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Acting Chief, Engineering Branch

8 June 1950

Chief, Electronic Development Section

Report of tests on ES-1, EF-1 Electrowriter Equipment.

1. Transmitted herewith is the complete test report on the ES-1 & EF-1 Electrowriter equipment, as submitted by the [redacted] 25X1 25X1

2. Summarizing the tests conducted on the equipment indicates that the use of Electrowriters on normal communication circuits is not feasible due to extreme sensitivity of the Electrowriter to an interfering signal of either Sine wave or noise. The maximum tolerable amplitude of interfering signal must be about 40 to 50 db below the received signal, a condition rarely encountered in practice.

3. The design of the equipment was such that numerous failures occured during the tests, these failures indicating that the units are not sufficiently rugged for field use. Some of the failures are traceable to design and construction errors which could be corrected but with the limitations of para. 2 above, it would be pointless to continue along the present line of design criteria.

4. Should a definite need exist for equipment of this nature, it may be advisable to consider a new development along lines which would eliminate the critical operating conditions enumerated in the report.

[redacted] 25X1

ELM/lk

cc: Contract 101-PSC
Project 2023
Development

15

DOC 14 REV DATE 2/14/80 BY 37169
ORIG COMP 33 OPI 56 TYPE 2
ORIG CLASS S PAGES 8 REV CLASS C
JUST 22 NEXT REV 2010 AUTH: HR 10-2

SECRET

CONFIDENTIAL

Project No. 2024

EQUIPMENT TEST REPORT

ELECTROMETER EQUIPMENTS

EM-1 & ET-1

Submitted

Approved

25X1

1. The ET-1 and ES-1, electrowriter station and tele-transmitter/receiver, submitted by [redacted] has been tested by this activity and, except for major mechancial difficulties and limitations within the fundamental design, may be considered, after being suitably modified, to meet the specifications of this Agency but not the requirements for use. 25X1

2. Considerable electrical and mechanical trouble was encountered in testing these equipments. Among the basic troubles encountered were:

a. One of the screws retaining the sockets for the 524 rectifier tube was missing and the one remaining screw soon became loose.

b. The band-pass filter and relay sub-assembly were intended to be mounted by means of four screws and nuts. It was noted, however, that one screw and nut were missing entirely and one screw had no nut assembled to it; thus, the entire assembly was fastened with only two screws which loosened sufficiently to permit the assembly to rattle around.

c. The AC line meter failed to read after about five hours. An inspection and test revealed an intermittent open circuit in the multiplier resistor, R-124.

d. The horizontal and vertical center trim condensers were both set at minimum capacity thus permitting no adjustment to be made. It was further noted that the frequency of the X position oscillator had shifted by a sufficient amount to displace the tracking between the transmitter and receiver unit by approximately 1/4" from the right hand edge of the paper.

e. The 6 volt DC supply to the motor and pen heater failed after about 10 hours of operation. A check revealed a loose solder connection on pin no. 12 of the main power transformer.

f. The lead to the X servo unit became loose due to poor soldering and thus eliminated motion in the X direction.

g. The lever and cam operated switch mechanism actuating the warning bell and paper feed was of very poor construction. The assembly, in general, was reminiscent of "erector set" construction. The adjustment of this assembly is very critical and gets out of adjustment very easily. Complete redesign of this assembly will be necessary before the unit can be acceptable.

h. The limit switch controlling the paper feed motor failed in the open position thus making it impossible to feed the paper automatically.

i. A screw holding the open insulated bearing support plate of the X transmitter of ES-1 interfered with the lateral motion of the X pantograph arm. This may have been caused by the armature of the X transmitter unit shifting to a lower position. It was necessary, however, to remove the interfering screw in order to continue the tests.

j. The pen heater became inoperative on several occasions. This component was removed and has been checked, and it is believed that an intermittent open circuit, which we have not been able to locate yet, is responsible.

k. The 1L4 tube in the 300 cycle pen lift oscillator failed after about 12 hours of operation due to marked reduction in the mutual conductance of the tube. Referring to the schematic diagram of the ET-1 it was noticed that this tube, although used as an oscillator, has no provision

(k. con't) for grid current bias in the grid circuit. It is believed that excessive current has been drawn, thus shortening the operating life of the tube. It was further noticed, in checking this oscillator, that the operation of the pen lift switch severely loaded the oscillator circuit, reduced the amplitude of oscillation in some cases, and at times even prevented the stage from oscillating.

l. An inspection of the EF-1 servo unit shows that although a reduction in size of the original model has been accomplished, the basic principles of miniaturization have not been completely and accurately carried out. It was noted that the power transformer could be turned on its side and recessed into the chassis to reduce the overall height by a factor of approximately 2". The overall layout could be reworked to save considerable space without miniaturizing any of the present components.

m. The paper feed drive roller and roller follower have a tendency to collect wax from the surface of the paper. This wax then builds up in thickness and the paper begins to jam between the rollers, becoming wrinkled and illegible.

3. Sensitivity Measurements - An attempt was made to measure the minimum voltage required by the servo amplifier to operate the pen satisfactorily. It was found that the minimum tolerable voltage depended upon the speed of the response of the pen and the accuracy desired. Measurements indicated that for the X and Y motion a voltage of at least .01 volts would be necessary. In checking the EF-1 it was determined that the output voltage of the transmitter unit varied from about .18 to approximately .205 volts thus giving an operating voltage range of approximately 20 to 1. A check of the output voltage of the

300 cycle pen control oscillator showed that a range of .088 to approximately .025 gave satisfactory operation.

b. Interference and noise measurements - A test was set up to determine the extent of tolerable interferences from both a Sine wave signal and a random noise signal. The set-up consisted of operating the ES-1 from the ET-1 and determining the maximum tolerable signal that would produce a definite level of distortion. The interfering signal was introduced via an audio transformer connected in the line between the ET-1 and the ES-1.

TEST NO. 1 Y Interference and Distortion Input from ET-1

Signal = .18 volts (X ≠ Y)
Interfering Signal 1910 cycles = .0006 volts
Signal to noise ratio = 300 which corresponds to 49.4 db.

TEST NO. 2 X Interference and Distortion Input from ET-1

Signal = .18 volts (X ≠ Y)
Interfering Signal 2680 cycle = .0025 volts
Signal to noise ratio = 72 corresponding to 37.147 db.

In the above tests the X signal distortion, as measured under above conditions, constituted a line variation having a total of excursion approximately 1/8" as shown on the electrowriter test chart under Test No. 1. It was not possible to measure the Y amplitude distortion in the same manner but was necessary to swing the pen laterally across the paper while the interfering signal was present. This is shown on electrowriter Test No. 2 which has a maximum excursion of over 1/16" from the nominal.

TEST NO. 3 Affect of noise interference - Random noise was introduced into the isolating transformer connected in the line between the ET-1 and the ES-1.

This random noise was taken from a receiver which was tuned to an unused frequency. The input from the EF-1 was measured and the noise amplitude was increased until the operation of the ES-1 became very erratic, corresponding to approximately 1/4" random pen excursion. This pen excursion was both the X and Y planes.

Input from the EF-1 = .202 volts
Maximum tolerable noise amplitude = .002 volts peak
Signal to noise ratio = 100 to 1 corresponding to 40.086 db.

The above amplitude of noise would make the copy entirely illegible.

5. Conclusions - Outside of the above enumerated mechanical and electrical difficulties and the fact that the general design and construction will have to be cleaned up, a question arises as to the tactical value of the present equipment for use by this Agency. These questions are:

a. The operation of the equipment in a normal radio comms circuit

b. The operation of this equipment in the presence of random receiver noise.

c. The operation of this equipment on a circuit being jammed by a Sine wave jammer such as "Bagpipe", etc.

From the interference and noise measurements, under 4 above, it can be demonstrated that the signal to noise requirements of this equipment are almost fantastic from a practical sense. The requirements of a 300 to 1, or a 49.54 db signal to noise ratio imposes such a rigorous restriction upon the accompanying radio circuit and equipment as to almost preclude its use. Its suceptability to jamming, as determined in the interference tests of Para. 4, is extremely high. Where we consider a good radio circuit to be 25 or 50 microvolts of signal input to a receiver, it can be demonstrated that only a fraction of a microvolt will be necessary to make the system completely inoperative;

conversely, to avoid the effects of interfering jamming signal, it would require almost 1000 microvolts input to a receiver of electrowriter signal to overcome the jammer. The same reasoning can be applied to noise. If the receiver used has an equivalent noise input of 1/2 microvolt, it will require approximately 150 microvolts of electrowriter signal to completely mask the random receiver noise.

The above analysis demonstrates the extreme sensitivity to intentional and unintentional interference.

6. Recommendations - If the need for electrowriter equipment is sufficiently pressing as to warrant an expenditure of funds for further investigation, it is recommended that an entirely new set of design criteria be applied. Among the principles that may be investigated is the application of higher control frequencies, perhaps in the supersonic or low I.F. range. This would limit the effects of jamming and interference and probably make for more stable equipment operation. It would, however, eliminate the use of this equipment with normal types of communication gear.