

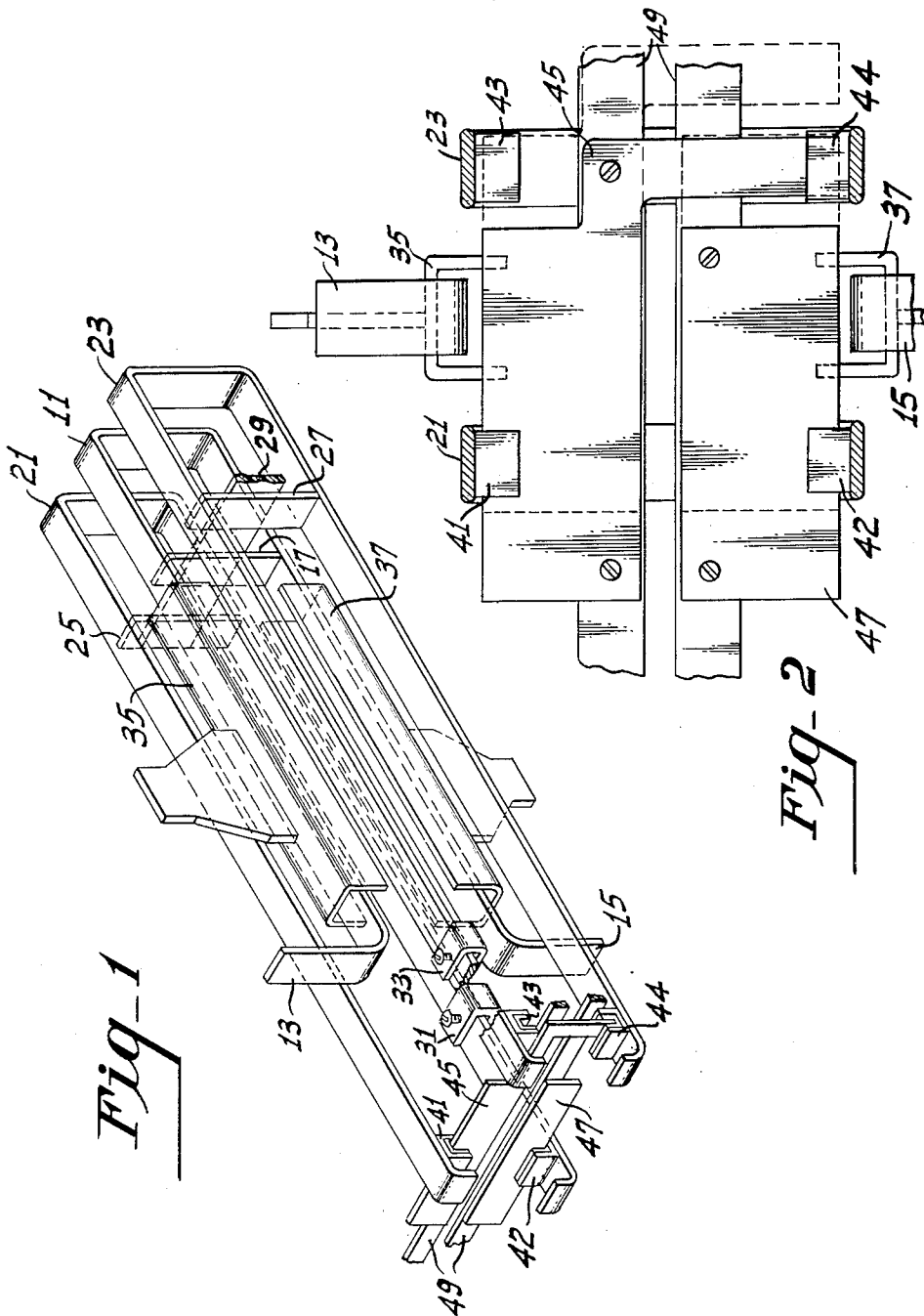
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RADIO COUPLING SYSTEM

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RADIO COUPLING SYSTEM

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This invention relates to a coupling system for radio frequency energy, and more particularly to apparatus operative over a wide range of frequencies for coupling large amounts of radio frequency power from one tuned circuit to another.

It is an object of this invention to provide a novel mechanical construction for a radio frequency coupling system capable of transferring large amounts of power between two circuits.

Another object of this invention is to provide a novel transformer in the form of a plurality of spaced U-shaped loops for coupling a source of radio frequency energy to a load, wherein means are provided to change the inductance and extend the tuning range of the transformer without altering the coefficient of coupling between the source and the load.

It is another object of this invention to provide an improved construction of a radio frequency transformer coupling system for transferring large amounts of power between two circuits in which either a balanced or unbalanced source of power may be coupled to either a balanced or unbalanced load device.

Briefly, in accordance with this invention, there is provided a transformer having a single centrally-positioned U-shaped loop which may be utilized as a primary, and two similar U-shaped loops which may be utilized as a secondary which are located symmetrically on either side of and spaced from the first U-shaped loop. A non-magnetic conductive shield in the form of a channel slightly shorter than the single primary loop is interposed between the centrally-positioned loop and the other loops on opposite sides thereof to electrostatically shield at least a portion of the primary from the two portions of the secondary. The two secondary U-shaped loops may be connected either in series or in parallel relation by a sliding switch plate. Both the single loop primary and the two symmetrically arranged loops of the secondary are tunable by means of sliding shorting bars, which are preferably arranged to contact the inside surfaces of the loops.

One advantage of the present invention is that it enables the transfer of large amounts of radio frequency power from an unbalanced source to a balanced load, and vice versa. For example, the transfer of large amounts of power from an unbalanced or "single-ended" source through conventional lumped coupling transformer circuits to a balanced load results in undesired components of unbalanced current and voltage in the balanced load device. These unbalanced components are due to undesired coupling arising from the size and configuration of the circuit elements. This invention provides structure which overcomes this difficulty in a high-power coupling system.

A more complete understanding of the operation and features of the invention, together with additional objects thereof, may be gained from a reading of the following description in connection with the accompanying drawing, in which:

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Fig. 1 shows a perspective view of the radio frequency transformer coupling device of this invention; and

Fig. 2 is an end view of the transformer of Fig. 1 showing the switching arrangement in detail.

Referring to Fig. 1, the radio frequency transformer coupling device includes a single U-shaped conductive member or primary loop 11 which is adapted to be fed by a source of radio frequency energy, not shown, across the terminals 13, 15 thereof. The primary loop 11 is tuned to the radio frequency to be transferred by means of an adjustable metallic shorting bar 17 and series or parallel capacitors in circuit with the terminals 13, 15, but not shown herein. Arranged either side of the primary loop 11 are two identical U-shaped conductive members or loops 21, 23 which together form the secondary of the transformer. All three of the U-shaped members 11, 21 and 23 may be made from a flat ribbon-like conductor bent to form legs and a base, as shown.

Each of the secondary U-shaped loop members 21, 23 is also adjustable by means of metallic shorting bars 25 and 27, respectively. It is preferred that these shorting bars 17, 25 and 27 engage the inner surface of the legs of the associated U-shaped loop members 11, 21, 23 as shown. The shorting bars 17, 25 and 27 are slideable over the respective loops with which they are associated, and are preferably uni-controlled by means of a cross-piece of insulating material 29 to which they are all mechanically attached, but remain electrically insulated from each other.

The output from the secondary loop members 21, 23 is connected to an output load device, not shown, which may be for example a balanced or unbalanced transmission line or an antenna, by means of output terminals 31, 33. One terminal 31 is mechanically and electrically secured to one leg of one of the secondary loop members 21, and the other terminal 33 is likewise mechanically and electrically secured to a leg of the other secondary loop member 23. Like the primary loop 11, the secondary loop circuit 21, 23 is tuned to the radio frequency to be transferred by means of the secondary shorting bars 25 and 27 and series or parallel capacitors in circuit with the terminals 31, 33, but not shown herein.

The U-shaped primary loop 11 is electrostatically shielded from the secondary loops 21, 23 by means of conductive channels 35, 37 which are placed over, and the sides of which are interposed between two legs of the primary loop 11 and the correspondingly positioned legs of the secondary loops 21, 23 over a substantial portion of the length of the primary loop 11. The electrostatic shield channels 35 and 37 are preferably grounded by being connected to a point of reference potential, such as a grounded chassis member. Electrostatic coupling between primary and secondary is mainly detrimental at the upper end of the band of frequencies for which the transformer is designed. The lengths of the shields 35 and 37 therefore, as a practical matter, need not extend the entire length of the legs of the primary loop 11 since the working portion of the loop 11 at the upper end of the frequency band for which the coupling system is designed is that included between the terminals 13, 15 and the shorting bar 17. This shorting bar 17 will be nearer the terminals 13, 15 of the primary loop 11 when the upper end of the frequency band is being utilized.

In order to operate over a very wide frequency range, say, for example, from 3.9 to 22 megacycles, a very large change in inductance in the output coupling means is necessary. This change in inductance is achieved, according to the present invention, by connecting the two secondary loops either in electrical series or parallel relation according to the frequency of the radio power to be transferred.

A switching arrangement to change the connection of

the two secondary loops from parallel to series according to the frequency of the radio power to be transferred will be described in connection with both Figs. 1 and 2. Secured to each end of both of the secondary loops 21 and 23 are contacts 41 and 42 for one secondary loop 21, and 43, 44 for the other secondary loop 23. Two contacting or switching plates 45 and 47 are mounted upon insulating rods 49 and are arranged to engage a slotted portion in each of the contacts 41, 42, 43, 44 and make electrical contact therewith.

The switching plates 45, 47 have two positions. The lower plate 47, which may be, for example, rectangular in form, in one of its positions (that shown in solid lines in Fig. 2 of the drawing) makes mechanical and electrical contact with only one contact 42, on one side of one of the secondary loops 21. In the other position of the two switching plates 45, 47 (that shown in dotted lines in Fig. 2) the lower plate 47 makes contact with two of the contacts 42 and 44, one on each of the secondary loops 21 and 23. The upper plate 45, which is shown as having a rectangular portion with an outwardly and downwardly extending tang, in its left-hand position (that shown in solid lines in Fig. 2) makes contact with one contact 41 on one secondary loop 21 and an oppositely disposed contact 44 on the other secondary loop 23. In the other position of the two switching plates 45, 47 (that shown in dotted lines in Fig. 2), the upper plate 45 makes contact with two of the contacts 41 and 43, one on each of the secondary loops 21 and 23, respectively.

The output from the secondary loops 21 and 23 is taken across the output terminals 31 and 33 which are mechanically and electrically secured to the secondary loops 21 and 23 near oppositely disposed contacts 42 and 43. With the switching plate in its left-hand position, that is, with the upper switch plate 45 electrically connecting the upper contact 41 of one secondary loop 21 to the lower contact 44 on the other secondary loop 23, it will be seen that the two secondary turns are connected in series between the output terminals 31 and 33. With the switching plates 45 and 47 in their right-hand position, that is, with the upper switch plate electrically connecting the upper contact 41 on one secondary loop 21 with the upper contact 43 on the other secondary loop 23, and the lower switch plate 47 electrically connecting the lower contact 42 on one of the secondary loops 21 with the lower contact 44 on the other secondary loop 23, the two secondary turns 21 and 23 are electrically connected in parallel.

It will be apparent therefore that for any setting of the secondary shorting bars 25 and 27, an inductance change of 4:1 is obtainable by means of the secondary switching device. In practice, of course, as stated above, it is contemplated that both primary and secondary loops of the coupling device of this invention will be tuned by either series or parallel capacitors. Normally a rough adjustment of the tuning would be made using the shorting bars 17, 25 and 27 in both the primary and secondary loops, and a final vernier adjustment of the tuning would be accomplished by means of variable capacitors.

An embodiment of the invention successfully tried out in practice had the following dimensions: The single turn loop 11, utilized as the primary, was made of $\frac{1}{4}$ x $1\frac{1}{4}$ " copper bus, approximately 2' 6" long and 10" in height. The two secondary loops 21 and 23 were of the same material and had the same dimensions as the primary loop 11, and were placed symmetrically one on each side of and spaced from the primary loop 11 by a distance of $1\frac{1}{4}$ ". The electrostatic shield channels 35 and 37 were formed of $\frac{1}{16}$ " aluminum, the channels themselves being $2\frac{1}{2}$ " wide and $3\frac{1}{2}$ " deep. The channels 35 and 37 extended approximately 2" beyond the straight portions of the primary loop 11 toward the center of the coupler structure. The rectangular lower

switch blade 47 was of $\frac{1}{4}$ " copper, 7" long by $3\frac{1}{2}$ " wide. The rectangular portion of the upper switch blade 45 had the same dimensions, while the outwardly and downwardly extending tang portion was $1\frac{1}{4}$ " wide. The insulating rods 49 were of micalex $\frac{3}{4}$ " x $1\frac{1}{2}$ ", secured together at the ends remote from the switch and moved by a lever-arm arrangement.

In the embodiment successfully tried out for a power transfer of 50 kilowatts, the inductances of both the primary and secondary loops were adjusted by mechanically coupling, but electrically insulating, the three shorting bars 17, 25 and 27 together. It was found that with fixed coupling between primary and secondary, the series connection of the secondary loops 21, 23 permitted a tuning range of 3.9 to 15 megacycles. With a parallel connection of the secondary loops 21 and 23, the coupling system was tunable over a range of from 15 to 22 megacycles.

The electrostatic shield structure enables the coupling device of this invention to be operated at frequencies up to at least 26 megacycles with the design dimensions listed above and still have output voltages which are balanced with respect to ground, regardless of whether the input is coupled to a source of power which is balanced or unbalanced.

I claim:

1. A radio frequency coupling system comprising a single U-shaped loop tunable by means of a sliding shorting bar, said loop having a conductive shielding channel adjacent to and effective over the greater part of its length on each side of the said loop, two additional U-shaped loops symmetrically located on opposite sides of and spaced from said first loop, adjustable shorting bars contacting the inside surfaces of said additional loops, switching means for connecting said additional loops in series or parallel including two sliding switch plates, each having two positions, the first plate in one position contacting only one side of one of said additional loops and in the second position contacting one side of both of said additional loops, and the second plate in said first position contacting one side of the other of said additional loops and the other side of the said one of said additional loops, and in the second position contacting the other side of both of said two additional loops, terminals for said first loop member, and terminals for said additional loop members on said one side of one additional loop and on the other side of the other additional loop.

2. A variable coupling system comprising, a first U-shaped loop having oppositely extending end terminals, second and third U-shaped loops symmetrically located on opposite sides of said first loop, said three loops lying in parallel planes and having right legs and left legs, two conductive shielding channels each partially surrounding a different one of the legs of said first loop along the greater part of the length thereof, a terminal on the right leg of said second loop, a terminal on the left leg of said third loop, and switching means for connecting said second and third loops in series or parallel including first and second sliding switch plates which in one position connect the left leg of said second loop to the right leg of said third loop, and in the other position connect the right legs of said second and third loops and the left legs of said second and third loops.

3. A variable coupling system as defined in claim 2, and in addition, three uni-controlled shorting bars for determining the effective lengths of said loops.

4. A variable coupling system as defined in claim 2, wherein said two conductive shielding channels include sides extending between the legs of said first loop and said second loop, and between the legs of said first loop and said third loop.

5. A variable coupling system comprising, a first U-shaped loop having oppositely extending input terminals on the open ends thereof, second and third U-shaped

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loops symmetrically located on opposite sides of said first loop, said three loops lying in parallel plane with the open ends of the loops extending in the same direction, said loops having right legs and left legs, three uni-controlled shorting bars for determining the effective length of said loops, two conductive shielding channels each partially surrounding a different one of the legs of said first loop along the greater part of the length thereof, said channels including sides extending between the legs of said first loop and said second loop, and between the legs of said first loop and said third loop, an output terminal on the right leg of said second loop, an output terminal on the left leg of said third loop, and switching means for connecting said second and third loops in series or parallel including first and second sliding switch plates which in one position connect the left leg of said second

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loop to the right leg of said third loop, and in another position connect the right legs of said second and third loops and the left legs of said second and third loops.

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