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A method of telemetering chronometric radiosonde data through rawin channel

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ABSTRACT. The paper describes a method of telemetering chronometric radiosonde data on the F-M channel of the receiver of the radio-theodolite. A squegging oscillator is used in conjunction with the chronometric radiosonde to obtain F-M signals from the 400 Mcs rawin transmitter at each contact of the meteorologically sensitive pens with the contacting helix of the radiosonde. With the ground-based rawin receiver an auxiliary electronic unit is used to work the radiosonde recorder, whenever the F-M signals are picked up by the radio-theodolite receiver. The details of the balloon borne unit and auxiliary equipment are also described.

1. Introduction

For about a decade both C-type (Mathur 1946, 1948) and F-type (Venkiteshwaran et. al 1948) radiosondes have been in use at 12 stations in India for the determination of temperature and humidity aloft. Recently, a number of these radiosonde stations have been equipped with radio-theodolites for the determination of upper winds. The method has generally been to attach to the same balloon a 400 Mcs transmitter along with the radiosonde instrument. The radiosonde transmitter operates at 80 Mcs and the signals from the meteorograph unit are recorded on a ground-based receiver and recording equipment tuned to 80 Mcs. The receiver of the radio-theodolite works on a frequency of 400 Mcs and tracks the rawin transmitter by means of an antenna system utilising split-pattern tracking. There are four antenna bays consisting of 32 half-wave elements spaced half wave-length apart. There are four positions of the antenna lobes and four pips appear on the oscilloscope, each pip representing one position of the lobe. When the pips are of equal height, the antenna system is directed normal to the direction of propagation of the radio beam from the rawin transmitter in the balloon. The receiver of the radio-theodolite has two channels (Metox Tech. Manual); (1) through which the F-M radiosonde signals can pass and (2) in which the receiver carrier is pulse-modulated in synchronism with the antenna phasing. Through these two channels information is received regarding radiosonde data comprising values of pressure, temperature and humidity and rawin data giving the angular co-ordinates (azimuth and elevation) of the balloon at minute intervals. The height values are obtained from the pressure data from the radiosonde and thereby the wind velocity and its direction is measured at different levels in the upper atmosphere.

For quite some time the need for obtaining both radiosonde and rawin data from the same transmitter has been keenly felt. The use of a single transmitter also helps in eliminating a separate radiosonde receiver in the ground equipment. The main problem was how to adapt the chronometric radiosonde to obtain temperature, pressure and humidity data on the F-M channel of the radio-theodolite receiver. In the present paper a method has been described whereby the 80 Mcs radiosonde transmitter has been dispensed with and the 400 Mcs rawin transmitter has been made to give F-M signals at each contact of the meteorologically sensitive pens with the contacting helix of the meteorograph unit of the radiosonde. This simplification has naturally decreased the cost of the combined rawin-radiosonde flight and has also eliminated a separate operator for the radiosonde recorder. The method described in the following paragraphs can be modified in other ways also to telemeter the radiosonde data to the ground station, but here we have confined our attention to the use of the existing F-M channel of the radio-theodolite receiver to collect the radiosonde intelligence.

2. Balloon-borne instrument

The balloon-borne instrument consists of (*a*) chronometric radiosonde, (*b*) 400 Mcs oscillator, (*c*) 2 Mcs squegging oscillator, (*d*) common voltage dropping resistor, and (*e*) high and low tension batteries. A functional diagram of the balloon-borne unit together with the block-diagram for the radio-theodolite is given in Fig. 1.

Both the high frequency and the squegging oscillators have the same plate voltage supply through a common voltage dropping resistor. In addition the plate supply of the squegging oscillator is completed through the C-type meteorograph unit, so that when the pens of the meteorologically sensitive elements touch the contacting helix of the radiosonde the squegging oscillator is thrown into oscillations. When the squegging oscillator is thus supporting oscillations it draws plate current. This plate current from the squegging oscillator is superposed on the plate current due to H. F. oscillator through a common voltage dropping resistor. In this way, there is an extra voltage drop across the common plate resistor. This results in the droppage of the plate voltage of the H. F. oscillator, thereby causing the frequency of oscillation to drop also. Thus, at each contact of the pen with the helix, the H. F. oscillator emits F-M signals under the control of the squegging oscillator. In the normal operation, when the squegging oscillator is not on, we will have a non-frequency-modulated carrier at 400 Mcs.

A circuit diagram of the squegging oscillator of the rawin transmitter is given in Fig. 2.

The H. F. oscillator employs a sub-miniature tube R242P10(RT) which has extremely small electronic transit-time and inter-electrode capacity. The transmitter includes a Lecher bar tank circuit instead of the conventional lumped condenser and inductance circuit, thus rendering it capable of operation on the ultra high frequency of 400 Mcs. The squegging oscillator employs the tube IL4 which is connected as a triode in a Hartley circuit with a frequency of oscillation of 2 Mcs. The time constant of the IL4 grid circuit is purposely kept large so that it gets 'blocked' and 'unblocked' alternately at an audio-frequency rate of approximately 500 cycles/second. While the tube IL4 is unblocked and is supporting oscillation it draws plate current causing an additional voltage drop across the common voltage dropping resistance of 500 ohms. When the tube IL4 is blocked there are no oscillations and the plate current is zero and in this condition there is no voltage drop across the 500 ohms common resistor. The tube IL4 oscillates only during a small part of each audio-frequency period and during these brief periods the high frequency oscillation rate is also reduced by several hundred kilocycles below the carrier frequency of 400 Mcs. In this way, the carrier is frequency-modulated at an audio-frequency rate on each occasion the C-type meteorograph keys the squegging oscillator. The voltage supply is obtained through a dry battery pack which supplies 7·5 volt D.C. for the filament and 100 volt D.C. for the plate supply of the H.F. oscillator and 1·5 volt D.C. supply for the squegging oscillator.

3. Auxiliary equipment for ground-based radio-theodolite receiver

The F-M signals from the meteorograph unit of the balloon borne transmitter do not produce any change in the D.F. channel of the radio-theodolite receiver as all the I.F. coils have a broad selectivity with a band-pass of 3·5 Mcs. These signals are, however, detected by the F-M channel of the conventional F-M detector called the phase discriminator. This F-M detector is followed by an audio amplifier. These amplified audio signals are shaped into saw-tooth waves by the last stage of the F-M channel called the amplifier shaper. Thus during the short contact when the meteorograph keys the squegging oscillator there appear at the output of the F-M channel saw-tooth waves of the same

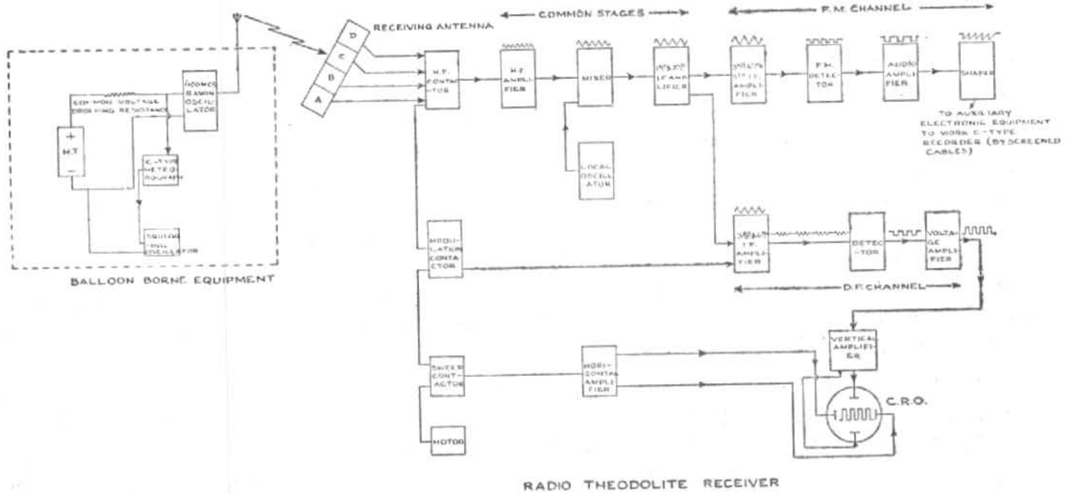

Fig. 1. Block diagram of balloon borne equipment and radio-theodolite receiver

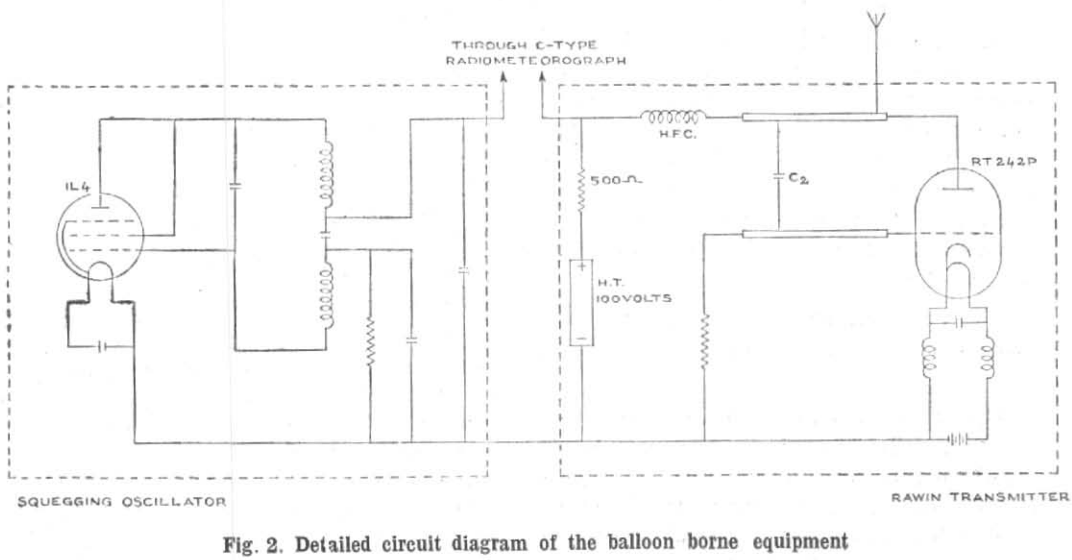

Fig. 2. Detailed circuit diagram of the balloon borne equipment

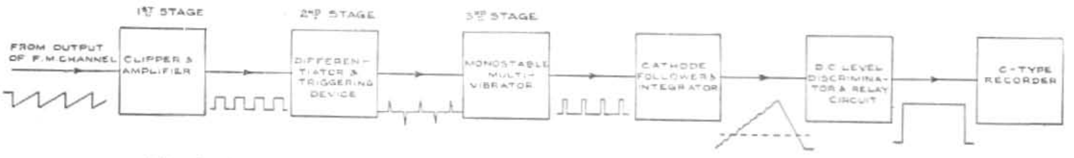

Fig. 3. Auxiliary electronic equipment to work C-type recorder (block diagram)

frequency as the squegging rate. At other times there is no output at the F-M channel.

This output from the F-M channel of the ground-based receiver is fed into an auxiliary equipment by means of a long screened cable. as the radiosonde recorder is housed inside a room whereas the radio-theodolite remains outside in a well exposed site. The auxiliary electronic equipment to work the C-type recorder is shown in a block diagram in Fig. 3.

It consists of five stages, *viz*, (*i*) clipper and amplifier, (*ii*) differentiator and triggering device, (*iii*) monostable multi-vibrator, (*iv*) cathode follower and integrator, and (*v*) D.C. level discriminator and relay circuit.

The saw-tooth waves from the output of the F-M channel are shaped into rectangular pulses by the clipper and amplifier which are then differentiated in the second stage and only positive triggers are amplified and applied to the monostable multi-vibrator. For each trigger pulse the monostable multi-vibrator gives one pulse of constant amplitude and width. The pulse width, however, can be varied by a potentiometer control at this stage. The next cathode follower stage isolates the previous stage from the integrator as each pulse is received from monostable multi-vibrator. A D.C. voltage is developed across the integrator which goes on rising as the pulses are fed into this stage from the multi-vibrator. The next stage is the D.C. level discriminator and the relay circuit. This discriminator has two stable stages. The one is in which the D.C. voltage across the integrator is below a pre-determined level in which condition no current flows through the relay and the second is in which the D.C. level across the integrator rises above the pre-determined level and the current flows through the relay. Thus by adjusting the duration of the pulse from the monostable multi-vibrator the D.C. voltage across the integrator is allowed to rise above the discriminating level due to incoming saw-tooth waves from the frequency modulated channel and the relay operates. When the relay in the D.C. level discriminator circuit works, it energises in turn the electro-magnetic relay of the 'C-type' recorder which operates the tapper bar over the recording styles, thus producing the conventional record of the chronometric radiosonde.

The detailed circuit diagram of the auxiliary electronic equipment used in conjunction with the F-M channel of the radio-theodolite receiver is given in Fig. 4. The actual equipment can be seen in Fig. 5. This chassis can be easily slided in the radiosonde ground equipment set in the space meant for the super-regenerative receiver of the radiosonde. The function of each stage of the auxiliary equipment is given in the following paragraphs:—

(*i*) *First stage* (Amplifier and Clipper stage)

In this stage a 6SL7GT type tube is used. The cathode of V_1 is kept at a 2 volt-positive potential with respect to ground by R_2 and R_3 combination. Negative saw-tooth voltages from the F-M channel are applied to the grid of V_1. The negative peaks are clipped off when the grid is driven beyond cut off. The signal then appears as positive truncated saw-tooth voltage at the plate of V_1. This is applied to the grid of V_2. The tube V_2 is kept beyond cut off by the R_6-R_7 combination. Whenever the grid of V_2 becomes positive with respect to cathode, grid current flows resulting in a drop across R_8. The positive clipping is effected. So in the plate of V_2 we obtain rectangular pulses of the same frequency as the input saw-tooth wave.

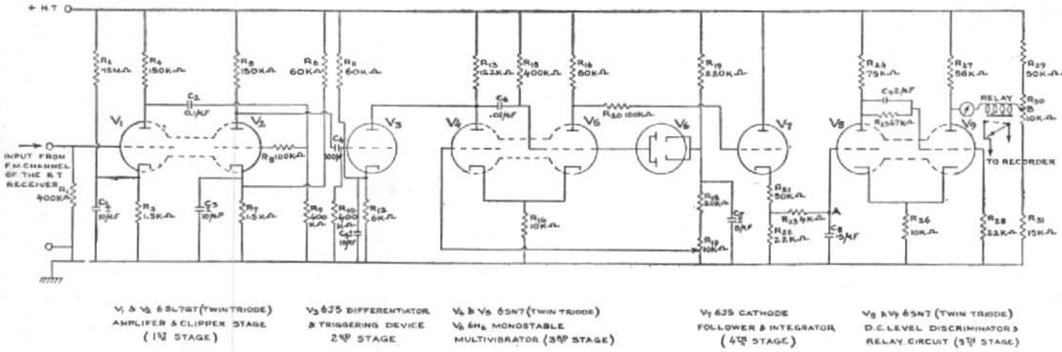

Fig. 4. Detailed circuit diagram of the auxiliary electronic equipment to work C-type recorder

(*ii*) *Second and third stages* (Differentiating and triggering device and monostable multi-vibrator)

The rectangular pulses from the plate of V_2 are differentiated by the C_4-R_{10} combination. V_3 is biased to cut off by the R_{11}-R_{12} combination. So only the positive triggers at the grid of V_3 make the tube conducting and therefore these positive triggering pulses are allowed to pass through the tube V_3. This appears as negative triggering pulses at the common plate load R_{13} of V_3 and V_4. This amplified negative triggering pulse actuates the monostable multi-vibrator.

The monostable multi-vibrator has a conventional circuit (Chance et. al 1949). C_6 and R_{15} combination ($\cdot 01\ \mu F$ and 400 K. ohms) is the timing circuit which determines the duration of the pulse. The diode V_6 (6H6) is used to define the initial level of the grid of V_5 which would otherwise vary greatly according to the cathode emission of V_5. The voltage of the grid of V_4 which can be controlled by a potentiometer R_{19} (10 K. ohms) determines the amplitude of negative rectangular pulse at the plate of V_4, consequently determining the time required by grid of V_5 to recover from this negative amplitude to the voltage at which the transition from unstable to stable stage is effected. Thus the duration of the pulse is also a function of the grid voltage of V_4. This enables us to have an extra control for the width of the output pulse of the monostable multi-vibrator.

(*iii*) *Fourth stage* (cathode-follower and integrator)

Positive rectangular pulses from the plate of V_5 are applied to the grid of V_7 which operates as a cathode follower. R_{20} (100 K. ohms) is connected in series with grid of V_7 to prevent the grid to become much positive with respect to the cathode of V_7. A fraction of the output of the cathode follower is integrated by the R_{23} and C_8 combination (4 K. ohms and $0 \cdot 5\ \mu F$). The average D.C. level at 'A' depends on the frequency and width of the incoming pulses.

(*iv*) *Fifth stage* (D.C. level discriminator and relay circuit)

When grid of V_8 is below a certain positive potential the tube V_8 is cut off, V_9 is heavily conducting and plate of V_9 is at a lower potential than the H.T. The recorder relay is connected between the plate of V_9 and the bleeder circuit at the point B. The voltage at B is adjusted for no current through the relay by equalising the potential at plate of V_9 and point B by potentiometer R_{30} (10 K. ohms). Now when grid of V_8 crosses a predetermined positive D.C. level, so as to allow current to flow through V_8, the plate potential of V_8 falls rapidly. This produces a quick transition and grid of V_9 goes beyond cut off. Thus plate voltage of V_9 rises, producing a difference of potential across the relay terminals and a current flows through the relay. When the grid of V_8 falls below the predetermined level, transition takes place from this stage to the original state in which V_8 is again cut off and thus stopping the flow of current through the relay and restoring the relay to its normal condition. Thus the relay operates only when the F-M signals are received.

4. Conclusion

Perhaps one would attempt to work the recorder relay of the chronometric radiosonde ground equipment set by employing a conventional relay circuit preceded by a few amplifier stages. This simple arrangement, however, was found to give rise to lot of difficulties on account of the spurious recording of unwanted noise signals. This difficulty was, however, eliminated by utilising frequency discriminating properties and employing a squegging rate of approximately 500 cycles/second. The saw-tooth waves at the output of the F-M channel appear only when the pens of the meteorologically sensitive elements touch the contacting helix of the meteorograph unit. During the time the contacts are not made by the helix there is no saw-tooth wave on the last stage of the F-M channel. A number of trial ascents were made with this equipment and very encouraging results were obtained. The auxiliary electronic equipment has been built on a chassis of the same dimensions as the old super-regenerative receiver of the radiosondes. Thus, by the replacement of the present radiosonde receiver with the auxiliary equipment the existing ground equipment sets can be utilised at our rawin stations. The radiotheodolite together with the modified type of radiosonde ground equipment set can be seen in Fig. 6. The photograph shows clearly the disposition of the auxiliary unit in relation to the main equipment.

5. Acknowledgements

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