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# A 403 mc/s Radiosonde Receiver

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ABSTRACT. The paper describe a radiosonde receiver that can handle frequency modulated signals in the 403 mc/s band. It works on superheterodyne principle and its output containing meteorological intelligence is in the form of pulses of constant height and width which are suitable for being fed to a frequency meter type recorder.

## 1. Introduction

The 403 mc/s radiosonde flight equipment now in use or projected for future use in the India Meteorological Department consists of a balloon borne 403 mc/s transmitter whose frequency is modulated at some audio frequency. In some models, this audio modulation is made "off" when one of the contact arms representing a meteorological element makes contact with the rotating helix in the meteorograph. In other models using a baroswitch, the modulation frequency is changed as the contact arm sweeps over different baroswitch contacts representing different meteorological elements. The need was felt for sometime to develop a receiver that can receive this 403 mc/s signal, extract the intelligence from it and process it in a way suitable for being fed to a frequency-meter type recorder or, as in the former case, simply on-off type recorder. The present paper describes such a receiver that has been designed, built and successfully tested under field conditions at the Instrument Laboratory of the Meteorological Office, New Delhi.

## 2. Objectives

To meet the system objective for radiosonde service, the receiver must satisfy the following general requirements —

(*a*) The receiver should be designed to permit reception in the frequency range between 398 to 408 mc/s,

(*b*) The receiver should respond to a carrier frequency which is frequency modulated with audio-frequency. This modulation frequency may vary between 10 to 200 c/s or may be of on-off type. The frequency deviation is about 300 kc,

(*c*) The I.F. should have a bandwidth of at least 1·5 mc/s,

(*d*) The output from meteorological data amplifier should be in the form of pulses of 30 volts peak to peak and 1000 to 2500 $\mu$ width,

(*e*) The minimum detectable carrier level should be of the order of 80 dbm, and

(*f*) Its operation and maintenance should be easy even under field conditions, where no great technical skill or costly testing equipment is available.

The following is a description as to how these performance objectives have been achieved in practice.

## 3. Principle of operation

The sensitivity requirements dictated the choice of the superheterodyne operating principle for the receiver and is illustrated in Fig. 1. The signal from the aerial is amplified in the R.F. amplifier. The mixer output is 30 mc/s I.F. which is amplified, limited and discriminated to give the audio output that carries all the meteorological intelligence. The meteorological data amplifier contains audio amplifiers and shapers to give an output waveform whose height and width are constant irrespective of the input frequency. Part of the audio amplifier is fed to the speaker to give an aural indication of the modulation. Part of I.F. is taken out, rectified and fed to the magic eye indicator.

## 4. Circuit description

For convenience of discussion, the circuit of the receiver is considered as consisting of the following major parts — carrier stage, I.F. circuits, meteorological data amplifier, indicators and power supply.

### 4.1. *Carrier stage* (Fig. 2)

It consists of a grounded grid input amplifier, a wide band modified semibutterfly local oscillator and a balanced triode mixer. The grounded grid configuration has wide band-width, high stability and low noise. Input is matched to 50 $\Omega$ antenna cable. All inductances are made up of thin strips of silver coated copper. The bandwidth of this amplifier is about 15 mc/s and gain 8 db.

The local oscillator is of the modified semibutterfly type (Sen Roy and Prakash 1966) and has a

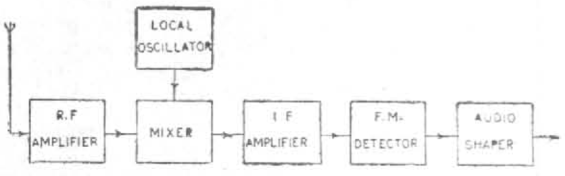


Fig. 1.

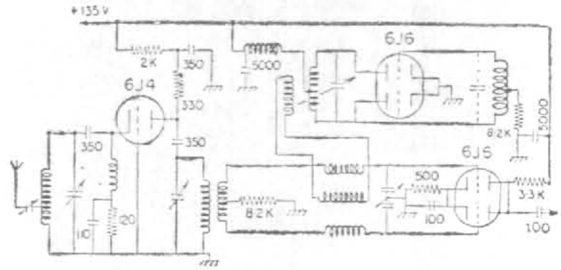


Fig. 2. R.F. amplifier

tuning range of about 75 mc/s so that tube or component replacement does not take out the required pass band completely outside the receiver operation. The rotor of the tuner is connected to the panel knob through a gear reduction of 40 which gives sufficiently smooth tuning. The mixer is of balanced triode type. This type has got the property of reducing noise from the local oscillator.

4·2. *I. F. amplifier and Ratio detector* (Fig. 3)

The I.F. amplifier consists of five stages of 6AK5 tubes. Because of low bandwidth requirement (1·5 mc/s), synchronous single tuned amplifiers were chosen. The design of individual stage has been made according to the procedure outlined by Valley and Wallman (1948a) and takes into account the fact that the overall bandwidth of $n$ such identical stages shrinks by a factor $(2^{1/n}-1)^{\frac{1}{2}}$ from the single stage bandwidth. The last two stages are made slightly different from the rest in order to protect them from overloading. Though additional capacitive loading to first two stages reduces gain bandwidth product of the stages, it nevertheless, improves the stability of pass band against variation of interelectrode capacitances when the tube is replaced. The coils are wound on bakelite tubing. In the absence of suitable ferrite cores, brass plungers are screwed in or out of the tube in order to have inductance variation. By this means inductance variation of the order of 50 per cent can be obtained.

The overall I.F. gain is about 86 db and bandwidth 1·5 mc/s. This excludes the small signal gain of about 10 db introduced by the limiter. The ratio detector gives good protection against noise due to random amplitude fluctuation, which itself is less because of the limiter.

4·3. *Meteorological data amplifier* (Fig. 4)

The ratio detector output is filtered and fed to three stages of audio amplifiers. The third stage is normally in cut-off condition and conducts only when the signal amplitude exceeds the noise level. This eliminates noise considerably. The final shaper stage is a Schmitt trigger that gives rectangular pulses of constant height and width for the input pulses which are in the shape of negative spikes of frequencies 10 c/s to 200 c/s. Frequencies above 600 c/s are progressively attenuated. The output pulse, as is shown in Fig. 5, has a width of 1·6 mc/s and peak to peak amplitude of 60 V.

4·4. *Indicators*

There are two tuning indictors provided in the receiver, one for the carrier and the other for modulation. For the carrier, a part of the I. F. output is rectified by means of a voltage doubler made up of two crystal diodes (Fig. 3) and is applied to a magic eye type indicator. A small transparent scale in front of the magic eye window enables the gap width to be measured, if necessary, and the carrier strength determined from previous calibration. Because of this scale, the magic eye can be used for the same purpose and with same accuracy as the conventional monitoring meter with the added advantage that the magic eye absorbs much less signal power than the meter.

For modulation indication, the output from the second audio stage (Fig. 4) is amplified and fed to a speaker with provision for volume control. Correct tunning is attained when the sound is maximum, even though the magic eye sometimes shows a little off-tuning of the carrier due to slightly different mid frequencies of the I.F. stages and the ratio detector. This aural indicator is also helpful from the operational point of view and under conditions when the fluctuating carrier level makes carrier tuning difficult.

4·5. *Power supply* (Fig. 5)

Regulated power supply giving 135 V is provided for the I.F. and R.F. stages so that mains fluctuations do not affect tuning. For the rest of the circuits, however, unregulated supplies are used.

#### 5. Mechanical design

The mechanical design of the receiver has been done with an eye to ease of operation and maintenance (Fig. 6). The magic eye has been placed on top right end of the receiver for optimum visibility. There are only three controls on the panel, power

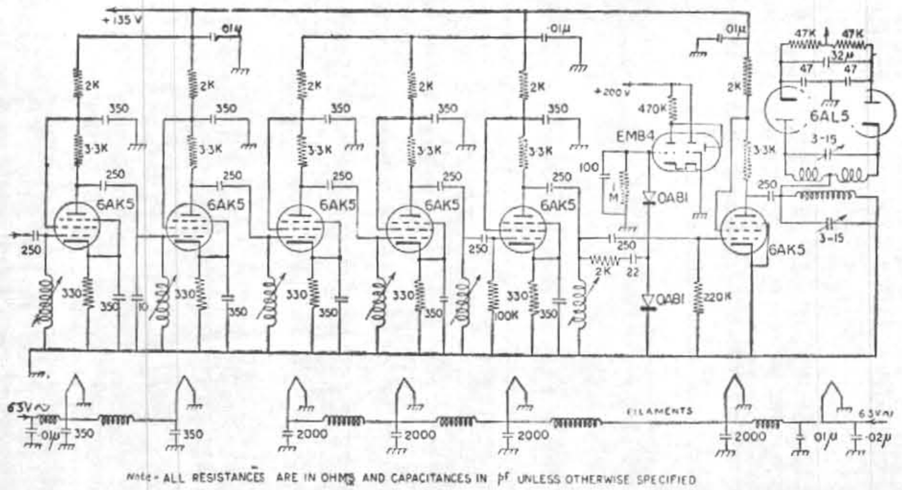


**Fig. 3. I. F. amplifier**

All resistances in ohms and capacitances in pf unless otherwise specified

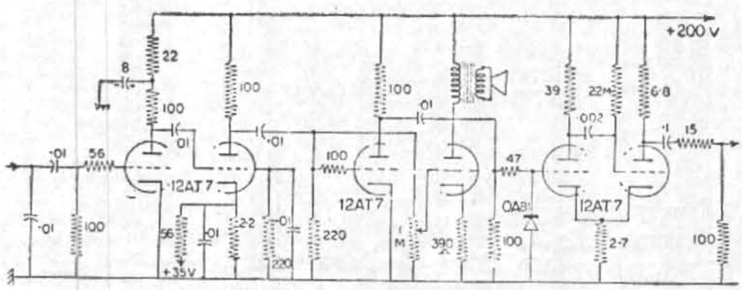


**Fig. 4. Meteorological data amplifier**

(capacitances in μF, resistances in kΩ unless otherwise specified)

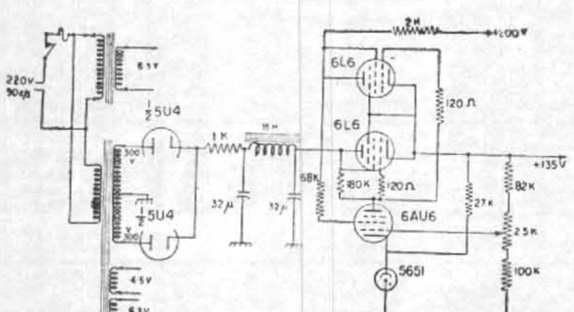


**Fig. 5. Power supply**

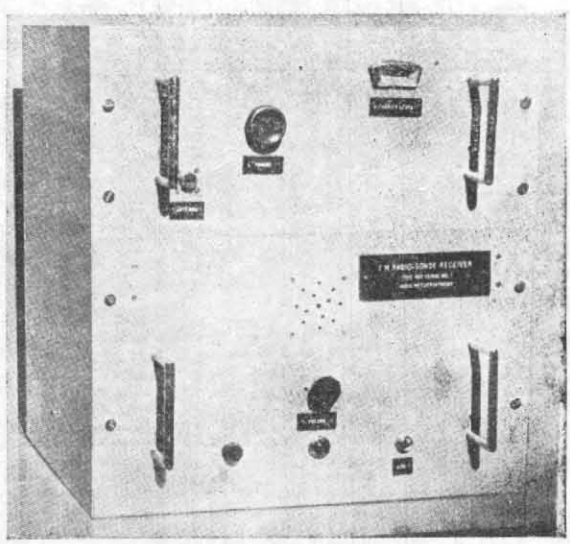

**Fig. 6**

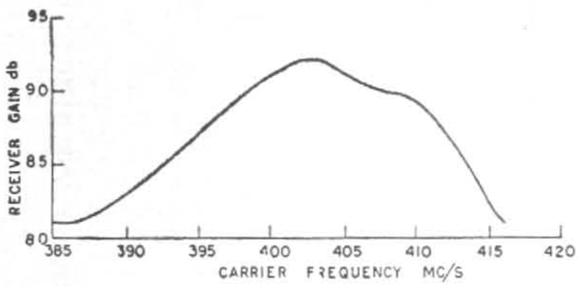


Fig. 7

switch, tuning knob and the volume control. The circuitry has been laid out in a logical pattern so that the mechanical flow from one end of chassis to the other follows the same sequence as the signal flow. The chassis is in the form of two decks. The power supply containing heavy transformers etc has been put in the lower deck while the upper deck contains the rest of the circuitry. The two decks are connected through multipin plugs and are removable independently from the cabinet. The upper deck circuitry is divided into three plug-in shielded sub units, carrier stage, I.F. stage including second detector and the meteorological data amplifier. This arrangement reduces the problem of maintenance to that of replacement of the defective sub units.

### 6. Testing and alignment technique

In testing the high frequency stages, *viz.*, carrier and I.F. Sections, a.c. measurement with the V.T.V.M. was not found to be very useful, as its probe not only disturbs the a.c. conditions but also introduces undesirable regenerative tendencies (Valley and Wallman 1948b) that are originally not present in the circuit. For this reason all h.f. measurements were carried out by means of the d.c. voltage coming out at the grid of magic eye tube. The calibration curve for this rectifier does not show any noticeable change within the frequency band 30 $\pm$ 2 mc/s. I.F. tuning has been done by feeding signal at I.F. input and measuring this d.c. voltage. For carrier tuning, 403 mc/s is fed at the antenna point after I.F. is tuned, and then the local oscillator is tuned for maximum detector output. All the variable elements in the R.F. stage are then changed to maximise this value. For aligning the ratio detector, the secondary is first tuned to get the cross-over point at 30 mc/s. The primary is then tuned for getting a symmetrical S-curve with maximum swing on either sides.

### 7. Performance

The minimum detectable signal is less than 7$\mu$V (90 dbm). The overall receiver characteristics of Fig. 7 have been drawn by feeding constant level carrier frequencies at the antenna point and measuring the I.F. output at the rectifier point after the receiver has been tuned. This curve, however, excludes about 10 db gain introduced by the limiter for small signal operation.

By using metox Radiotheodolite aerial and a 500 mW balloon borne transmitter a large number of successful radiosonde soundings have been made with this receiver at New Delhi. There was hardly any failure that could be ascribed to the limitation of the receiver. The cause of termination of the flight is almost exclusively the bursting of balloon, the longest recorded flight being of 100 minutes duration (better than 10 mb pressure level).

### 8. Acknowledgements

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*REFERENCES*

Sen Roy, N. and Prakash, S. 1966 *Indian J. Met. Geophys.*, **17**, 3, p. 477.

Valley, G. E. and Wallman, H. 1948a *Vacuum Tube Amplifiers*, Rad. Lab. Series, **18**, Chap. 4, McGraw Hill, N. Y.

1948b *Ibid.*, Chap. 8.