Dec. 29, 1925. 1,567,204

J. S. STONE

RADIO TRANSMITTING SYSTEM

Filed Jan. 29, 1925 2 Sheets-Sheet 1

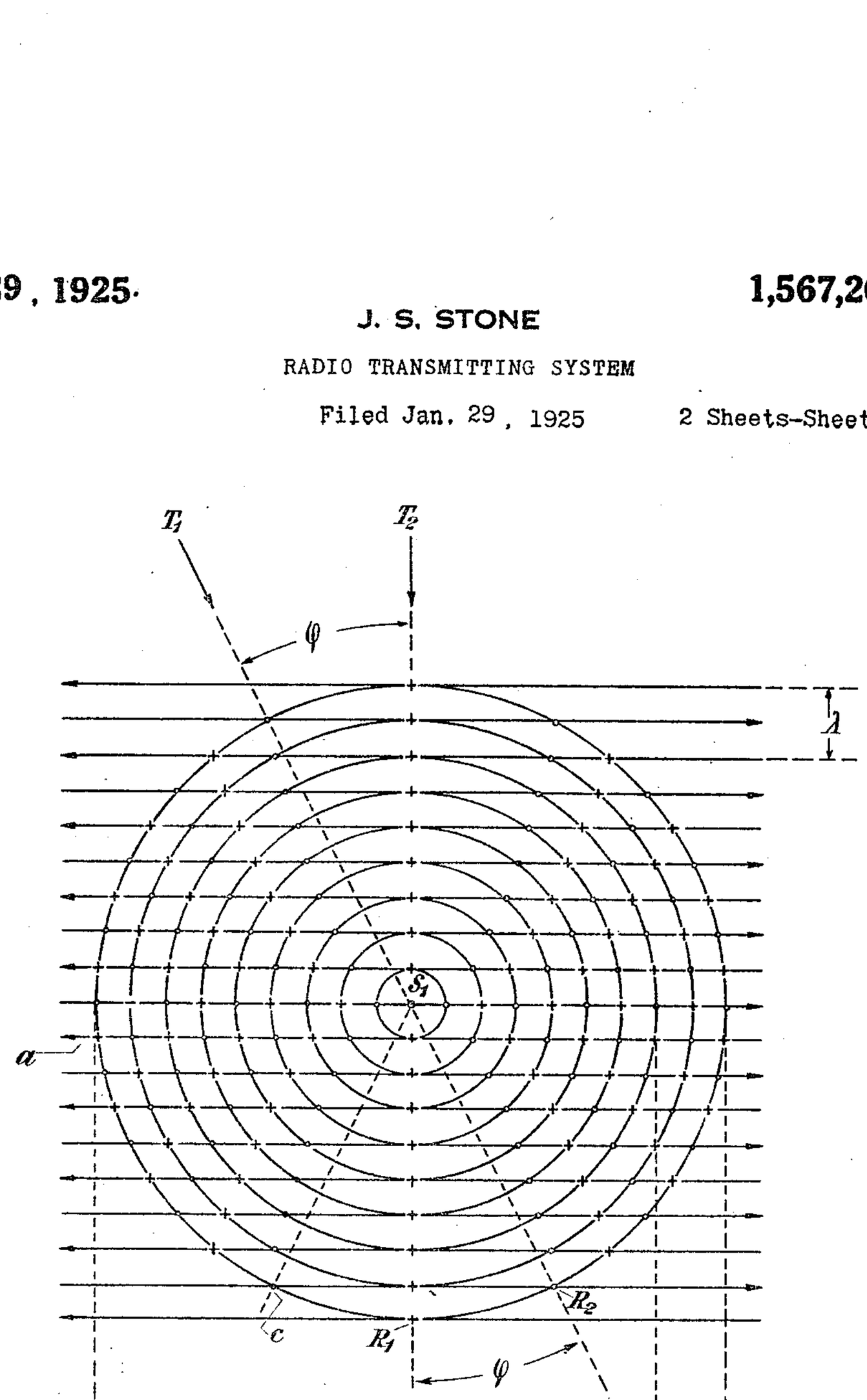

Fig. 1

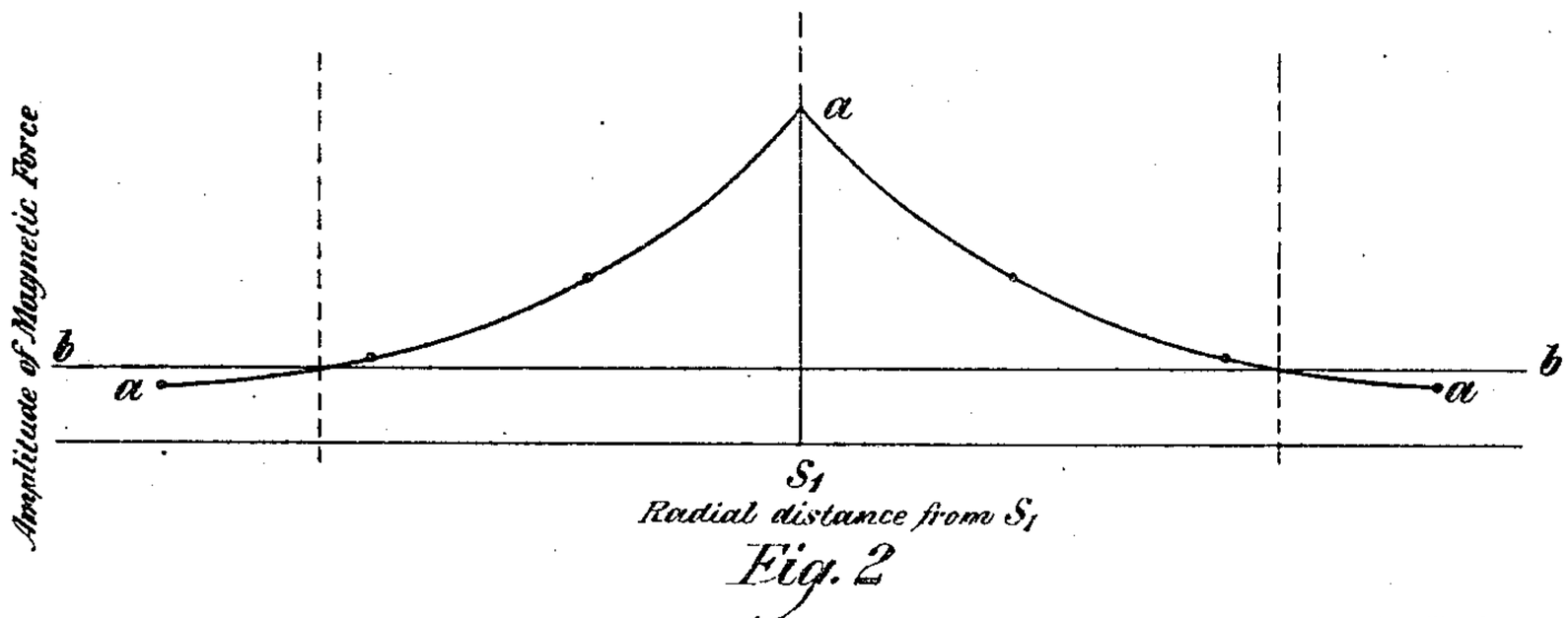

Fig. 2

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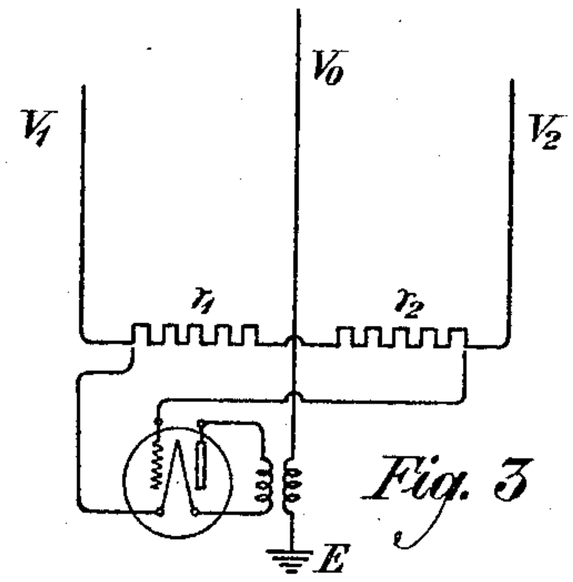

Fig. 3

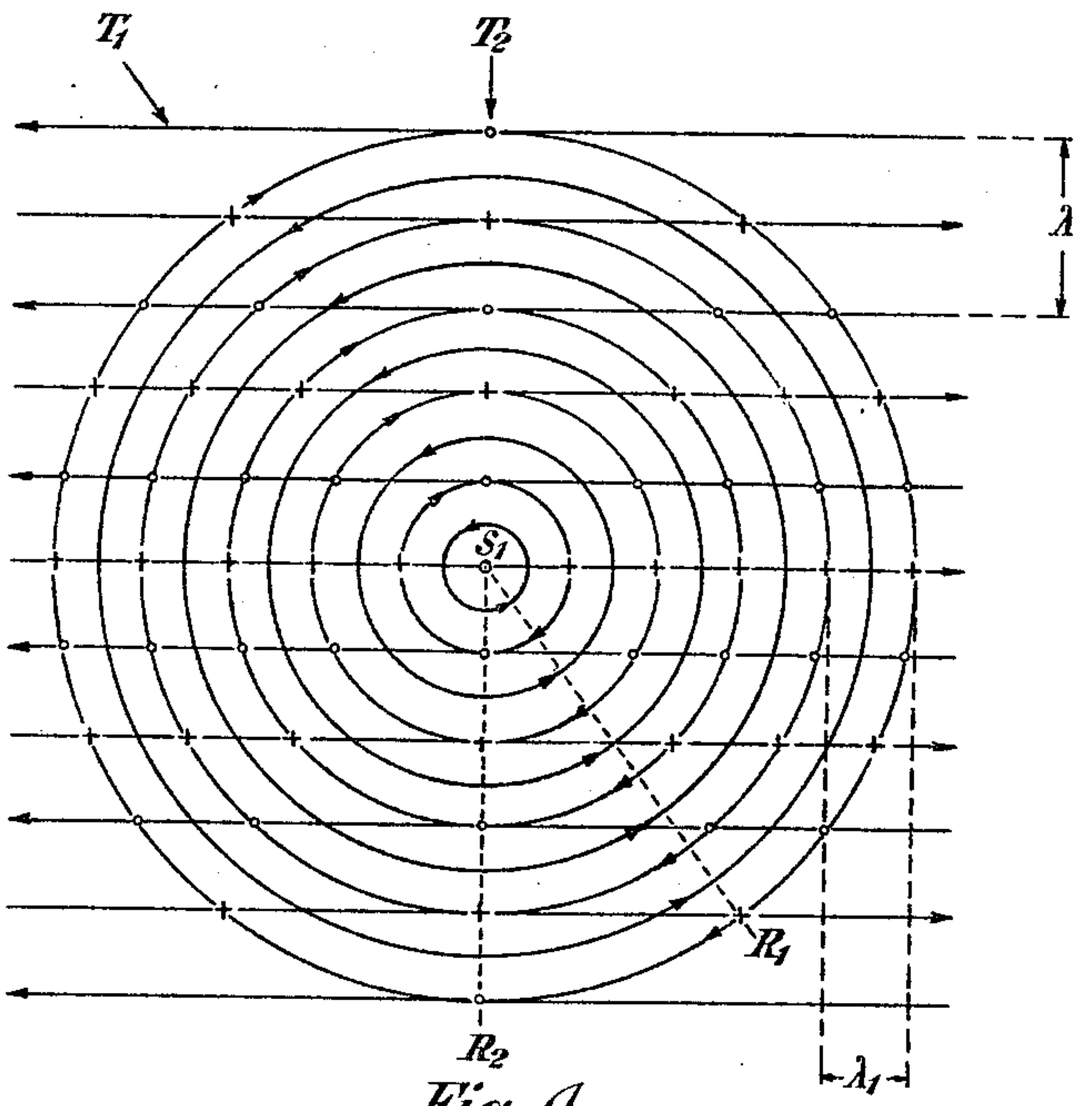

Fig. 4

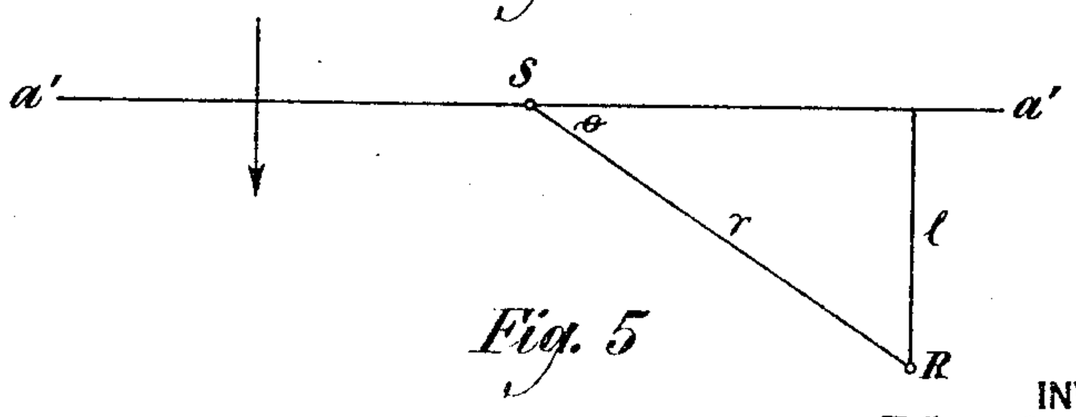

Fig. 5

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Patented Dec. 29, 1925. 1,567,204

UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF SAN DIEGO, CALIFORNIA, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

RADIO TRANSMITTING SYSTEM.

Application filed January 29, 1925. Serial No. 5,580.

To all whom it may concern:

Be it known that I, JOHN STONE STONE, residing at San Diego, in the county of San Diego and State of California, have invented certain Improvements in Radio Transmitting Systems, of which the following is a specification.

An object of my invention is to provide a new and improved system of radio transmission by which interference between one transmitting system and another may be obviated. Another object of my invention is to provide for two independent radio transmissions in the same neighborhood and on the same frequency without objectionable interference. Another object of my invention is to provide a receiving system by which a receiver can get the radiated waves of a certain frequency from a certain transmitter and exclude the waves of the same frequency from another transmitter. These and various other objects of my invention will become apparent on consideration of examples of the invention which I have chosen for presentation in the following specification and in the accompanying drawings. It will be understood that the description that follows relates more particularly to these examples of the invention and that the definition of the invention will be given in the appended claims.

Referring to the drawings, Figure 1 is a plan diagram of a system embodying my invention; Fig. 2 is a diagram showing a certain functional relation that will be referred to in explaining the principle of my invention; Fig. 3 is a diagrammatic elevation of a relaying station that may be employed in this connection; Fig. 4 is a plan diagram of a modification in which the output from the relaying station goes to metallic conductors; and Fig. 5 is a diagram that will be used in explaining the principles involved in the invention.

The arrow in the upper part of Fig. 1 shows the direction of incoming waves from a transmitter T_2. The horizontal lines in Fig. 1 represent the magnetic lines of the waves from T_2, and the arrowheads on these horizontal lines are directed alternately right and left, so that the space between two successive horizontal lines indicates a half wave length.

At S_1 there is a relaying station which radiates waves of the same frequency, that is, the same wave length as those which it receives. These radiated waves are represented by the circles, and the equivalence of wave length just mentioned is indicated by the same spacing for the circles as for the parallel lines. The plane waves represented by the horizontal lines and the waves of curved front represented by the circles will form an interference pattern producing enforcement at certain points marked by *o*'s and annulment at points marked by *x*'s Accordingly a receiving station R_1, placed at one of the *x*'s as shown, will not be affected by the waves from the transmitter T_2, but the receiving station R_2 at one of the *o*'s will be affected by the waves from the transmitter T_2.

The angle from the point S_1 between the two receiving stations R_1 and R_2 is φ. Let the waves of equal length from another transmitter T_1 come in a direction making the same angle φ with the direction of the transmitter T_2. It will at once be evident that the relations already pointed out are reciprocal and that R_2 will be blind to the transmission from T_1 but will receive from T_2.

Thus it is established that each receiver R_1 or R_2 receives only from its intended transmitter T_1 or T_2 and is blind to the transmission from the other transmitter T_2 or T_1.

While the receivers R_1 and R_2 have been placed each at a particular point of the interference pattern in Fig. 1, it will readily be seen that there are many other points where they might have been placed and that appropriate points can be selected corresponding to different values of the angle φ between the two transmitting stations.

At increasing distances from the relaying station S_1 the radiation will fall off in intensity as shown by the diagram in Fig. 2, whereas the radiation from the transmitters T_1 and T_2 will be of substantially uniform intensity within the limited area involved in the diagram of Fig. 1. Accordingly the intensity of radiation from the relaying station S_1 should be adjusted, so that at the distance of the receivers R_1 and R_2 the relayed waves will have the same intensity as the direct waves. This condition is fulfilled in Fig. 2 because at the distance from S_1 of the stations R_1 and R_2, the curves *aa* intersect

with the line *bb* whose ordinates represent the intensity of the waves from T_1 and T_2.

The relaying station S_1 is shown in Fig. 3. The three antennæ V_0, V_1 and V_2 are placed in a plane transverse to both the sets of wave fronts from T_1 and T_2. Accordingly there will be a periodic difference of potential on the antennæ V_1 and V_2, and the corresponding electromotive force drop in the resistances r_1 and r_2 will be applied to the grid of the three-electrode vacuum tube. The corresponding plate circuit current goes to the middle antenna V_0 which is caused thereby to radiate waves of the same frequency.

Since V_1 and V_2 are equidistant from V_0, the effect of the waves radiated from V_0 is null on the input side of the vacuum tube. With the resistances r_1 and r_2 as shown, the radiation from antenna V_0 will be in phase with the incident waves. When some other phase relation is required, these resistances may be replaced in whole or in part by inductance capacities, or transformers.

As shown in Fig. 1, the radiation from the secondary source S_1 proceeds equally on all sides, although it is utilized only at the receivers R_1 and R_2. Instead of radiating to the ether from S_1, the transformer secondary of the antenna V_0 of Fig. 3 may be bent down and connected to conductors such as S_1 R_1 and S_2 R_2 of Fig. 4, so that the currents from the secondary source S_1 will be conveyed in this manner to the receiving stations R_1 and R_2.

In general, the speed of propagation along such a conductor may be different from that through the ether thus giving rise to a different interference pattern from that shown in Fig. 1. The diagram in Fig. 4 has been prepared for the case in which the propagation along the conductors is at half the velocity of that through the ether. The wider spacing of the horizontal lines, as compared with the circles, exhibits this difference of velocity to which allusion has just been made. With the pattern in Fig. 4 it will be seen that various locations are possible for the two receiving stations, one at an *x*-point and the other at an *o*-point. For any given angular separation between the transmitting directions from T_1 and T_2, there will be a variety of possible locations for the two receiving stations R_1 and R_2, and further flexibility will be obtained by varying the retardation in the conductors from S_1 to R_1 and R_2.

To facilitate the employment of the principle of my invention in any special case, certain appropriate formulas involved will now be pointed out. The station S_1 is shown in Fig. 5, and a receiver is shown at R in the lower right-hand quadrant of the interference pattern of Fig. 1 or Fig. 4. Let the plane waves of periodicity ω and wave length λ from a distant transmitter be traveling in the direction of the arrow. Let these waves be of phase α at the line $a'a'$. Then the phase of these waves at R will be $\alpha+\frac{2\pi}{\lambda}l$.

Let the phase of the waves at R from the source S_1 be $\alpha-\beta-\frac{2\pi}{\lambda_1}r$, where λ_1 is the wave length in the conductor extending from S_1 to R, for waves of the periodicity being ω. But if S_1 radiates to the ether instead of sending its output over a conductor, then $\lambda_1=\lambda$.

The condition that the sum of the waves shall be zero at R is given by the equation.

$$\frac{2\pi}{\lambda}l=-\beta-\frac{2\pi}{\lambda_1}+k\pi,$$

where *k* is an odd integer. For *b* in the foregoing equation substitute its obvious equivalent value,—r sin Θ, where Θ is the complement of φ, and the equation becomes

$$\theta=-\sin^{-1}\left\{\frac{\lambda}{2r}\left(\frac{\beta}{\pi}-k\right)+\frac{\lambda}{\lambda_1}\right\}$$

By similar reasoning it can readily be shown that when the sum of the waves is to be a maximum at R, the equation of condition is

$$\theta=-\sin^{-1}\left\{\frac{\lambda}{2r}\left(\frac{\beta}{\pi}-k-1\right)+\frac{\lambda}{\lambda_1}\right\}$$

I claim:

1. In a radio transmission system, two transmitters and two receivers on the same frequency, and a secondary relay station, each receiver being at a point where the waves build up from a respective transmitter and the said relay station and where they are null from the other transmitter and said relay station.

2. In a radio transmission system, two transmitters on the same frequency, a receiver and a relay station whose radiation annuls the effect of one transmitter at the receiver and enforces the effect of the other transmitter at the receiver.

3. In a radio transmission system, two transmitters in different directions from a certain locality, a relay station in that locality to set up an interference pattern with the waves from the distant transmitters, and a receiving station at a null point with respect to one transmitter and a point of maximum intensity with respect to the other transmitter.

4. In a radio transmission system, two transmitters in different directions from a certain locality, a relay station in that locality to set up an interference pattern with the waves from the distant transmitters, and two receiving stations, one of them located at a null point with respect to one transmitter and a point of maximum intensity

with respect to the other transmitter, and the other receiving station at a point of maximum intensity for the first mentioned transmitter and a null point for the other transmitter.

5. The method of receiving respectively from two transmitters on the same frequency, which consists in relaying from a secondary station and thereby establishing an interfering pattern with enforcement of the waves from one transmitter and annulment from the other transmitter at one receiver, and vice versa at the other receiver.

6. The method of receiving without interference from one of two transmitters on the same frequency, which consists in relaying from a secondary station and thereby establishing an interfering pattern with enforcement of the waves from one transmitter and anulment from the other.

7. The method of preventing interference from one of two radio transmitting stations on the same frequency, which consists in relaying from a secondary station and thus establishing an interference pattern, with the receiving station at a null point with respect to the radiation from the said transmitter.

In testimony whereof, I have signed my name to this specification this 21st day of January, 1925.

JOHN STONE STONE.