

March 26, 1968

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3,375,524

ANTENNA DISTRIBUTOR CIRCUIT FOR FOUR DIPOLES WITH
ADJACENT DIPOLES IN PHASE QUADRATURE

Filed Oct. 9, 1964

6 Sheets-Sheet 1

Fig. 1

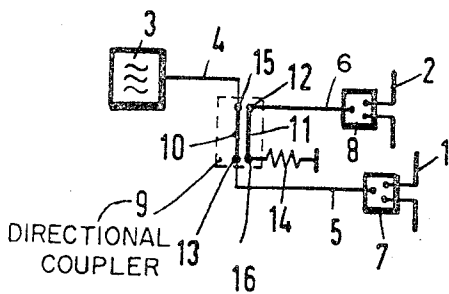


Fig. 2

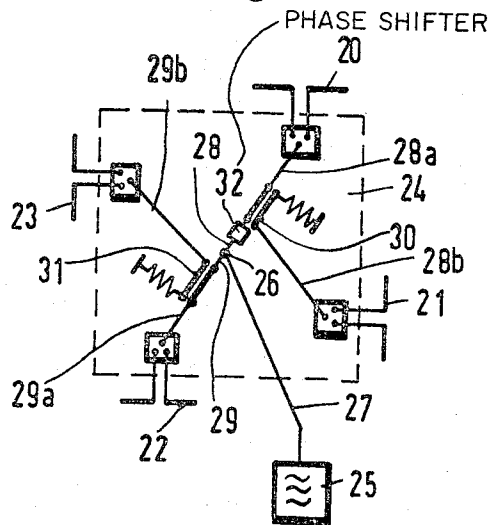
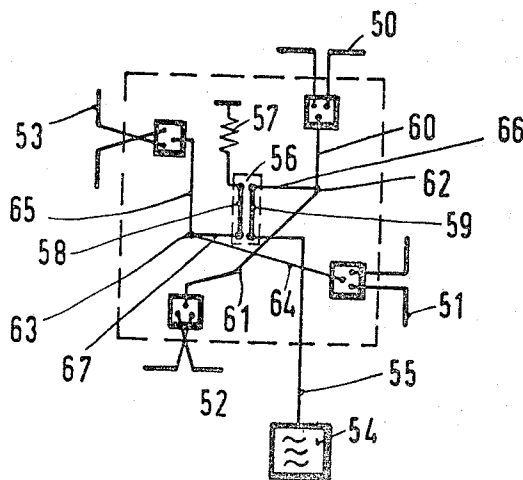


Fig. 7



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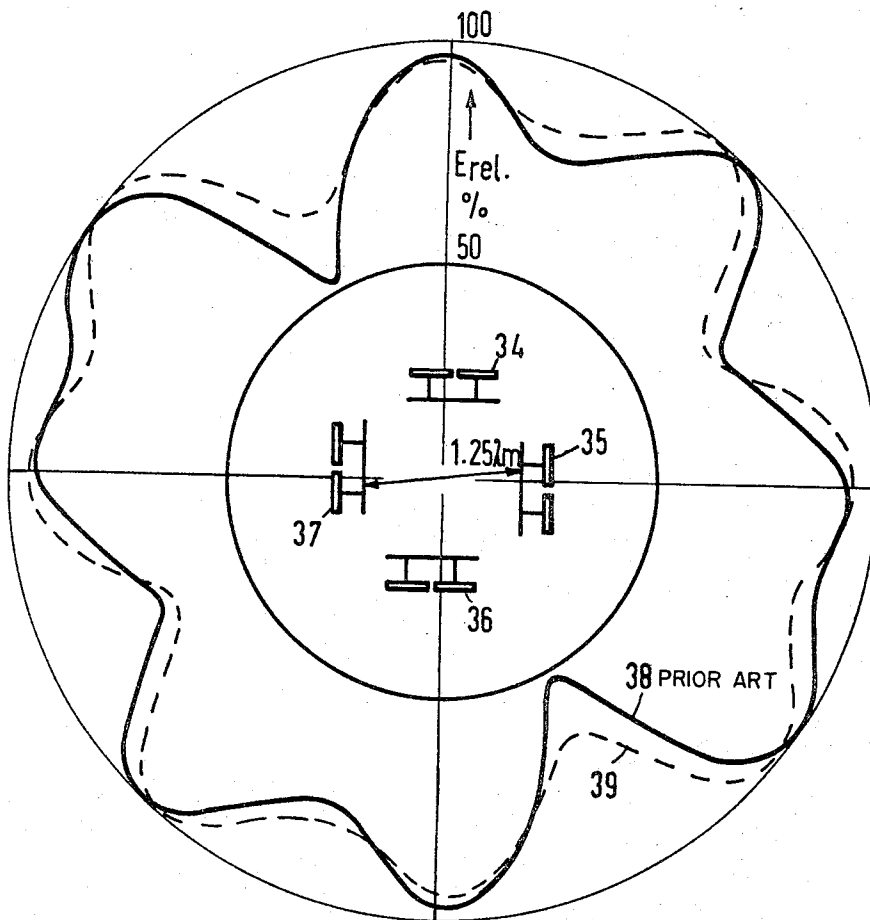
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Fig. 3



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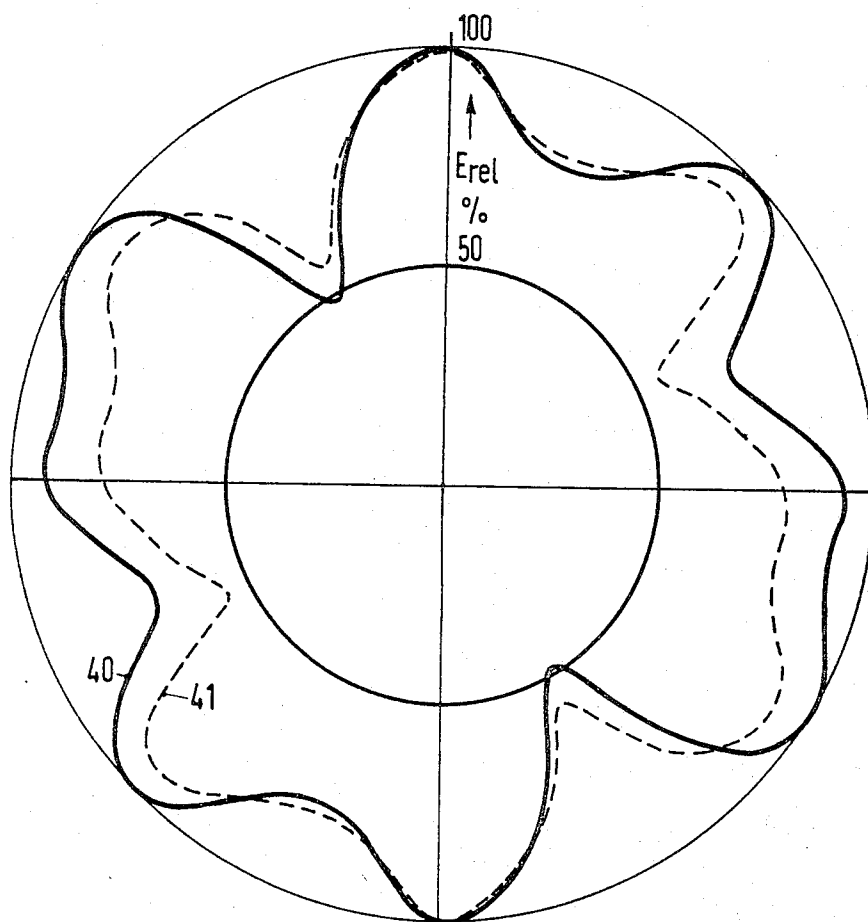
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Fig. 4 PRIOR ART



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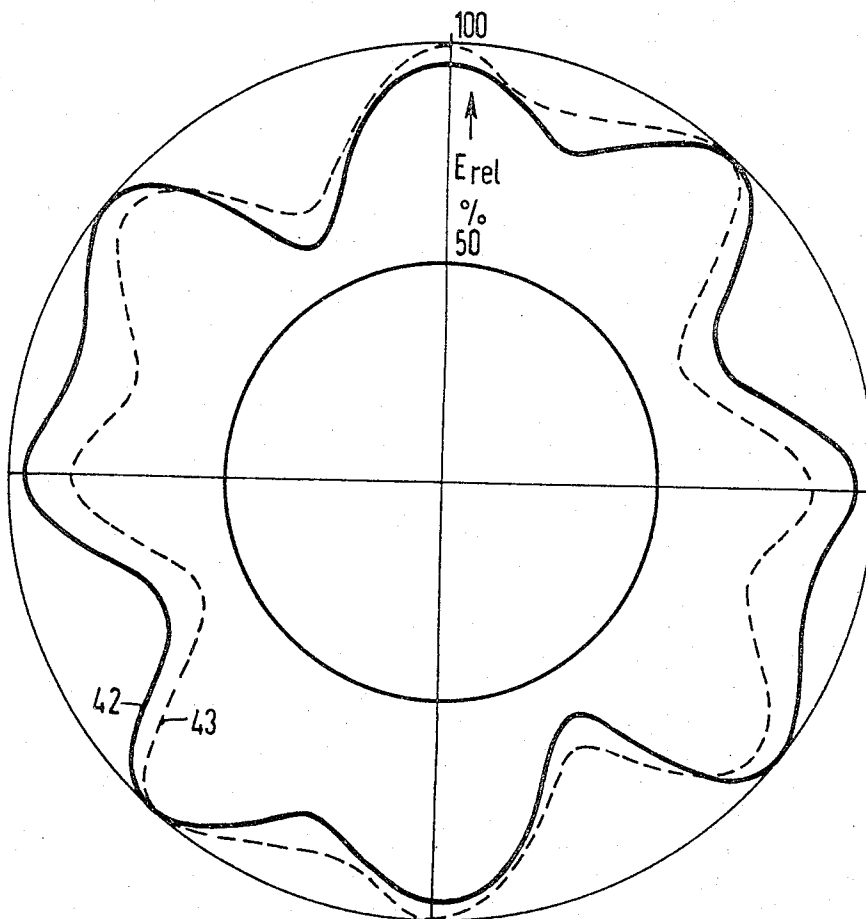
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Fig. 5



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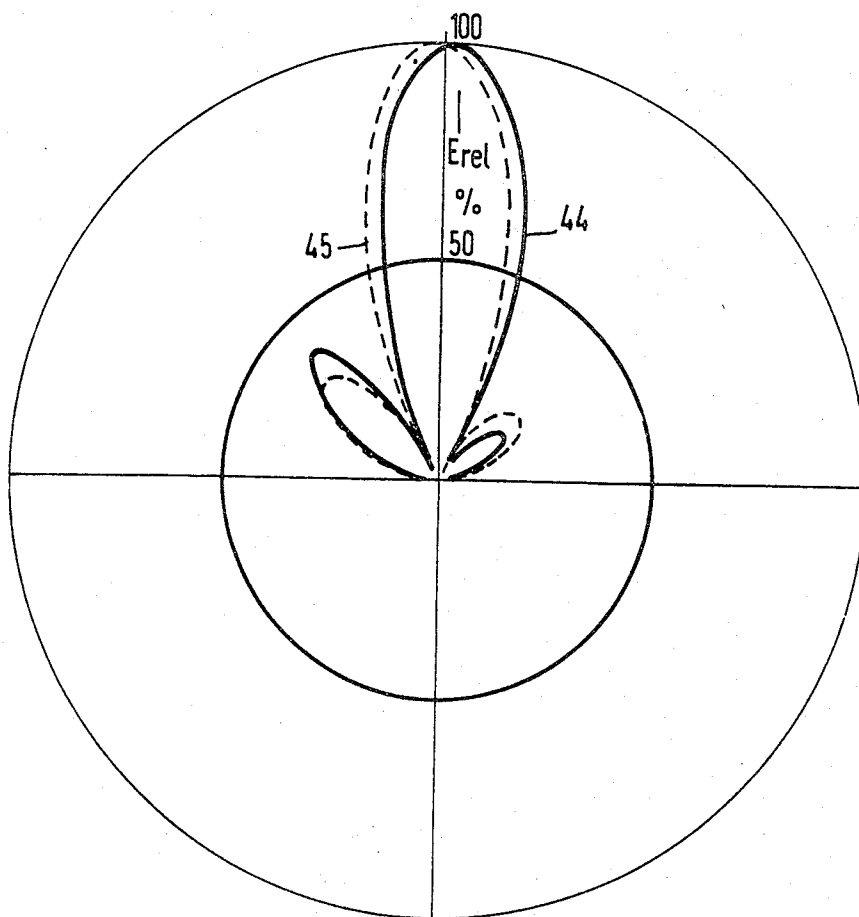
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Fig. 6



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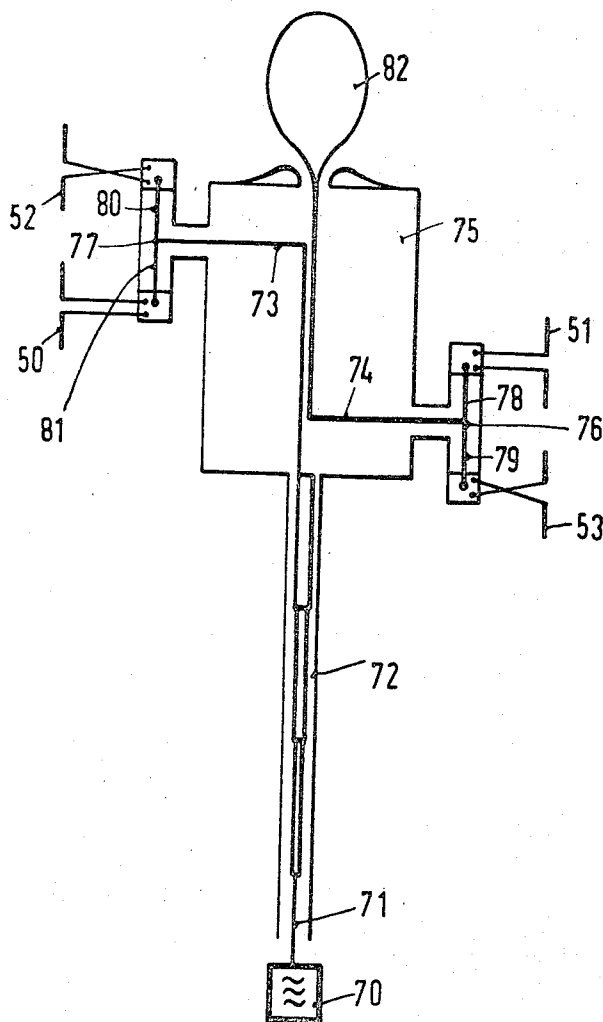
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Fig. 8



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ANTENNA DISTRIBUTOR CIRCUIT FOR FOUR DIPOLES WITH ADJACENT DIPOLES IN PHASE QUADRATURE

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Filed Oct. 9, 1964, Ser. No. 402,752

Claims priority, application Germany, Oct. 10, 1963, S 87,802

5 Claims. (Cl. 343—799)

ABSTRACT OF THE DISCLOSURE

A distributor circuit for plural load devices fed in the rotary field of a polydirectional antenna having phase differences of 90° in the adjacent load devices including a 3-db directional coupler connected in the main feed line, and connecting lines of equal length for opposite load devices connected to distributor points from the directional coupler.

It is a known practice to feed like-type load devices with in each case 90° phase displacement and thereby to achieve an improvement of the matching. In this manner, reflected energy constituents arrive at the junction point in counter-phase and, in order to avoid renewed reflections, can be fed to an absorber resistor. In consequence of these favorable properties, the so-called phase quadrature is utilized especially in transmitting antennas serving for the radiation of television programs, where extremely low reflection factors are necessary.

For the production of phase differences in known systems transmission sections, each of $\lambda/4$ length difference, are utilized. Thereby, while it is possible for a certain frequency for which the particular length differences are laid out to maintain exact phase steps of 90°, for other operating frequencies other phase steps occur from one radiator to the other which may involve a considerable impairment of the uniformity of the radiation diagrams.

The present invention has primarily as its problem to overcome these difficulties as simply as possible, and thereby achieve wide-band uniform phase differences also in loads fed in phase quadrature. According to the invention this is achieved by the method that a 3-db directional coupler is inserted into the common feed line for the two loads, so that both at the remote point of the through line, as seen from the transmitter, and also at the output of the coupling line adjacent the transmitter, in each case one or more load devices are connected, and the line lengths and/or phase members between a point on the feed line common to the loads and the particular connecting point of the two loads, apart from the phase relations effected by the directional coupler, are substantially equal. Through the connection of the directional coupler, at the connecting points for the two loads there is achieved a practically frequency-independent phase difference of 90°, through which the frequency-dependent phase steps, otherwise existing in use of lines with different lengths between the loads, are largely precluded. Although as before, in most cases, lines for the feed of the loads still have to be installed, a frequency course of the phase differences between the loads is avoided, because the line lengths are equal with respect to one another. As a further advantage, through the distributor circuit constructed according to the invention there can be achieved a simplification of the absorber devices otherwise serving for the removal of the reflected energy components.

With use of omnidirectional antennas, which consist of four antennas each fed with 90° phase difference in a rotary field, as loads, the distributor circuit according to

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the invention can be so utilized that in each case one directional coupler is allocated to two antennas and in the feed to one of the antenna pairs a phase member with 180° phase displacement is inserted in the circuit thereof, which can advantageously be formed by a pole reversal of the connecting lines. It is expedient to insert the phase member, in this case as viewed from the transmitter, after the distributor point and before the particular directional coupler. A further advantageous possibility for the production of the desired phase relations consists in reversing the polarity of the connections of the antennas.

The output of the coupling line of the directional coupler, lying opposite the connection of the through line at the transmitter side, is expediently provided with an absorber dimensioned according to the reflected components occurring in the particular antenna system, whereby the directional coupler serves simultaneously as a distributor circuit, producing the necessary phase difference between the antennas and, without additional means, feeds the reflected energy components to the absorber.

The feed of four load devices can advantageously also be carried out that only one directional coupler is provided, to the outputs of which to the loads, in each case there is connected, over a distributor circuit, a load pair, for example, two antennas. For four antennas fed in a rotary field, the arrangement is constructed expediently in such a way that in each case the connections of one antenna of each antenna pair are reversed in polarity.

For operation in which the wave resistance (Z) of the common feed line is equal to the input resistance of each of the load devices, and an even number (n) of loads is to be connected, a common directional coupler can be so designed that its input resistance, both as viewed from the transmitter and also from the load sides is made equal to $Z_e = 2 \cdot Z/n$. On the transmitter side there is provided a corresponding matching transformer between feed line and coupler. The loads are arranged in two like groups, which are then connected to the direction coupler outputs without other matching circuits.

Further details of the invention are explained in detail with the aid of the drawings, in which:

FIG. 1 illustrates the feed of two antennas;

FIG. 2 illustrates the distributor circuit for a polydirectional antenna system;

FIG. 3 illustrates the diagrams of an omnidirectional antenna system with phase steps created over cable lengths, respectively direction couplers;

FIGS. 4 and 5 illustrate the radiation characteristics of an omnidirectional antenna with relatively great reflections at the individual antennas, utilizing directional couplers for the distributor circuit;

FIG. 6 illustrates the radiation characteristics of a directional antenna system; and

FIGS. 7 and 8 illustrate distributor circuits for four loads with in each case only one directional coupler.

In FIG. 1 the dipoles 1 and 2 are fed from a common transmitter 3 over a main feed line 4 and branch lines 5 and 6. For the transition from the unsymmetrical, for example, coaxial, feed lines to the symmetrical antennas there are provided symmetrizing members 7 and 8. The two antennas 1 and 2 are to be fed in phase quadrature, that is with 90° phase difference, and are therefore for the balancing of the phase difference, spatially staggered with reference to the main radiation direction by $\lambda/4$. A directional coupler 9 is utilized for the generation of the phase difference, which coupler consists of a through line 10 and a coupling line 11, the degree of coupling being so selected that one-half of the transmitting energy is fed to the feed line 5 and the other half is fed to feed line 6 (3-db coupler). Between the connection points 12 and 13 of the directional coupler there exists a phase difference of 90°, which within the operating frequency range of the

directional coupler is largely independent of frequency. The voltage at point 12 leads by 90° with respect to that at point 13, so that with use of equally long transmission sections 5 and 6 for the feed lines to the antennas 1 and 2, phase steps of 90° are there achieved. Aside from the phase relations imparted by the directional coupler, as figured from a certain point of the feed line 4, the phase rotation up to the antennas operating as loads is always equal, independently of the frequency for the two branch lines. The energy components reflected in the case of an at least approximately like type false matching at antennas 1 and 2 pass largely into the absorber resistor 14, which is connected at the terminal 16 lying diagonally opposite the input terminal 15 of the through line 10.

FIG. 2 illustrates the construction of a distributor circuit, according to the principles explained in FIG. 1, in which a polydirectional antenna consisting of dipoles or dipole fields 20 to 23 is to be fed in a rotary field, whose individual elements are illustrated as mounted on the sides of a mast 24 indicated in broken lines. The feed line 27 leading from the transmitter 25 to the distributor point 26 is there divided into two lines 28 and 29, over which the radiator pairs 20, 21, 22 and 23 are supplied. The further subdivision of the energy into two equal parts and the setting of the phase difference of 90° is in each case achieved by the directional couplers 30 and 31, which are respectively allocated to antenna pairs 20, 21, and 22, 23. Since there is to be progressively achieved a phase difference of 90° between the radiators, before the input into the directional coupler 30 there is provided a phase member 32, which effects a phase displacement of 180° . This can be achieved most simply by a polarity reversal of the connecting line 28, in which case such phase difference also is frequency independent. Also a polarity reversal of the antenna connections is possible. The lengths of the cable sections 28a, 28b and 29a, 29b connected to the outputs of the directional couplers 30 and 31 are made equal, as are the lengths of the lines 28 and 29 between the distributor point 26 and the input into the directional coupler 30 and 31, respectively. Thereby phase displacements caused by different line lengths, which otherwise occur in wide band operation, are avoided, and the set phase steps of 90° , in each case from one radiator of the rotary field system to the other, remain preserved even over a wide frequency band.

FIG. 3 represents the radiation diagrams for an antenna system fed in a rotary field, it being assumed that the operating frequency f_B lies at $0.75 f_m$ and f_m forms the middle frequency of the antenna system. Moreover, it is assumed that no mismatching exists at the loads. With use of cable sections with a length difference of $\lambda_m/4$ for the generation of the phase steps between the radiators of the rotary field system there results $f_B = 0.75 f_m$ the radiation diagram designated by the numeral 38 with deep valleys between the radiators 35 and 36 and between the radiators 37 and 34. It is there assumed that two fields are reversed in polarity for the achievement of the desired rotary field feed. If, on the other hand, the feed of the four antennas is effected in the manner illustrated in FIG. 2, there then results the radiation diagram 39, indicated in broken lines, whose valleys are considerably smaller. The distributor circuit according to the invention accordingly is better suited for the operation of wide band antenna systems.

In FIGS. 4 and 5 there are represented radiation diagrams of an omnidirectional antenna formed of four individual antennas fed in a rotary field. In FIG. 4 it is assumed that the phase steps between the radiators are achieved through the use of feed cable sections differing in their length by $\lambda/4$ and in the radiators with 180° and 270° phase displacement, respectively, a polarity reversal is additionally provided. For an operating frequency f_B of $0.75 f_m$ and a reflection factor of the loads of 10% there result radiation diagrams with valleys to below $0.5 E_{\max}$. The solidly drawn curve 40 designates the field strength course with maximum possible phase difference

between oppositely situated fields (34, 36 in FIG. 3), while the curve 41, drawn in broken lines, designates the course of the maximum possible power difference. In FIG. 5 there are drawn for the same operating conditions the omnidirectional radiation characteristics of the same antenna system, but with a distributor circuit according to the invention, it being assumed that the reflection factor of the absorber resistor has the value of 1, that is, corresponding to the system of FIG. 4 no absorber is provided. The solidly drawn curve 42 indicates the field strength course at maximum possible phase difference, while the broken line curve 43 at maximum possible power difference between oppositely situated radiators. In comparison to FIG. 4 there appears a considerably more uniform radiation diagram. The uniformity of the radiation diagram can, in the case of distributor circuits with directional couplers, be still further improved by connection of an absorber resistor ($r_a < 1$). In the arrangement according to FIG. 4 this would only be possible if additionally an echo suppressor were used together with an absorber resistor, in which case, however, in the second case the improvement is considerably less and more narrow banded.

In FIG. 6 there is illustrated the radiation diagram for a directional antenna system of the type represented in FIG. 1. The reflection factor of the antenna is assumed at 20%, the reflection factor of the absorber resistor at 50%. The reflection factor is a measure of mismatch and is defined as $m = R - Z/R + Z$, where m is the reflection factor, R is impedance of the line being fed and Z is the impedance of the feed line. Under the assumption that the phase of antenna 1 in FIG. 1 is set at 0° , the phase of antenna 2 at $90^\circ + \Delta\phi$, there results the radiation diagram 44 and for $90^\circ - \Delta\phi$ the radiation diagram 45. The position of the main radiation direction and to a certain extent its magnitude can be influenced by modification of the amount and/or of the phase of the reflection factor of the absorber device, so that here, by simple means, without connection into the feed lines proper, returning possibilities may be achieved. Thus, with the above mentioned phase relations, the lateral deviations of the main radiation directions could in this manner be corrected.

FIG. 7 illustrates an antenna system operated in a rotary field feed, which consists of individual radiators or radiator groups (for example dipole fields) 50 to 53. From the transmitter 54 over the main feed line 55 there is fed the directional coupler 56 operating as a distributor, whose absorber resistor is designated at the coupling conductor 58 by the numeral 57. At the output of the through conductor there are connected the antenna pairs 50 and 52, which with equal line lengths 60 and 61 are operated in like phase calculated from the distributor point 62. The phase difference needed for the rotary field feed between the radiators 50 and 52 is achieved by polarity reversal of the connecting line to radiator 52. At the distributor point 62 a matching must be effected. The radiators 51 and 53 are supplied from the distributor point 63 over equally long lines 64 and 65, with the phase difference of 180° being achieved by polarity reversal of the connecting line of radiator 53. If the line lengths 60 and 67 as well as 60 and 64 are equal to one another, then the radiators 51 and 53 have a phase lead relative to the radiators 50 and 52, respectively, in each case of 90° , so that a rotary field antenna results.

In FIG. 8 a distributor is represented in which, for the simplification of the line transmission, the radiators are not represented in their actual spatial position. In order to facilitate the allocation to the arrangement represented in FIG. 7, the same reference symbols have been selected for corresponding radiators. To the output side of the main feed line 71 proceeding from the transmitter 70 is connected a three-stage transformer 72. The directional coupler 75 is so dimensioned in the case of n loads that its input resistance, as measured both at the through line 73 and also at the coupling line 74, amounts to $Z_e = 2Z/n$ if, as is assumed, all the field lines 71, 78,

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79, 80, 81 have the same wave resistance Z . At the distributor points 76 and 77, matching is then automatically achieved. In four loads and feed cables with 60Ω wave resistance, the directional coupler is to be dimensioned with input resistances $Z_e=30$ ohms and the transformer 72 is to be dimensioned for a matching of 60 to 30 ohms. The absorber is executed as a wide band radiator 82 whose radiation is so polarized or directed that it does not disturb the main radiation. Thus, as shown in FIGURE 8, the radiator 82 is positioned to radiate upwardly (relative to the figure) at right angles to dipoles 50, 51, 52 and 53 and thus causes no distortion of omnidirectional pattern.

Changes may be made within the scope and spirit of the appended claims which define what is believed to be new and desired to have protected by Letters Patent.

We claim:

1. An distributor circuit for feeding four dipoles forming an omnidirectional antenna comprising,
 - a mast with the dipoles symmetrically mounted about the mast,
 - a main feed line,
 - a matching transformer connected to the main feed line,
 - a directional coupler connected to the matching transformer, and having a pair of outputs,
 - four pairs of antenna feed lines connected respectively to the four dipoles and a first two pairs of said feed lines connected to one of the outputs of the directional coupler and a second two pairs of said feed lines connected to the other output of said feed lines, and
 - one of the first pairs of antenna feed lines transposed from the other of the first pair before attaching to the

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dipoles and one of the second pairs of antenna feed lines transposed before connecting to the dipoles.

2. A distributor circuit according to claim 1 wherein the impedance of the pairs of antenna feed lines is twice the impedance of the input and output impedances of the directional coupler, and the input impedance of the matching transformer is twice the input and output impedance of the directional coupler, and the output impedance of the matching transformer is equal to the input and output impedances of the directional coupler.

3. A distributor circuit according to claim 2 wherein the matching transformer is a multistage transformer.

4. A distributor circuit according to claim 3 wherein the directional coupler includes energy absorber means for absorbing energy reflected from the dipoles and antenna feed lines.

5. A distributor circuit according to claim 4 wherein said energy absorber means comprises an antenna which radiates energy in a direction which does not interfere with the energy radiated from the four dipoles.

References Cited

UNITED STATES PATENTS

2,415,932	2/1947	Brown	343—814
2,990,548	6/1961	Wheeler	343—854 X
3,222,677	12/1965	Fink	343—854
3,295,134	12/1966	Lowe	343—854 X
3,314,069	4/1967	Dubost	343—853 X

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