

Dec. 20, 1938.

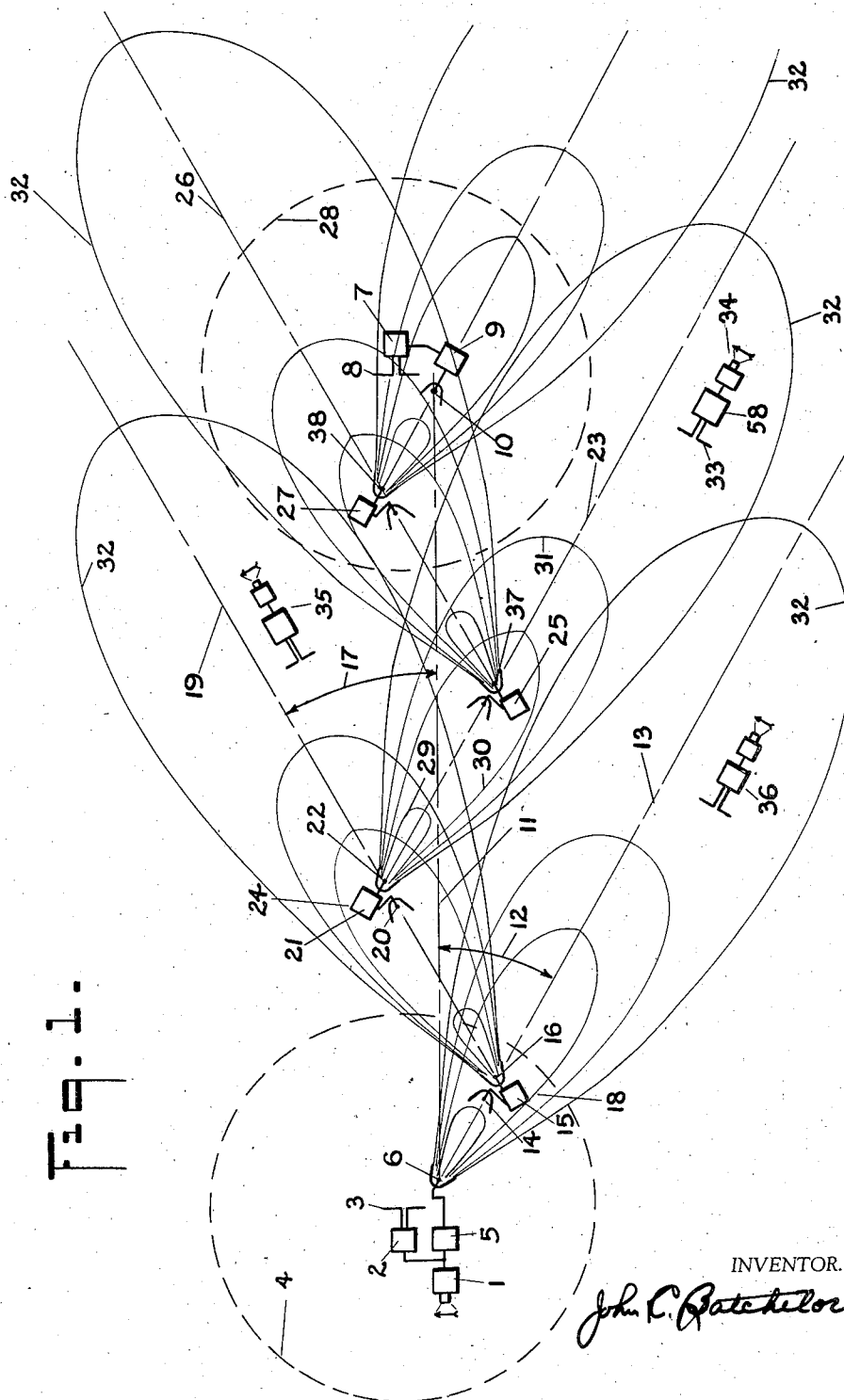
J. C. BATCHELOR

2,140,730

SYSTEM OF COMMUNICATION

Filed Jan. 31, 1935

2 Sheets-Sheet 1



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Fig. 2.

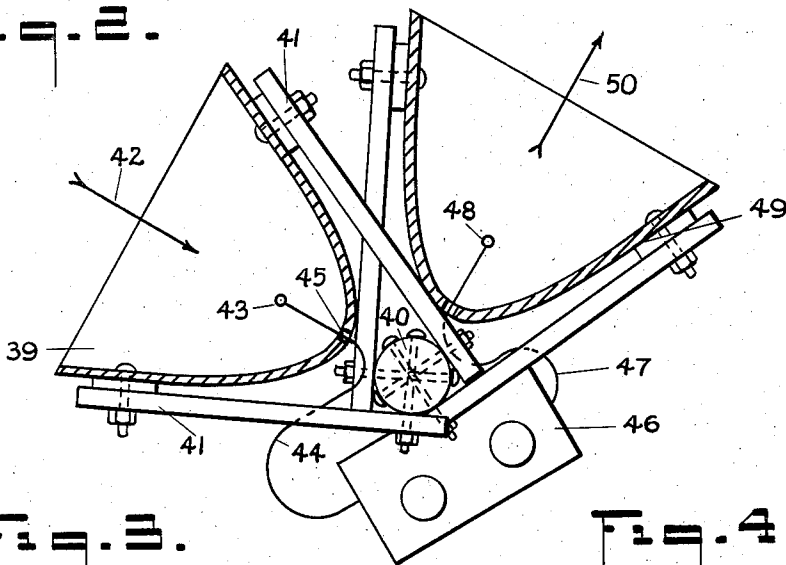


Fig. 3.

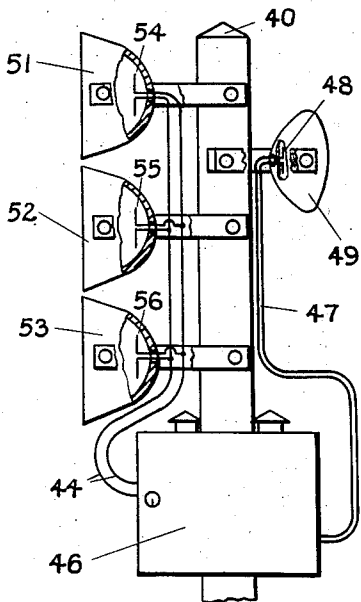


Fig. 4.

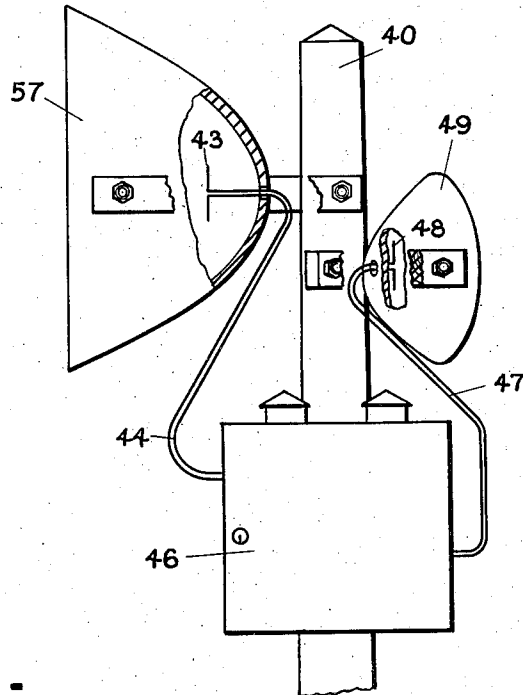
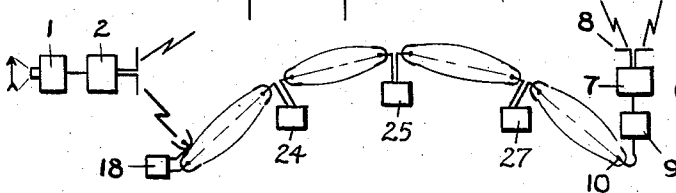


Fig. 5.



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UNITED STATES PATENT OFFICE

2,140,730

SYSTEM OF COMMUNICATION

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2 Claims. (Cl. 250-15)

My invention relates to a system of communication, and, more particularly, to such a system wherein broadcast communication is accomplished by meter waves in areas adjacent large centers of population, and the broadcasting stations in a plurality of such centers of population are interconnected by radio beam communication using meter or shorter waves.

It has been proposed in the visual communication art to provide broadcasting transmitters in metropolitan areas, and, using wave lengths of the order of 6 meters, to transmit programs, such as television images, with sufficient power to cover distances as great as 40 miles, or perhaps more.

Furthermore, it has been proposed, when two or more such broadcasting transmitters are operated in two or more such metropolitan areas, to provide along the lines joining the two areas, a succession of radio receiving and rebroadcasting installations operating on wave lengths of the order of one meter and having sufficiently directional characteristics that only a relatively small amount of power is required for satisfactorily repeating the signals received from the next preceding station.

Inasmuch as the number of repeater stations in such an installation is relatively large, it is essential that the receiving element of each repeater station be operated at a point of relatively high field intensity in order that the ratio of communicated signal to extraneous noise signal will be of sufficiently high order to prevent undue accumulation of noise in the transmitted signal upon successive retransmissions. Because of this limitation and the limitation imposed by the optical nature of the signals transmitted, the practical limit of the interval between transmitter stations in a long series of relay stations appears with present technique to be about 20 miles. It is true, however, that if the signal radiated from any given repeater station were not to be used for successive retransmissions, it would be possible to reproduce an image from a signal of considerably lower field intensity, and in many instances it is possible to reproduce an image directly from a signal received from a low power beam transmitter such as are used in repeater systems at distances as great as 60 miles. Thus it is apparent that, when a series of repeater stations are employed along a line joining two broadcast transmitters between which intercommunication is desired, the service range along the axis of transmission is considerably smaller when a number of repetitions are used than would be required were an image to be reproduced directly

from the signal transmitted by any given repeater transmitter.

Moreover, with broadcast transmitters serving only the metropolitan areas, it is clear that a large percentage of the population residing in rural districts will be denied the privilege of receiving television images except in such cases where receiving apparatus may be used directly along the axis of a beam repeater system. In this latter case, a receiver capable of responding to radiation of the wave length being used by the repeater stations will be capable of reproducing images from intercepted signals.

With the foregoing in mind, it is an object of my invention to provide visual communication service and the like to a larger portion of the rural population than has heretofore been possible. This and other objects will be apparent upon examination of the following description of my invention.

In accordance with my invention, I have provided a television broadcasting station of a non-directional type, associated with which is a directional radio transmitter, by means of which I am enabled to transmit a beam of television signals in a direction not coincident with a line between the broadcast transmitting station and another similar broadcast transmitting station located at a remote point, and with which communication is desired. Thus, even in the absence of the curvature of the earth's surface, and with sufficient power provided, no signal would be receivable at the remote point from the first beam transmitter. Along the axis of this first beam transmitter, I have provided directionally responsive receiving apparatus at a point where the field intensity from the beam transmitter is of an appropriate value greater than the noise level at the point of reception. Associated with this receiving apparatus I have provided a second beam transmitting apparatus directed in a direction having substantially equal divergence with but in an opposite sense to the divergence of the first beam transmitter from the line connecting the first broadcast transmitter and the remote point.

Similarly, I have provided a plurality of receiver-transmitter repeater stations each having a definite angular divergence from the line between the first broadcast transmitter and the remote point, each cooperating with the preceding one to provide retransmission of the signal, and alternate stations transmitting over adjacent areas having parallel axes. Terminating this succession of repeater stations, I have provided a final repeater station whose transmitter is di-

rected toward directional receiving means associated with the broadcasting station at the remote point, whereby signals radiated from the first broadcasting station may be relayed to and retransmitted by the remote broadcasting station.

Thus, by providing less than 15 percent more repeater stations than would be required for transmission along lines joining various broadcasting stations, I am enabled to serve an area comprising a relatively wide strip of territory along the lines joining the various broadcast stations.

Further, in accordance with my invention, I have in some instances provided a plurality of repeater stations interconnecting a plurality of broadcasting stations, the repeater stations being disposed in a geometrical configuration such that certain adjacent repeater stations serve areas which are substantially non-overlapping.

In order to make possible a clearer understanding of my invention, attention is directed to the accompanying drawings, of which Figure 1 represents a plan view of a system in accordance with my invention; Figure 2 is a plan view of a repeater station adaptable to my system; Figure 3 is an elevation view of a modification of the embodiment shown in Figure 2; Figure 4 is an elevation view of a still further modified repeater station; and Figure 5 is a plan view of a modified form of my system.

Referring to Figure 1, a television scanner 1, or other source of electrical signals corresponding to intelligence to be communicated, is provided whereby signals may be impressed upon a radio transmitter 2 operating on a wave length of, say, 6 meters whereby signals may be radiated by the non-directional radiator 3 over the area enclosed in the dotted circle 4, which may have a radius of 20 miles. Thus, if the radiator 3 is located in the city of New York, broadcast service may be provided for the entire metropolitan area of that city.

Similar signals from the output of the scanner 1 are conducted to the transmitter 5, which is in turn connected to the directional radiator 6. A second broadcast transmitter 7 provides a radio frequency carrier wave which may be radiated by the non-directional radiator 8, and is located in a second center of population, such as, for example, Philadelphia; the transmitter 7 is adapted to be modulated by signals from the radio receiver 9, the input of which is taken from the directional receiving antenna 10. Thus we may draw the line 11 between the radiator 6 and the receiving antenna 10 to represent the axis along which communication is required, and which line I shall refer to as the mean axis of transmission.

Returning now to the radiator 6, it may be seen in Figure 1 that an angle 12, which may be 30 degrees, exists in the horizontal plane between the line 11 and the axis of transmission 13 of the radiator 6. A directional receiving antenna 14 is provided along the axis of transmission 13 of the radiator 6, and is so disposed as to receive energy radiated by the radiator 6. In order to reach the receiving antenna 14 from the radiator 6, energy must in many instances, particularly in the example shown, traverse essentially metropolitan territory where buildings and other structures cause more rapid attenuation of radiation than is encountered by radiation over rural territory, and therefore in this embodiment of my invention I have located the antenna 14 at a dis-

tance of 10 miles from the radiator 6. This distance may under favorable conditions be substantially increased. The antenna 14 is connected to a combined receiver-transmitter 15 which may consist of conventional radio receiving apparatus adapted to modulate a radio transmitting apparatus, but, alternately, it may be a radio frequency amplifier designed to amplify in power the energy received from the antenna 14. The transmitter portion of the receiver-transmitter 15 is in turn connected with the directional radiator 16 adapted to radiate energy at an angle on a horizontal plane from the line 13 of twice the angle 12 and at an angle 17 from the line 11 substantially equal to the angle 12. If clockwise angles are considered to be positive, and counterclockwise angles are considered to be negative in sense, then with reference to the line 11 between the two broadcasting stations, the axis of transmission 13 of the radiator 6 is positive thirty degrees, and the axis of transmission 19 of the radiator 16 is negative thirty degrees, the angle between the axes 13 and 19 being thus double the angle 12. Thus there is provided a repeater station 18 comprising the directional receiving antenna 14, the receiver-transmitter 15 and the directional radiator 16. A second directional receiving antenna 20 is provided along the axis of transmission 19 of the radiator 16 at a distance of, say, 20 miles from the radiator 16, which antenna provides an input signal to the receiver-transmitter 21 which in turn provides energy to the directional radiator 22 having an axis of radiation 23 parallel to the axis of radiation 13 or in a sense of positive 30 degrees in the example shown. A second repeater station 24, then, is constituted by the antenna 20, the receiver-transmitter 21 and the radiator 22.

At a point, say, 20 miles along the axis of transmission 23 of the radiator 22 is provided another repeater station 25 similar to the repeater station 18 and so disposed as to receive energy from a direction substantially parallel to the direction from which energy is received by the antenna 14, and, further, adapted to radiate energy in a direction substantially parallel to the axis of radiation 19 of the radiator 16, or in a sense of negative 30 degrees in the example shown. Thus the axis of radiation of the repeater 25 may be represented by the line 26.

At a point of the order of 20 miles distant from the repeater station 25 is provided an additional repeater station 27 similar to the repeater station 24, adapted to receive energy from the station 25 and to transmit energy controlled by said received energy to the directional receiving antenna 10 in a direction parallel to the axis of radiation 23 of the repeater station 24, or in a sense of positive 30 degrees in the example shown. The transmitted energy in travelling from the radiator 38 to the receiving antenna 10 in the example shown is required to traverse metropolitan territory and I have therefore in the example located the receiving antenna 10 at a point of the order of 10 miles distant from the radiator 38.

Thus I have provided a system whereby controlled energy may be communicated from the scanner 1 to the transmitter 7 and radiated broadcast over the area described by the dotted circle 28 which in this embodiment is presumed to represent the city of Philadelphia.

It may be recognized that, in order to maintain the overall ratio of signal to noise at a sufficiently low value throughout the repetitions, it

is necessary to locate successive repeater stations at points sufficiently close to preceding stations to maintain a relatively great field strength at the receiving antenna of the repeater station.

Thus, if we take as an example the repeater station 24 and indicate its field intensity distribution in the conventional way, we may show, for example, the line 29 along which the field intensity is 100 millivolts, the line 30 along which the field intensity is 10 millivolts, the line 31 along which the field intensity is one millivolt and the line 32 along which the field intensity is 100 microvolts. For the purpose of receiving a sufficiently strong signal at the repeater station 25, it may be desired that the received field intensity be of the order of 10 millivolts, necessitating locating the station 25 approximately at the intersection of the line 30 and the axis of radiation 23, whereas, since it is possible to provide satisfactory receiving equipment capable of operating on a signal of the order of 100 microvolts, a receiver 58 may be located as shown in connection with the receiving antenna 33 and the image reproducer 34 whereby satisfactory reception of transmitted images may be realized at a point outside of the area enclosed by the circle 28. Similarly, television receiving apparatus 35 and 36 may be provided at various points within the zone of coverage of the radiators 6, 16, 22, 37 and 38. It may be seen that, assuming the maximum sensitivity of a receiver is 100 microvolts, the area served by my system is that area included within the lines 4, 28 and 32, and this area has, at a relatively small cost, been increased appreciably over that area which would be served were the axes of reception and transmission of the repeater stations separated by 180 degrees, or, in other words, co-linear.

Referring now to Figure 2, in which is shown a plan view of a repeater station which may to advantage be employed in my invention, a paraboloidal reflector 39 is supported near the top of the pole 40 by the wooden members 41 in a manner such that the axis of reception of the reflector 39 is co-linear with the axis of transmission of the next preceding radiator in the system (not shown in Figure 2). At the focus of the reflector 39 is disposed an energy-receptive antenna 43, which may be a dipole or any other suitable type, and a transmission line 44 is provided leading from the antenna 43 through the opening 45 in the reflector 39 to the box 46, which is attached to the pole 40, and which contains a radio receiver excited by the antenna 43. The output of the receiver is used to modulate a radio transmitter also provided in the box 46. Batteries may also be provided within the box 46 for operating the receiver and the transmitter, or, as an alternate method, a power line may run to the box 46.

From the radio transmitter in the box 46 is a transmission line 47 which communicates power to the radiating antenna 48, which may be a dipole or other suitable type, situated at the focus of the paraboloidal reflector 49 having an axis of radiation as shown by the line 50. The reflector 49 is supported upon the pole 40 in a manner similar to the reflector 39. Thus a unit is provided comprising a directional receiver and a directional transmitter, the latter modulated by the former, capable of receiving energy from one direction and transmitting energy proportional to the received energy in a direction not co-linear with the direction from which energy is received.

The height of the pole 40 is chosen from a number of considerations; the height should be relatively large as compared with the wave length of the received and radiated energy in order to avoid interference effects from the surrounding terrain; moreover, the height of the pole chosen will largely determine the radius of communication possible, because of the quasi-optical characteristics of the wave-lengths used. For example, with a height of 100 feet, a range of approximately 12 miles may readily be realized, and with both receiving and transmitting antennae elevated 100 feet above the surface of the earth, the range will be increased to approximately 24 miles. These ranges, it should be understood, refer to the useful range as a repeater station; usable signals for direct reception are transmitted over appreciably greater ranges, and in many instances, even beyond the optical horizon.

Figure 3 represents a modified form of my repeater station wherein a plurality of paraboloidal reflectors 51, 52 and 53 are provided, and all are so directed as to receive energy radiated from a preceding repeater station and focus that received energy upon the receiving antennae 54, 55 and 56 which are in turn coupled to the transmission line 44 in a manner such that the signals received by all of the antennae are impressed upon the transmission line in phase. The received energy is then conducted by the transmission line 44 to the receiver-transmitter of the box 46 and energy is communicated by the transmission line 47 and radiated by the radiator 48 in the reflector 49 in a manner similar to that described in connection with Figure 2.

Figure 4 shows a further modified repeater station in which a paraboloidal reflector 57 of relatively large dimensions is provided for the purpose of receiving a relatively great amount of energy from a transmitter which is directed along the axis of reception of the reflector 57, and that energy is in turn reflected upon the receiving antenna 43, communicated along the transmission line 44 to the transmitter-receiver in the box 46, the output of which transmitter is communicated by the transmission line 47 to the radiator 48 in the reflector 49 which may be of smaller size than the reflector 57. Thus, in both Figure 3 and Figure 4, the effective aperture of the receiving reflector is greater than the effective aperture of the transmitting antenna.

It may be seen that various modifications are possible without departing from the spirit of my invention. For example, as shown in Figure 5, the initial unit of the interconnection between the scanner 1 and the transmitter 7 may be the non-directional transmitter 2, and the repeater station 18 may be located within the service area of the transmitter 2, thereby eliminating the cost of the initial beam transmitter.

Further, in Figure 5, the repeaters have been disposed in a manner such that their locus constitutes substantially an arc of a circle.

Such a configuration is of value when a great preponderance of population lies in one sense with respect to the line between the broadcasting transmitters being interconnected, and with such a system it is clear that territory on one side only of that line is served. Moreover, it is desirable in certain conditions to employ a plurality of configurations of stations, particularly on long distance relay transmission lines. For example, it may be desirable on certain long lines to employ the configuration of Figure 1

for a given distance, following which co-axial repeaters are used through a sparsely settled area for some distance. Then, when the line passes a community having appreciable density of population, an arcuate form may be employed having its center of curvature on the side of the line opposite the community. Immediately thereafter an arcuate form having its curvature in the opposite sense may be employed to serve another community, following which another group of co-axial repeaters may be employed over territory having few inhabitants. Thus, it is clear that various combinations of geometrical configurations may be used in my system within the spirit of my invention.

Furthermore, various degrees of directionality and various angles of divergence of transmitters may be found advantageous. For example, when very sharp bundling of radiation from the repeater station is used, the angle of divergence between my repeater stations will be small, whereas, when it is feasible to allow substantial spreading of the radiation, and the population along the line of transmission is relatively dense, it will often be advantageous to use angles of divergence of more than thirty degrees.

Still further, the specific types of radiators and reflectors shown are by no means the only ones adaptable to my invention; any type of radiator and reflector may be applied in a system employing my principle. Moreover, the wave-lengths specified have been chosen merely for example as being wave-lengths which are used at present for such communication; any of the wave-lengths which follow optical laws in any respect and which are designated as meter waves, decimeter waves, centimeter waves and infra-red rays may be employed to advantage in my invention.

It may be seen, further, that it is not essential that the transmitter 2 in Figure 1 be used in connection with the scanner 1. It is possible to utilize the relay system of my invention when a

scanner is used at a point where local broadcasting is not desired, yet the degree of coverage possible using my invention may be desirable between the scanner 1 and the remote transmitter 2. In this case, the omission of the transmitter 2 is entirely within the scope of my invention.

I claim.

1. A television system comprising means for analyzing an image, broadcasting means remote from said analyzing means, and a plurality of directional repeater stations having predetermined field intensity distribution characteristics whereby signals from said analyzing means may be communicated to said broadcasting means, at least several of said repeater stations being so disposed that energy radiated thereby crosses the line joining said analyzing means and said broadcasting means at each successive retransmission, the angle between said line and the direction of radiation of said energy being such and so related to said distribution characteristics that the areas served by alternate repeater stations are substantially contiguous but non-coincident.

2. A television system comprising means for analyzing an image, broadcasting means remote from said analyzing means, a plurality of directional repeater stations having predetermined field intensity distribution characteristics adapted to communicate signals from said analyzing means to said broadcasting means, at least several of said repeater stations being so disposed that energy radiated thereby crosses the line joining said analyzing means and said broadcasting means at each successive retransmission, the angle between said line and the direction of radiation of said energy being such and so related to said distribution characteristics that the areas served by alternate repeater stations are substantially contiguous but non-coincident, and image receiving means within the field of at least one of said areas served.

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