VOICE FREQUENCY TELEGRAPH SYSTEMS - ROUTINE TESTS

(AMPLITUDE MODULATED SYSTEMS ONLY)

1. INTRODUCTION.

1.1 This E.I. has been completely revised and replaces Issue 1. Details of the periodicity and the types of routine tests to be conducted on Amplitude-Modulated Voice Frequency Telegraph Systems are described. Forms TRM.47 and TRM.48 are hereby cancelled and Forms TRM.52, 53 and 54 originated.

2. TESTING AND RECORDING PROCEDURE.

2.1 Reference should be made to the relevant system handbooks for details of testing procedures not fully described herein, as testing facilities vary with different systems.

2.2 Forms TRM.52, 53 and 54 illustrated in Figs. 3, 4 and 5 shall be used to record the results of tests and may be obtained from the Superintendent of Stores by requisition. A supply sufficient for two years is to be held by the technical staff at stations concerned.

3. ABNORMAL TEST RESULTS.

3.1 In cases where the test results depart from the limits prescribed and cannot be corrected by normal adjustments or component replacements, details must be forwarded to the Trunk Service Section for further investigation.

4. BEARER CIRCUITS.

4.1 For each V.F. telegraph system there will be a patch bearer circuit provided in accordance with E.I. LONG LINE EQUIPMENT General P 0010.

4.2 Changeover from the normal to the patch bearer, and vice versa, should be as rapid as possible and to this end the following conditions should apply:-

(i) The normal and patch bearer circuits should be routed via the same patching or switching panel or via a suitable relay set at the terminal stations concerned.

(ii) Changeover must take place at two points of the same relative power level.

(iii) Both bearer circuits should have as near as possible the same frequency response over the frequency range employed by the telegraph channels.

5. REDUCTION OF INTERRUPTIONS TO TELEGRAPH CIRCUITS.

5.1 Mutilations of telegraph signals transmitted over V.F.T. systems are caused by circuit interruptions, abrupt changes of transmission levels and carrier or power supply surges. In order to provide the desired degree of reliability of telegraph circuits, maintenance work must be arranged to keep the number and duration of interruptions to a minimum and permit all work of a routine nature to take place only during periods of low telegraph traffic except where specified to the contrary.

5.2 Long Line Equipment maintenance staffs should ensure that the following principles are observed:-

(i) Routine tests and adjustments on telegraph channels are performed only at times determined by mutual agreement with the Telegraph Service Branch.

(ii) Interruptions to, or changeover of, carrier supplies for telegraph channels or telephone bearer circuits are kept to an irreducible minimum and confined to periods of light telegraph traffic. Although carrier supplies for multi-channel carrier telephone systems are designed to enable changeover from normal to standby supplies with minimum interruption to service, errors on V.F. telegraph channels do occur.

(iii) When it is necessary to perform work on the bearer telephone system, at either terminal or repeater stations, particularly when the work is of a nature likely to cause transmission level changes, the V.F.T. system will be patched to an alternative bearer system if possible.

(iv) Switching of power supplies and power plant routine tests at all carrier terminal and repeater stations on routes over which V.F.T. systems operate, are only performed at times of low telegraph traffic.

(v) Close liaison should be maintained between technical and lines staff to enable advance information to be obtained of proposed line work on trunk routes. This will allow telegraph systems to be patched to an alternate route where possible, or to the opposite side of the pole from that on which work is to be done.

6. DAILY TESTS.

6.1 Machine Generator Speed Check. Check the speed of the in-service multi-frequency generator using the stroboscopic display. With the stroboscope oscillator set at 1020 c/s the number of black segments which appear to pass a stationary point each second should be not greater than four.

The apparent speed of rotation of the segments must be steady and show no evidence of hunting when observed for a period of one minute.

6.2 Carrier Supply Voltage Measurement. This test applies only to carrier supplies from machine generators.

The voltage of each carrier frequency output of the in-service machine will be measured at the carrier supply rack; the values are not recorded. If necessary the voltages may be re-adjusted but only during a period of light telegraph traffic.

7. WEEKLY TESTS.

7.1 Machine Generator Changeover. The in-service and standby machines should be changed over at a time of low telegraph traffic. This changeover may only be effected at more frequent intervals than weekly if proved necessary by local experience and approved by the Supervising Engineer, Trunk Service. As mutilations of telegraph signals result from a changeover of carrier supplies, it is essential that this operation is not performed more often than necessary.

Following changeover of the machine generators the output voltage of each frequency will be checked and if necessary adjusted to the correct value.

7.2 Stroboscope Oscillator Frequency Check. The frequency of the 1020 c/s strobscope oscillator will be synchronised with an accurate frequency reference.

8. THREE MONTHLY TESTS.

8.1 Bearer Circuit Loss Measurement. The loss of both normal and patch bearer circuits will be measured at a frequency of 800 c/s. In each case the measured value should be within ± 2 db of nominal, and where these limits are exceeded the cause must be investigated. It will be necessary to determine whether the cause is a telephone channel or a telephone system abnormality, and the most suitable adjustment must be made to restore the telegraph system bearer to within the prescribed limits.

8.2 Amplifier Detector Gain Adjustment. With the telegraph system operating on its normal bearer circuit, adjust the gain of each amplifier-detector with respect to the limiting point and carrier input level. Detector amplifier gain control stops are recorded on Form TRM.53.

For systems which are adjusted on a Mark signal the following method should be used:-

(i) Connect a 600 ohm, 5 db pad between RECEIVE LINE and RECEIVE EQUIPMENT or at a suitable point individual to each channel.

Caution: Care must be taken to ensure that a balanced pad is not inserted at a point where the circuit is unbalanced with respect to ground; at such points an unbalanced pad must be used.

(ii) Adjust the amplifier-detector gain control on each channel to the point of minimum gain.

(iii) Apply a Mark signal to all channels at the far terminal.

(iv) Observing the plate current of the detector stage, increase the gain of the amplifier-detector of channel 1 until the point is reached where the plate current ceases to rise.

(v) Repeat for the remaining channels in turn.

(vi) Remove the 5 db pad.

(vii) Record gain control stops on Form TRM.53.

8.3 Plate and Filament Current Measurement. (Valve operated equipment). Filament and plate currents of all tubes, or equivalent readings as provided by the equipment, are measured and recorded on Form TRM.52. Where a reading falls outside the specified limits the cause will be located and corrected.

The plate current of each amplifier detector valve will be measured with both Mark and Space signals applied. With a Mark Signal applied the plate current of each detector valve should be observed for a period of approximately 5 seconds to ensure that a steady reading is obtained. Any variations of current during this period must be investigated and the cause corrected.

8.4 Channel Bias Adjustment. Before the commencement of this test, the neutrality of the transmitted reversals must be checked at the transmitting terminal and adjusted if necessary.

The bias of each telegraph channel will be adjusted to zero with the telegraph system operating on the normal bearer circuit.

A Telegraph Distortion Measuring Set (T.D.M.S.), of a type which measures instantaneous distortion such as a B.A.T.E. Type 6, will be used where available. Instructions for the operation of this instrument are given in Appendix 1. Only at locations where a T.D.M.S. is not available the channel bias may be adjusted using a centre-zero milliammeter to indicate the point of zero bias. When a T.D.M.S. is employed the channel should be terminated as shown in Fig. 1. When a milliammeter is used the channel should be terminated in a circuit similar to that illustrated in Fig. 2 to minimise the error due to unequal Mark and Space signalling potentials.

(i) Using a T.D.M.S. With 2:2 reversals transmitted over the channel, the bias control will be adjusted for minimum bias distortion which should not exceed 4%. The T.D.M.S. display will be checked for evidence of instability of the received reversals. Record the measured distortion value on Form TRM.53.

(ii) Using a Centre-Zero Milliammeter. With 1:1 or 2:2 reversals transmitted over the channel, the bias control will be adjusted to obtain zero meter deflection. The meter deflection should be free from kicks or swings.

The speed of reversals in bauds must be that of the normal operating speed of the channel under test. (For telegraph channels which operate at a speed of 50 bauds, 1:1 reversals are equivalent to a 25 c/s square-wave alternating current and 2:2 reversals are equivalent to a $12\frac{1}{2}$ c/s current.)

8.5 Channel Distortion Measurement. The adjustment of channel bias will be followed by the measurement of signal distortion; peak values of isochronous distortion are recorded on Form TRM.53.

(i) Measure the distortion of 1:1 reversals and record the observed peak values which should not exceed 4%.

(ii) Measure the distortion of the channel on 1:5 and 5:1 signals; in cases where only 1:6 and 6:1, or $1\frac{1}{2}$:6 and 6:$1\frac{1}{2}$ signals are available, these may be used. (The ratio 1:5 refers to a repeated signal comprising Marking polarity of one element duration followed by Spacing polarity of five elements duration.) Where the observed peak value of distortion exceeds 10% corrective action will be taken. After any channel fault has been cleared the channel bias will be checked and readjusted if necessary.

(iii) With the telegraph system transferred to the patch bearer circuit the signal distortion measurement of 2:2 reversals will be repeated without prior readjustment of channel bias. Results will be recorded, the same limits of acceptance apply.

(iv) For V.F.T. systems where a T.D.M.S. is available at one terminal only, distortion measurements on a loop-back basis are required. After the bias of all channels has been adjusted for both directions of transmission as described in para. 8.4, signal distortion is measured on each channel at the terminal equipped with a T.D.M.S., signals being transmitted from the far terminal. Each channel is then looped back at the far terminal, by patching from REC. LEG V.F. to SEND LEG V.F., and signals are transmitted over the looped circuits to the T.D.M.S.. Under this latter condition the distortion limit is 18%.

8.6 Alarms Check. Check for the correct operation of all alarms associated with the system tested.

9. TWO-YEARLY TESTS.

9.1 The Two-Yearly tests are to be performed in conjunction with the Three-Monthly tests of Section 8. Some or all of the following tests may be performed more frequently if high values of telegraph distortion, or other local experience, indicate that this is necessary. The order in which the following tests are listed is a guide to the order in which they should be performed.

9.2 Calibration of Meters. Check the calibration of all meters associated with the carrier telegraph terminal under test. Arrangements are to be made through the Divisional Engineer for the provision of Precision grade meters to enable these tests to be carried out.

9.3 Filament and Plate Currents. Carry out this test as described in para. 8.3.

9.4 Alarms Check. Carry out this test as described in para. 8.6.

9.5 Machine Generator Overhaul. Periodic overhaul of multi-frequency generators will be performed at workshops determined by the Supervising Engineer, Trunk Service. It is important that this work is undertaken by staff experienced in the servicing and repair of such machines and that the required workshop facilities are available. The servicing of machines should include the following :-

(i) Clean and burnish governor contacts.

(ii) Clean dust from brush guides and holders and if necessary replace brushes. Check and adjust brush pressures.

(iii) Clean the commutator and slip-rings by wiping with a rag dipped in an approved cleaning fluid. Check that spaces between the commutator segments are correctly undercut and free of dust and metal particles.

(iv) Remove and clean the bearings and inspect for wear; replace bearings if necessary. Refill with the correct grease indicated on the machine plate. Check that the grease overflow outlet is clear and remove excess.

9.6 Carrier Supply Frequency Check. Where channel carrier oscillators are employed, adjust the frequency of each to the centre of the pass band of the channel filters using the following procedure:-

(i) At the far terminal a T.M.S. having the required sensitivity is connected to RECEIVE FILTER OUT of the channel concerned.

(ii) Adjust the frequency of the channel oscillator to obtain maximum deflection on the T.M.S. at the far terminal.

9.7 Carrier Supply Level Measurement. Measure the carrier supply level of each V.F.T. channel and record the results on Form TRM.54. Where the measured values lie outside tolerances specified in the system handbook the cause should be determined and corrected. This test applies to both oscillator and machine-generated carrier supplies.

9.8 Send and Receive Amplifier Gain Measurement. Where such amplifiers are in use measure the gain of each send and receive amplifier at a frequency of 800 c/s. Record the results on the Form TRM.54. Where the amplifier gain does not agree with the nominal value the cause will be investigated and corrected.

9.9 Modulator Discrimination Measurement. Measure the output levels of each channel modulator (static relay) under Mark and Space conditions and record the values on Form TRM.54. The discrimination should be not less than 35 db.

9.10 Channel Send Level Measurement. This test must be performed after that in para. 9.7. Measure the send level of each channel at "Send Line Equipment" by sending Mark on each channel in turn while all other channels are at Space. Record the results on Form TRM.54. If necessary adjust the levels to the correct values listed in Table 1. These values must not be exceeded without the authority of the Engineer-in-Chief.

Number of Channels in Telegraph System.	Maximum Power per Telegraph Channel at a Zero Relative Level Point for Sending Continuous Mark (db referred to 1mW.)
24	-21
18	-18
12 or less	-15

CHANNEL SEND LEVEL.

TABLE 1.

9.11 Bearer Circuit Check. Perform the following tests on both normal and patch bearer circuits including the common equipment of the telegraph system.

(i) Frequency Response.

(a) For telegraph systems employing the frequency range 400 to 3200 c/s approximately, measure the circuit loss of normal and patch bearer circuits at 300, 400, 600, 800, 1400, 2000, 2400, 3000 and 3200 c/s. and record the results on Form TRM.57. The response of each bearer circuit should be within the limits shown on TRM.57 and preferably within those listed in Table 2. In addition to meeting these requirements the circuit loss of the patch bearer circuit at each test frequency should also be within ± 2 db of the loss of the normal bearer circuit.

Test Frequency c/s	Gain Relative to that at 800 c/s	
	Maximum db	Minimum db
300	1.7	-4.0
400	1.7	-2.7
600	1.7	-1.7
1400	1.7	-1.7
2000	1.7	-1.7
2400	1.7	-1.7
3000	1.7	-1.7
3200	1.7	-2.7

PREFERRED BEARER CIRCUIT FREQUENCY RESPONSE
FOR TELEGRAPH SYSTEMS EMPLOYING THE BAND 400 TO 3200 c/s.

TABLE 2.

(b) For Telegraph Systems employing all or part of the frequency range 400 to 2500 c/s measure the circuit loss of normal and patch bearer circuits at 300, 400, 600, 800, 1400, 2000, 2400 and 2600 c/s and record the results on Form TRM.56. The response of each bearer circuit should be within the limits shown on Form TRM.56. In addition to meeting these requirements the circuit loss of the patch bearer circuit at each test frequency should also be within $\pm$ 2 db of the loss of the normal bearer circuit. For telegraph systems employing only part of the frequency range 400 to 2500 c/s, the limits specified above need apply only to that portion of the frequency band concerned.

Where bearer circuits do not conform to the above requirements, the cause should be corrected or alternative bearer circuits selected.

(ii) Noise. This test is not compulsory but may be performed if it is required to make an initial assessment of V.F.T. bearer circuits before performing the more extensive Spacing Interference Test described in para. 9.12.

The total weighted noise on the bearer circuits will be measured with a Noise Measuring Set and the results recorded on Form TRM.54. The average value of noise should be not greater than -60 db at a point of zero relative level with occasional peaks not greater than -52 db. The noise on the idle bearer circuit will be measured during the busy hour of a normal busy day. Measurement on the operating bearer will be performed after the V.F.T. system has been transferred to the idle bearer.

9.12 Spacing Interference Test. With all other channels transmitting a Mark signal, apply a Mark and then a Space to channel 1. At the distant terminal measure the levels received at RECEIVE FILTER OUT of channel 1 for the two signal conditions. Record the observed levels on Form TRM.54 and calculate the Mark to Space margin which should be not less than 30 db. Repeat the measurement for each channel in turn.

9.13 Amplifier-Detector Gain Adjustment. Carry out the test as described in para. 8.2 and record results on Form TRM.53. The gain control should be in the middle, one-third of its range.

9.14 Channel Bias Adjustment. Adjust the bias of each channel in accordance with para. 8.4.

9.15 Channel Distortion Measurement. Perform this test as described in para. 8.5 and record the results on Form TRM.53.

9.16 Amplifier-Detector A.G.C. Range. With 2:2 reversals transmitted over the channel under test, measure the bias distortion when the input signal to the amplifier-detector is increased and decreased by 3 db from the normal value. Measure peak values of distortion which should not exceed 4%. Results are recorded on Form TRM.54.

9.17 Amplifier-Detector Sensitivity Measurement. Measure the sensitivity of each amplifier detector in the following manner:-

(i) At the distant terminal apply a Mark to the channel under test.

(ii) Connect a variable attenuator between RECEIVE LINE and RECEIVE LINE EQUIPMENT. Increase the loss until the receive relay operates from Mark to Space.

(iii) Reduce the attenuator loss until the receive relay just re-operates to Mark.

(iv) Record the second attenuator value on Form TRM.54. The recorded value should not exceed 18 db.

10. TERMINAL INSPECTION AND VIBRATION TEST.

10.1 Detailed inspection of equipment in conjunction with a Vibration Test should be performed on installation and again within a period of twelve months to ensure that the system meets with the contractual requirements. Subsequently each V.F.T. system should be overhauled and vibration tested every four years, or more frequently if an analysis of fault reports indicates that this is necessary. Each panel should be examined to detect any defects in wiring or in any items of equipment and to remove dust, solder or other material likely to affect the operation of the terminal. Special attention should be given to the contact testing of bias and gain controls. (See E.I. LONG LINE EQUIPMENT General TE 0020 "Vibration Testing".)

APPENDIX

OPERATION OF B.A.T.E. TYPE 6 T.D.M.S.

1. GENERAL.

1.1 The following is a summary of the method of operation of the B.A.T.E. Type 6 telegraph distortion measuring set as used to measure isochronous telegraph distortion for the maintenance tests specified in this E.I.. A more detailed description may be obtained from the instrument handbook.

2. PRINCIPLE OF OPERATION.

2.1 On the T.D.M.S. screen a circular time base is produced, the time taken for the trace to complete one revolution is variable and an adjustment is performed to ensure that exactly one circle is completed in the time corresponding to the average duration of the elements of telegraph signal. (Where the telegraph signalling speed used is 50 bauds the duration of each element is 20 milliseconds.) With telegraph signals applied to the input terminals each transition from Mark to Space or Space to Mark causes a bright spot to flash on the circular time base. When the time which elapses between successive transitions is not an exact multiple of 20 milliseconds the flashes will not be superimposed on each other, but will be spread over an arc of the circle. The length of this arc is directly related to the error in the duration of the Mark or Space signals and a calibrated scale enables this distortion to be read as a percentage of a signal element.

3. PRELIMINARY ADJUSTMENTS:

3.1 Preliminary adjustments are carried out in the following order:-

(i) Operate the mains switch to ON.

(ii) Adjust the RANGE control to 50 bauds.

(iii) The SIGNAL selector is operated to DOUBLE CURRENT - M.

(iv) Operate the time base selector to CONT.

(v) Adjust the AMPLITUDE control to obtain a circular trace of diameter approximately equal to that of the graduated scale.

(vi) Operate the DISPLAY switch to the SM and MS (centre) position.

(vii) Connect the T.D.M.S. to the circuit under test, as illustrated in Fig. 1, at terminals designated INPUT 1 and EARTH.

(viii) Operate the toggle switch to the INPUT 1 position.

(ix) With isochronous signals transmitted over the channel under test, the SPEED control is adjusted until the illuminated spots cease to rotate around the cathode-ray screen. Although the spots will constantly change position, the average position will be stationary. (This adjustment is most easily obtained with reversals transmitted over the channel.)

4. ADJUSTMENT OF CHANNEL BIAS.

4.1 To adjust the neutrality of a V.F. telegraph channel in accordance with paragraph 8.4(i) of this E.I., the channel bias control is adjusted until the distortion measured on 2:2 reversals is a minimum, i.e. the length of arc over which the illuminated spots are distributed is a minimum.

5. MEASUREMENT OF SIGNAL DISTORTION.

5.1 With reversals or other synchronous signals transmitted over the channel under test, the cathode-ray screen is observed for a period of approximately 10 seconds during which time the maximum value of distortion is noted. The flashes which occur may constantly vary in position but the average position will remain the same when the speed of rotation of the circular time base is correct. The angle between the extreme clockwise and anticlockwise positions of the flashes measures the peak distortion during the period of observation.

The flashes can appear in a number of different forms depending on such factors as the nature of the transmitted signal and the interference and distortion which occur.

The zero distortion condition is represented by a single bright spot which remains stationary. Two spots which are stationary indicate the presence of a constant value of bias and/or characteristic distortion.

The effect of fortuitous distortion, superimposed on the above cases, is to cause the position of the flashes to vary continuously in a random manner. The distortion value to be recorded is given by the extreme clockwise and anticlockwise positions of the flashes during the period of observation.

The case can occur where a single spot only will be seen to swing in either a random or a rhythmic manner, and care must be taken under these conditions to observe the extreme limits of the flashes during the sampling period.

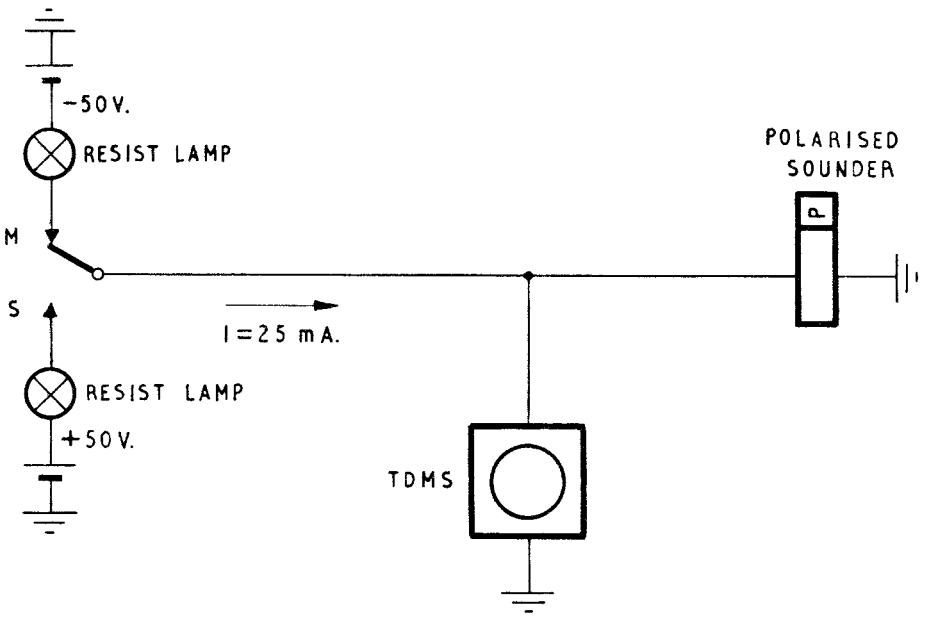
-50V.
RESIST LAMP
M
S
I=25 mA.
RESIST LAMP
+50V.
POLARISED
SOUNDER
P
TDMS

FIG. 1.

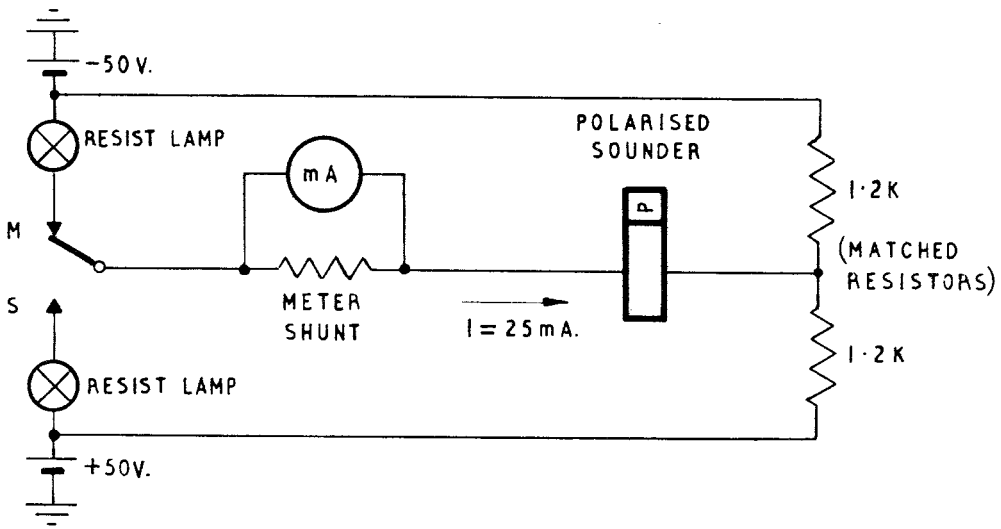
-50V.
RESIST LAMP
mA
M
S
METER
SHUNT
I=25mA.
RESIST LAMP
+50V.
POLARISED
SOUNDER
P
1·2K
(MATCHED
RESISTORS)
1·2K

FIG. 2.

TRM. 52

ROUTINE TESTS

AMPLITUDE MODULATED V.F. TELEGRAPH SYSTEMS

STATION ..... SYSTEM No. .....

CHANNEL	FILAMENT AND PLATE CURRENTS						
	OSCILLATORS		AMPLIFIER DETECTORS				
				MARK		SPACE	
	FILAMENT	PLATE	FILAMENT	V_1	V_2	V_1	V_2
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
LIMITS							
REC. AMP.			SIGNATURE				
SEND AMP.							
			DATE				

FIG. 3.

TRM.53

ROUTINE TESTS

AMPLITUDE MODULATED V.F. TELEGRAPH SYSTEMS

STATION ..... SYSTEM No. .....

CHANNEL	PERCENT DISTORTION					AMPLIFIER DETECTOR STOP
	NORMAL BEARER CIRCUIT				PATCH	
	2:2	1:1	1:5	5:1	2:2	
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
LIMITS	4 % MAX.	4 % MAX.	10 % MAX.	10 % MAX.	4 % MAX.	—

NORMAL BEARER : CHANNEL..... SYSTEM.....

PATCH BEARER : CHANNEL..... SYSTEM.....

SIGNATURE .....
DATE .....

FIG. 4.

TRM. 54

ROUTINE TESTS

AMPLITUDE MODULATED V.F. TELEGRAPH SYSTEMS

STATION..... SYSTEM No.....

CHAN.	CARR. LEVEL	MOD. DISCRIM. S.F. OUT MARK dbm	MOD. DISCRIM. S.F. OUT SPACE dbm	DISC. db	SEND LEVEL dbm	INTERFERENCE R.F. OUT MARK dbm	INTERFERENCE R.F. OUT SPACE dbm	INT. db	A.G.C. RANGE 2:2 REVS% DIST. BEARER 3db HIGH	A.G.C. RANGE 2:2 REVS% DIST. BEARER 3db LOW	AMP. DET. SENS. db.
1											
2											
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
LIMITS		–	–	35		–	–	30	4 %	4 %	

	GAIN AT 800 c/s. db
SEND AMP.	
REC. AMP.	

BEARER CIRCUIT	NOISE db AVERAGE	NOISE db PEAK
NORMAL		
PATCH		

NORMAL BEARER: CHANNEL..... SYSTEM.....
PATCH BEARER: CHANNEL..... SYSTEM.....

SIGNATURE.....
DATE.....

FIG. 5.

END.