for properly holding it exposed for arcing and automatically making contact with the measuring circuit. Adjustment may be made after the dielectric has been assembled with its contacting lugs on the terminal board 32, to reduce its fragility and minimize breakage. A sufficient amount of the strata 76, 78 may be left exposed for this purpose as shown in Fig. 2, so that portions may be removed from adjacent the corners of the dielectric for example. The automatic capacitance measuring circuit may also be connected to deenergize the arcing circuit when a condenser is properly adjusted, so that it is unnecessary to carefully watch the adjustment.

The invention is not limited to the specific forms described above. The coil windings for example may be of any other suitable types. For example the low frequency winding portions 1—62, 2—62 may each be of the single coil type well-known in the art instead of the double sections shown. The condenser electrodes may be of any other shape as desired. The saving of volume and dielectric by the techniques described above may be combined with only a single band transformer winding construction and conversely the two-band crossed winding feature may be utilized with other condenser assemblies.

Although the coil pins are shown as cylindrical, they may be of any other suitable configuration such as square or rectangular in transverse section. The coils may be directly wound on the pins or the sleeve type construction may be used with some or all the windings. The square or rectangular forms of coil pins may carry inner thread-like protuberances for threadedly receiving cylindrical cores, or the cores may also be correspondingly squared or rectangular in transverse section and slidably fit within the pins.

For the purposes of this application, where the term "core" is used, it is understood that this refers to any high permeability magnetic material placed in the magnetic field of the windings. Thus the magnetic material or core may either fit around or within the windings without affecting the operation of the invention. In the construction of the invention in which the high permeability material surrounds the coating coils, it may be slidably held on one or more guides fitted around the coils or the outer surfaces of the coils themselves may act as a guide, as for example by interposing a protective sheath around the windings. The high permeability materials may be arranged so that they are all adjusted from one end of the housing. They may be molded around or secured to adjusting extensions extending to positions where they are conveniently available for operation when desired. Internal cores such as are shown in Fig. 1 may, for example, have axial extensions brought out to the same or opposite ends of the housing and threadedly received for adjustment. One axial extension may be tubular for receiving the extension of the core behind it in the single-ended adjustment modification.

A particularly desirable core construction for use with the invention is one which extends both inside and outside of an associated coil in the general shape of a cup having an inner central projection formed on the bottom of the cup. The space between the central projection and the inner walls of the cup is arranged to receive the coating windings. The windings may be carried by short pins held centrally between the windings to permit the cup bottoms to approach the windings and the additional core supports around the pins may threadedly or slidably guide the cores and also serve as mounting structure for holding the coil pins.

In addition to the conventional core materials such as molded and bonded powdered iron or magnetite, the cores may also be of the ferrite composition described in Harvey et al. application Serial No. 719,594 filed December 31, 1946 or Leveranz et al. application Serial No. 776,292 filed September 26, 1947. These ferrites exhibit large permeability changes under the influence of D. C. magnetic fields of variable intensity. With such constructions the coils may be tuned by using fixed cores and small adjustable magnets.

Among the further modifications of the invention, the windings may be arranged for mounting independently of the capacitors and/or the terminal board. As one example the coil pins may be fitted generally parallel to the terminal board and be held between opposing walls of the housing as by making the walls yieldable and providing them with sockets or projections engaging the pins. The pins may then be pushed into place, the walls giving slightly so that the pins snap into position. The lead wires may then be pulled through terminal board slots and soldered to prongs on the board after the board is secured in place. This soldering, as well as that for the construction of Fig. 1 may be effected by dipping all the prongs simultaneously into molten solder. According to this modification, the lead wires of any resonant circuit is not objectionably close to a coupled circuit or to the lead wires of a coupled circuit.

The transducer construction of the invention will have its terminal board 32 impregnated or coated with wax or other sealing composition, if it is desired that it be rendered more insensitive to variable external influences such as changes in humidity. This is especially important with those types of terminal boards having a fibrous construction such as those made by impregnating of textile, woven glass cloth for example, molded within thermosetting resinous material. The wax coating or impregnating operation may be performed before or after capacitor elements are assembled and clamped to the board. In those forms of the invention in which a relatively large portion of the conductive coatings of the dielectric sheet 59 are exposed, it is desirable to avoid impregnation between the contact ears and the conductive coatings, where dipping is effective after assembly. For best results where the upper contact ears 36 are resiliently held they may be of the types such as shown in Figs. 1 and 7 wherein they are held in substantially flat engagement with a large proportion of conductive coatings.

According to the invention the individual winding portions may be arranged so that the small capacitance tending to couple them either assists or opposes any magnetic coupling.

Fig. 8 shows one form of transfer circuit in which the transducer of the invention may be connected. As described above, the windings 1—61, 2—61, 1—62, 2—62 are connected so that windings 1—61 and 1—62 form series connected portions of an input circuit, each winding being separately tuned by capacitances 81, 83. The output circuit is similarly constituted by windings 2—61, 2—62 and capacitances 85 and 87. The desired coupling is provided between windings 1—61, 2—61 and between windings 1—62, 2—62. At the pass band of one coupled pair of tuned windings, the other windings are sufficiently far from resonance to be of negligible impedance, so that winding portions may remain series connected while either portion is utilized for coupling, and no coil switching is needed. The invention is also suitable for connection in transfer networks involving switching circuits.

Another feature of the invention is that it may be incorporated in transducers having transfer characteristic differing from those of the conventional transformer. For example where sharp cut-off band-pass characteristics are desired the transducer may be of the so-called "M-derived" type such as shown in the circuit diagrams of Figs. 9 and 10.

Fig. 9 is a circuit diagram of a band pass transfer network including four tuned parallel resonant sections 91, 93, 95, 97 each of which has a separate resonating capacitance. Two sections 91, 93 are connected across the transfer path and the remaining two 95, 97 are inserted in series in the transfer path. The sections are tuned in any conventional relationship to establish the desired transfer characteristics, as is well known in the art. The network may be connected for coupling the output of a suitably operated space discharge tube 96 to the input of another space discharge tube 98, a blocking capacitor 99 being inserted to suitably isolate the different D. C. tube operating voltages.

The four resonating capacitors may be embodied in the simple single-dielectric form of the invention, as shown in Figs. 2, 3 and 4. The common connection between two adjacent capacitor electrodes are readily provided by merely forming the capacitor electrodes of unseparated conductive strata. Additionally the blocking capacitor 99 may also be similarly built on the single dielectric sheet and interconnected so that the external connections are simplified. In those modifications where the distributed capacitance of one or more coil windings is the only resonating capacitance for those windings a blocking capacitor of even relatively large capacitance is easily included.

The coil windings of such a construction operate without magnetic coupling but no special shielding precautions need be taken where the coupling between coils is so limited as to affect the transfer characteristics in remote portions of the frequency spectrum. For example, a circuit of the type shown in Fig. 9 has been successfully operated with a coil distribution essentially as shown in Fig. 1. The unshielded magnetic coupling not opposed by bucking capacitive coupling was adjusted to have no effect in the transfer band used. Where desired of course, the coil sections may be shielded from each other by any well-known arrangements.

Fig. 10 is a modified transducer network similar to that of Fig. 9. In this network sections 91—1 and 93—1 are parallel resonant and the sections 95—1 and 97—1 series resonant. The parallel resonant circuits 91—1, 93—1 are inserted in series in the transfer path while the series resonant circuits 95—1, 97—1 are connected in parallel across the transfer path.

The arrangement shown in Fig. 10 may be generally similar in construction to that described in connection with Fig. 9. If desired, the resonating capacitances of sections 91—1 and 93—1 may be directly returned to ground instead of the common coil connection. This modification provides capacitance pairs with a common connection, simplifying the external wiring and electrode contacting arrangement.

While several exemplifications of the invention have been indicated and described above, it will be apparent to those skilled in the art that other modifications may be made without departing from the scope of the invention as set forth in the appended claims.

What is claimed is:

1. A dual frequency transformer comprising, two elongated winding supports, a relatively low frequency primary winding formed on one of said supports adjacent its upper end, a relatively low frequency secondary winding formed on the other support adjacent its lower end, two sleeves having inside dimensions corresponding substantially to the outside dimensions of said supports, relatively high frequency primary and secondary windings formed on said respective sleeves, the sleeve carrying the relatively high frequency primary winding being mounted adjacent the lower end of the support carrying said relatively low frequency primary winding and the sleeve carrying the relatively high frequency secondary winding being mounted adjacent the upper end of the support carrying said relatively low frequency secondary winding, a housing for said transformer having a substantially closed end and an oppositely disposed open end, a terminal board adapted to be affixed to said housing substantially closing the open end thereof, tuning capacitors for connection to said windings, fasteners securing said capacitors to said terminal board at spaced points thereon, two of said fasteners having formed at the inner ends thereof means for receiving and mounting the corresponding ends of said respective supports, and the closed end of said housing being provided with means in substantial alignment with said fasteners for receiving and securely mounting the other corresponding ends of said supports.

2. A dual frequency transformer comprising, two cylindrical winding supports, a relatively low frequency primary winding formed on one of said supports adjacent its upper end, a relatively low frequency secondary winding formed on the other support adjacent its lower end, two tubular sleeves having inside diameters corresponding substantially to the outside diameters of said supports, relatively high frequency primary and secondary windings formed on said respective sleeves, the sleeve carrying the relatively high frequency primary winding being mounted adjacent the lower end of the support carrying said

relatively low frequency primary winding and the sleeve carrying the relatively high frequency secondary winding being mounted adjacent the upper end of the support carrying said relatively low frequency secondary winding, a metallic housing for said transformer having a substantially closed upper end and an open lower end, a non-metallic terminal board adapted to be affixed to said housing substantially closing the lower end thereof, tuning capacitors for connection to said windings, rivets securing said capacitors to said terminal board at spaced points thereon, said rivets being formed respectively at the upper ends thereof for receiving and mounting the lower ends of said supports, and the upper end of said housing having deformations therein in substantial alignment with said rivets for receiving and securely mounting the upper ends of said supports.

3. A dual frequency transformer comprising, two hollow winding supports, a relatively low frequency primary winding formed on one of said supports adjacent its upper end, a relatively low frequency secondary winding formed on the other support adjacent its lower end, two hollow sleeves having inside dimensions corresponding substantially to the outside dimensions of said hollow supports, relatively high frequency primary and secondary windings formed on said respective sleeves, the sleeve carrying the relatively high frequency primary winding being mounted adjacent the lower end of the support carrying said relatively low frequency primary winding and the sleeve carrying the relatively high frequency secondary winding being mounted adjacent the upper end of the support carrying said relatively low frequency secondary winding, an electrically conductive housing for said transformer having a substantially closed upper end and an open lower end, an electrically non-conductive supporting sheet adapted to be affixed to said housing substantially closing the lower end thereof, tuning capacitors for connection to said windings, tubular rivets securing said capacitors to said supporting sheet at spaced points thereon, said rivets having projections formed respectively at the upper ends thereof for receiving and mounting the lower ends of said supports, and the upper end of said housing having recesses formed therein in substantial alignment with the projections of said rivets for receiving and securely mounting the upper ends of said supports.

4. A dual frequency transformer comprising, two tubular winding supports, a relatively low frequency primary winding formed directly on one of said supports adjacent its upper end, a relatively low frequency secondary winding formed directly on the other support adjacent its lower end, two tubular sleeves having inside diameters equal substantially to the outside diameters of said tubular supports, relatively high frequency primary and secondary windings formed directly on said respective sleeves, the sleeve carrying the relatively high frequency primary winding being mounted adjacent the lower end of the support carrying said relatively low frequency primary winding and the sleeve carrying the relatively high frequency secondary winding being mounted adjacent the upper end of the support carrying said relatively low frequency secondary winding, an electrically conductive housing for said transformer having a substantially closed upper end and an open lower end, a dielectric supporting sheet adapted to be affixed to said housing substantially closing the lower end thereof, tuning capacitors for connection to said windings, hollow tubular rivets securing said capacitors to said dielectric sheet at spaced points thereon, said rivets having sockets formed respectively at the upper ends thereof for receiving and mounting the lower ends of said supports, and the upper end of said housing having recesses formed internally thereof in substantial alignment with the sockets in said rivets for receiving and securely mounting the upper ends of said supports.

5. A dual frequency transformer as defined by claim 4 and also including a high permeability core for each of said windings disposed in said supports, each of said cores being positioned within at least a part of its associated winding.

6. A dual frequency transformer as defined by claim 5 in which the closed end of said housing is provided with openings in alignment with said winding supports, providing, with said hollow rivets, means for rendering said cores accessible for adjustment.

7. In a transducing apparatus for transferring alternating electric currents of different frequency bands from one circuit network to another: a pair of elongated supports disposed in substantially coplanar relation; a first primary winding responsive to relatively low frequency signal potentials and formed on one of said supports adjacent one end; a second primary winding responsive to relatively high frequency signal potentials and formed on said one of said supports adjacent the other end; a first secondary winding responsively to said low frequency signal potentials and formed on the other of said supports adjacent said second primary winding and magnetically coupled with said low frequency primary winding; a second secondary winding responsive to said high frequency signal potentials and formed on said other support adjacent said low frequency primary winding and mutually magnetically coupled with said high frequency primary winding.

8. A transducing apparatus as defined by claim 7 in which the elongated supports are hollow and high permeability magnetic cores are movably positioned within the pins and adjacent the windings for independently adjusting the inductance of the windings.

9. A transducing apparatus as defined by claim 7 in which the first and second primary windings are held on one support, the first and second secondary windings are held on the other support, and capacitance elements are mounted adjacent the end of at least one of said supports, said capacitance elements being connected across windings held on the support adjacent the end of which it is mounted, for tuning the connected windings to the desired frequency.

10. A transducing apparatus as defined by claim 9 in which the capacitance elements are formed of a single dielectric layer with electrically conductive strata secured to opposite faces of the layer, at least one of the conductive strata being divided into portions forming condenser electrodes of different condensers.

11. In a high frequency transfer apparatus for transferring alternating electric currents of selected frequencies from one circuit to another; deformed housing means having electrically conductive bounding wall portions and an electrically non-conducting surface portion; at least one pin mounted within said housing means, input windings and output windings mounted in spaced relation on said pin and in spaced relation from the housing walls; supporting structure including

the deformed part of said housing means constituting at least one support for said pin; said supporting structure also holding capacitance elements connected with said windings to form resonant circuit means tuned to the desired frequencies; said capacitance elements including a plurality of electrically conductive connector elements and at least some of said connector elements include metallic yieldable spring means, and a dielectric sheet with electrically conductive strata coated on and adherently bonded to the faces of the sheet; said connector elements include inner and outer elements having portions overlying said non-conducting surface portion; said dielectric sheet being resiliently clamped between the inner and outer connector elements and to said surface portion by rivet means penetrating at least said non-conducting surface and said outer connector elements; said rivet means including extending supporting elements for holding said pin in place within said housing, said housing means including securing structure for securing said non-conducting surface and supporting elements of the rivet means in fixed relation to the conductive housing walls, and holding the housing supporting element and the rivet means supporting elements in cooperative position for securely retaining said pin in place.

12. In a transducing apparatus for transferring alternating electric currents of different frequency bands from one circuit network to another: a pair of tubular supports in spaced relation; input circuit means including a first input winding mounted directly on one of said pair of tubular supports adjacent one end thereof, and a second input winding mounted on a separate sleeve carried by said one of said pair of tubular supports adjacent the other end thereof; output circuit means including a first output winding mounted directly on the other of said pair of tubular supports adjacent the other end thereof and in proximity with said second input winding, and a second output winding mounted on a separate sleeve carried by said other of said pair of tubular supports adjacent the one end and in proximity with said first input winding thereof said windings forming part of band pass circuits in which the first input windings are spaced from and mutually magnetically coupled in crossed relation with the first output windings, and both said first windings are tuned to resonate to a band of high frequency currents to selectively transfer such currents from the input to the output circuit means; the second input windings being spaced from and mutually magnetically coupled with the second output windings and both said second windings being tuned to resonate to a different band of high frequency currents to selectively transfer such currents from the input to the output circuit means; and a plurality of substantially identical high permeability magnetic cores mounted within said tubular supports for positioning interiorly of at least parts of each winding.

DONALD MACKEY.

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