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Frequency Modulated Rawinsonde

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ABSTRACT. The paper describes a method of frequency modulating a 400 mc/s U.H.F. transmitter by utilising the ionising properties of a neon tube to change the terminating impedance of a transmission line (tank circuit) periodically. With this method a 400 mc/s transmitter can be used for both radiosonde and radio-wind-finding work. The paper also describes how the method has been adopted to telemeter radiosonde data. Brief description of the relay circuits and changes in the design of radio-theodolite receiver (ground equipment for radio-wind-finding) for recording the data are given.

1. Introduction

At present the India Meteorological Department uses two transmitters for radiosonde and radio-wind-finding purposes; one operates on 400 mc/s and is used for radio-wind-finding with radio-theodolite while the other operates on 75 mc/s and is used for telemetering chronometrically radiosonde data. By introducing the intelligence telemetered by the 75 mc/s transmitter, in the form of frequency modulation to the high frequency 400 mc/s transmitter, it has been possible to combine the functions of the two transmitters in one which operates on 400 mc/s. The combined signal is separated in the two different channels provided in the radio-theodolite and are known as A. M. and F. M. channels. The A. M. channel output gives the wind information and is fed to a C. R. tube while the F. M. channel output is fed to the recorder through a relay unit and it gives information regarding temperature, pressure and humidity.

The need for combining the two transmitters and for replacing them by a single 400 mc/s frequency modulated one was felt for quite a long time in order to gain the following advantages—

(1) The reception is done by an antenna directed towards the transmitter and hence the received signal is always of good strength, (2) Interferences which occur when operating in 75 mc/s band are eliminated, (3) The fading which is frequent for radiosonde signal received with a vertical dipole receiving antenna is also eliminated in this method, (4) The cost per flight is reduced considerably by the use of one transmitter and battery instead of two, and (5) The reception of the signal is easier as the F. M. signal is always visible on the C. R. tube screen.

Although some work had already been done to combine the two transmitters by Mathur, Dhar and Bhattacharya (1956), their method was found to be uneconomical as it required a large number of additional components including one additional tube. Therefore the method could not be adopted for routine use. The method described in this paper is a very simple and economical one.

2. The principle of the present system

A 75 mc/s transmitter for radiosonde observation and a 400 mc/s transmitter for wind observation is attached to the sounding balloon. The H. T. of the low frequency transmiter is connected through the contact of the meteorograph so that when contact is made between the rotating helix of the meteorograph and one of the pens connected to the datum, temperature or pressure element, the transmitter is switched on and the signal is received on the ground. From the distance between datum and temperature or pressure which is obtained on the recorder, the temperature or pressure can be

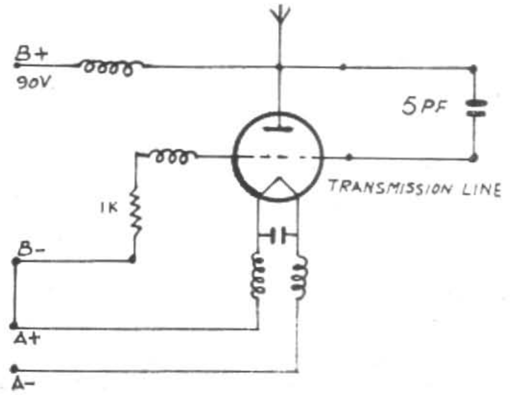

Fig. 1. 400 Mc/s Transmitter

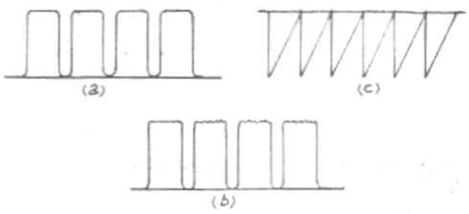

Fig. 3. Waves showing receiver outputs

(a) Receiver output for unmodulated signal
(b) Receiver output for modulated signal
(c) Frequency modulation signal and receiver F. M. channel output

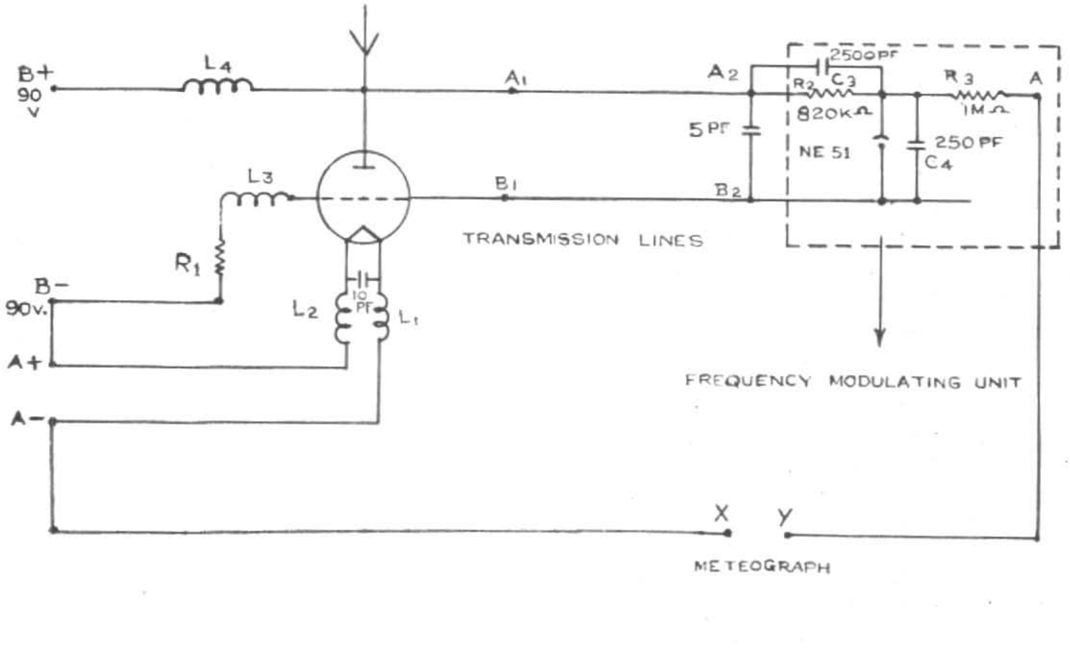

Fig. 2. Frequency Modulated Rawin Transmitter

found from a previously prepared calibration chart. The receiver is a regenerative one which detects the r.f. signal and feeds its output to the recorder where marks are obtained on a moving graph paper whenever the transmitter is on.

The 400 mc/s transmitter is a c.w. one. The radiated signal from this transmitter is tracked by a directive antenna having four bays or sections. Each bay consists of eight half-wave elements spaced one-quarter wave-length apart. The bays are connected to the receiver in succession by a motor driven switch known as phasing switch. The receiver has two channels, one for receiving amplitude modulated and the other for frequency modulated signal. The 400 mc/s signal is received through A.M. channel and is fed to a C. R. tube where it appears in the form of four pips. When normal to the antenna plane is directed towards the transmitter carried by the balloon all the four pips are then balanced and are equal in height. The azimuth and elevation angles indicated on the rawin equipment are the azimuth and elevation of the balloon.

When frequency modulated signal is received, it passes through the F. M. channel and after discrimination the modulating signal only is received at the output of the F. M. channel. This wave form of the modulating signal can also be seen on the C. R. tube by switching the C. R. tube circuit on to the F. M. channel.

3. Principle of the modified instrument

For frequency modulating, the U. H. F. transmitter with transmission line as tank circuit, the ionising properties of a neon tube and the consequent change of the tube's conductance to bring in a desired change in the carrier frequency of the U. H. F. transmitter was used.

The carrier frequency change is a function of —(1) The additional impedance that is thrown across the lines parallel to the terminating impedance required for 400 mc/s operation, (2) The change brought about in the grid bias of the U. H. F. transmitting tube; while the rate at which this is brought is governed by the rate of ionisation of the neon tube.

Figs. 1 and 2 give the circuit diagrams of U. H. F. transmitter radiating unmodulated carrier and frequency modulated carrier respectively.

4. Description of the circuit and its working

The working of the 400 mc/s transmitter radiating unmodulated carrier is very simple and needs no description here. Only a brief description of frequency modulated transmitter will be given here.

A1 A2, B1 B2 are resonant lines. R3, R2, C3, C4, NE 51 are the modulator circuit components.

The condenser C3 charges through R2 from 90 volts battery source and when the P. D. across the neon rises to ionising potential, the neon fires and remains conducting till the potential across it falls to a value where the gas can no longer remain ionised. During the period the tube is conducting (1) a positive voltage is applied on the grid of the rawin transmitter, and (2) a change is brought about in the terminating impedance of the transmission line. The effect of these two operations results in a shift of carrier frequency and frequency will remain shifted till the neon is deionised. The rate or frequency with which the carrier frequency is shifted gives the frequency of modulating signal. Graphically, it can be represented as in Fig. 3.

It will be seen that the rate of ionisation can be controlled by choosing the values of R2 and C3 while frequency shift can be adjusted to the desired modulation level by proper choice of R1, the grid resistor of the rawin transmitter.

C4 is to bypass the H. F. as any H. F. potentials developed across the neon ionise it.

Values of the components used are:

R1—3·3 Kohm 1/4 watt carbon, R2—820 Kohm 1/4 watt carbon, R3—1 Mohm,

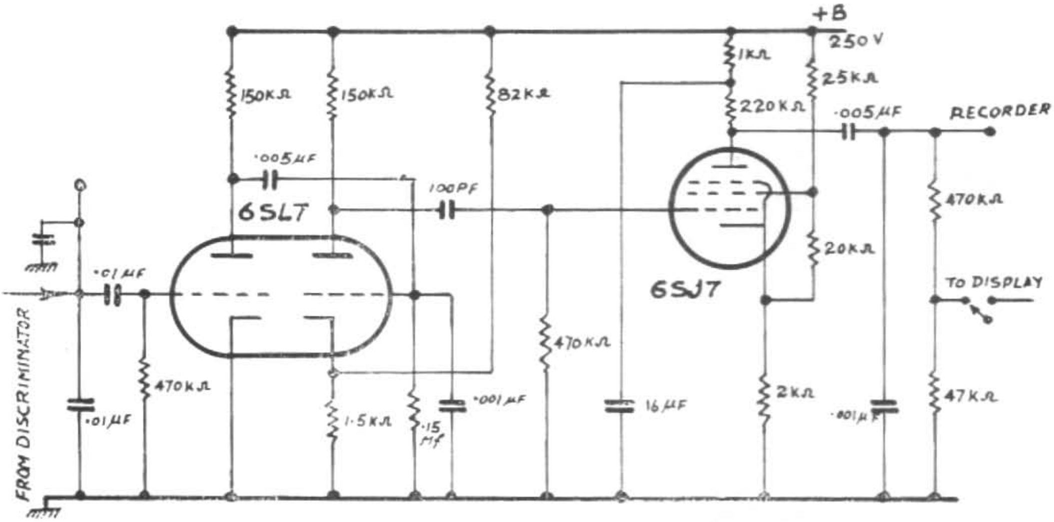

Fig. 4. Rawin receiver low frequency stages (modified) after discrimination

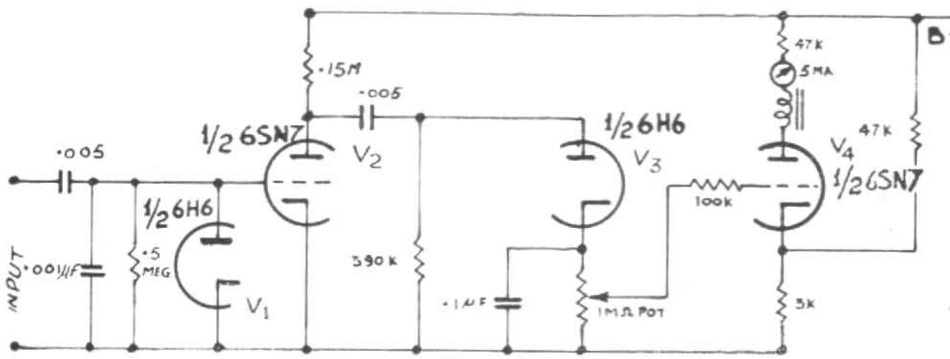

Fig. 5. Rawinsonde relay unit

C3—2500 Pf. paper, C4—250 Pf. mica, and Ne2 or Ne51—Neon tubes.

The meteorograph is connected across the points X and Y. When the meteorograph pen makes a contact, the terminal A of R3 is grounded. The P. D. across the neon is steadily kept at 45 volts, which is far below the striking potential of it. The condensor C3, therefore, cannot build up charge to ionise the neon. Thus, the neon is in a deionised state so long as the meteorograph is closed. During this period there is no frequency modulation.

A modulating frequency of 500 cycles is used. The low frequency stages following discriminator stage in the F. M. channel, (Inverter, Clipper Differentiator, and Shaper) of rawin receiver are redesigned to have a band width of 300 to 1500 c/s from its original band width of 10-200 c/s. (The modified circuit of the low frequency stages is shown in Fig. 4). Large band width of the receiver is necessary to allow for the drift in modulating frequency with change of H. T. battery voltage. A circuit operating at 650 c/s with 'B' battery 90 V will give a frequency of 400 c/s when the voltage falls to 78 V. This

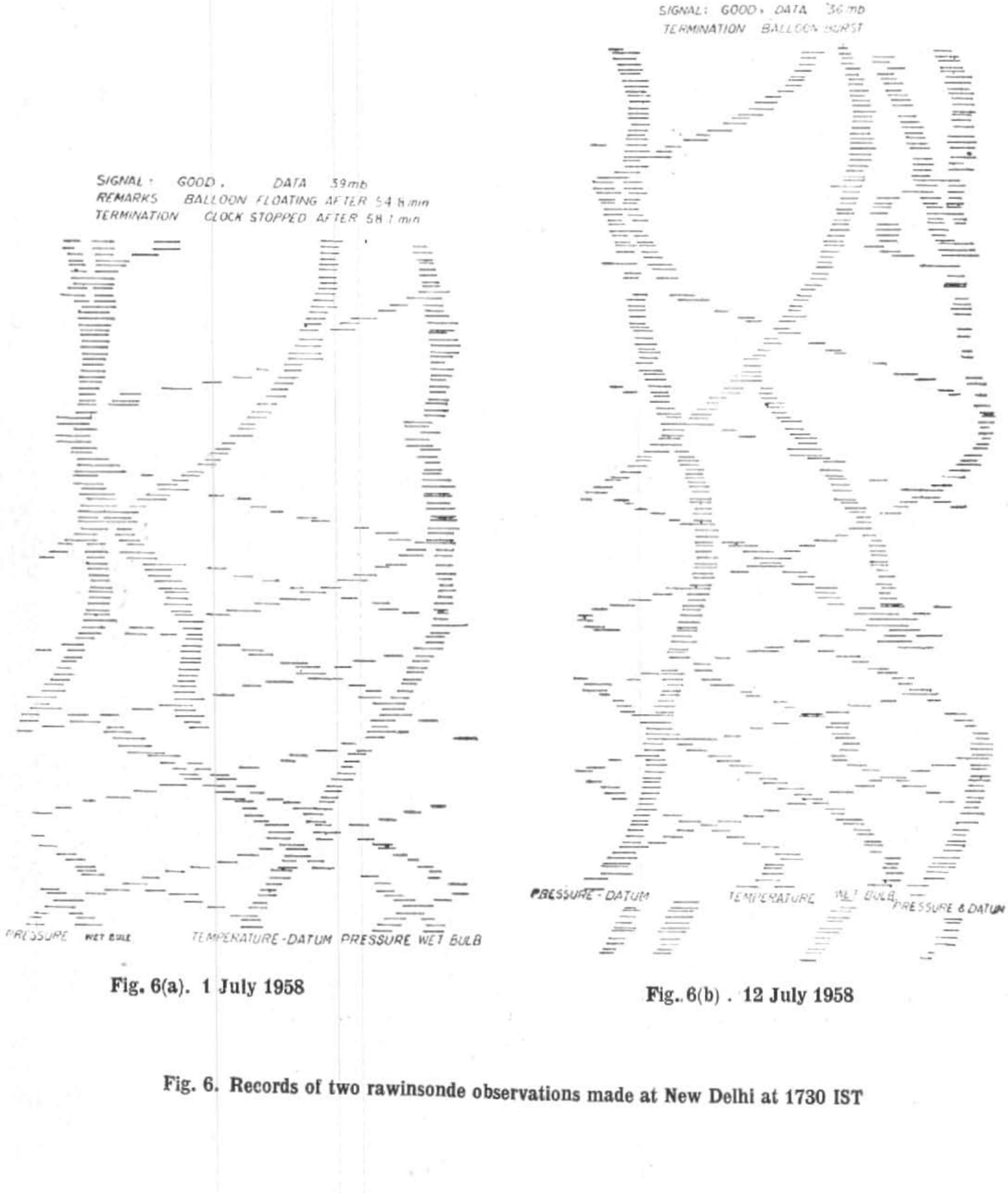

Fig. 6(a). 1 July 1958

Fig. 6(b). 12 July 1958

Fig. 6. Records of two rawinsonde observations made at New Delhi at 1730 IST

TABLE 1

Height (mb)	Total No. of flight terminated in the range	Reason for termination being either clock stop or balloon burst	Reason of termination being signal failure
500	2	2	0
200—500	7	5	2
200—100	30	21	9
100— 50	73	59	14
50	17	15	2
Total	129	102	27

drain is entirely due to the transmitter H. T. current of about 30 ma. The neon draws only 5 microamperes of current.

To operate the recorder relay, the output of the F. M. channel consisting of negative saw-tooth pulses, are fed to a relay unit (Fig. 5), where they are clamped to zero, inverted and rectified. The D. C. voltage developed after rectification is applied to the grid of the valve kept at cut-off by applying positive potential at its cathode. When signal is applied to the relay unit the tube V4 draws current and actuates a relay RL1. The values of R and C are so chosen that the voltage across R developed by noise is below the level required for rendering the tube V4 conducting. This makes the relay respond only to the signal frequency.

When the meteorograph pen makes a contact, the modulation is off and the tube V4 is driven to cut off, thereby releasing the relay RL1 and operating the recorder.

The advantages of putting off modulation when the pen makes a contact is that the observer following the balloon with the rawin theodolite can at his convenience switch on to the F. M. signal and observe the radiosonde signals which are seen on the scope as saw-tooth pulses. When the pens of the meteorograph make a contact, the saw-tooth signal on the scope disappears, thus enabling him to observe the state of signal and the pen contacts all the time the flight is in progress, unlike the method of switching on radiosonde transmitter by pen contact wherein the signal could be observed only 4 times in every thirty seconds, *i.e.*, when meteorograph pen contacts are made.

The records of two flights are shown in Fig. 6. It may be seen from the records that signal is free from interference and the record obtained is very clear till the end.

5. Flight reports

At Delhi the method was used in 129 regular flights for getting upper air observations between June and November 1958. Table 1 indicates the performance of the rawinsonde.

In some cases, signals from the transmitter could be picked up even after 90 minutes after release of the balloon. The cases of signal failures are due to the received signal becoming noisy and this happened mostly after 60 minutes of flight. In 80 per cent of the cases the flights had to be abandoned as the balloon burst or the clock stopped, when the frequency modulated signal was quite good.

REFERENCE

Mathur, L. S., Dhar, N. C. and Bhattacharya, H. S. 1956 *Indian J. Met. Geophys.*, 7, p. 165.