UNIDIRECTIONAL DIRECTION FINDER OF ATMOSPHERICS

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Summary—The author devised an unidirectional C.R.D.F. A sense amplifier, with a small vertical antenna, was added to conventional twin channel amplifiers, with brilliance modulation device.

Being equiped with special accessories, it keeps fairly high accuracy in direction finding compatible with the unidirectional characteristics.

1. Introduction

In order to afford convenience to determination of atmospherics at a long distance by triangulation or by telemetry, we devised an unidirectional direction finder of atmospherics after ordinary principles but with advantages not to reduce its sharp directivity of bidirectional one. To keep strictly same characteristics among N-S amplifier, E-W amplifier, and sense amplifier, we accorded exactly equal circuit Q for every amplifier system by choosing suitable circuit elements; at the same time, to compensate 90° phase difference between vertical antenna system and frame antenna systems, we inserted a single resonance circuit between the antenna coupling circuit and the sense amplifier. As is ordinary the case outputs of N-S and E-W amplifiers are connected respectively to proper deflecting plates and that of sense amplifier to control grid of cathode ray tube by way of billiance modutation circuit. Fig. 1 shows a block diagram of this system.

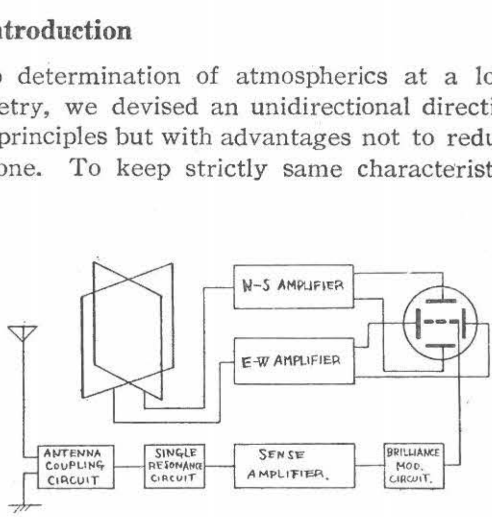

FIG. 1

2. Antenna System

To obtain for the output of vertical antenna system exactly the same amplitude and phase with those of N-S and E-W systems we must keep the following relation as shown in Fig. 2,

$$MG = \frac{NA}{Ch_v} = \frac{h_l}{\omega h_v}$$

where M is a mutual inductance, G transmission conductance of antenna coupling circuit, h_v its effective height, N number of turns of frame antennas, A their area, h_l their effective height, C velocity of light in vacuum, and ω circular frequency. In equation (1) N, A, C, h_v, and M are all real quantities, and so G must be also real, *i.e.* G must consist of pure conductance, and we see further that characteristics of this circuit is independent of frequency, which is one of the important advantages

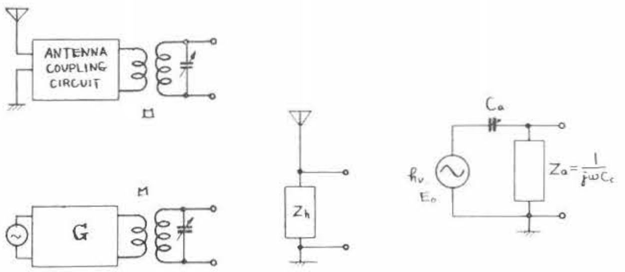

FIG. 2

in our case, and it must have a wide passband too for minimizing transit time in it.

As the vertical antenna is 5 m in length, which is very short compared with the receiving wave length (30 km), it can be represented by an equivalent capacity (10 pF), and therefore to avoid phase change in this part we inserted a condenser C_c in series with the vertical antenna and its terminal voltage was connected to the control grid of 6 SH 7, output of which was then derived by cathode follower and put into the control grid of 6 SK 7 as shown in Fig. 3.

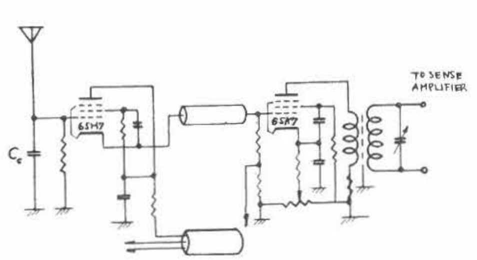

FIG. 3

If we take g_{m_1} and g_{m_2} as mutual conductances of 6 SH 7 respectively, we get

$$g_{m_2}=\frac{h_l(C_a+C_v)(1+g_{m_1}R)}{\omega M h_v C_a g_{m_1} R}$$

and could evaluate its value, *i.e.* g_{m_2} 200 in our case which can be attained easily by adjusting a variable resistance. In Fig. 4 we show a Lissajous figure, in various frequencies, composed of a frame antenna output impressed on a vertical deflection plate of oscilloscope and a vertical antenna output on its horizontal one. The frequency compensation was found to be 87°50′ instead of 90° and $Q=20$, but it is quite tolerable in our practice.

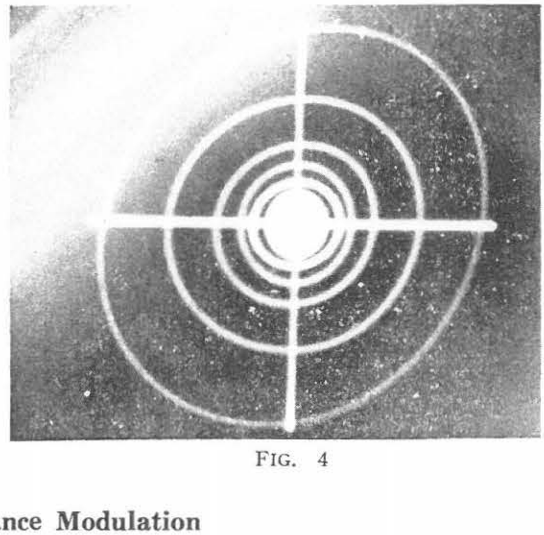

FIG. 4

3. Brilliance Modulation

Output of the sense amplifier is impressed on the grid circuit of oscilloscope to control the electron beam so that it may keep either a half luminant line on the screen between the arriving sense and the origin or a full line of arriving direction through the origin except a small dark space near the origin on the opposite side of arrival. Fig. 5 shows a connection diagram which meets well the above requirements by switching appropriately a following circuit system A, B, and C. A system generates a rectangular wave for a fixed interval in synchronizing with atmospherics, and B system a rectangular wave at every half cycle of atmospherics, and C system a rectangular wave at every half cycle when the intensity of atmospherics exceeds certain fixed value. Consequently when A system is used, the direction finder reveals bidirectional characteristics, and when A and B are used, the direction finder reveals unidirection characteristics in which one half line on the oscilloscope vanishes, and finally when A, B and C system are used, the direction finder reveals unidirectional characteristics in which a full line appears on the

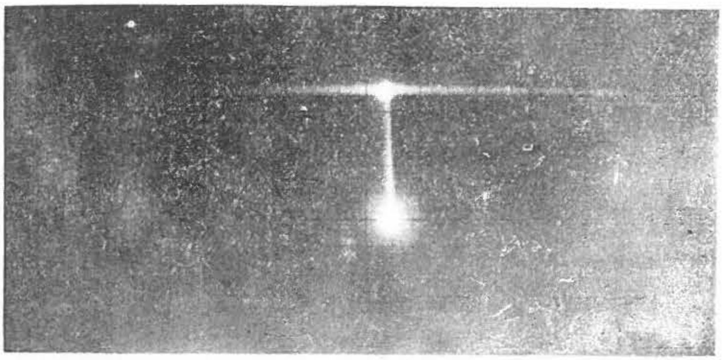

FIG. 7

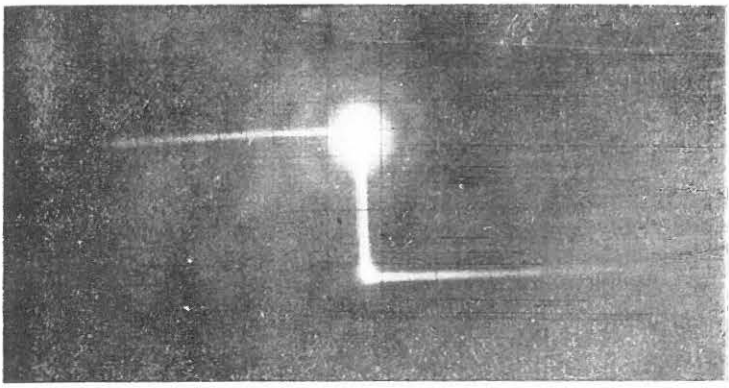

FIG. 8

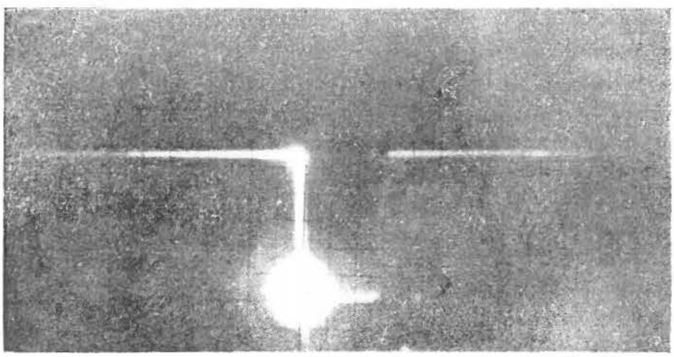

FIG. 9

scope except a small dark space near the origin in the opposite side of the arrival of atmospherics.

In Fig. 6 (1) shows a wave form of atmospherics which enters into the brilliance modulation circuit. (2) is a half-wave rectified rectangular wave generated by wave (1) through a cathode coupled rectangular wave generator composed of 1/2-6 SN 7 and 6 AC 7 in Fig. 5. The level of the rectangular wave (2) is controled by a variable resistance in 6 AC 7. (3) shows output of a biased rectifier circuit and the duration of the rectangular wave depends on the amplitude exceeding the bias voltage. In order to get wave (4) in adding waves (2) and (3) we employed anode coupling which reveals fairly good limiting characteristics. This was further

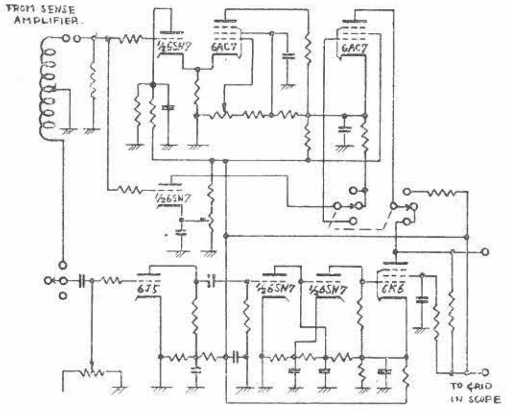

FIG. 5

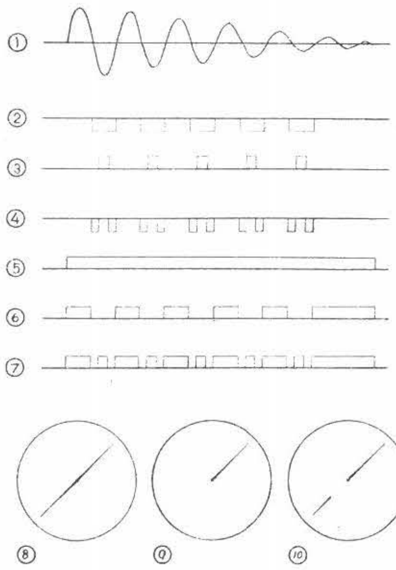

FIG. 6

amplified by 6 AC 7 which improved limiting characteristics further more in addition to phase reversal. (5) is the rectangular wave which appears for a fixed duration and synchronized with (1). This is obtained through 6 J 5 and 6 SN 7 which is improved further at the stage of 6 K 6. (6) is obtained by adding (5) and (2) through anode coupling, and (7) by adding (5) and (4). If we impress waves (5), (6), (7) to the grid, biased negative, of the oscilloscope we obtain a luminous line on the scope as shown in the figure by (8), (9), and (10) respectively.

Figs. 7, 8 and 9 show behaviour of pulse in brilliance modulation circuit, when a damped wave pulse is impressed on the horizontal deflection plate and to the input of the brilliance modulation circuit whose output is put on the vertical deflection plate. These pictures on the scope show that all requirements are fully satisfied.

4. Conclusion

It is of no saying that the unidirectional direction finder of atmospherics has many advantages over the bidirectional one so long as the former does not reduce the sharp directivity of the latter.

The one discussed above is a proposal which satisfy the requirements, and we should like to improve behaviours, stability, facilities for treatment in future study.