A METHOD OF MEASURING MODULATION PERCENTAGE BY USING AN OSCILLATOR-MIXER-AMPLIFIER AND OSCILLOGRAPH

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SUMMARY

This report describes a method of measuring modulation percentage at very high frequencies using an oscillator-mixer-amplifier and an oscillograph The method described here originally was developed for measuring the modulation percentage of the TS67/ARN-5 test set However, by connecting it to a receiving antenna, it was subsequently used to measure the modulation percentage of the localizer and omnirange transmitters and will prove generally useful In measuring the modulation of the TS67/ARN-5 test set which is used in adjusting the gain of localizer and glide path receivers, this method is the simplest and yet most satisfactory of the several methods which were tried

INTRODUCTION

In the past the audio or course sensitivity of the BC-733-D localizer receivers has been adjusted in flight for a desired value of course-width. The procedure for measuring the sensitivity has been to fly perpendicular to the course in both directions at a 1500-foot altitude and 10 to 15 miles distant from the transmitter and measure the time required for the deviation indicator to go from full scale blue to full scale yellow and vice versa, and to convert this measured time to angular degrees of course-width The receiver was assumed to be calibrated when the audio sensitivity was so adjusted that the measured course-width was some predetermined value such as 5°

A receiver thus calibrated was used to calibrate the TS67/ARN-5 test set by means of which other receivers were then adjusted to the same audio sensitivity as the originally flight-calibrated receiver. It was found that receivers calibrated by this method did not always show the same course-width on localizers at other airports even though the localizer stations were constructed and adjusted to the same specifications Because of these discrepancies, there was need of a receiver calibration method independent of the transmitter

Such an absolute method was recommended by the Radio Technical Commission for Aeronautics in August 1946. The language of the recommendation is quoted as follows

> "All civil and military receivers shall be adjusted immediately to the following standards
>
> a. On-course modulation for each MF, 20%
> b rf input to receiver, 1000 microvolts
> c db ratio for 90-150 cps, 4 db
> d Voltage at receiver power input terminals, that value normally obtained in aircraft installation with aircraft in cruise flight.
> e Deflection in one of two indicators, 90 μ amp
>
> The foregoing shall maintain until service experience dictates a change which can be agreed to by all concerned "

An absolute method similar to the above has been recommended by RTCA for adjusting the rf and audio sensitivity of glide path receivers. It is described in RTCA paper 106-47/DO-6 and prepared by RTCA Special Committee SC32, dated October 14, 1947

Use of this method requires not only a properly modulated rf signal generator, but also a means of measuring rf microvolts at the receiver terminals and a means of measuring the modulation percentage of rf signal voltages from the signal generator. This report describes one method of measuring modulation percentage of low intensity VHF signals

DISCUSSION OF METHOD

The modulation percentage of amplitude modulated rf voltages may be measured by linear measurement of the modulated rf pattern on an oscillograph. If the amplitude of the rf voltage is sufficient, the signal may be introduced directly on the plates of a cathode ray tube and the pattern scaled. If the signal is too low in intensity, it must be amplified. In some of the better oscillographs

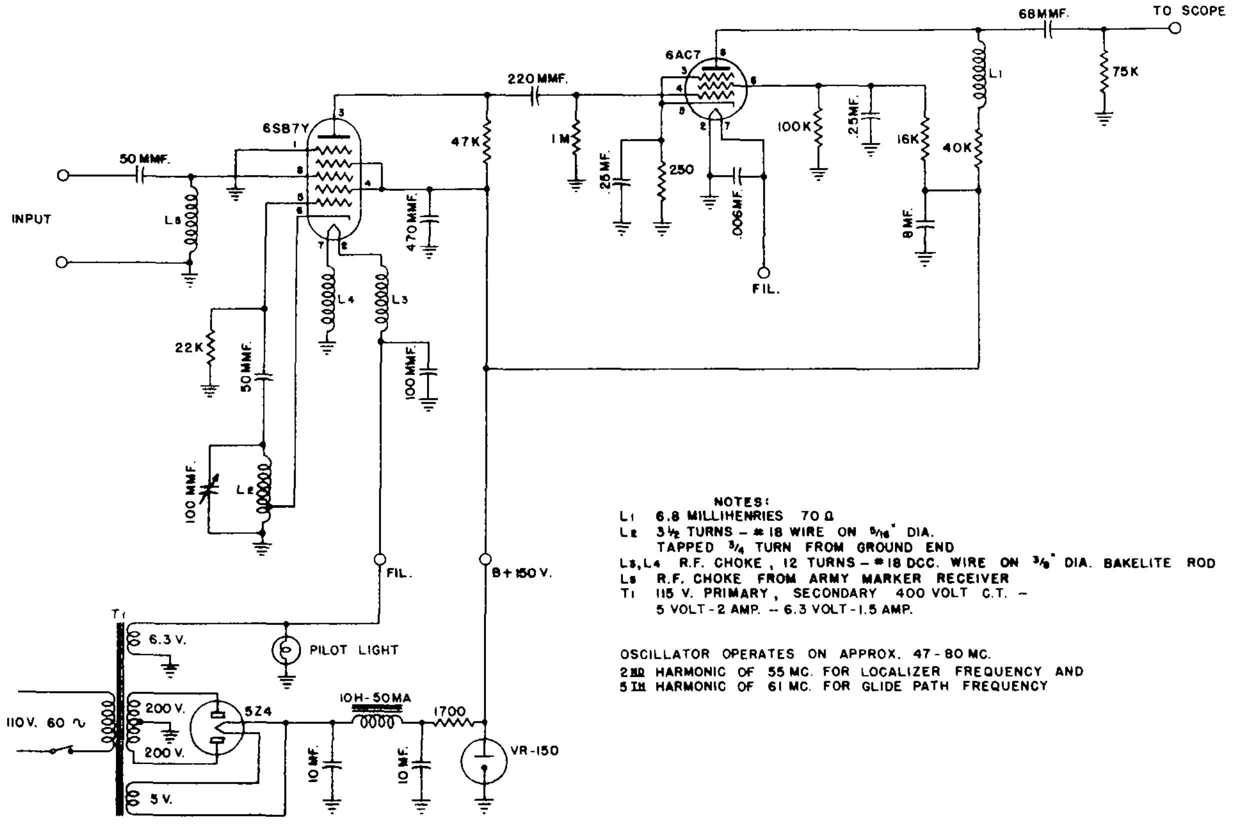

Fig. 1 Schematic diagram of oscillator-mixer-amplifier as used in modulation percentage measurements

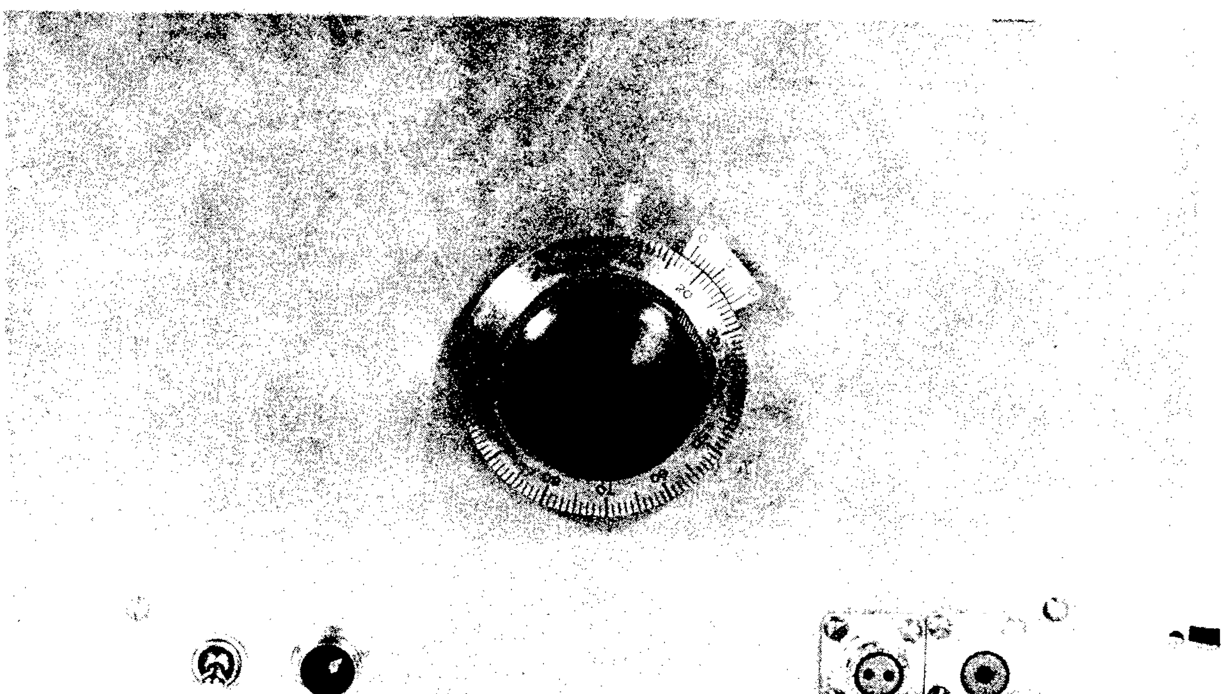

Fig. 2 Front view of oscillator-mixer

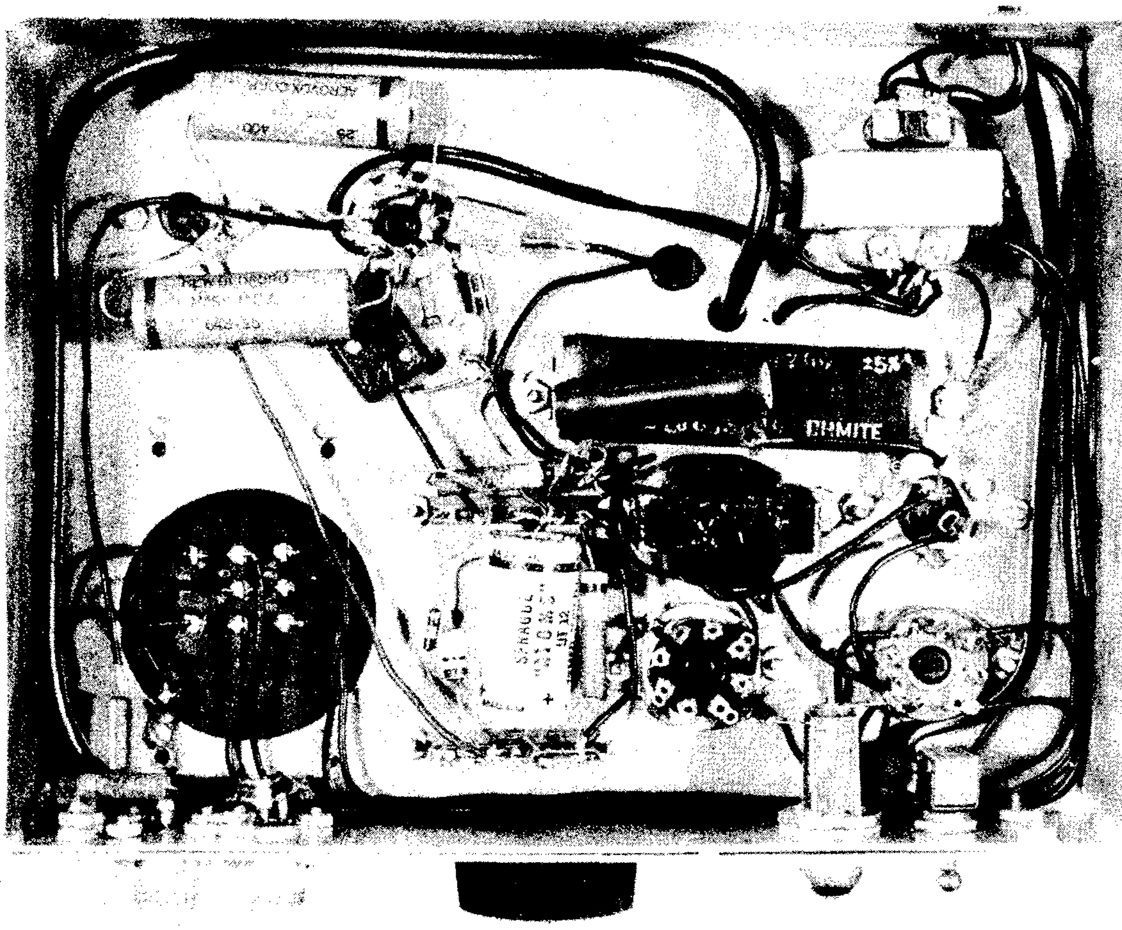

Fig. 3 Bottom view of oscillator-mixer

having internal amplifiers which are flat to 2.0 Mc, the low intensity signals below that frequency may be introduced directly into the input terminals to obtain a sufficiently large undistorted rf modulated pattern.

For low intensity rf signals above 2 Mc, oscillograph amplifiers of the type mentioned can be used if the high frequency (for example, 110 or 330 Mc) is heterodyned down to a frequency less than 2 Mc without distorting the envelope. This is the method used to measure the modulation percentage of the signal generator in the TS67/ARN-5, a test set used at the Experimental Station for calibrating localizer and glide path receivers. The method described here is a modified form of the oscillator-mixer-amplifier originally developed by the Electronic Subdivision of the Air Materiel Command which is used with a 5-in. cathode ray oscillograph.

CONSTRUCTION

Fig. 1 is a schematic diagram of the oscillator-mixer-amplifier. Illustrated in Figs. 2, 3, and 4 are different views of the oscillator-mixer-amplifier, showing the circuit and the location of parts. The location of parts is not critical. The arrangement shown here operates satisfactorily and is recommended. Construction details are clearly shown in the illustrations and schematic diagram. The oscillator, mixer, and amplifier with the regulated power supply are constructed as a unit and enclosed in an aluminum cabinet. The unit requires complete shielding because it will pick up any stray, VHF signals in the vicinity. The oscillator-mixer tube is the newly developed 6SB7Y. This tube was developed for use as an oscillator-mixer in the region of 80-108 Mc. In this particular

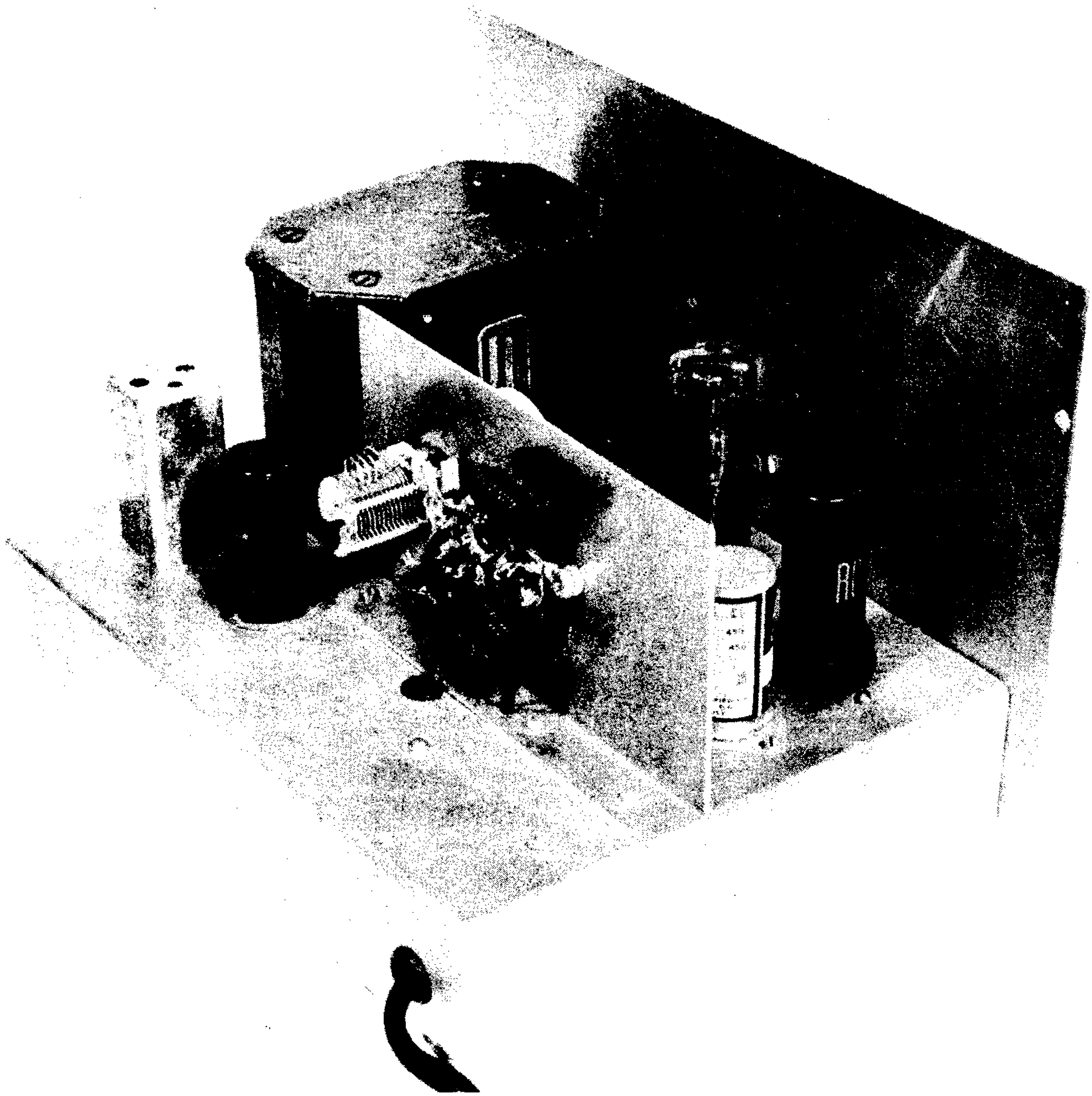

Fig. 4 Three-quarter view of oscillator-mixer

circuit the local oscillator operates between 47-80 Mc. The calibration curves of Fig. 5 show dial divisions versus frequency for the fundamental and several harmonics.

At first glance, it would appear that the local oscillator would not be stable enough to secure a steady pattern, but due to the broad-band characteristic of the video amplifier, a very stable and steady pattern may be obtained. Frequency drift due to temperature change has very little effect on the stability and can, therefore, be neglected. However, very short leads and rugged mechanical construction, especially in the oscillator-mixer section, are essential to good stability. Mechanical vibration will cause frequency modulation to appear on the pattern being viewed.

The 6AC7 video amplifier which follows the oscillator-mixer was broadbanded and no construction difficulties were encountered. The frequency response of the video channel

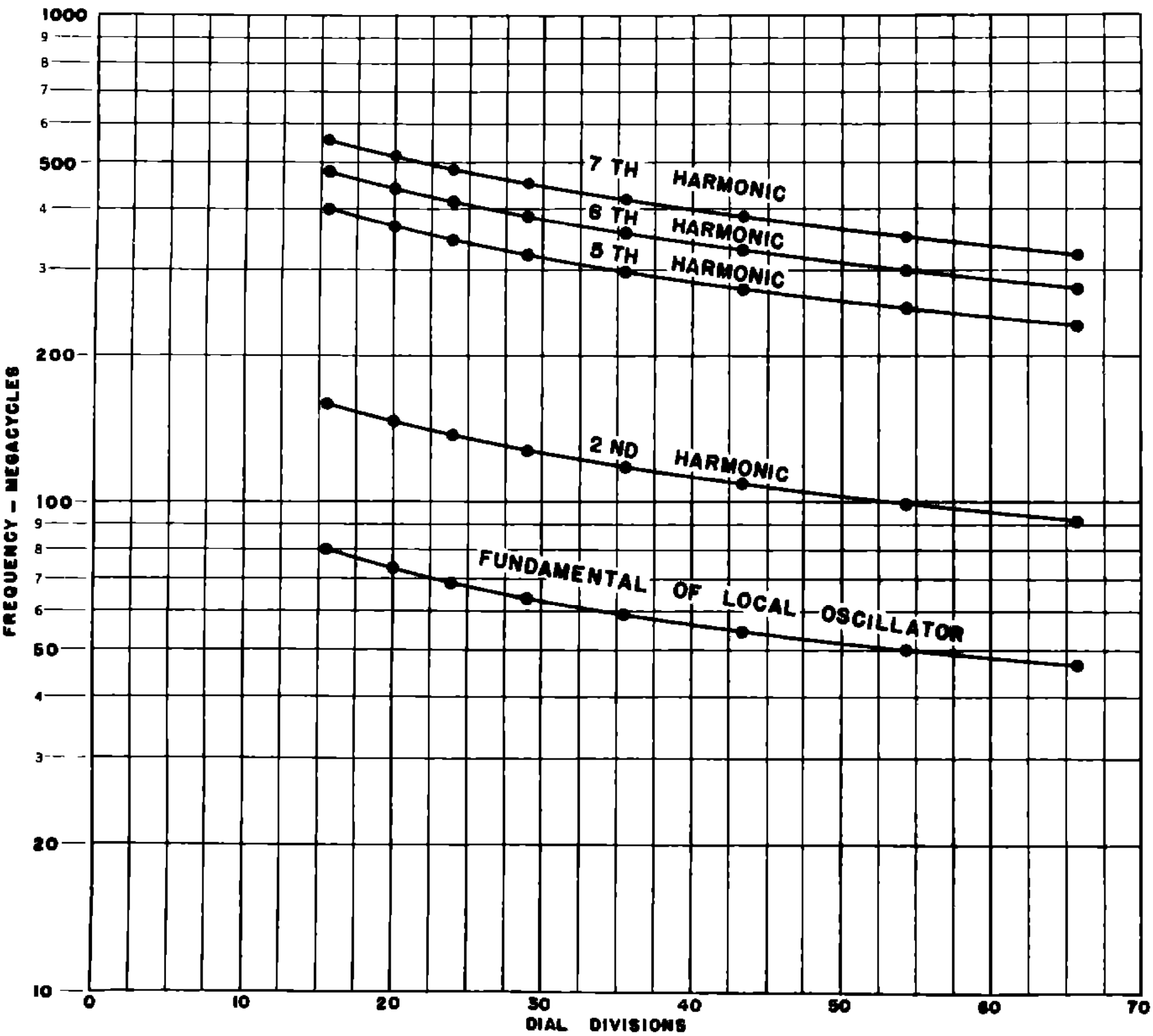

Fig 5 Frequency versus dial divisions for oscillator-mixer

versus relative deflection is shown in Fig. 6 This was found to be satisfactory between 30 kc and 1.3 Mc As the Dumont 241 oscillograph used, is flat only to 2 0 Mc, it was not necessary to further improve the response of the video amplifier

Referring to Fig 7, the TS67/ARN-5 is connected to the twin contact connector The oscillograph is connected to the single contact connector with a short shielded single conductor The dial of the 100-mmf condenser across L_2 (see schematic Fig 1) is very carefully adjusted until the modulation pattern, that is seen on the oscillograph, is of maximum amplitude Experimental evidence has shown that an input signal of not more than 10,000 microvolts nor less than 4000 microvolts should be used in the adjustment of the modulation of the 110 and 330 Mc channels of the TS67/ARN-5 test set

By using the second harmonic of the oscillator and mixing it with the 110 Mc signal from the signal generator, the resulting difference, approximately 110 kc, is amplified by a broad-band video amplifier and fed to the oscillograph amplifier and cathode ray tube For checking the 330 Mc frequencies of the TS67/ARN-5 test set, the fifth or

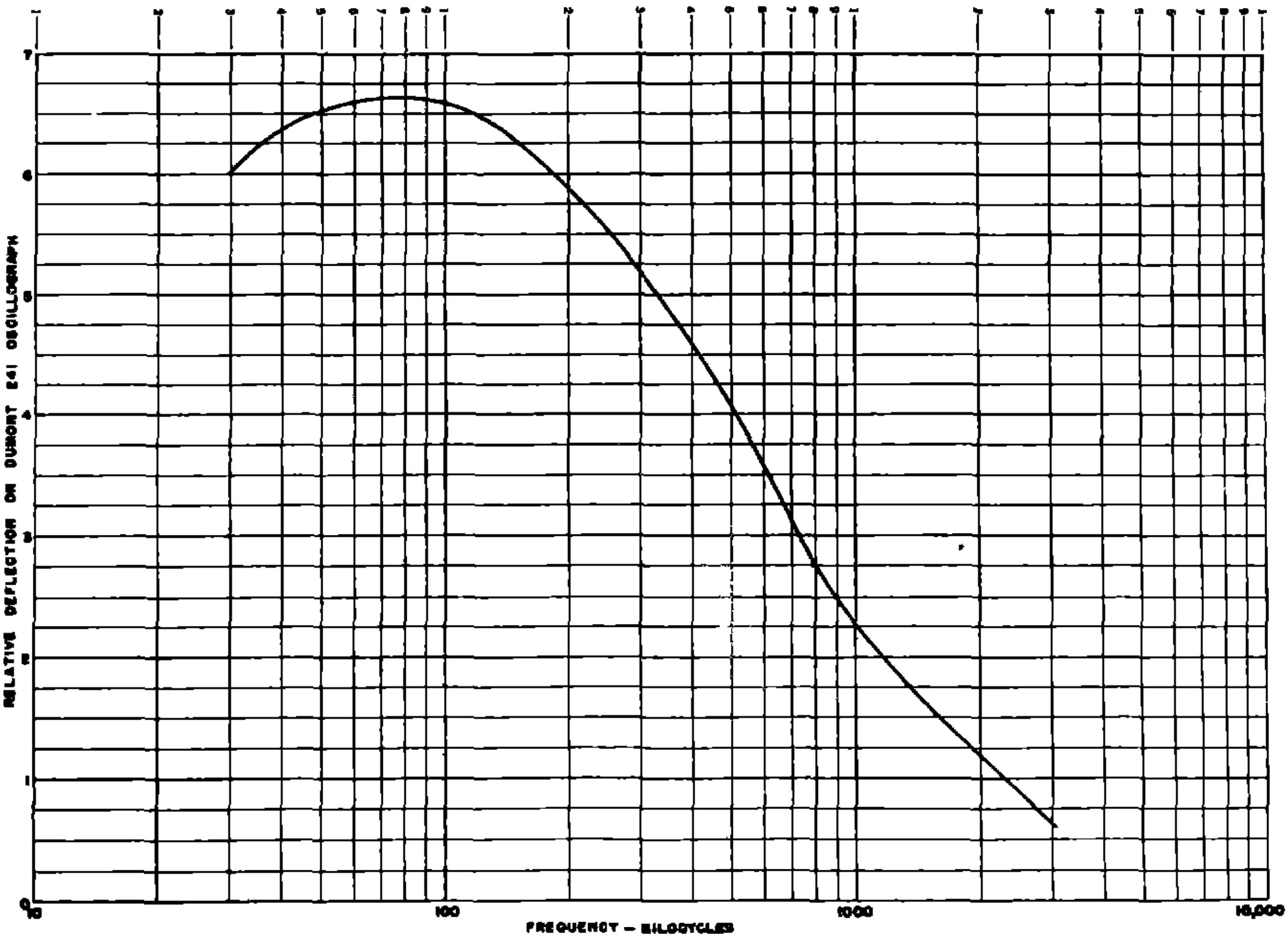

Fig 6 Frequency response of video channel versus relative deflection on Dumont 241 oscillograph

seventh harmonic is used. The sixth harmonic is unusable because of the multi-pattern appearing on the cathode ray tube

Figs. 7, 8, and 9 are photographic reproductions of 110 Mc rf envelopes modulated with 90, 150, and 90-150 cps, respectively, using a 5-in Dumont Model 241 oscillograph When measuring modulation, only one modulating frequency is used at a time The amplitudes of both the peak and trough of the pattern are measured The difference between these values is divided by their sum and multiplied by 100 to obtain percentage modulation To obtain the required precision, at least a 5-in cathode ray tube should be used Even with considerable care, this method does not have a high order of precision, although sufficient precision is obtained to adequately standardize ILS receivers.

ACCURACY

Some estimate of the accuracy of this method of measuring modulation was obtained by comparing it with another method in which the if voltage from a BC-733-D receiver was amplified and applied directly to the plates of the cathode ray tube The amplifier used in this second method incorporates a cathode follower type of probe Connecting the probe to the receiver had negligible effect on the receiver if voltages Using this amplifier with 5 different BC-733-D receivers, modulation percentage measurements were within the limits of 19 5 to 20 5 per cent when the signal generator was adjusted to 20 per cent by the method described in this report.

CONCLUSIONS

The oscillator-mixer-amplifier method of measuring modulation percentage has sufficient precision to be satisfactory in setting the modulation of the 90 and 150 cps channels in the TS67/ARN-5 signal generator for the standardization of the ILS localizer and glide path receivers. It has also been used with satisfactory results to measure modulation percentage of the localizer and omni-range signals by connecting it to a pick-up antenna. Input signals of approximately 4000 to 10,000 microvolts are necessary for a clear pattern at either 110 or 330 Mc.

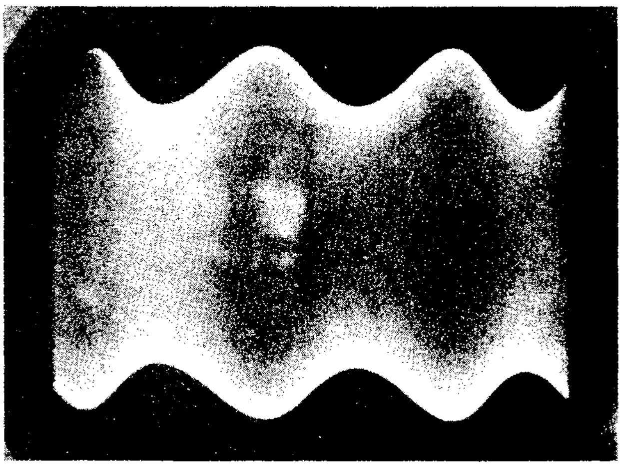

Fig. 7 Radio frequency envelope showing 90-cps modulation

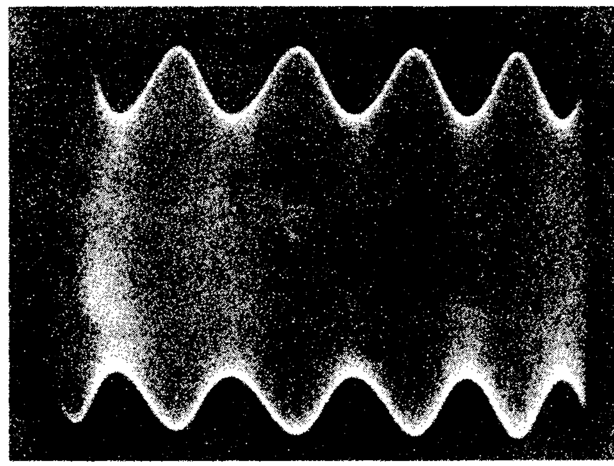

Fig. 8 Radio frequency envelope showing 150-cps modulation

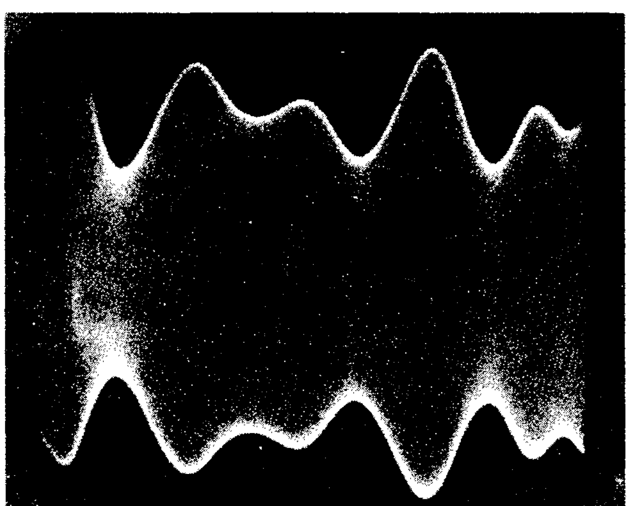

Fig. 9 Radio frequency envelope showing 90-150-cps modulation