

March 10, 1936.

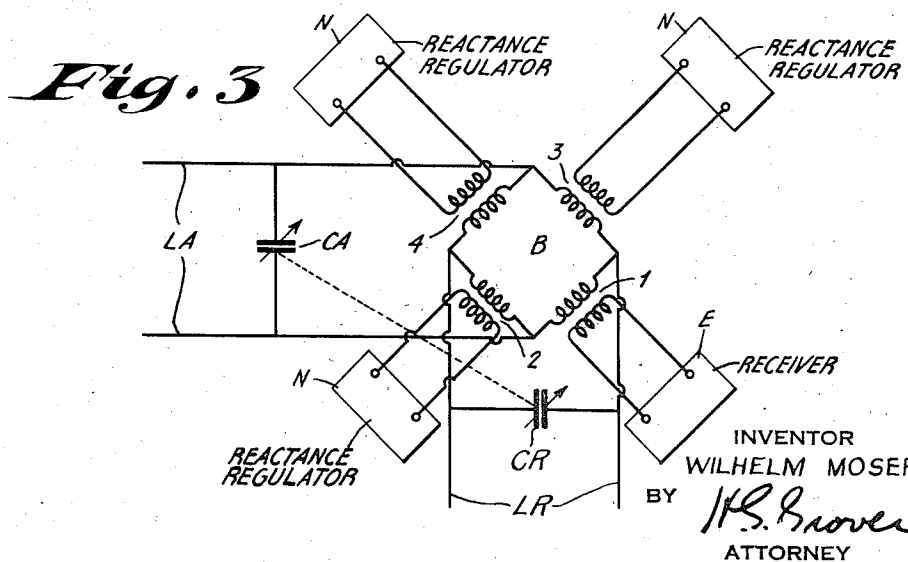
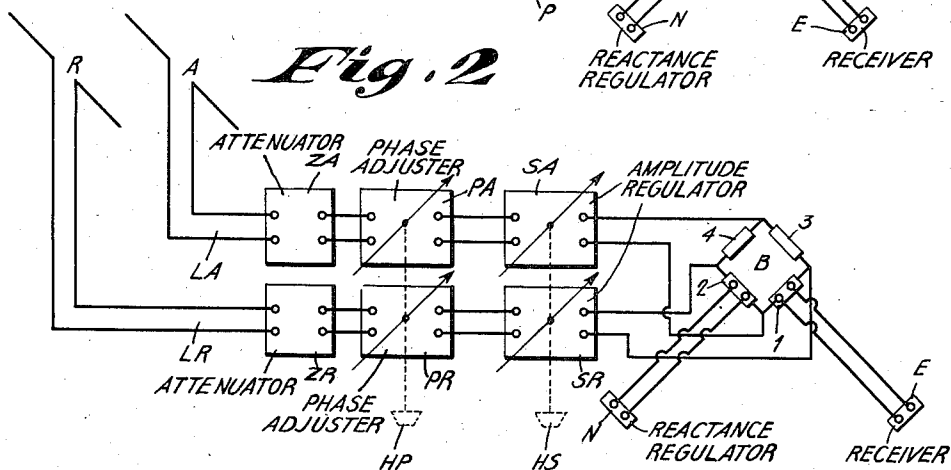
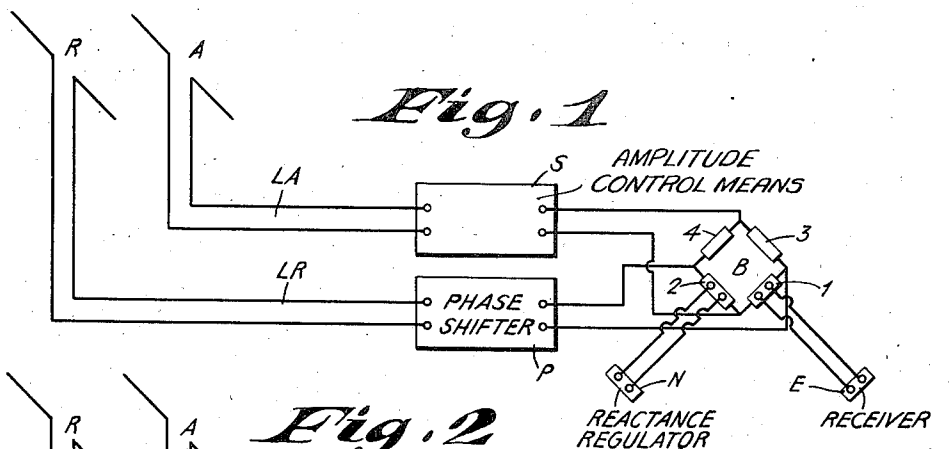
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2,033,390

ANTENNA SYSTEM

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3 Sheets-Sheet 1



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Fig. 4

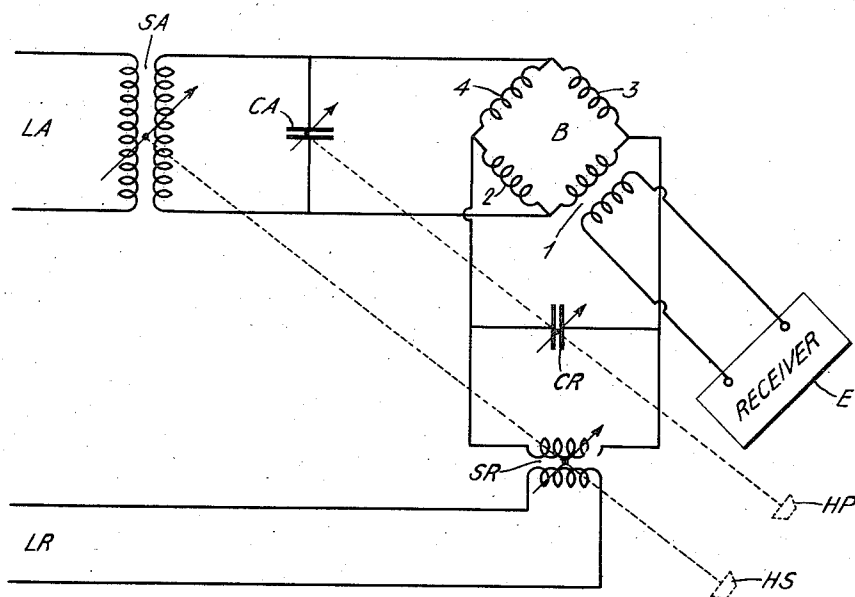
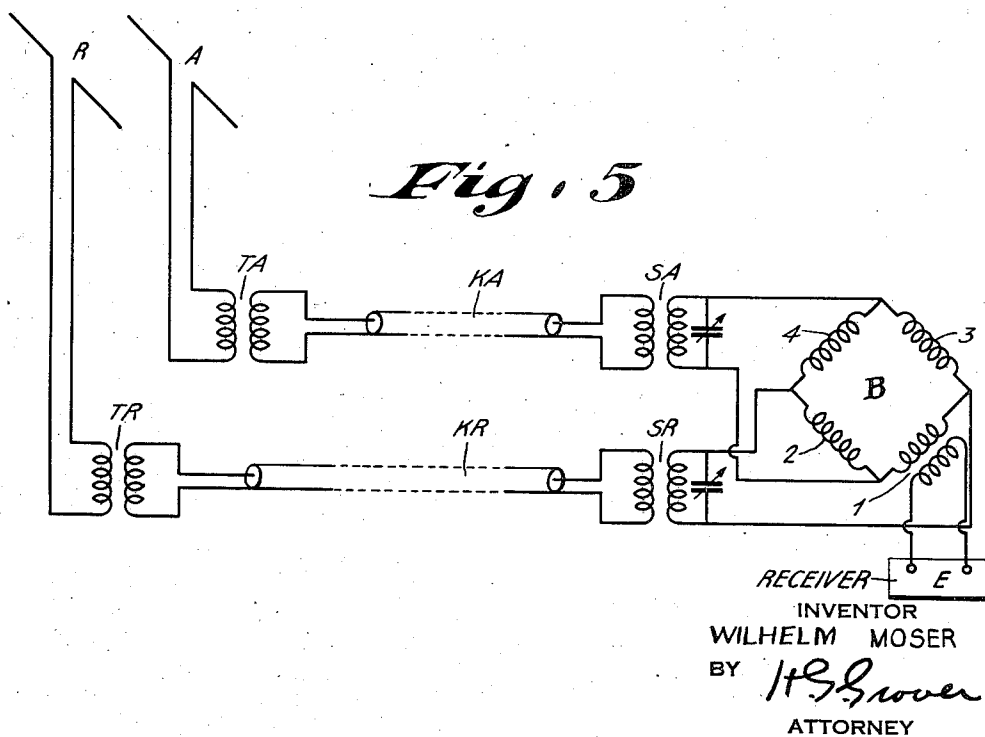


Fig. 5



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Fig. 6

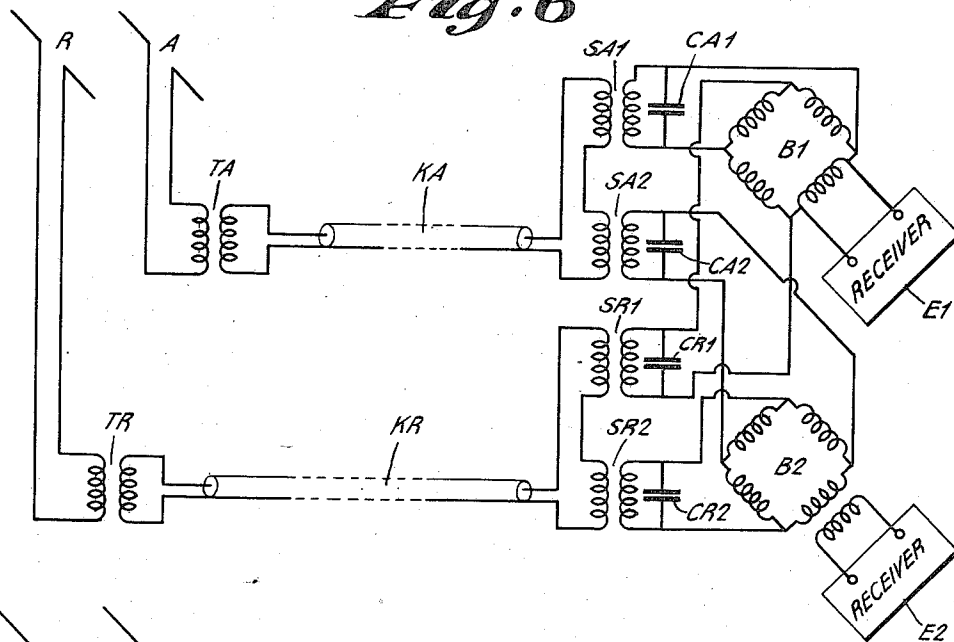
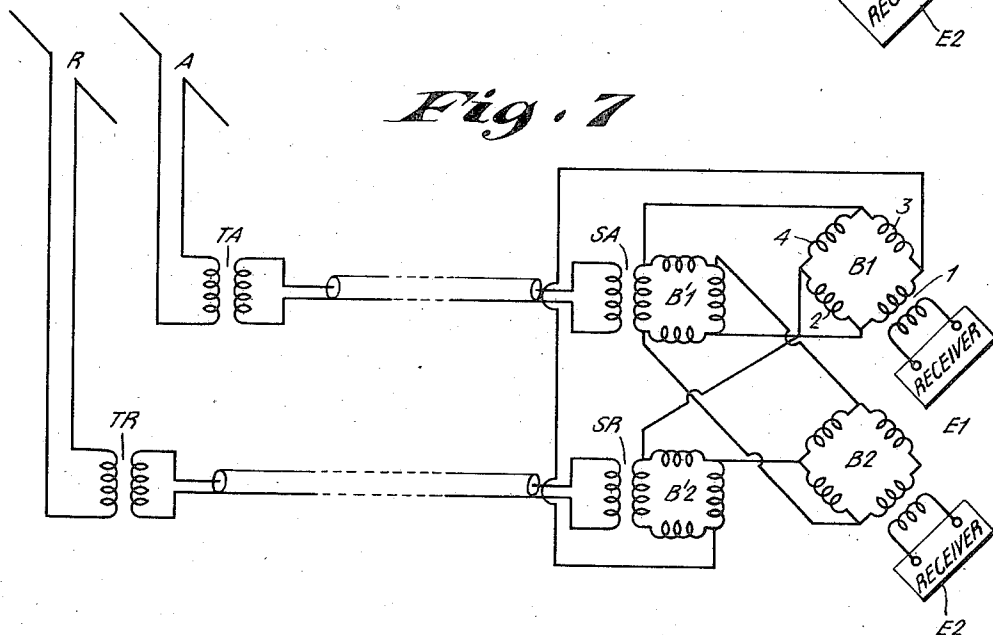


Fig. 7



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ANTENNA SYSTEM

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7 Claims. (Cl. 250—11)

This invention relates to aerial systems and, in particular, aerial arrangements for directional reception.

It is known in the prior radio art to unite antenna and reflector by way of leads with a coupling arrangement such as an antenna transformer with which the receiver is associated either directly or else by way of additional down-leads or energy-feed wires. The said coupling arrangements are invariably so chosen that the antenna circuit and the reflector circuit are coupled with a joint third circuit, e. g., a circuit brought to the receiver either directly or else by the intermediary of further circuit or conductor elements. In an arrangement of the said sort, no matter what changes are made or adopted in any one of the said three circuits, there will always be repercussions or reactions upon the respective other two circuits. The consequence is that, for adjusting conditions to optimum, especially optimum reflector effect, successive settings of the circuits are required in order that by tentative and successive approximation the desired effect, i. e., equality of the currents in the antenna and reflector and formation of phase as required for the shielding may be insured.

Now, the present invention discloses a new arrangement whereby reaction of the antenna circuit upon the reflector circuit by way of and beyond the coupling means will be precluded.

According to this invention the energy-feed or down-leads from the antenna and the reflector terminate in the symmetric points of a bridge arrangement, with one arm of which the receiving apparatus is connected. The receiver is thus fed with energy both from the sending as well as from the receiving antenna, while no energy will travel from the antenna circuit by way of the bridge into the reflector circuit whenever the bridge is in a state of balance. When this condition is satisfied, the coupling between bridge and receiver may be insured by ways and means well known in the art. For instance, the receiver itself could constitute one arm of the bridge, or else it may be in inductive coupling relationship with an inductance coil which represents the arm of the bridge in question. In one of the two neighboring arms of the bridge there is provided a simulation which in accordance with the variable resistance of the receiver may be made variable. More particularly, the variation in the value of the said simulation could, according to this invention, be connected with the setting means for the receiver coupling in a positively acting manner with the result that, upon a change

being brought about in one of them, there is caused also a corresponding and similar change in the respective other one, with a view to maintaining the bridge balance stable.

In order that a proper reflector effect may be obtained it is necessary that between the voltage from the antenna end and the voltage from the reflector end set up in the input circuit of the receiver there will prevail a certain amplitude and phase relation, to be more precise, the amplitudes must be equal, while the phases must fulfill a definite known function of the space between the reflector and the antenna. For instance, if the said distance is equal to a quarter wave, then, as is well known, the reflector current must present an angle of lead of 90 degrees in reference to the antenna current being of like amplitude. According to the invention, for insuring the proper phase relations between the antenna and the reflector current, phase-shifting devices are provided at least in one of the two energy-feed leads. The said phase-shifters could also be of the adjustable type. Because of the radiation coupling between reflector and antenna, the currents flowing in the two energy leads will by no means be alike, even if the said leads and the bridge arms are made otherwise equal. Hence, according to another object of this invention, potentiometers (weakening resistances or attenuators) may be inserted at least in one of the two energy feed-leads which are so set that in the end of the feed-lead of the antenna and the reflector, currents of the same amplitude will flow.

It is finally advisable, though not necessary, that "completion" elements be inserted in the down-leads coming from the antenna and the reflector which, together with the elements previously mentioned, such as bridge, potentiometers and phase-shifters, will render the termination of the energy-lead free from reflections in the direction of the bridge.

The novel features of my invention have been pointed out with particularity in the claims attached hereto. The nature of my invention and the manner in which the same is carried out will be best understood from the following detailed description thereof and therefrom when read in connection with the attached drawings in which Figures 1 to 7 inclusive show various modifications of my novel arrangement for coupling aeri-als and reflectors to receiving systems.

Figure 1 illustrates the scheme in its most simple and rudimentary form. The antenna A which may be a horizontal dipole and the reflector R which may be exactly identical in design are

united by way of the parallel wires LA and LR with the bridge B. Inductively associated with the arm 1 of the bridge is the receiver E. The arm denoted by 2 contains the simulation N. The ohmic or the inductive or the capacitive or mixed resistance values of 3 and 4 are so chosen, as known in the art, that the bridge will be in a state of balance. The down-lead LR contains means P adapted to effect shifts in the phase, of a kind also well known in the art. If the radiation coupling is negligibly small, in other words, if the length of the dipoles is very small in contrast with the distance, and if the device P occasions no appreciable amplitude reduction, there is obtained with this arrangement in the input of the receiver E a resultant voltage consisting of antenna and reflector potential, with the two partial or constituent amplitudes being alike. If, then, by the aid of P the phase shift and angle is properly effected to result in the correct value as above indicated, say, to the value $\frac{1}{2}$ in the presence of an intervening distance between antenna and reflector equal to $\frac{1}{4}$ wave-length, a sharp reflector effect suitable for reception will be insured.

If the radiation coupling between A and R turns out to be of appreciable influence, it will be found that, quite apart from a certain supplemental phase change or shift, the antenna will not receive the same amplitude as the reflector, but that in case of reception the amplitude from the antenna end may be smaller. The phase-shifter moreover will mostly result in an attenuation of the amplitude. Hence, according to a further object of this invention, amplitude-control means S is additionally included in the feed-lead or down-lead LA whereby an additional reduction is occasioned.

The idea would be self-suggesting to provide phase-shift means and amplitude-control means symmetrically in both leads in a way as illustrated in Figure 2. This latter figure shows by way of example also the possibility of including "completion" elements ZA and ZR which serve the purpose of insuring ohmic adaptation of the subsequent means to the energy leads LA and LR. The said completion elements may preferably consist of circuit elements known in the prior art, e. g., the H-type links or sections known from line telephony. According to this invention SA and SR, and PA and PR, respectively, could be so intercoupled as to their variability that they will simultaneously be altered in contrary sense. The amplitude relations could then be set by the regulation of a handle or knob HS, and the phase relation by adjustment of a knob HP in the desired manner.

Figure 3 shows a suitable arrangement of a more special type. All four arms of the bridge are made exactly identical, arm 1 containing the receiver E, while arms 2, 3, 4 contain equivalent simulations N. In parallel relation to the downlead LA is connected the variable condenser CA, while in parallel relation to the downlead LR is the variable condenser CR. By changing the values of CR and CA, phase and amplitude will be altered in the respective arm. According to the invention, the two condensers may be coupled so as to operate oppositely when adjusted, to be more precise, in such a way that, when equal, resonance is present for the respective wave in connection with the bridge inductances. Then, by turning knob HP varying both of the two condensers simultaneously, it is possible to set the proper phase between antenna and reflector cur-

rent. By choosing suitable cross-sectional shapes for the plates, conditions may then be made so that the amplitude relation of the antenna and the reflector circuits will not be altered. On the contrary, the amplitude can be set by the aid of the amplitude controllers SA and SR in a way as hereinbefore stated.

Figure 4 shows an exemplified embodiment of the amplitude regulators SA and SR in radio frequency transformers. These amplitude regulators SA and SR are also coupled contrariwise by their knob HS when manipulated, so that a single knob makes it feasible to regulate the amplitude relation of the antenna and the reflector current.

All setting and regulating devices are preferably designed in a form of reduced size and easily manipulable as customary in receiving sets, and they are mounted alongside the receiver set. In the case of short-wave equipment it is often advisable to mount the receiver in a suitable building and at a favorable spot removed from the antenna. In the light of what has been stated before, a downlead being symmetric in reference to earth should be laid from the antenna to the bridge arrangement. Now, in order that such difficulties as are known to reside in such mode of installation may be precluded, the smaller part of the energy-feed lead (downlead) according to this invention is laid inside a dissymmetric and shielded cable energy feed line. For instance, as shown in Figure 5, the downlead brought from the antenna and from the reflector may be connected by way of the radio frequency transformers TA and TR to the input end of the two cable feed-lines KA and KR. The output end of the latter, in a manner as has hereinbefore been described, could be united by way of the transformers SA and SR provided to act as amplitude regulators, with the corresponding points of the bridge B. In this scheme, in a way well known in the prior art, care may be taken so that the radio frequency transformers will be free from disturbing electrical coupling in order that no disturbances in the condition of symmetry may be caused.

Figure 6 finally shows that with the said arrangement it is also possible to practice multiple reception. The radio frequency transformers, for instance, are doubly subdivided so that the four transformers SA1, SA2, SR1, and SR2 result. The primaries by pairs are connected in parallel or in series with the respective cable ends. The secondary ends are separately connected with the bridges B1 and B2, respectively, in a way as illustrated. Connected with the bridge B1 is connected in a manner as described the receiver E1, while with the bridge B2 is united in the same way the receiver E2. Supposing that the coupling between the energy feed-lead and the bridge-diagonal points established by the transformer SA1, SA2, SR1, and SR2 is extremely loose then the phase adjustments, which, for instance, are effected by the aid of CA1 and CR1, will be without any effect upon the phase adjustments effected by the aid of CA2 and CR2. As a result, it is possible to use for the two receivers E1 and E2 different receiving means independently of one another. For instance, the receiver E1 may receive from the front, and the receiver E2 at the same time from the rear. The extremely loose coupling which this scheme requires can be put up with and be accepted as long as the absolute value of the incoming signals (signal level) lies above the threshold value of the re-

ceiver, especially since the relationship to the atmospherics is not incidentally altered.

If the incoming volume or amplitude is to be fully utilized, in other words, if the coupling is to be made close, then a circuit scheme of the kind shown, e. g., in Figure 7 will be useful in which the reaction by B1 and B2 is avoidable by the provision of the bridges B'1 and B'2 in a way as illustrated.

Also other arrangements adapted to insure amplitude regulation, for instance, ohmic resistance elements as known in the art disposed H-fashion could be employed in an arrangement as here disclosed. These H-sections should then be so dimensioned that their resistance value is equal to the characteristic of the energy-lead or downlead (surge impedance). In that case reflections will be avoided, and the efficiency of the downleads will be raised. Furthermore, radio frequency amplifiers may be included in the said downleads according to this invention. In this connection, phase shifters and/or amplitude regulators, as well as adaptor resistances may be combined with the intermediate amplifiers by ways and means well known in the earlier art.

Having thus described my invention and the operation thereof, what I claim is:

1. In a radio receiving system, in combination, an antenna, and a reflector spaced from said antenna, a bridge circuit comprising four arms, said antenna being coupled to one diagonal of said bridge, an amplitude regulator located between said antenna and said diagonal, said reflector being coupled to the other diagonal of said bridge, a phase shifter located between said reflector and said other diagonal, a receiver coupled to one of said arms, and a reactance regulator coupled to another arm of said bridge.

2. In a radio receiving system, in combination, an antenna and a reflector spaced from said antenna, a bridge circuit comprising four arms, said antenna being coupled to one diagonal of said bridge and said reflector being coupled to the other diagonal of said bridge, individual variable condensers across said diagonals, a receiver electromagnetically coupled to one arm of said bridge, and a reactance regulator electromagnetically coupled to each of the other arms of said bridge, and unicontrol means for varying said condensers simultaneously.

3. In a radio receiving system, in combination, a bridge circuit comprising four arms, an antenna and a reflector spaced from said antenna,

a first radio frequency transformer having variable primary and secondary windings, and a second radio frequency transformer having variable primary and secondary windings, the primary winding of the first transformer being coupled to the antenna, and the primary winding of the second transformer being coupled to the reflector, the secondary winding of the first transformer being coupled to a diagonal of said bridge and the secondary winding of said second transformer being coupled to the other diagonal of said bridge, a variable condenser across each secondary winding, unicontrol means for simultaneously varying both condensers, and separate unicontrol means for varying the inductance of the windings of both transformers, and a receiver coupled to one of said arms of said bridge.

4. In a radio receiving system, in combination, a reflector and an antenna, a bridge circuit comprising four arms, said antenna being electromagnetically coupled to one diagonal of said bridge through feed leads, and said reflector being electromagnetically coupled to the other diagonal of said bridge through other feed leads, a variable reactance across each diagonal and a receiver coupled to one of said arms, said feed leads being shielded lines.

5. In a radio receiving system, in combination, a reflector and an antenna, a bridge circuit comprising four arms, said antenna being coupled to one diagonal of said bridge and said reflector being coupled to the other diagonal of said bridge, a variable condenser across each diagonal, unicontrol means for varying said condensers, and a receiver coupled to one of said arms.

6. In a radio receiving system, in combination, a reflector and an antenna, a bridge circuit comprising four arms, said antenna being coupled to one diagonal of said bridge and said reflector being coupled to the other diagonal of said bridge, a variable condenser across each diagonal, means for simultaneously varying said condensers in opposite senses, and a receiver coupled to one of said arms.

7. In a radio receiving system, in combination, a reflector and an antenna, a bridge circuit comprising four arms, said antenna being coupled to one diagonal of said bridge and said reflector being coupled to the other diagonal of said bridge, a condenser across each diagonal, means for varying said condensers, and a receiver coupled to one of said arms.

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