A method of using the Radar AA No. 3 MK III to track the F-type radio-meteorograph to obtain both radiosonde and upper wind data

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ABSTRACT. The paper describes a method of adapting the radar AA No. 3 MK III operating on 204 mcs to track F-type radiosonde signallers on this frequency and thus obtain in addition to radiosonde data, information about upper winds also at levels higher than what is possible with the radar tracking a dipole passive target. The details of construction of the signaller on 204 mcs and the radiosonde recording equipment are briefly described. The advantages of this type of adaptation in meteorological technique is indicated.

1. The radar equipment

The India Meteorological Department obtained a few radars—AA No. 3 MK III—for measurement of upper winds during cloudy weather (Fig. 1). Some of the specifications of this radar are—

Frequency . . . 204 mcs (wave length: 1·5 metre)

Pulse recurrence frequency . . . 1000 c/s

Pulse width . . . 1 microsecond

Peak power . . . 90 kw

Presentation . . . Type A with strobing device

Accuracy . . . ± 1° in angle between 20 to 70° for elevation and
± 100 yards in range

Range . . . Upto 16,000 yards

Antenna . . . Transmitting antenna is a single Yagi array with a folded dipole as an active element backed by a mesh reflector. Receiving antenna consists of four Yagi arrays mounted at the four corners of a square, with one of its diagonals in the vertical plane for elevation angles and the other for azimuth angles.

This radar is in regular use at Poona since 1949 for obtaining upper wind information, by tracking passive targets. As the wave-length of the radar is 1·5 metres, dipole targets are used. They are made out of three lengths of bare copper wires (18 S.W.G.), each of 27·5 inches in length, soldered in their middle at right angles to each other and fixed in a light bamboo frame. This type of target is simple to make and is also very light weighing only about 150 gms. Due to this, it is possible to use smaller size balloons to lift the target or to increase the free lift of the balloon to keep the target at fairly high angles to avoid "clutter" effects on the radar which appears when the target is at low angles at great distances.

When radar observations were first started in June 1949 at Poona, the target was attached to the F-type radiosonde balloon (1948) released at 1400 GMT and the rate of ascent was about 20 km/hr⁻¹. But during the monsoon months June to August, the winds in the lower levels at Poona are from the west up to nearly 6 km and blow at approximately 30 km hr⁻¹ in some levels. The balloons were, therefore, found to drift to low angles before they had reached any appreciable height and the radar echoes used to get lost in the ground clutter. To obtain upper wind information to greater heights, the rate of ascent of the balloon had to be increased to nearly 30 km hr⁻¹. The high rate of ascent, however, could not be employed with the radio meteorographs, and therefore the practice of
following targets attached to radiosonde balloons was given up and separate balloons were used to carry the light targets only. The balloons weighed about 350 gm and were given a free lift of 2000 gm. A summary of the upper winds obtained at Poona with the radar up to a height of about 13 km during the monsoon months in the two years 1949 and 1950 have already been published (Venkiteshwaran and Yegnanarayanan 1951).

2. Adapting the radar to track active targets

For obtaining upper winds with the radar AA No. 3, MK III up to a height of about 12 km separate ascents with fairly big sized balloons and high free lift will have to be adopted even with the light dipole passive targets mentioned above, not only during the monsoon months in Peninsular India, where the winds are strong westerly in the lower levels, but also in northern India during winter where also the winds are strong westerly.

Again, with this type of radar, it is possible to obtain upper wind information only up to a height of about 12 to 14 km under the best conditions. It was, therefore, examined whether the radar can be adapted to follow the F-type radio-meteorograph itself, if it is operated with a signaler with the same wavelength as that of the radar, viz., 204 mcs. In this case, the transmitting portion of the radar will not operate. The signals received from the radiosonde signaler will naturally be very much stronger than that from the dipole target scattering the energy from the radar transmitter. It can, therefore, be followed to much greater distances. Normally, when using the radar, the passive dipole target has to be followed through a telescope for centering the spot in the angle units till the target has moved to a distance of more than 1000 yards and the transmitted and received pips separate on the cathode ray tube for range. With the radiosonde signaler, the centering can be done from the instant the balloon is released.

When the radiosonde signaler is tracked with the receiving portion of the radar, it should be possible to obtain a record of the radiosonde signals with the usual F-type radiosonde recorder after some simple modifications. The radiosonde signals, together with the readings of the elevation and azimuth angles of the signaler every minute, will give both the radiosonde data and upper wind information. When the radar is working normally the height of the balloon is computed from the range and elevation angles. When tracking the radiosonde signaler, the height will have to be obtained from the values of pressure and temperature.

Normally the radar requires three people to operate it, one for the range, a second for the elevation and a third for the azimuth. However, the practice at Poona has been to have one person to operate the range and another for both the elevation and azimuth controls. A third person was necessary only for the first few minutes to keep the balloon in the field of view of the telescope fixed on the aerials till the transmitted and received pulses separated on the range oscilloscope.

Three persons including an observatory attendant are necessary to operate the F-type radiosonde. A total of five persons will be necessary for operating the radiosonde and radar simultaneously. If, however, the radar receiver can track the radiosonde signaler, both pressure, temperature, humidity and winds in the upper air can be obtained with three persons.

The method of obtaining information about pressure, temperature, humidity and winds in the upper air from the signals from radiosonde transmitter has been practiced in America (Kirkman and Lebedda 1948). Here the radiosonde transmitter operating on a frequency of 400 mcs is tracked with the Rawin equipment SCR-658. To obtain the humidity, pressure and temperature data, the output of the frequency modulated channel of the Rawin receiver is fed to the external radiosonde recording equipment where the results are recorded on a moving paper chart.

The two units, viz., the SCR-658 and the radiosonde ground equipment are independent
units. However, if information about upper
wind alone is required, it can be obtained
only by letting off with a balloon a
wireless transmitter operating at least a
pressure switch to obtain the height of the
balloon at different instants when azimuth
and elevation angles are noted. This method
is more costly and difficult than by following
with the radar a simple and light dipole target
made out of three pieces of 18 S.W.G. copper
wire let off with a small size balloon.

By the method described in this paper, the
radar can follow and record the radiosonde
signals and it will, therefore, be possible to
obtain both the radiosonde and upper wind
data. At the same time, when only upper
wind information is required, the equipment
can be used as a radar. The super-heterodyne
radar receiver can replace the super-regenera-
tive radiosonde receiver, and therefore only
the radiosonde recorder has to be suitably
coupled to the radar receiver.

The method of constructing the wireless
signaller for use with the radiometerograph
so that it can be tracked with the radar receiv-
er and the details of the radiosonde recorder
equipment are described below.

3. Signallers for use with F-type radio-meteorographs
for following with the radar

The feasibility of using the radar receiver
to follow the radio-meteorograph signaller
depends upon the construction of a suitable
radiosonde transmitter working on 204 mcs.
This was effected by altering suitably the
signallers used with the American Rawin
equipment SCR-658. The specifications of
these signallers are given below—

Frequency 400 mcs
Oscillator valve Type 955
Plates voltage 108 V
Filament voltage 6 V
Grid voltage 36 V

Fig. 2 (a) shows the diagram of connection
and Fig 2(b) is an exploded view of one of the
transmitters adapted to operate on 204 mcs
for use with the radio-meteorograph to be
tracked with the radar. The original sig-
naller on 400 mcs was modified as follows—

(a) The grid and anode Lecher wires were
extended by 5½ inches with 16 S.W.G. bare
copper wires. These wires were bent suitably
to minimise the overall size of the signaller.

(b) To minimise the drain on the H.T.
battery, the anode current was reduced by
increasing the grid resistance from 1500 ohms
to 20,000 ohms.

(c) A small R.F. choke is used in the H.T.
line to prevent any R.F. oscillations reaching
the battery. A 0·0005 mfd. mica condenser
across the meteorograph connections prevents
sparking at the contacts in the meteorograph
affecting the oscillator.

(d) The aerial used with the original sign-
naller (17 S.W.G. wire, 13 inches long) is
extended to 28 inches by soldering another
piece of copper wire.

(e) The H.T. and L.T. for the original
signaller was obtained from specially con-
structed lead cells manufactured for this
purpose in America. As such cells cannot
be obtained now in India, about 60 unit cells
of the type used with the F-type radio-
meteorograph were assembled to get on load
about 80 volts for the H.T. These cells
were assembled in a separate cardboard box
along with 5 unit cells (Eveready No. 935)
for the filament voltage. The plate current
is about 10 to 15 ma. during oscillations.
The grid bias of +35 to +40 was tapped from
the H.T. source. The weight of this whole
unit is about 600 gm and compares favourably
with the special lead cells manufactured for
this purpose in America weighing about
700 gm.

(f) The oscillator is placed in a wooden box
of size 7½” × 3½” × 3½” with the cardboard
box containing the batteries above it, and
the aerial hanging below. (Fig. 2 c).

(g) The R.F. power output of the modified
signaller is about 150 n illiwatt. Its overall
efficiency is about 30%. The signallers had
been tested in the laboratory for two hours
continuously. No appreciable instability in
their performance was noticed due to limited
Fig. 1

Fig. 2 (a). Oscillator producing 204 MHz

Fig. 2 (b)

Fig. 2 (c)
Fig. 3. Block diagram of arrangement for using the radar receiver to track the radiosonde signaller

Fig. 4. Connections for radiosonde recorder to coupling to the radar receiver

Fig. 5
anode or filament voltage changes. But
during actual flights there were slight fre-
quency drifts mainly due to temperature
changes experienced in the atmosphere.
There was, however, no difficulty in handling
this drift with the radar receiver.

4. Modifications in the radar receiver for using it with
the radiosonde recorder

For tracking the signaler on 204 mc coupled
to the radio-meteorograph, only the
receiver unit with its four aerials and phasing
switch, the signal selector, range calibrator
and the angle units are used. The trans-
mitter and the automatic range unit of the
radar are not necessary.

The receiver is a super-heterodyne set with
two R.F. stages, four I.F. stages followed by
video and peak rectifier stages; it has also
an arrangement for gating at the end of the
video stage. The angle units are fed from
the output of the peak rectifier. Nor-
maHy on C.W. or I.C.W., no signals will
pass beyond the second detector stage, and
it is necessary to modulate the signal at or
near 1000 cs to get the angle sensitivity.
This is obtained by the jamming location
device provided in the receiver. With this
device, a bias of 80 volts can be applied to
the first two I.F. stages in the receiver, thera-
by making these valves insensitive to the
incoming signals. At the same time, the
strobe pulse generated in the signal selector
unit by the calibrator, which is at about 80
volts, a frequency of 1000 cs and a duration of
6 microseconds is fed to the suppressor grids
of the I.F. valves already biased to 80 volts.
Thus when the strobe pulse is on, the signal
will pass through the I.F. stages and as the
frequency of repetition of the strobe pulse is
1000 cs the receiver angle units behave as
they do in the normal radar operation. Thus
when the jamming location device is brought
into operation, the radar is ready for tracking
active targets, and can, therefore, track the
signaler on 204 mc attached to the F-type
radio-meteorograph. The elevation and
azimuth of the signaler can be known by
keeping the spots in the centre of the cathode
cathode ray tubes in the angle units. Fig. 3 is a
block diagram of the arrangement for using
the receiver in the radar for tracking the
radiosonde signaler. Fig. 4 shows the
details of electronic circuit in the radiosonde
recorder and the method of coupling the
radar receiver to it.

For tracking the active target with the
radar, the calibrator is kept continuously on
and the strobe pulse set between two calibra-
tion pips. The jamming location switch in the
receiver should also be on and the gain
tcontrol adjusted till the strobing pulse is
about half an inch in size. The receiver can
be tuned to the signal from the radio-meteoro-
graph with the oscillator tuning condenser
on the radar receiver as usual. When the
signal is received, the broad patch on the
angle units will become a sharp line or spot
depending on the previous setting of the oscilloscopes. Signal and no signal can be
distinguished on the signal selector unit also
by the strobe pulse becoming short or long.

The signals from the F-type radiosonde are
intermittent and occur with a frequency of
about 10 to 20 per second, and the spot on the
angle units will, therefore, be vibrating in size.
But there will be a signal of comparatively
longer duration during the contacts of the
pressure, D.B., W.B. and fix reference points
with the silver spiral. Usually a complete
cycle is performed in about 2 minutes and
during this period there will be 5 long period
signals during which the receiving aerials can
be adjusted for both elevation and azimuth by
keeping the spots on the respective cathode
cathode ray tubes in the centre.

5. The recording equipment for the radiosonde signals

The output from the peak rectifier in the
radar receiver feeds the angle display units
through the phasing switch. In following
the radiosonde signaler, a portion of the
output from the peak rectifier is fed to the
F-type recording unit (Fig. 5). The record-
ing unit is fitted in the radar housing, near
the angle units, so that two observers or even
one can manipulate the equipment. This
radiosonde recording unit can be easily
disconnected from the radar receiver when
the radar has to be used for following passive
targets.
The radiosonde recorder is described briefly below.

In the centre of the recorder panel (Fig. 5) is mounted an electro-magnet with the moving coil and recorder assembly. A spool of paper tape is mounted on the right and the tape pulling rollers on the left.

The recorder coil is wound on a tubular former and moves freely in an annular space in the electro-magnet. The moving coil is fixed on an arm, with a vertical pivot at one end and a capillary tube fed with ink at the other for writing on a moving paper tape.

There is another arm fixed on a vertical pivot. This arm also carries a capillary tube at one end for recording on the paper tape, but the other end of the arm is linked to a lever which is moved once in 15 seconds by a cam on the speed reduction train of worms and gears on the tape pulling motor.

The tape pulling arrangement consists of a 1/20 H.P. motor (capacitor type, 220 volts A.C., 50 cycles, 1440 r.p.m.) coupled to a gear train, with the final shaft projecting into the panel. This shaft is fitted with a rubber tube. A knurled roller is kept pressed on this shaft by a spring; these two rollers move the paper tape between them with a speed of about 4 ft min⁻¹.

Nearly 20 flights were made in clear weather with the radio-meteorograph operating a signaller on 204 mcs and they were followed simultaneously with the radar and a theodolite. With the exception of a few, all the flights could be followed till the balloon burst. There was good agreement also between the values of winds obtained by the two methods.

Simultaneous radiosonde ascents were also made with one meteorograph operating a signaller on 204 mcs and the other on 75 mcs; the signals from the former were recorded on the radar and those from the other with the usual radiosonde ground equipment. It was observed that upper air data were obtained with the radar up to as high a level as with the other instruments and sometimes even to a higher level. Even when the signals were weak for obtaining radiosonde records, the signaller could be tracked with the angle units for a longer time.

6. Conclusion

Radars operating on a frequency of 204 mcs or less have become obsolete now and are no longer being manufactured. These have all been replaced with those on centimetre waves. If simple and light signallers operating on centimetre waves can be constructed and sent up with the radio-meteorographs, centimetre radars can also probably be used to track them.

Attempts were being made in America in designing a radio set, AN/GRD-1 (Kirkman and Lebedda 1948) operating on a frequency of 1725 megacycles capable of even automatically tracking the targets. But they are designed only for use with active targets. When upper wind information is required frequently during the day at a number of places, the radar capable of tracking a passive target will be cheaper and simpler. Therefore radars capable of tracking, as required active or passive targets sent up with balloons summarised in this paper, appear to have certain additional advantages in meteorological technique.

REFERENCES