Counterpoise-Mounted VOR Monitor Detector Units

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COUNTERPOISE-MOUNTED VOR MONITOR DETECTOR UNITS*

SUMMARY

A monitor detector unit for mounting on the edge of the counterpoise of a VHF omnirange has been developed at the Civil Aeronautics Administration Technical Development Center The monitor detector unit was designed to meet certain requirements which are considered necessary for reliable operation, namely (1) reradiation from the detector antenna shall not cause more than plus or minus 0 2° error in VHF omnirange bearings, (2) the detector shall be completely weatherproof and operate satisfactorily over a temperature range of minus 20° F to plus 150° F , (3) vehicular reflections shall have a negligible effect on course information from the detector, and (4) the detector shall be satisfactory for use in making phasing and modulation adjustments to the VHF omnirange. Additional modifications found necessary after production models of the detector unit failed to operate satisfactorily are discussed.

INTRODUCTION

The development of a successful method for ground calibration of the VHF omnirange (VOR)[1] prompted the Office of Air Navigation Facilities to request the development of a single monitor detector unit for permanent mounting on the edge of the counterpoise. The single unit would replace the present system utilizing two Type CA-1278 VOR field detectors The possibility of using a modified Type CA-1278 VOR field detector unit was to be investigated.

The present VOR monitoring system has one Type CA-1278 VOR field detector located at magnetic north 200 feet from the VOR and a second detector located 200 feet south of the VOR but offset 10° from the 180° position. The detector units are mounted on poles at counterpoise height The detected signals are transmitted to the monitor through RG-22/U coaxial cable buried underground. The south VOR field detector is offset from the 180° position in order that a change in the direction of rotation of the figure-of-eight sideband pattern can be detected This change can be detected equally well with a single detector at azimuths of 90° or 270° The other functions of the two standard VOR field detectors are performed equally well by a single detector on the edge of the counterpoise.

Tests with a Type CA-1278 VOR field detector mounted on the edge of the counterpoise showed that this location was impractical The bearing errors caused by reflections from such a large detector unit were excessive Further tests showed that the antenna of the detector unit must be less than 90° in over-all length if reflections were to be kept to a negligible value

This report describes the most satisfactory detector unit of several models developed specifically for mounting on the edge of the counterpoise Further improvements necessary in production models of the detector unit are included

DESCRIPTION

The most satisfactory type of monitor detector unit developed employed a dipole antenna approximately 13 inches in over-all length The antenna was made moistureproof by fabricating the elements of RG17/U coaxial cable from which the Vinylite covering and shielding had been removed The elements were attached to the detector housing by means of Lucite blocks A plastic cover over the entire assembly provided protection from snow

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*Manuscript submitted for publication January 1958

[1] Robert B. Flint and William L Wright, "Ground Calibration of the VOR," CAA Technical Development Report No. 227, October 1955.

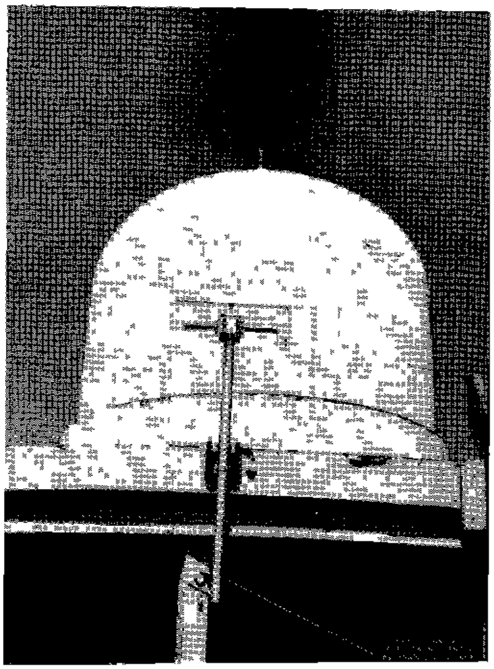

Fig 1 Counterpoise-Mounted Detector Unit with Dipole Antenna

Figure 1 shows the detector unit mounted on the edge of the counterpoise Figure 2 is a close-up view of the detector A schematic diagram of the detector unit is shown in Fig 3 Electrical balance of the antenna is maintained by the use of a split-stator condenser across the antenna inductance and use of a full-wave rectifier in the secondary circuit The first detector units tested, using a half-wave rectifier, exhibited considerable unbalance and instability The radio-frequency (r-f) coils were wound on grooved Lucite forms to minimize temperature effects

A circuit for balancing out the diode detector emission current is shown in Fig 4. Voltage is applied to a balancing potentiometer through a series resistor from the regulated

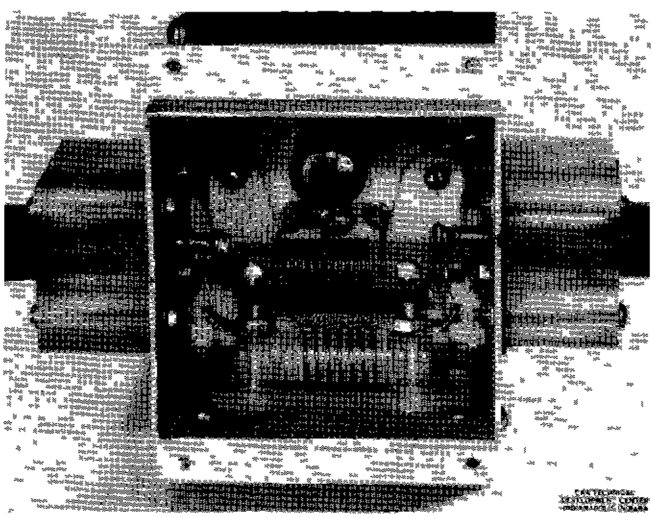

Fig 2 Internal View of Dipole Detector Unit

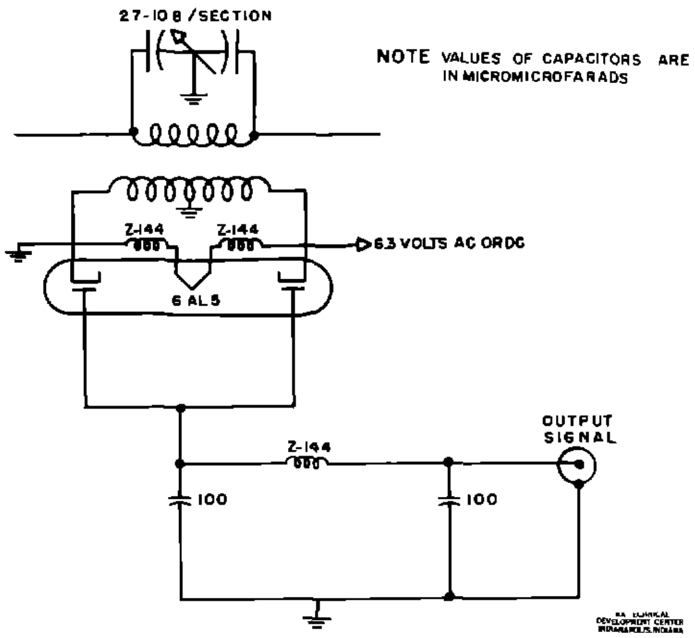

Fig 3 Dipole Detector Circuit Showing Full-Wave Connected Secondary

d-c source in the Type CA-1277 monitor The balancing voltage is introduced at the detector side of the input attenuator through a series resistor This circuit prevents attenuation of the signal voltage from the detector and provides complete cancellation of the diode emission current

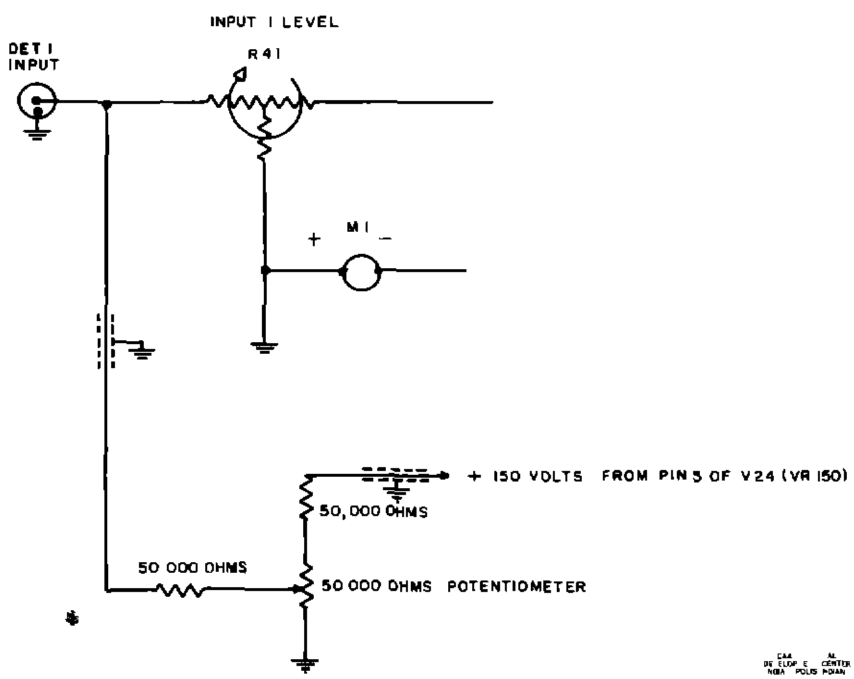

Fig 4 Schematic Diagram of Circuit for Balancing Out Emission Current From Detector Diode in the Type CA-1277 VOR Monitor

RERADIATION FROM MONITOR DETECTOR UNITS AND VEHICLES

The reradiated energy from a monitor antenna mounted on the edge of the VOR counterpoise will cause bearing errors, often referred to as course scalloping, at some azimuths Maximum course scalloping occurs at radials 45° and 135° from the radial on which the antenna is mounted. For example, an antenna at 90° will cause maximum scalloping at 45°, 135°, 225°, and 315° The magnitude of the reradiated energy depends on the length of the antenna and the amount of energy coupled into the diode load. It was determined by experiment that an antenna 45° or less in length when efficiently coupled to a load would cause less than plus or minus 0 2° course scalloping. It also was noted during tests that, when a half-wave antenna was inductively coupled to a tuned secondary circuit, the course scalloping increased as the secondary was detuned The dipole antenna, because of its small dimensions, was tuned and coupled to an untuned secondary, in order to obtain adequate detector output. Detuning of the antenna caused the course scalloping to decrease This characteristic of the short dipole antenna makes it unlikely that course scalloping will be encountered because of improper tuning of the detector

The course scalloping was determined by recording the course deviation indicator current as the detector unit was moved through the 0° to 180° sector around the counterpoise The recordings were made with a Collins 51R2 VOR receiver located 500 feet from the VOR at 90° azimuth The maximum course scalloping due to the detector unit was less than plus or minus 0 1°

Energy reflected from vehicles near the VOR cause monitor course deviations of less than plus or minus 0 25° A course alarm never has been observed on this VOR monitor because of vehicles in the vicinity of the VOR

ELECTRICAL BALANCE

The electrical balance of the detector unit becomes quite critical as the antenna is shortened In the first models employing a half-wave rectifier, the detector was balanced by moving the antenna coil toward one antenna element or the other The electrical balance was checked by observing the bearing on the monitor with the detector in normal position and again with the detector rotated 180° in the horizontal plane The true bearing was midway between the two observations, and the detector was adjusted until this bearing was obtained. The difficulty in obtaining electrical balance in the detector unit was solved by changing the secondary circuit from a half-wave to a full-wave rectifier Of the several detector models tested with the full-wave circuit, the electrical unbalance did not exceed plus or minus 0 1°

DETECTOR UNIT HEIGHT

The optimum height for a counterpoise monitor detector unit was determined by observing the indicated course and detector unit output as the height was varied There was no course shift for heights of 15 to 40 inches with the mounting support maintained in a vertical position Below a height of 20 inches, however, the detector unit output dropped rapidly All tests described in this report were made with a detector unit 20 inches above the counterpoise

EFFECT OF WEATHER

The first detector unit tested was equipped with an antenna made of small-diameter brass rods supported by small feed-through insulators The presence of moisture on the insulators caused the detector output to change Various sizes and shapes of antenna elements did not remedy this characteristic To eliminate the effect of moisture on the antenna, it was necessary to use completely waterproof elements It also was necessary to add a plastic cover over the entire detector unit to prevent snow from accumulating on the detector Wet snow, in particular, when allowed to accumulate on the detector unit caused a large change in the output

Early production models of the detector unit performed unsatisfactorily at Regional facilities The common complaint was variations in detector output Tests of the production models of the detector indicated that the output varied with temperature Figure 5A illustrates the variation in detector output of one of the first production models for a 100° F.

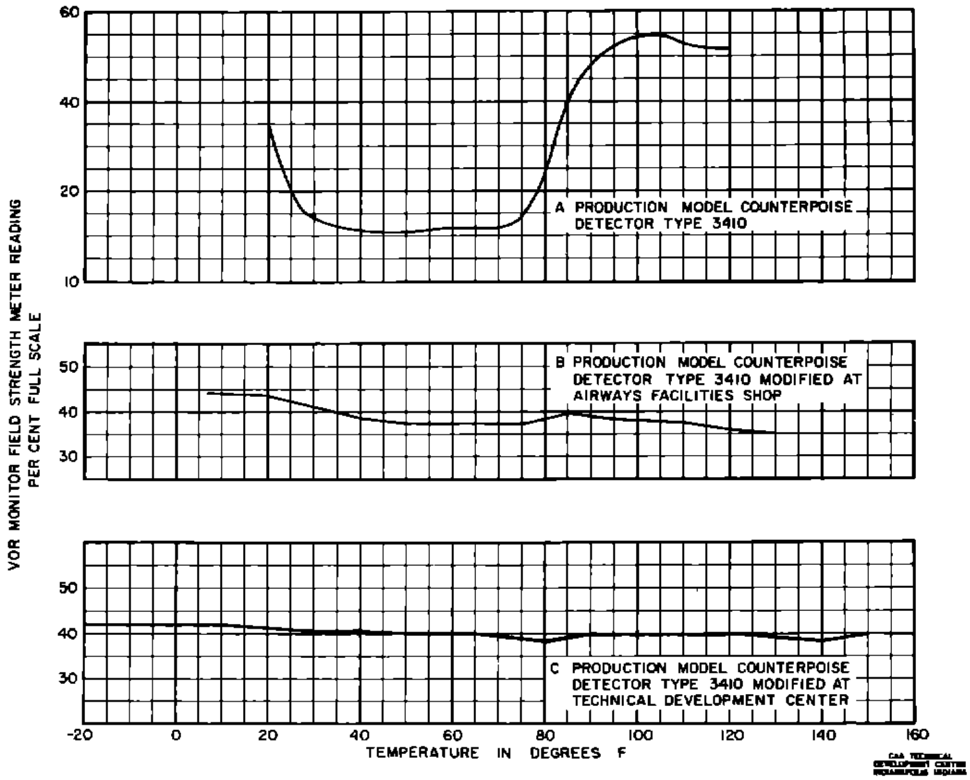

Fig. 5 Variation in Detector Unit Output with Temperature

change in temperature The variation in output was greatly reduced in later production models by mounting the r-f coils rigidly and coating them with cement The results of a test of the modified production model are shown in Fig 5B. Further tests showed that winding the r-f coils on grooved Lucite forms reduced the effect of temperature to a negligible value as shown in Fig. 5C. The temperature tests were conducted by packing the entire detector unit in dry ice to reduce the temperature The detector unit was placed on the edge of the counterpoise, and the detector output was recorded as the temperature increased to the ambient level. The detector unit then was placed in a heated enclosure and the temperature raised Then the detector unit was placed on the edge of the counterpoise and the output was recorded as the temperature returned to normal

Winding the r-f coils on grooved forms also greatly reduced vibration of the turns caused by wind on the detector unit Vibrations from wind previously had resulted in rapid fluctuations in the course

DETECTOR UNIT OUTPUT

The VOR monitor requires an input of 1 volt d-c and 0 3 volt a-c of the variable and reference audio signal from the detector unit These voltages are measured across the input attenuator. The output of the detector unit as the input was varied is shown in Fig 6. The output of the detector unit was varied by changing the r-f tuning The curves in Fig 6 apply for a half-wave or full-wave connected 6AL5 diode rectifier The output of the detector unit can be adjusted to the desired level by varying the coupling between the secondary and primary r-f coils. The monitor will operate satisfactorily with the detector output ranging from 1 to 5 volts d-c.

The standard practice is to set the field intensity indicator of the VOR monitor to read 40 per cent of full scale by adjusting the input attenuator The curves of Fig. 7 show the variation in the variable and reference output levels as the monitor input attenuator is adjusted for 40 per cent of full-scale for various d-c output levels of the detector unit Figures 6 and 7

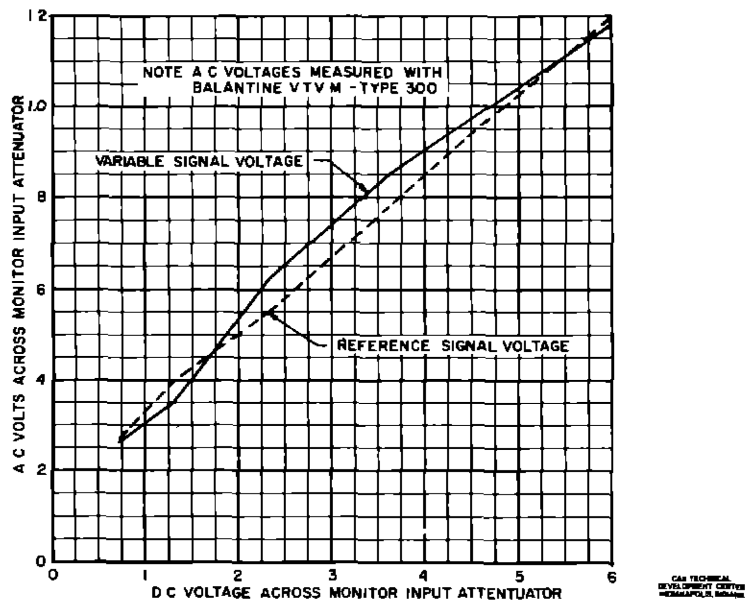

Fig. 6 Variable and Reference Signal Voltages at Monitor Input Attenuator as D-C Output of Detector Unit is Varied

show that the variable and reference signal voltages are approximately 30 per cent of the d-c level at a d-c detector output of 1 volt, and 21 per cent at a d-c detector output of 5 volts.

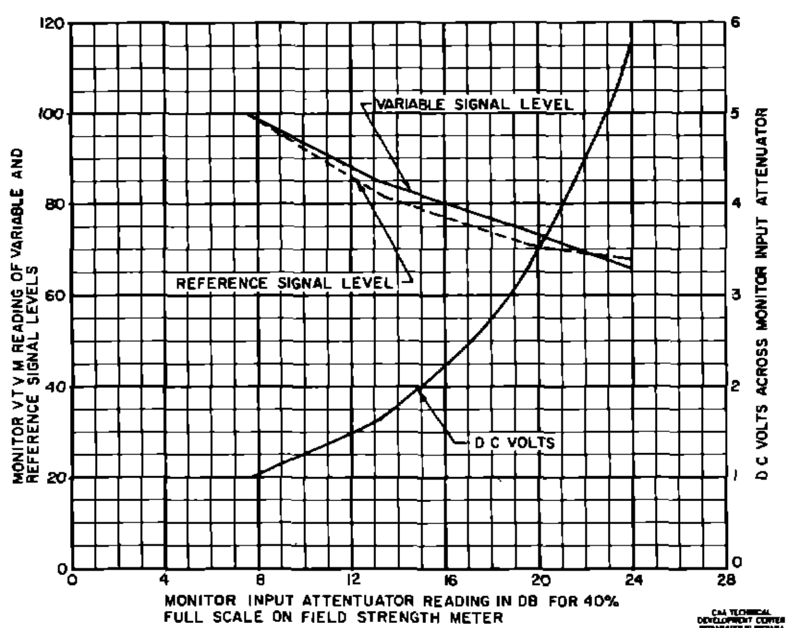

Fig 7 Variation in Variable and Reference Output Levels as Monitor Input Attenuator is Adjusted for Constant Input Level

VOR STATION ADJUSTMENTS

Measurements of the variable phase modulation level and phase relations between sidebands and carrier using the counterpoise detector units have proved entirely satisfactory. The differences in these measurements with the detector unit at 0° or 90° are negligible, whereas a difference in the phaser position of 5 divisions (approximately 5°) was noted when using the Type CA-1278 VOR field detector located 200 feet north of the VOR. VOR calibration curves obtained with the r-f phaser 10 divisions above and below the correct position indicated negligible changes in the VOR calibration curves However, this is true only when the goniometer loads presented by the VOR antenna sideband inputs are equal. The only effect on the VOR operation by the r-f phaser being 5 to 10 divisions from the correct position is a slight decrease in the variable phase modulation level.

On occasions, the sideband lines may be unintentionally interchanged when changing goniometers or making station adjustments This will cause the rotation of the figure-of-eight pattern to reverse. A single detector unit located at 90° azimuth will give 270° azimuth information instead of 90° azimuth information to the monitor, causing it to alarm The single detector unit performs this function as well as the present monitor system in which the VOR field detector units are located 200 feet south and north of the VOR.

CONCLUSIONS

1 A monitor detector unit is described, which meets the requirements (1) reradiation equivalent to a VOR bearing error less than plus or minus 0.2°; (2) completely weatherproof construction, and operating satisfactorily from minus 20° F. to plus 150° F.; and (3) negligible effect on course information due to vehicular reflections

2 A single dipole detector unit of the type described in this report, mounted on the edge of the counterpoise at 90° azimuth (or 270° azimuth), will provide sufficient information for monitoring the VOR adequately.

3. Station adjustments can be made as accurately with the counterpoise-mounted detector unit as with the present VOR field detectors located 200 feet from the VOR antenna.

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