

[54] **NON-ROTATING ANTENNA**

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[52] U.S. Cl. **343/106 R, 343/854, 332/51 W**

[51] Int. Cl. **G01s 1/50**

[58] Field of Search **343/106 R, 854; 332/51 W**

[56] **References Cited**

UNITED STATES PATENTS

3,713,167 1/1973 David 343/854

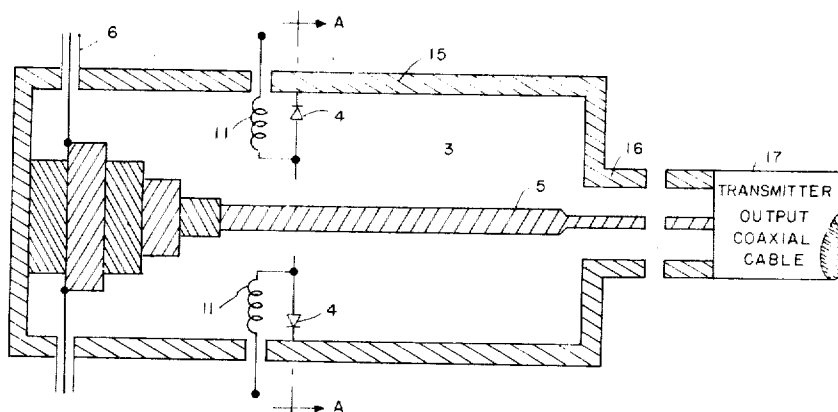
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[57] **ABSTRACT**

This invention relates to a method of providing modulation within the distribution and mode generating cavity of a non-rotating antenna, which antenna radiates a rotating limaçon radiation pattern. The H_{11} coaxial mode is induced in the distribution cavity by inhibiting or exciting currents to flow in certain ones of a plurality of probes arranged in a circle in the cavity. This is accomplished by means of switching devices incorporated into each of the probes and external digital logic for controlling the pattern of excitation. The excitation voltage for each probe is supplied by the normal TEM mode of the input carrier signal. Diodes are placed at the base of each probe so that with the appropriate bias voltage applied, RF current is controlled.

7 Claims, 14 Drawing Figures



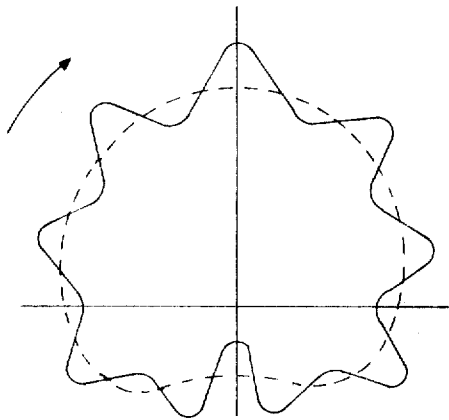


FIG. 1

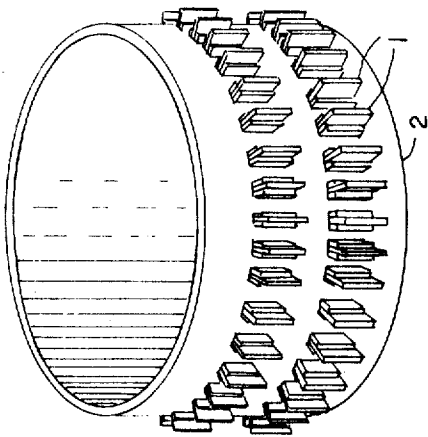


FIG. 2

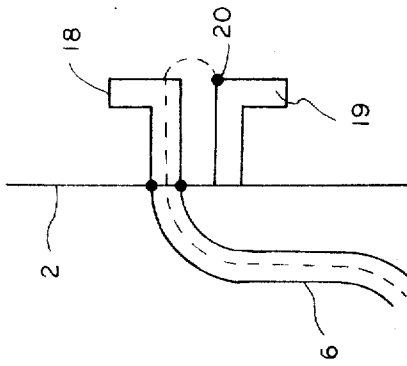


FIG. 2a

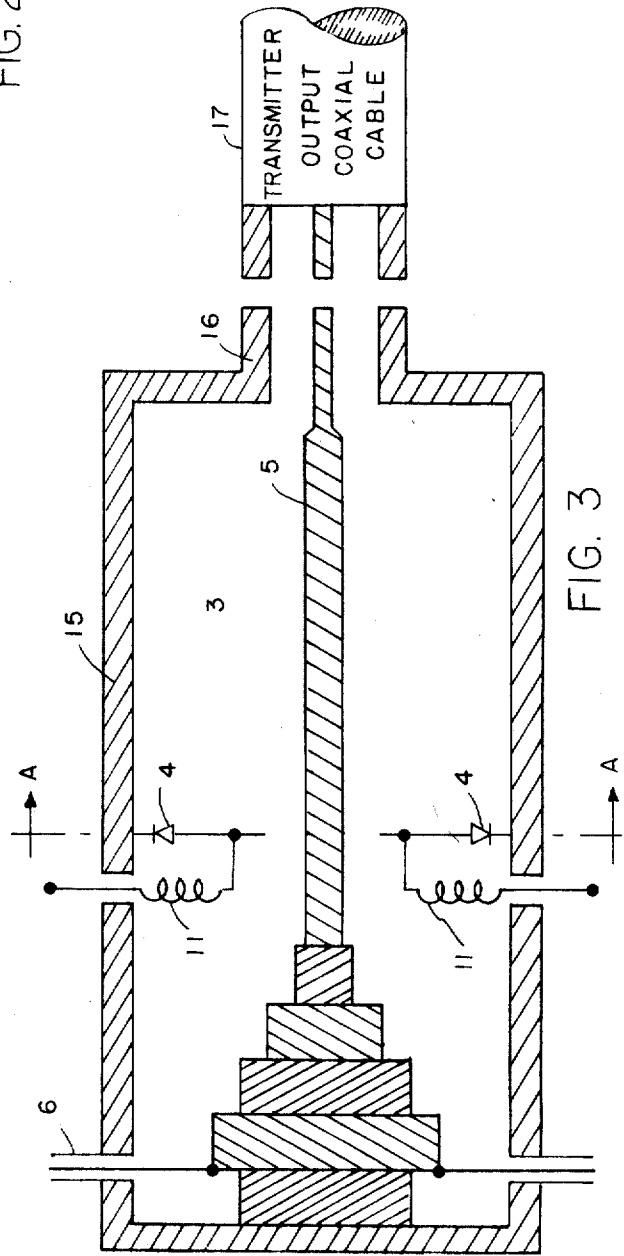


FIG. 3

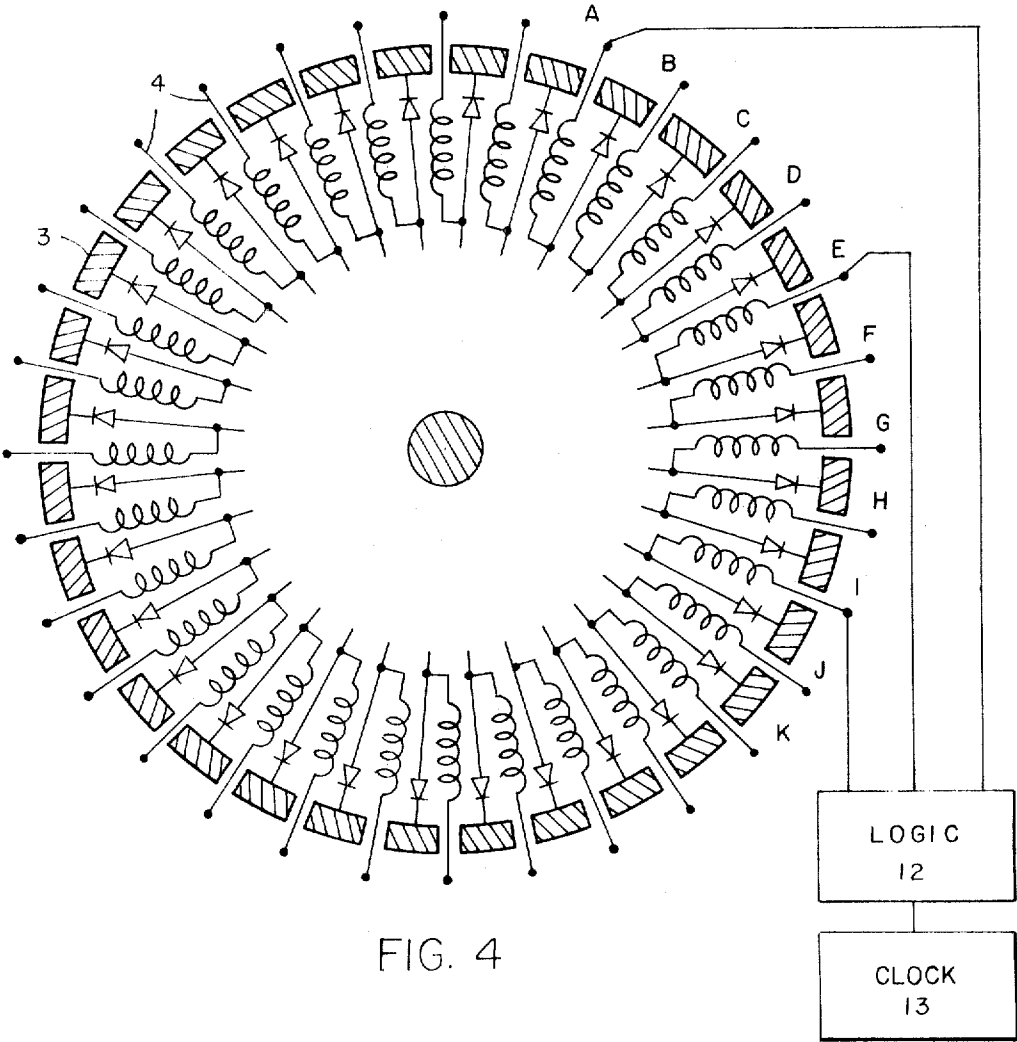


FIG. 4

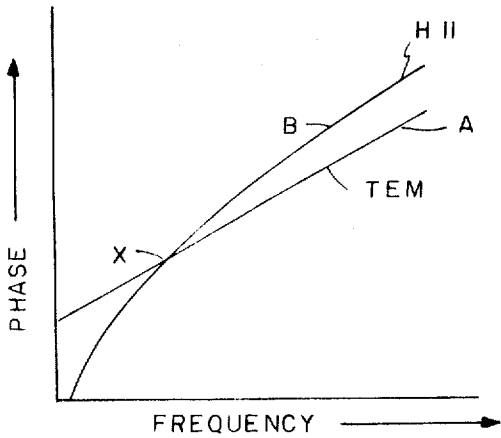


FIG. 5

Fig. 6 *Fig. 7* *Fig. 8* *Fig. 9*

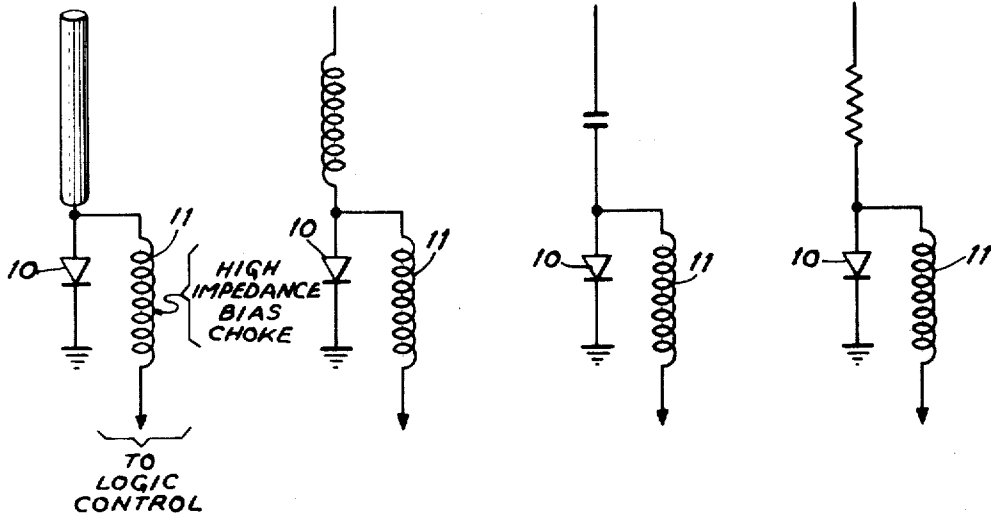
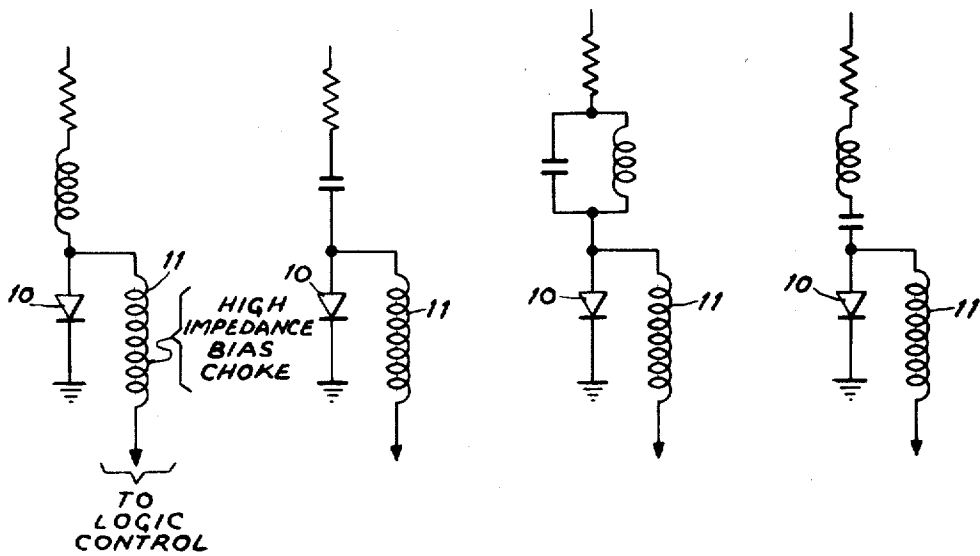


Fig. 10 *Fig. 11* *Fig. 12* *Fig. 13*



NON-ROTATING ANTENNA

BACKGROUND OF THE INVENTION

This invention relates to a method for providing a rotating limaçon radiation pattern from a non-rotating antenna and more particularly to a method of providing the required 15 Hz modulation in the distribution and mode generating cavity of a non-rotating Tacan antenna.

The distribution cavity of a Tacan antenna consists of an RF coaxial transmission line impedance transformer or an RF radial transmission line impedance transformer coupled between the power source of the transmitter and a plurality of output cables connected around the periphery of the transformer at the low impedance end (at the opposite end from the feed point). These output cables feed a plurality of radiators located concentrically around the periphery of a conductive cylindrical surface. Each output cable contains a two state RF switch, to produce the desired 135 Hz modulation required in present Tacan systems.

Previously, as described in U.S. Pat. No. 3,560,978, the required 15 Hz modulation was provided by a second plurality of radiators located concentrically around the antenna and excited by a central radiating element or array.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method of modulating a carrier signal within the distribution cavity of a non-rotating antenna by means of a circular ring of probes located within said cavity and associated means for energizing said probes, according to a predetermined pattern, located external to said cavity.

According to a broad aspect of the invention there is provided a method of modulating a transmitter carrier signal in the distribution cavity of a non-rotating antenna, which antenna produces a limaçon radiation pattern comprising injecting said transmitter carrier signal into the center conductor of an RF impedance transformer located within said distribution cavity, sequentially exciting, according to a predetermined pattern, a plurality of probes projecting into the distribution cavity to excite the H_{11} coaxial mode of propagation in the cavity, adjusting the phase of the RF currents in said excited probes to bring the resulting modulation component in phase with the carrier at a desired center frequency and extracting signals having the desired amplitude and phase functions from the outputs of said transformer.

The above and other objects of the present invention will be better understood from the following detailed description taken in conjunction with the accompanying drawings in which:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a rotating limaçon radiation pattern radiated by present Tacan antennas;

FIG. 2 shows the cylindrical surface of a Tacan antenna having an array of radiators located around its periphery;

FIG. 2a shows more clearly one of the radiators located on the periphery of the Tacan antenna and the means by which the radiator is fed;

FIG. 3 shows an arrangement for modulating the transmitter output signal within the distribution cavity of an antenna according to the invention;

FIG. 4 shows the transformer and distribution cavity of FIG. 3 in a plan view taken from the front along line A—A;

FIG. 5 illustrates the phase shift relationship between the carrier signal, or normal TEM coaxial mode of propagation, and an induced H_{11} coaxial mode of propagation within the distribution cavity of FIG. 3;

FIG. 6 shows a single probe having a diode and a high impedance bias choke coupled to the control logic for biasing the diodes; and

FIGS. 7-13 illustrate various means of resistively and/or reactively loading the probes.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a rotating limaçon pattern having a 135 Hz modulation component superimposed thereon for meeting the requirements of present Tacan systems.

The 135 Hz modulation component (ninth harmonic spatial function) is generated by sequentially switching the RF amplitude and phase of the radiators 1 located on the outer surface of antenna 2 shown in FIG. 2. Each column of radiators 1 is coupled to one of the outputs 6 located at the low impedance end of the RF impedance transformer. The technique of sequentially switching an array of radiators on the antenna to generate the 135 Hz component is not related to the problem of generating the 15 Hz modulation component. A further discussion of this technique is not deemed necessary.

FIG. 3 shows a distribution and mode generating cavity 3 of a Tacan antenna having a single port input line and a multi-port output and having a plurality of radially located probes 4 projecting in from the outer wall of the transformer. Each probe comprises a diode 10 grounded to the outer wall and a high impedance bias choke 11 extending through cylindrical wall 15; coupled to the control logic 12 for biasing the diode to either conduct current or block current. The excitation voltage on each probe 4 is supplied by the normal TEM mode of the carrier input signal. As shown in FIG. 3, the wall of the cavity tapers at 16 for coupling to transmitter output coaxial cable 17. The required 15 Hz modulation is produced by sequentially biasing the diodes of radially located probes 4 projecting into the distribution cavity through its outer wall and near its input end to excite the H_{11} coaxial mode of propagation, said switching occurring according to a predetermined pattern and sequence.

If the current in probes 4 is permitted or restricted from flowing, a disturbance is created which interacts with existing TEM, or normal coaxial mode in the transformer, to produce the H_{11} mode of propagation. The appropriate pattern of biasing probes 4 is guaranteed by means of shift registers and digital logic 12. Varying the pattern will vary the resulting radiated limaçon pattern. A master clock 13 controls the timing of the shift registers and digital logic. It should be clear that the digital control logic can be designed in any one of a number of ways and further discussion is not deemed necessary here. Distribution and mode generating cavity 3 also contains an impedance transformer 14. As shown in FIG. 3, the impedance is reduced in stages so as not to sacrifice band width. Coupled to the

low impedance and of impedance transformer 14 is a multi-port output consisting of output lines 6 which are each coupled to a respective column of radiators 1.

FIG. 4 illustrates a configuration for generating 15 Hz modulation required by Tacan systems. The transmitter output, or carrier signal, is fed into center conductor 5. The TEM mode, or normal coaxial mode, then propagates along the distribution and mode generating cavity. As stated previously, the H_{11} mode is induced by the excitation of probes 4 and propagates through the distribution cavity to the impedance transformer 14. Thirty-two probes are located radially within the distribution cavity of the antenna. Certain of these probes have been given letter designations to facilitate the explanation of operation. It has been found that the excitation of three probes having the proper angular displacement is beneficial in reducing the H_{21} mode within the cavity. For use in the TACAN system it is important to reduce this component which would result in a second harmonic modulation function in the radiated signal. In our example, three probes are simultaneously excited each separated by 45° . As stated previously, the required 15 Hz modulation is produced by the excitation of the probes. In this manner, the H_{11} coaxial mode of propagation is generated. The excitation of the probes, however, is not necessarily advanced simultaneously. One example of a usable sequence for TACAN would be: first probe I is advanced to J; then probe E is advanced to F; then probe A is advanced to B etc. In order to produce a rotating modulation pattern, the pattern of excitation would rotate around the circular array of 32 probes. Therefore, the sequence of excitation will be as follows:

AEI, AEJ, AFJ, BFJ, BFK, etc. After impedance reduction via impedance transformer 14, the RF energy is applied to output lines 6 which are, in turn, coupled to radiators 1.

In the above example, a rotating limaçon pattern is radiated. However, it should be clear that this method can be used to sequentially orient the limaçon pattern in any predetermined sequence of directions. This would have the effect of encoding the modulation function. In order to encode a TACAN signal both the 15 Hz and 135 Hz switching sequences could be simultaneously encoded.

The transmitter output, or carrier signal is fed into center conductor 5, and the outputs 6 at the low impedance end of the transformer are coupled to radiators 1 located on the periphery of antenna 2. FIG. 2a illustrates in more detail a radiator 1 and the means by which it is connected to the output of distribution cavity 3. As can be seen, the dipole may be tubular such that the center conductor of coaxial cable 6 extends through element 18 and is coupled to element 19 at point 20. The outer connector of coaxial cable 6 is coupled at the wall of antenna 2 to element 18.

The TEM mode, or normal coaxial mode in the transformer propagates along the distribution cavity, and its phase shift is a linear function of frequency as shown by curve A in FIG. 5. The H_{11} mode induced by the excitation of probes 4 also propagates through the distribution cavity; however, its phase shift is a variable function of frequency. This is shown by curve B in FIG. 5.

It can be seen from FIG. 5 that the phase of the H_{11} mode along the distribution cavity shifts at a slower rate than that of the normal TEM mode, and that they

are in-phase at only one frequency denoted in FIG. 5. The point of intersection of the two curves is fixed by choosing the proper design criteria of the RF transformer, distribution cavity and location of the probes.

A broader bandwidth can be obtained by proper location of an additional ring or additional rings of modulating elements within the cavity.

By appropriate adjustment of the phase of the RF currents in the excited probes, the resulting modulation component may be brought into phase with the carrier near the design center frequency of the band. The maximum bandwidth can then be determined from the dimensional considerations of the transformer section. The adjustment of the phase of the RF current in the probe is accomplished by controlling the self-impedance characteristic of the probe assembly. The basic probe assembly is shown in FIG. 6. Diode 10 is grounded to the outer conductor of the transformer section and, at its other end, coupled to high impedance bias choke 11. The free end of choke 11 is coupled to the digital logic control.

FIGS. 7-13 show various ways of resistively and/or reactively loading the probes. FIG. 7 shows pure inductive loading, FIG. 8 pure capacitive loading and FIG. 9 pure resistive loading. FIGS. 10-13 illustrate more complex loading techniques. The proper loading configuration would be a function of the particular problem to be solved and a particular environment.

It is to be understood that the foregoing description of specific examples of this invention is made by way of example only and is not to be considered as a limitation on its scope.

We claim:

1. A method of modulating a transmitter carrier signal in the distribution cavity of a non-rotating antenna, which antenna produces a limaçon radiation pattern comprising:

injecting all of said transmitter carrier signal into the center conductor of an RF impedance transformer located within said distribution cavity;

sequentially exciting, according to a predetermined pattern, a plurality of probes projecting into the distribution cavity to excite the H_{11} coaxial mode of propagation in the cavity;

adjusting the phase of the RF currents in said excited probes to bring the resulting modulation component in phase with the carrier at a desired center frequency; and

extracting signals having the desired amplitude and phase functions from the outputs of said transformer.

2. A method according to claim 1 wherein said rotating limaçon function is a rotating cardioid.

3. A method according to claim 1 wherein said probes are resistively loaded.

4. A method according to claim 1 wherein said probes are reactively loaded.

5. A method according to claim 1 wherein said probes are resistively and reactively loaded.

6. A method according to claim 1 wherein probes excited in succession are angularly displaced from each other to reduce excitation of higher modes within the distribution cavity.

7. A method according to claim 6 wherein said angular displacement is 45° .

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