Dec. 9, 1924.

L. ESPENSCHIED

1,518,495

SELECTIVE CIRCUITS

Filed Sept. 26, 1919

3 Sheets-Sheet 1

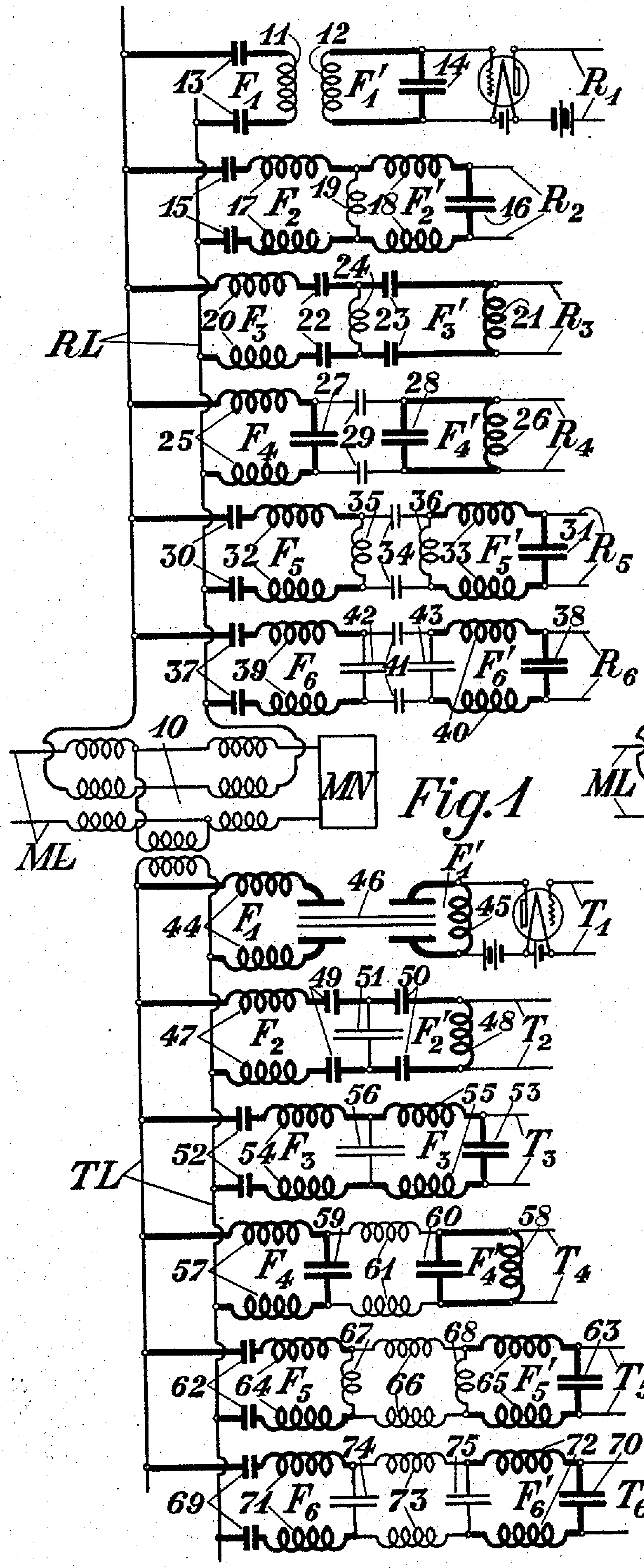

Fig. 1

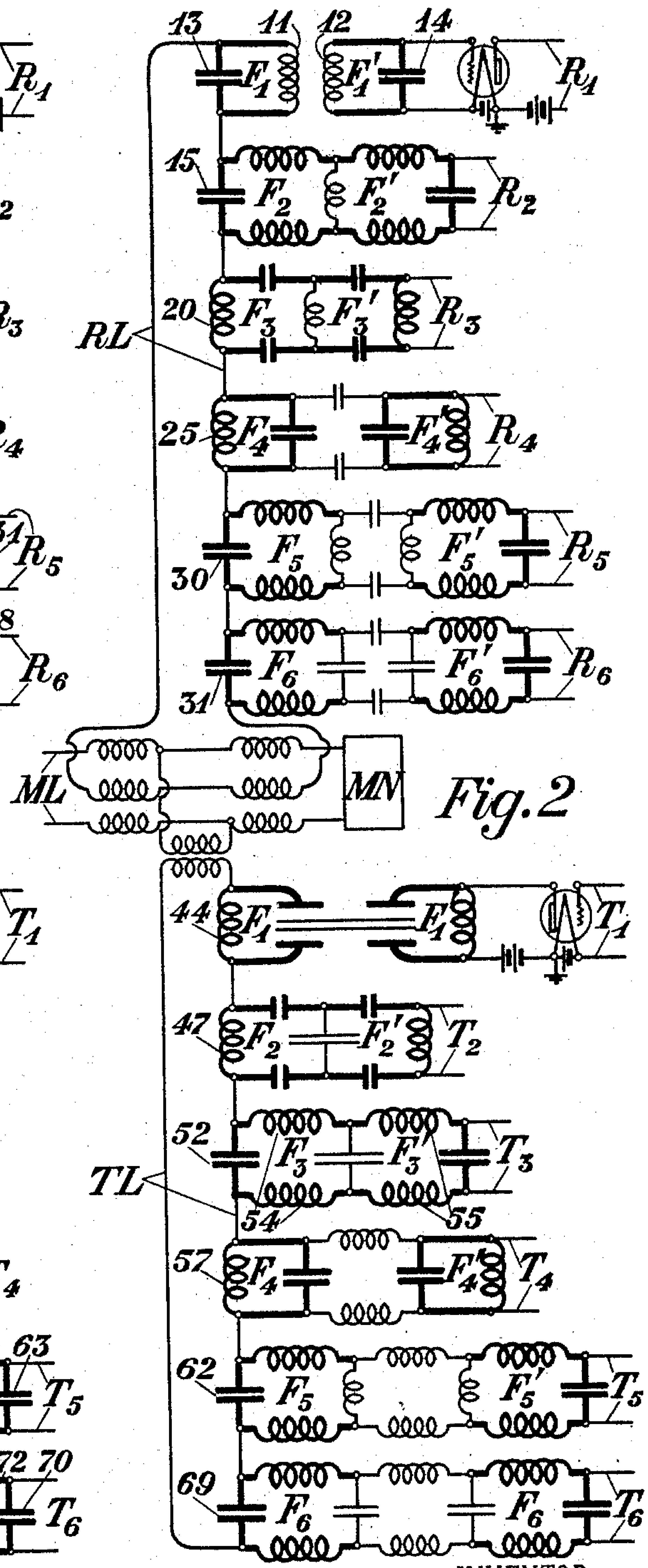

Fig. 2

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SELECTIVE CIRCUITS

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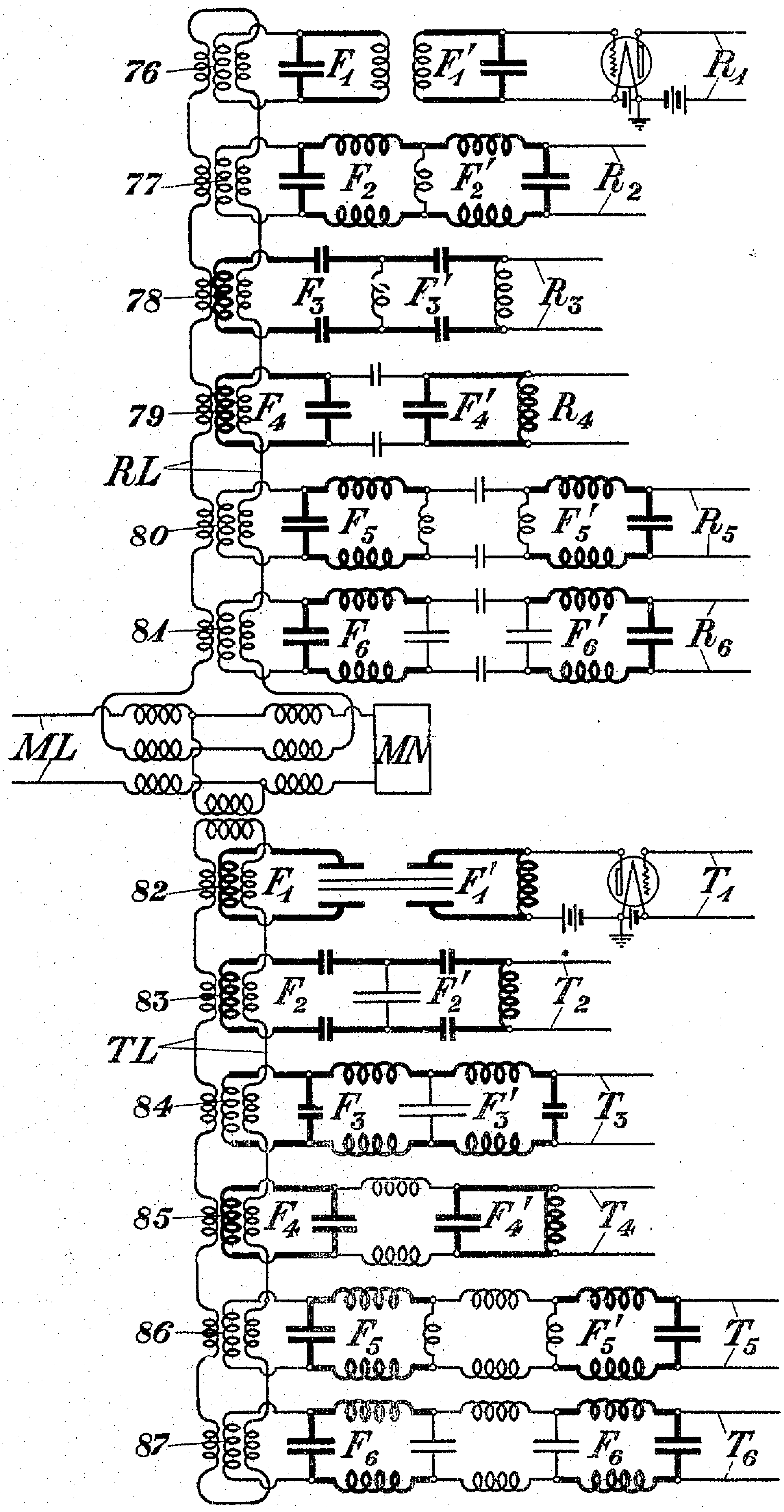

Fig. 3

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Dec. 9, 1924. 1,518,495

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SELECTIVE CIRCUITS.

Filed Sept. 26, 1919 3 Sheets-Sheet 3

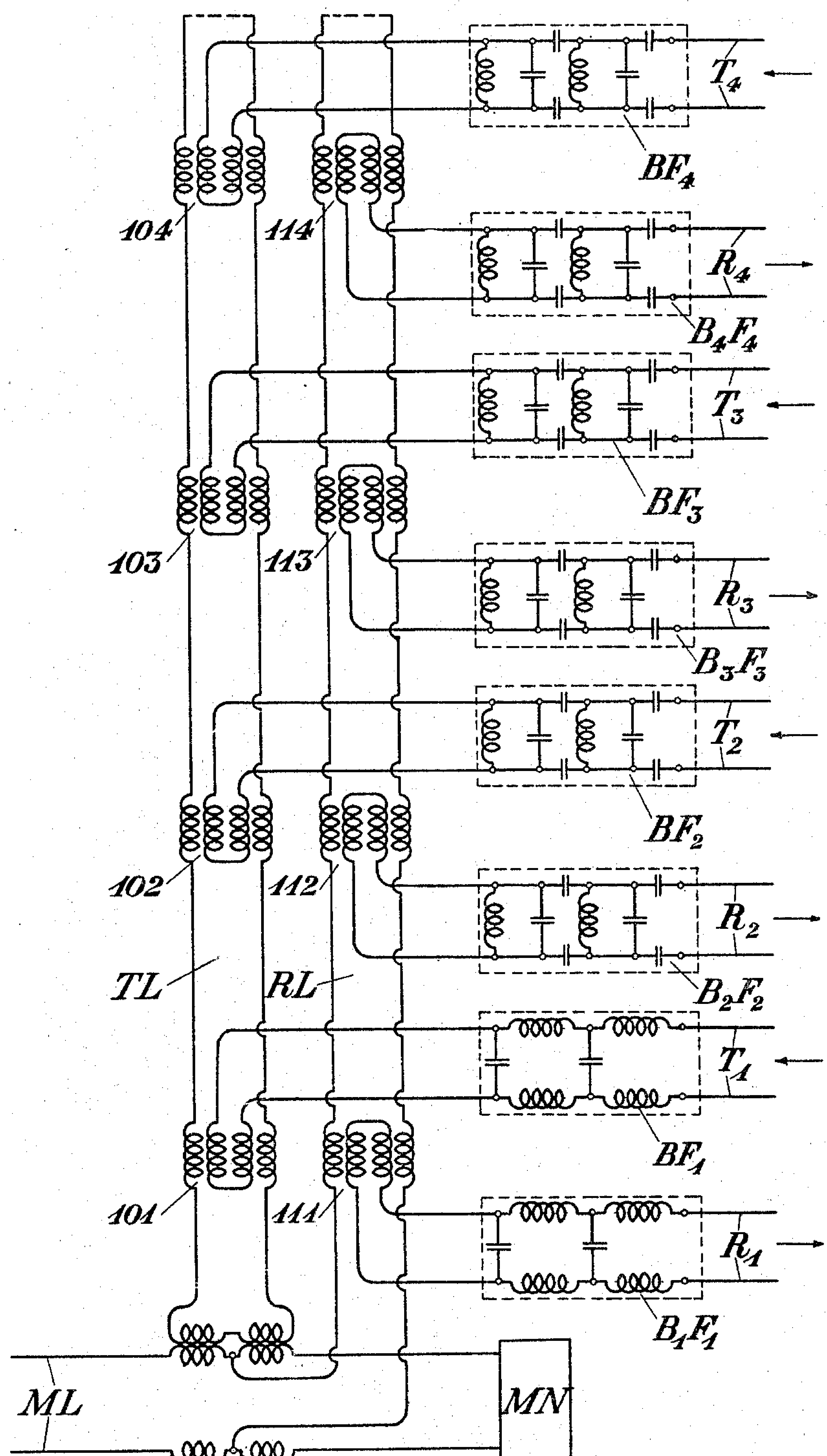

Fig. 4

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Patented Dec. 9, 1924. **1,518,495**

UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF HOLLIS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

SELECTIVE CIRCUITS.

Application filed September 26, 1919. Serial No. 326,521.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, in the county of Queens and State of New York, have invented certain Improvements in Selective Circuits, of which the following is a specification.

This invention relates to multiplex transmission circuits and more particularly to arrangements whereby a plurality of channels may be associated with a common transmission circuit without interference between the channels.

One of the features of the invention resides in the provision of novel selective devices to prevent interference between the channels.

Another feature of the invention relates to a form of coupling device for coupling tuned selective circuits in such a manner as to obtain sharp selectivity and efficient transmission.

Another feature of the invention relates to the provision of means whereby a plurality of channels may be serially related to a common transmission circuit in such a manner that the two sides of the transmission circuit will be balanced.

Other and further features of the invention will be clear from the following description when read in connection with the accompanying drawing, Figures 1 to 4 of which illustrate a plurality of embodiments of the invention.

Referring to Figure 1, ML designates a transmission line over which a plurality of transmissions may take place simultaneously. A common transmitting circuit TL and a common receiving circuit RL are associated with the line ML through a balanced transformer arrangement 10 and the line ML is balanced by an artificial line or network MN, in order to render the circuits TL and RL substantially conjugate. A plurality of transmitting channels T_1, T_2, etc. are bridged across the common transmitting circuit TL, whereby a plurality of signals may be simultaneously impressed upon the line ML for transmission to a distant station. In a similar manner a plurality of receiving channels, R_1, R_2, etc. are bridged across the common receiving circuit RL, whereby a plurality of signals simultaneously transmitted over the line ML from a distant station may be received and separated to proper receiving devices.

In order to prevent interference between the channels, selective devices are included in the channels. These selective devices may assume a wide variety of forms and for purposes of illustration a different form of selective device is shown associated with each of the channels of Figure 1. For instance, the selective device associated with the channel R_1 may comprise a pair of resonant circuits F_1 and F'_1 loosely coupled through a transformer comprising windings 11 and 12. The windings 11 and 12 also serve as inductances which, in conjunction with capacities 13 and 14, serve to tune the resonant circuits to a desired frequency.

Instead of using the mutual inductances of the two windings of the transformer for coupling the two resonant circuits, an auto-transformer arrangement may be used, as shown in connection with the resonant circuits F_2 and F'_2 of the channel R_2. In this case the circuits are tuned by means of condensers 15 and 16 and inductances 17 and 18, while a small coupling inductance 19 is shunted across the resonant circuits F_2 and F'_2 at the junction points. The self-inductance of the element 19 is equivalent to the mutual inductance of the transformer comprising the windings 11 and 12 of the channel R_1.

The arrangement associated with the channel R_3 is similar to that associated with R_2, except that the tuning inductances and capacities are interchanged; thus the tuning inductance 21 of the resonant circuit F'_3 is in shunt relation with respect to the channel, instead of in series, as in the case of inductance 18 of channel R_2. So also the capacity 23 is in series instead of in shunt, with respect to the channel R_3. The coupling inductance 24 is in all respects similar to the inductance 19.

Instead of an inductive coupling, a capacity coupling may be utilized, as illustrated in connection with the channel R_4. In this case the resonant circuits F_4 and F'_4 are tuned by means of inductances 25 and 26 and capacities 27 and 28, these capacities being shunted across the channel and being relatively large in value. For coupling purposes capacities 29 may be serially included in the channel between the resonant circuits and for loose coupling these capacities should be relatively small in value.

If desired, a series-shunt coupling may be employed, as illustrated in connection with the channel R_5. In this case the resonant circuits F_5 and F'_5 are tuned by means of capacities 30 and 31 and inductances 32 and 33, while the two circuits are coupled by means of series capacities 34 of relatively small value and shunt inductances 35 and 36 which are also of relatively small value.

Instead of shunt inductances of relatively small value, large shunt capacities may be substituted, as indicated in connection with the channel R_6, in which the resonant circuits F_6 and F'_6 are tuned by means of capacities 37 and 38 and inductances 39 and 40. The coupling in this case is obtained by means of small series capacities 41 and large shunt capacities 42 and 43.

Instead of a shunt inductive coupling having self-inductance for tuning the circuits and mutual inductance for coupling the circuits as shown in connection with channel R_1, a capacity arrangement having mutual capacity for coupling the circuits and individual capacity for tuning the circuits, may be substituted as illustrated in connection with the transmitting channel T_1. In this case the resonant circuits F_1 and F_1' comprise tuning inductances 44 and 45, while tuning capacity is obtained from a condenser arrangement 46. This condenser arrangement comprises a plurality of plates, certain of which are individual to the resonant circuits F_1 and F'_1 and other plates which are common to both circuits, the capacity of the latter plates serving as a mutual coupling capacity.

A shunt capacity coupling equivalent to the shunt inductive coupling associated with the channel R_2 is illustrated in connection with the channel T_2. In this case the resonant circuits F_2 and F'_2 are tuned by means of inductances 47 and 48 and individual capacities 49 and 50, while a relatively large shunt capacity 51 serves as the coupling element.

The equivalent arrangement corresponding to that shown in connection with the channed R_3 is illustrated in connection with the transmitting channel T_3. In this modification resonant circuits F_3 and F'_3 are tuned by means of condensers 52 and 53 and inductances 54 and 55, these elements being interchanged with respect to the corresponding elements shown in connection with the channel T_2. The large shunt capacity 56 serves as a coupling element.

Instead of a series capacitative coupling such as is illustrated in connection with the channel R_4, a series inductive coupling may be used, as shown in connection with the transmitting channel T_4. In this instance the resonant circuits F_4 and F_4' are tuned by means of inductances 57 and 58 and shunt capacities 59 and 60. Relatively large inductance elements 61 serially included in the sides of the channel between the resonant circuits F_4 and F'_4 serve as coupling elements.

In a similar manner the series capacities 34 and 41 of the coupling elements of the receiving channels R_5 and R_6 may be replaced by large series inductances 66 and 73, as illustrated in connection with the transmitting channels T_5 and T_6. The small shunt inductances 67 and 68 of the channel T_5 correspond to the similar inductances 35 and 36 of the channel R_5, while the large shunt capacities 74 and 75 of the coupling element associated with the transmitting channel T_6 correspond to the similar capacities 42 and 43 of the receiving channel R_6.

The several types of coupling elements illustrated in connection with the transmitting channels have a slight advantage over their prototypes illustrated in connection with the receiving channels, in that they tend to reduce harmonics; for instance, the large shunt capacity of the condensers 46, 51 and 56 associated with the channels T_1, T_2 and T_3 provide a shunt path for harmonics, of low impedance. So also the large series inductances 61, 66 and 73 of the channels T_4, T_5 and T_6 offer relatively large impedance to harmonics, thereby preventing the transmission of such harmonics from one tuned circuit to the other.

In the arrangement shown in Figure 1, the channels R_1, R_2, etc. T_1, T_2, etc. are all in bridged relation with respect to the common transmission circuits RL and TL. Figure 2 illustrates a modified arrangement in which the channels are associated mutually in series with respect to the common transmission circuits RL and TL. Thus the channel R_1 is associated with the circuit RL by including the shunt tuning capacity 13 of the resonant circuit F_1 serially in the transmission circuit R_1. In a similar manner the receiving channel R_2 is serially connected to the circuit RL by arranging the shunt tuning capacity 15 of the resonant circuit F_2 in series with the transmission circuit RL. In the case of the channel R_3 in which the tuning capacities and inductances are interchanged as regards the corresponding elements of the channel R_2 the series connection is obtained by including the shunt inductance 20 in series with the circuit RL. The same result is obtained as regards the channel R_4, by serially including the shunt inductance 25 in the circuit RL. Since the shunt tuning elements of the resonant circuits F_5 and F_6 of the channels R_5 and R_6 comprise capacity elements 30 and 31, said channels R_5 and R_6 may be serially related to the common circuit RL by including the capacities 30 and 31 in series with the circuit RL. The corresponding arrangement with respect to the several transmitting channels is obtained in a similar manner and need not be described.

In some instances the series arrangement shown in Figure 2 may be undesirable by reason of unbalances to ground and the partial short-circuiting of the terminal circuits. For instance, in the case of the channels T_2 and T_3, if a vacuum tube is included in the channels, as illustrated in connection with the channel T_1, then, with the filaments of the tubes grounded, as indicated in connection with the channel T_1, the terminal condenser 52 will be partially short-circuited over a path extending from the lower terminal of 52 over the lower side of tuning inductances 54 and 55 to the ground of the filaments and back through the lower side of circuits F'_2 and F_2 to the upper terminal of the condenser 52. Furthermore, the arrangement shown in Figure 2 is non-symmetrical with regard to the two sides of the transmission circuits RL and TL, since the series connection of the channels are included in one side only of the common circuits, thereby tending to unbalance the two sides of the circuits. These objections may be overcome by means of the arrangement illustrated in Figure 3, in which the channels are inductively associated with the common circuits RL and TL. The inductive connection permits of serially relating the channels to the common circuit and at the same time prevents short-circuiting of the terminal circuit in the manner above described. By arranging the inductive connections so that half of the inductance thereof is inclined in each side of the common transmission circuits RL and TL, unbalancing of said circuits will be prevented.

For example, the channel R_1 may terminate in a transformer 76, comprising three windings, one of which is serially included in the channel R_1, the other windings being serially included, one in each side of the circuit RL. The channel R_2 may be coupled in a similar manner by means of a transformer 77. In the case of the channel R_3, since the resonant circuit F_3 of Figure 2 terminates in a shunt inductance 20, the corresponding channel R_3 of Figure 3 may be associated with the circuit RL through a three-winding transformer 78, which not only serves as a means for associating the channel with the circuit RL, but also serves as a tuning inductance for the resonant circuit F_3. The same considerations apply to the transformer 79, which may be used for coupling the channel R_4 with the circuit RL. In the case of channels R_5 and R_6, since the resonant circuits F_5 and F_6 terminate in shunt condensers, the channels must be terminated in transformers 80 and 81, for the purpose of associating them with the common circuit RL.

The connections for the transmitting channels T_1, T_2, T_3, etc., are similar to those above described. Thus the channels T_1, T_2 and T_4 are associated with the common transmitting circuit TL through transformers 82, 83 and 85, respectively, which serve both for coupling the channels with the common circuit and for tuning the resonant circuits F_1, F_2 and F_4, respectively. The resonant circuits F_3, F_5 and F_6, however, terminate in shunt capacities and hence the corresponding channels T_3, T_5 and T_6 are associated with the common circuit TL through special transformers 84, 86 and 87.

A similar arrangement is illustrated in Figure 4, in which, instead of employing tuned circuits for frequency separation, broad band filters are used. These filters are preferably of the type illustrated in the United States patents to George A. Campbell, Nos. 1,227,113 and 1,227,114, dated May 22, 1917, and are designed to transmit bands of frequencies of sufficient width to allow for the transmission of signaling frequencies which extend over a considerable range, as is the case in the transmission of telephone currents.

In Figure 4 transmitting channels T_1 to T_4 inclusive, include broad band filters BF_1, BF_2, BF_3 and BF_4, respectively, while the corresponding receiving channels R_1 to R_4 inclusive, include broad band filters B_1F_1, B_2F_2, B_3F_3 and B_4F_4, respectively. The channels T_1 to T_4 inclusive, are associated with the common transmitting circuit TL through transformers 101, 102, 103 and 104, each of which is balanced by means of windings included in each side of the circuit TL. In a similar manner the receiving channels R_1 to R_4, inclusive, are associated with the common receiving circuit RL through balanced transformers 111, 112, 113 and 114, of similar construction. By means of this arrangement the channels are mutually arranged in series with respect to the common transmission circuit, while maintaining the two sides of the common circuit balanced.

It will be obvious that the general principles herein disclosed may be embodied in many other organizations widely different from those illustrated, without departing from the spirit of the invention as defined in the following claims.

What is claimed is:

1. A selective device comprising a pair of selective circuits, each circuit including inductance and capacity whereby the circuits may be tuned to the same desired frequency,

and means for loosely coupling the tuned circuits, comprising series and shunt impedance elements, one of which is inductive and the other of which is capacitative, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

2. A selective device comprising a pair of selective circuits, each circuit including inductance and capacity whereby the circuits may be tuned to the same desired frequency, and means for loosely coupling the tuned circuits, comprising series and shunt impedance elements one of which is inductive, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

3. A selective device comprising a pair of circuits, each including inductance and capacity whereby the circuits may be tuned to the same desired frequency, and means for loosely coupling the circuits, comprising impedance elements of two types, one type being individual to said circuits and the other type common to said circuits, one of said types of impedance elements being inductive and the other type being capacitative, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

4. A selective device comprising a pair of tuned circuits, each including inductance and capacity whereby the circuits may be tuned to the same desired frequency, and means for loosely coupling the circuits, comprising impedance elements individual to said circuits and impedance elements common to said circuits one of said impedance elements being inductive, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

5. A selective device comprising a pair of selective circuits, each including inductance and capacity whereby they may be tuned to the same desired frequency, and means for loosely coupling said circuits, including impedance elements of two types, one of said types being shunted across said circuits and impedance elements of the other type serially connecting said circuits, one of said types of impedance elements being inductive and the other type being capacitative, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

6. A selective device comprising a pair of selective circuits, each including inductance and capacity whereby they may be tuned to the same desired frequency, and means for loosely coupling said circuits, including impedance elements shunted across said circuits and impedance elements serially connecting said circuits one of said impedance elements being inductive, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

7. A selective device comprising a pair of selective circuits, each including inductance and capacity whereby said circuits may be tuned to the same desired frequency and means for loosely coupling said circuits, comprising an impedance in shunt relation with respect to said circuit and an impedance in series relation with respect to said circuit, one of said impedances having a capacitative reactance and the other having an inductive reactance, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against frequencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

8. A selective device comprising a pair of selective circuits, each including inductance and capacity whereby said circuits may be tuned to the same desired frequency, and means for loosely coupling said circuits, comprising an impedance in shunt relation with respect to said circuit, and an impedance in series relation with respect to said circuit, one of said impedances having an inductive reactance, and said impedance elements being so proportioned and related with respect to each other and with respect to said tuned circuits as to produce a greater discrimination against fre-

quencies on one side of the frequency to which the selective circuits are tuned than that due to the selectivity of the tuned circuits themselves.

9. In a multiplex transmission system, a transmission circuit, a plurality of signaling channels associated with said circuit at one end thereof and adapted for transmission in the same direction, selective devices in each signaling channel and series connections between each channel and said transmission circuit, said series connections being balanced with respect to the two sides of the transmission circuit.

10. In a multiplex transmission system, a transmission circuit, a plurality of channels associated with said transmission circuit at one end thereof and adapted for transmission in the same direction, selective means in each channel and means in each channel for associating each channel with said transmission circuit, comprising a transformer having balanced windings in each side of the transmission circuit.

11. In a multiplex transmission system, a transmission circuit, a plurality of channels associated with said circuit at one end thereof and adapted for transmission in the same direction, selective devices in each channel, and means for in effect serially relating each channel to the transmission circuit, said means comprising transformers, each transformer having windings in each side of the transmission circuit and a winding in the corresponding channel.

In testimony whereof, I have signed my name to this specification this 25th day of September, 1919.

LLOYD ESPENSCHIED.