REPORT NO. R-1498

DATE 14 December 1938

SUBJECT

FR-1498

Report of Test

of

Model TBF Transmitting and Receiving Equipment

by

[illegible] J. MacGregor

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

14 December 1938

NRL Report No. R-1498
BuEng.Problem T6-8C.

FR-1498

NAVY DEPARTMENT
BUREAU OF ENGINEERING

[redacted]

Report of Test

of

Model TBP Transmitting and Receiving Equipment

manufactured by

Westinghouse Electric and Manufacturing Company
Chicopee Falls,Mass.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
Washington, D.C.

Number of Pages:	Text - 15	Tables - 17	Plates - 3

Authorization: BuEng.let. C-NOs-51017(8-31-R8) of 9 Sept.1938.

Date of Test: 19 September - 1 December 1938.

Prepared by:

J.J. MacGregor, Asst.Radio Engineer

Reviewed by:

M.H. Schrenk, Radio Engineer,
Chief of Section.

A.Hoyt Taylor, Principal Physicist,
Superintendent, Radio Division.

Approved by:

H.M. Cooley, Captain, USN, Director.

Distribution:
BuEng. (5)

4 addl Copies sent BuEng 8-22-39 by Comdr Pierce

vhw

CONFIDENTIAL

TABLE OF CONTENTS PAGE

AUTHORIZATION.. 1
OBJECT OF TEST... 1
ABSTRACT OF TEST... 1
    Conclusions.. 1a
    Recommendations.. 1b
MATERIAL UNDER TEST.. 2
METHOD OF TEST... 3
DATA RECORDED.. 5
PROBABLE ERRORS.. 6
RESULTS OF TEST.. 6
CONCLUSIONS.. 15

APPENDICES

Weights and dimensions of equipment........................ TABLE 1
Frequency range and overlap of receiver.................... " 2
Calibration accuracy of receiver........................... " 3
Sensitivity of receiver.................................... " 4
Sensitivity of receiver.................................... " 5
Sensitivity of receiver.................................... " 6
Selectivity of receiver.................................... " 7
Fidelity of receiver....................................... " 8
Frequency range and overlap of transmitter................. " 9
Calibration accuracy of transmitter........................ " 10
Temperature coefficient of crystal......................... " 11
Power output of transmitter................................ " 12
Power consumption of equipment............................. " 13
Audio fidelity of transmitter.............................. " 14
Audio distortion of transmitter............................ " 15
Effect of variable temperature on output and frequency..... " 16
Effect of variable humidity on output and frequency........ " 17

Photograph of entire equipment in and out of knapsack........ PLATE 1
Photograph of internal arrangement of equipment.............. PLATE 2
Photograph of construction of power supply................... PLATE 3

[redacted]

AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter, reference (a). Two additional references, (b) and (c), pertinent to the problem are also listed.

Reference: (a) BuEng.let. C-NOs-51017(8-31-R8) of 9 Sept. 1938.
(b) Specifications RE 13A 535A.
(c) Descriptive Specifications R-930.

OBJECT OF TEST

2. The object of this test was to determine the suitability of the equipment for the purpose for which it is intended and for compliance with references (b) and (c).

ABSTRACT OF TEST

3. The equipment was laboratory tested for frequency range, overlap, calibration accuracy, sensitivity, selectivity, and fidelity of the receiver and power output, fidelity, percent modulation, audio distortion, frequency range, overlap and calibration accuracy of the transmitter. It was also field-tested for range of operation and interference between adjacent equipment.

[redacted]

Conclusions

(a) In its present condition the equipment is not entirely satisfactory for the use for which it is intended.

(b) Electrically the equipment meets the requirements of the specifications, reference (b), except on the following: receiver frequency range and overlap, accuracy of the calibration chart, sensitivity and audio fidelity, transmitter frequency range and overlap, accuracy of the calibration chart, power output and audio distortion of the power output.

(c) The equipment has an undesirable characteristic in that the full output of the side tone is applied to the telephone receiver when the key is pressed with the equipment in the receive condition and the crystal calibrator switch either on or off, and in the transmit condition with the crystal calibrator switch on.

(d) Another undesirable feature is the presence of voltages of the order of 125 to 150 volts inside the case when the battery is in place and the power switch is in the off position. There is a warning of this condition in the instruction book. Removing this voltage near its source by means of a switch when in the power-off position would greatly facilitate changing of tubes.

(e) Several mechanical defects were encountered in the equipment. The backlash of the tuning controls is excessive. The contacts of the band changing mechanism and the relay gave considerable trouble due mainly to poor alignment. Keying the transmitter for MCW telegraph was difficult due to binding in the key bearing. The arrangement of the acorn type tube sockets is such that they do not hold the tubes securely in place. Accessibility to the detector tube of the receiver is very difficult. The general construction of the knapsack is satisfactory, but the arrangement of the carrying straps are not conducive to the most comfortable load distribution for transportation on a man's back. The batteries are not sufficiently protected to prevent damage from moisture. The hand telephone of the so-called French type and the chest microphone described in the specifications were not supplied. There was supplied a Navy Type RS-38 hand microphone modified so that the push button is non-locking. This type of microphone is considered satisfactory. The head telephones have not the Navy Type A9028 head bands but are equipped with an adjustable webbing band and an adjustable chin strap. The latter is not of a comfortable design. The cords supplied with the key, head sets and microphones are not satisfactory. The snap fasteners for securing the cover of the transmitter-receiver unit in place are not sufficiently rugged. The design of the filament rheostat control knobs are not entirely satisfactory.

[redacted]

Recommendations

As a result of the tests it is recommended that:

(a) The audio frequency fidelity of the receiver be improved.

(b) The accuracy of the calibration charts be improved.

(c) If practicable, excessive signal be removed from the headphones when keying regardless of condition of equipment. If not practicable, the instruction book should contain a warning against keying the equipment in any other condition than for MCW telegraph. The side tone resistor is in series with the head phones only when the relay is in the transmit position.

(d) The contacts of the relay and band changing switches be made more positive and more carefully aligned.

(e) Construction of the key be modified to prevent tilting or binding in the bearing and provision made for securing the key to the transmitter-receiver unit in such a manner as to be easily and rapidly detachable.

(f) The carrying straps of the knapsack be so arranged that the weight distribution provides for more comfortable transportation.

(g) The construction of the acorn tube sockets be modified to hold the tubes more securely in place, and the detector tube of the receiver be made more accessible.

(h) The batteries be so constructed or suitable means provided to protect them from damage from moisture.

(i) The chin strap of the head phones be of a more comfortable design, preferably a wider leather strap with a buckle.

(j) The contractor submit samples of key, headset, and microphone cords for Navy approval before making up these units.

(k) The snap fasteners for securing the cover of the transmitter-receiver unit be more positive and rugged.

(l) The friction be increased on the filament rheostat controls, and round knurled knobs not over 5/8 inch in diameter be provided in place of the pointer type of knobs on the present equipment.

(m) Since under all conditions the correct setting of the transmitter plate milliammeter is at the center of the scale, the dial be provided with an indicating mark at this point rather than a graduated scale as on the present meter.

[redacted]

(n) The transmitter antenna loading, and the receiver antenna tuning controls be provided with stops at the maximum and minimum positions.

Subject to incorporation of the above recommendations, the equipment is considered satisfactory for the use for which it is intended.

[redacted]

MATERIAL UNDER TEST

4. Four Model TBP transmitter-receiver units were submitted by the contractor for test. The circuit of each unit consists of four distinct parts as follows: transmitter r-f section, receiver r-f section, audio amplifier section, and crystal calibrator section, which by means of the control system permits telephone or mcw transmission, telephone or mcw reception, transmitter and receiver calibration. Both transmitter and receiver cover the range of 28 to 65 megacycles.

5. The transmitter r-f section consists of two filamentary acorn triodes, Type A-2061, connected in push-pull acting as r-f oscillators. The receiver r-f section consists of a tuned r-f amplifier using a filamentary acorn pentode, Type 4068, followed by an inductively coupled super-regenerative detector employing a filamentary acorn triode, Type A-2061. The detector circuit is self-interrupting and the audio output circuit is provided with a filter to eliminate the interrupter frequency voltage components from the signal. The audio section serves the transmitter, receiver, and the crystal calibrator. It consists of a Type 30 low level audio amplifier (or audio oscillator) and a Type 1E7G high level audio amplifier (or modulator) which function as follows. For voice transmission, the Type 30 tube is not used. The 1E7G push-pull pentode is operated as Class AB1 and obtains its grid driving voltage directly from the microphone through the microphone winding on the interstage audio transformer. Its output is coupled to and plate modulates the transmitter r-f oscillator. For mcw transmission the Type 30 tube operates as a tone generator when the key is depressed. The output of this tube is coupled through a transformer to the grids of the 1E7G which modulates the r-f oscillator as previously described. For reception, the audio output of the detector is coupled to the grids of the 1E7G and the output of the 1E7G to the headphones through an output transformer. For transmitter calibration, the audio output of the crystal oscillator tube is connected to the grid of the Type 30 tube through a coupling condenser and transformer winding. The Type 30 and 1E7G tubes operate as for reception except the side tone resistor in series with the headphones during transmission is shorted out to allow full output in the phones. For receiver calibration, the audio tubes operate exactly as for reception.

6. The crystal calibration circuit consists of a 5,000 kilocycle crystal and a Type 30 tube with a pre-tuned plate circuit. When using this circuit to calibrate the receiver, it acts purely as a 5,000 kc oscillator with a high harmonic content. Radiation from this circuit on its harmonics is sufficient to cause a very marked reduction of the receiver hiss level which gives an accurate indication of receiver resonance. When checking the transmitter calibration the Type 30 tube acts as an oscillator-detector and its audio output, which would consist of an audio beat note between the transmitter and harmonics of the crystal frequency, is coupled to the audio system as described above.

7. The control relay normally is in the receive position. It is energized when the send-receive switch is thrown to send or when the push to talk button on the microphone is depressed. When this relay is energized, it shifts the antenna from receiver input to transmitter output, shifts the filament voltage from receiver tubes to transmitter tubes, disconnects the volume control from the Type 30 first audio tube and inserts a resistor in series with the headphones to reduce the side tone signal.

METHOD OF TEST

8. The methods used to determine the characteristics of the equipment are as follows:

(a) For frequency range and overlap of the receiver, the output of a microvolter was coupled to the input of the receiver and the output of the receiver to an output meter. The frequency was measured at the minimum and maximum of the tuning range of each of the three bands.

(b) For calibration accuracy the output of a crystal controlled frequency indicator was coupled to the input of the receiver and the tuning control settings of the receiver at various frequencies compared with the settings according to the calibration chart.

(c) For sensitivity of the receiver the output of a microvolter was coupled to the input of the receiver and the output of the receiver to an output meter. The input to the receiver was adjusted to maintain a constant output noise level without modulation at various frequencies and then the output was measured and recorded with the 400 cycle modulation of the microvolter applied.

(d) Further sensitivity measurements were made with the use of a beat frequency oscillator coupled through a transformer to the microvolter, the output of which was coupled to the receiver and the output of the receiver to an output meter. With the receiver volume control adjusted for full gain, the output was measured with the input varied from 1.0 to 100,000 microvolts modulated 30% at 1,000 cycles.

(e) With the same conditions as above, the output was measured with the input modulated from 10 to 75% at 200 to 3,000 cycles.

(f) For the selectivity measurements, the output of a microvolter was coupled into the receiver and the output of the receiver into an output meter. With the receiver adjusted to resonance with the microvolter frequency, the input and output were noted. The input was then increased 2, 10, 100 and 1,000 times and the microvolter frequency control adjusted above and below resonance until the same output as at resonance was obtained. The selectivity was determined as the frequency spread between points above and below resonance for the same output.

(g) For the audio frequency fidelity measurements of the receiver, a beat frequency oscillator was coupled through a transformer to the microvolter and the microvolter to the input of the receiver and the output of the receiver to an output meter. The receiver was adjusted for resonance with the input modulated at 1,000 cycles. The output was recorded and with no other changes the audio frequency was varied from 100 to 5,000 cycles. The decibels plus or minus from the reference point were determined from the ratio of the output at the various audio frequencies with the output at 1,000 cycles.

(h) The frequency range and overlap measurements of the transmitter were made with the use of a test signal generator. The frequency was measured at the minimum and maximum of the tuning range of each of the three bands.

[redacted]

(i) To determine the calibration accuracy, the tuning control settings according to the calibration chart and by crystal check were compared. The crystal frequency had previously been checked for accuracy and found to meet the specification requirements.

(j) For determining the temperature coefficient of the crystal, the equipment was installed in a temperature controlled chamber. With the temperature being varied over the specified range, measurements of the crystal oscillator frequency were made at regular intervals.

(k) For the power output measurement of the transmitter, an artificial antenna consisting of a 100 mmf variable capacitor and a 6.3 volt .15 ampere flashlight lamp in series was used in conjunction with a photo-electric cell and a microammeter. The photo-electric cell was placed as close as practicable to the lamp and with power in the antenna circuit the current of the photo-electric cell was recorded. Without changing the position of the apparatus external power was applied to the lamp and this power adjusted for the same photo-electric cell current as was originally obtained. The power output of the transmitter was calculated from the EI of the external source necessary to obtain this value of current.

(l) For the power consumption measurement tests were conducted concurrently on a General battery and a Burgess battery. As facilities for measuring the output were available for only one equipment, the second was set up for normal operation. Plate and battery voltage and power output of the transmitter were measured at regular intervals. The equipment was operated continuously and at alternate 15 minute periods of transmitting and receiving. The transmitting condition was for mcw with key locked. The power output was measured in the same manner as above.

(m) For the audio fidelity measurements a beat frequency oscillator was coupled through a mixer to the microphone input of the transmitter. The output was coupled to a cathode ray oscillograph to determine the percentage of modulation. The input voltage necessary for 70% modulation at various audio frequencies from 200 to 5,000 cycles was recorded. The decibels ± were determined from the ratio of these input voltages with that at the reference frequency of 1,000 cycles.

(n) For the distortion of the power output of the transmitter, a beat frequency oscillator was coupled through a mixer to the transmitter and the output of the transmitter through a rectifier to a wave analyzer. With the modulation constant the percentage of distortion was recorded at succeeding harmonics of the input frequency.

(o) For determining the effect of variable temperature on the output and frequency, the equipment was installed in a temperature controlled chamber and with the temperature varied over the specified range, the output was measured at regular intervals in the same manner as for the power output measurements. The frequency was measured at the same intervals.

(p) For the effect of variable humidity on the output and frequency, the same procedure as for variable temperature was used except the

[redacted]

humidity within the chamber was varied from a low percentage to nearly saturation or approximately 97 percent.

(q) In conducting the field tests, two of the equipments were set up at a fixed point and two others at various distances away to determine the range of communication and interference between adjacent sets.

DATA RECORDED

9. The following data were recorded:

Weights and dimensions of individual units and totals.

Frequency range and overlap - Frequency at minimum and maximum of the tuning range of each band. Percentage overlap.

Accuracy of calibration - Receiver setting by calibration chart, by crystal check and by frequency indicating equipment.

Sensitivity of receiver - Input microvolts, output milliwatts, percentage of modulation and modulation frequency.

Selectivity - Microvolter setting above and below resonance at 2, 10, 100, and 1,000 times the input microvolts and band width in kilocycles.

Fidelity - Audio input, milliwatts output and ± decibels from the output at 1,000 cycles.

Frequency range and overlap of transmitter - Frequency at minimum and maximum of tuning range of each band. Percentage overlap.

Accuracy of calibration - Transmitter setting by calibration chart and by crystal check.

Temperature coefficient of crystal - Time in minutes, temperature in degrees Centigrade and frequency.

Power output of transmitter - Output in watts.

Power consumption of equipment - Time in hours, plate voltage, battery voltage and watts output.

Audio fidelity - Audio input, input volts, percent modulation and decibels ± from the output at 1,000 cycles.

Audio distortion - Audio input, percentage of distortion at succeeding harmonics of input, and rms harmonic distortion.

Effect of variable temperature on power output and frequency - Time in minutes, temperature in degrees Centigrade, watts output and frequency.

Effect of variable humidity on power output and frequency - Time in minutes, percentage of humidity, temperature in degrees Centigrade, watts output and frequency.

Field tests - Range of communication and interference between adjacent sets.

PROBABLE ERRORS

10. The equipment used in conducting the tests is listed below with the percentage of error according to the manufacturer's guarantee:

Ferris microvolter, Model 18B, Ser.No. 65, accuracy ± 10.0%.

Weston selective analyzer, Model 665, accuracy ± 2.0.

Weston d-c voltmeter, 0 - 10, Model 45, Ser.No. 41660, accuracy 0.5%.

Weston d-c milliammeter, 0 - 500, Model 301, Ser.No. 330915, accuracy 2.0%.

Weston photronic cell

Weston microammeter, 0 - 200, Model 301, Ser.No. 997817, accuracy 2.0%.

General Radio output power meter, Type 583A, Ser.No. 72, accuracy 10.0%.

General Radio output meter, Type 483-C, Ser.No. 16, accuracy 5.0%.

General Radio beat frequency oscillator, Type 713-A, Ser.No. 209, accuracy 2.0%

General Radio cathode ray oscillograph, Type 687-A, Ser.No. 132

General Radio wave analyzer, Type 636-A, Ser. No. 318, accuracy 5.0.

General Radio test signal generator, Type 604-B, Ser. No. 16, accuracy ± 2.0.

NRL mixer panel, Ser. No. 1

NRL frequency meter, 35-350 Mcs. Ser.No. 1, accuracy 3.0.

Frigidaire temperature control unit.

Bendix Radio Company crystal frequency indicator, Ser.No. 1, accuracy ± .01%.

RESULTS OF TEST

11. The results of the tests will be discussed in the order in which they appear in the specifications, reference (b). The tables appended to this report are typical for the four equipments. Slight variations were observed in some instances and the tables show the performance wherein the departure from the specification requirements was greatest.

[redacted]

Section 1

General

1-1. The equipment under test is for high frequency transmitting and receiving. It is of the ultra portable or pack type for transportation as a knapsack load and for operation by one man. It is complete including battery power supply and antenna and is capable of two-way communication by either voice or mcw telegraphy. It is capable of being operated while being transported on a man's back.

1-2. Three of the types of tubes used in the equipment do not have Navy approval at this time. They are listed as follows: (factory type) 4068 pentode, A-2061 triode, and 1E7G pentode. These tubes perform satisfactorily for the purpose for which they are intended. The manufacturer has not as yet submitted samples of these tubes for test for Navy approval. There were no failures of tubes during the tests. There are no tubes on the Navy approval list of comparable size and weight that have equal performance capabilities.

1-3. The equipment in general is ruggedly constructed of the best material known to be suitable for each specific employment.

1-4. After considerable operation in moist atmosphere there was no evidence of corrosion.

1-5. The workmanship on the equipment in general is excellent.

1-6. The condensers and resistors are of satisfactory construction for use in the equipment.

1-7. All parts amenable to such treatment are impregnated before assembly in the equipment.

1-8. The insulating materials used in the equipment meet the requirements of these specifications.

1-9. The equipment operates satisfactorily in any temperature from -10 to 51.5° Centigrade.

1-10. The vacuum tube sockets are of the single unit type.

1-11. The equipment is completely shielded and the cabinet and all external parts are at ground potential. The body capacity effects while not entirely eliminated are reduced sufficiently to allow satisfactory operation of the equipment.

1-12. No name plates were submitted with the equipment.

[redacted]

Section 2

Items of Equipment

2-1. Each field equipment consists of the following units:

(a) Transmitter-receiver unit complete with batteries and tubes.
(b) Antenna.
(c) A chest microphone was not supplied.
(d) Head telephone receivers with cord and plug.
(e) A combination hand set (French phone type) was not supplied.
(f) Telegraph key with cord and plug.
(g) Canvas knapsack.
(h) and (i) Shipping chest and mobile spares were not supplied.

The microphone, head telephone receivers, and telegraph key are discussed later in these results.

2-2. According to these specifications, items (c) to (f) inclusive are hereinafter referred to as accessories.

Section 3

Stock Spare Parts

3-1. No stock spare parts were submitted.

Section 4

Description of Equipment

4-1. The transmitter-receiver unit is housed in a light weight, rugged metal cabinet with the exterior an olive green crystalline finish. The chassis is readily removable from the cabinet. No separate opening is necessary for the battery as it is strapped externally to the bottom of the transmit-receive unit.

4-2. All controls, jacks, instruments, etc., are on a single panel on the front of the unit.

4-3. The batteries are not "housed in" but are "strapped to" the bottom of the transmitter-receiver unit.

[redacted]

4-4. The antenna is constructed of tubing and is self-supporting. It is designed to secure to the transmit-receive unit and be supported thereby. It is capable of rapid assembly and attachment without the use of tools.

4-5. The entire equipment is housed in a knapsack for field transportation as a back load for one man.

4-6. No shipping chest was supplied.

Section 5

Weight, Size, and Frequency Range

5-1. The complete field equipment ready for operation and including the knapsack is 2.7 pounds under the specified allowance of 32 pounds.

5-2. The equipment is well within the specified dimensions. The weights and dimensions of the equipment are shown on Table 1.

5-3. The equipment is capable of operating at any frequency between the limits of 28 to 65 megacycles without hiatus. The frequency range and overlap of the receiver are shown on Table 2 and of the transmitter on Table 9.

Section 6

Transmitter-Receiver

6-1. The specifications state that the use to which the equipment is to be put is such that transmission and reception will always be on the same frequency at any one time. The equipment is capable of operation under these conditions. The transmitter and receiver may also be operated on any frequency within the frequency range, provided the antenna length is proper for the transmitter frequency.

6-2. The number of tubes used and the circuits employed have been described in MATERIAL UNDER TEST.

6-3. The equipment does not entirely meet the overlap requirements as shown on Tables 2 and 9. The frequency range is covered in three bands changeable by controls on the front panel.

[redacted]

6-4. Plug-in coils are not used.

6-5. The tuning controls can be locked after adjustment to prevent frequency shift.

6-6. Panel lights have been provided and are operated by a non-locking push button.

6-7. The panel of the transmitter-receiver unit is provided with the following male portions of plug receptacles for connection of the operating accessories:

(1) Two receptacles in parallel for connection of combination head phone and microphone cords.
(2) One receptacle for connection of a combination send-receive switch and hand telegraph key cords.

6-8. The transmitter-receiver unit is provided with a relay operated by a push button on the microphone to change from Receive to Transmit. Its normal position is for reception. For mcw telegraphic keying, the send-receive switch must be in the send position in which case the relay remains in the transmit position. The switch must be returned to the receive position for reception.

6-9. The transmitter-receiver unit contains a crystal calibrator with a fundamental frequency of 5,000 kilocycles. The design of the equipment is such that the transmitter and receiver can be tuned to harmonics of this crystal calibrator at 5 megacycle intervals throughout the frequency range. The specifications require that the equipment, including the crystal calibrator, shall be such as to permit adjustment of the transmitter-receiver frequency to frequency channels at 500 kilocycle intervals throughout the frequency range of the equipment. The equipment is capable of being adjusted to well within the .1% accuracy required.

6-10. A switch is provided to start and stop the crystal calibrator as may be required.

6-11. The crystal accuracy measured at 20° C. meets the specification requirement of .02%.

6-12. The crystals have a temperature coefficient within the specified requirements of 5 parts/million/degree Centigrade and are free from any sudden frequency changes within the temperature limits of -10 to +51.5° Centigrade. The results of this test are shown on Table 11.

[redacted]

Section 7

Operating Accessories

7-1. A handset of the French type was not supplied.

7-2. A chest microphone was not supplied. The microphone supplied with the equipment is a Type RS-38 with the push button modified to be non-locking.

7-3. The head telephone receivers are the Type 49016 but without the Navy Type 49028 head band. The head band supplied is an adjustable webbing strap. There is also supplied an adjustable leather chin strap. This chin strap is not of a comfortable design.

7-4. A plunger type key is provided mounted in a small metal box which also contains the send-receive switch. No provision is made for mounting this unit which must be held with one hand while keying with the other. The key was not sufficiently free acting. There was noticeable binding in the bushing.

7-5. The cords furnished with the above accessories were temporary and made up of bell wire. These cords are definitely unsatisfactory.

Section 8

Antenna

8-1. The antenna is of the jointed sectional type and is easily assembled and disassembled.

8-2. The material has a protective covering to offer maximum resistance to corrosion.

8-3. The antenna is composed of ten sections, approximately 12 inches in length. The number of sections necessary for proper tuning of the transmitter is listed on the calibration chart of the equipment.

8-4. The transmitter-receiver unit is so designed as to permit the antenna to be rapidly and securely attached thereto.

8-5. The antenna when unjointed is approximately 12 inches less than the specification allowance of 24 inches.

8-6. The antenna has sufficient resilience to bend through an arc of more than the specified 5° per section, and will not take a permanent set when so bent.

8-7. The calibration chart supplied with each equipment contains instructions as to the proper antenna length to be used for each frequency from 28 to 65 megacycles in increments of 0.5 megacycle.

Section 9

Carrying Case

9-1. An olive drab knapsack is provided with each equipment. It is provided with adjustable webbing shoulder straps. Compartments are provided for housing and carrying the transmitter-receiver unit, the disassembled antenna and the accessories. The flaps are provided with zipper fasteners. The design of the transmitter-receiver unit compartment is such as to permit operation of the equipment while being transported. The shoulder straps are not arranged for the most comfortable distribution of the weight for transportation on a man's back.

Section 10

10-1. No shipping chest was furnished with the equipment.

Section 11

Spare Parts

11-1 to 11-4. No spare parts except one set of batteries were furnished with the equipment.

Section 12

Performance

12-1. It was not practicable to have measuring instruments with the equipments separated 10 nautical miles for the purpose of determining the transmitter power output or receiver sensitivity. These measurements were made at the Laboratory. The results of the power output measurements of the transmitter are shown on Table 12 and sensitivity measurements of the receiver on Tables 4, 5, and 6 inclusive. The carrier power output of the transmitter does not quite meet the required 1 watt of power according to descriptive specifications, reference (c). On ncw the average power output is approximately twice the carrier power. The sensitivity of the receiver does not entirely meet the requirements of the specifications, reference (b).

12-2. Due to the topographical conditions of the terrain where the tests were conducted, the maximum line of sight distance was approximately 8 miles. The field test data were obtained over this distance.

12-2.1. The equipment is so designed that it is possible for two adjacent transmitters to communicate with two adjacent receivers without interference, with a channel separation of 5% of the working frequency or the closest 500 kilocycle channel thereto.

12-2.2. An adjacent transmitter and receiver separated 25 feet between antennas may communicate without interference with another adjacent transmitter and receiver with a channel separation of the specification requirement of 20% of the working frequency or the closest 500 kilocycle channel thereto. The tests show that operation under the above condition is possible at approximately 10% separation of the working frequency. Further tests showed that it was possible to receive either voice or mcw signals from a distant transmitter on any frequency within the band with another transmitter separated 500 yards from the receiver and transmitting on a frequency separated 500 kilocycles from the working frequency. On two occasions equipment was set up at the above mentioned 8 mile line of sight distance. In both instances the equipment performed as follows. Two-way communication was established on all frequencies with mcw telegraph. Two-way telephone communication was established on frequencies from 28 to 35 megacycles and from 50 to 65 negacycles. Voice signals were heard on frequencies between the above ranges but were too weak for intelligibility.

12-3. Two equipments are capable of operating for reception on the same frequency with full gain with a separation of 25 feet between antennas without appreciable interference with normal reception. The results of laboratory tests on the selectivity of the receiver are shown in Table 7.

DECLASSIFIED

[redacted]

12-4. Two types of batteries were submitted for the power supply of the equipment. Both are capable of 10 hours continuous operation on a basis of 50% transmission and 50% reception. During the test the equipment was operated alternately at 15 minute intervals for transmission and reception. The transmitter was operated in the mcw condition with the key locked. This is more severe than for telephonic operation as required by the specifications, reference (b). The results of these tests are shown in Table 13. During the test it was necessary to periodically adjust the filament rheostats to maintain the proper filament voltages. After 11 hours the 1-1/2 volt filament resistor was all out on the equipment using the Burgess battery, and at the end of the test (12 hours) the voltage was dropping off. After 11.5 hours the 1.5 volt filament resistor on the equipment using the General battery was all out. The voltage was still holding up at the end of the run.

The batteries are not housed but are strapped to the bottom of the transmitter-receiver unit. Since the use for which the equipment is intended might necessitate placing it on wet ground or shallow puddles of water, it was found that the batteries were not sufficiently protected. Two of each type of battery were set in water to a depth of 1 inch, the voltages being measured before the test. After several hours the voltage was again measured. The voltages of the Burgess battery showed no change. The 145 volt bank and 7 volt bank of the General battery showed complete discharge. In both cases the paper coverings of the batteries were damaged. Plate 3 shows the type of construction of both batteries.

12-5. The audio fidelity of the transmitter meets the requirements of the specifications, reference (b), but the receiver does not at all frequencies. The results of these tests are shown in Table 8 for the receiver and Table 14 for the transmitter.

12-6. The transmitter meets the undistorted power output requirements of the specifications, reference (b), except with 200 cycle input at 45 megacycles. The results of this test are shown in Table 15.

Additional tests were made as follows:

The calibration charts supplied with the equipment were checked for accuracy. The results of these tests are shown in Table 3 for the receiver and Table 10 for the transmitter. The stability of the equipment is such that with a reduction of the backlash of the tuning controls and more careful checking of the frequency of the various channels the calibration accuracy of the charts will be improved.

The equipment performs satisfactorily in temperatures from -10 to +50° C. The results of this test are shown in Table 16. The performance of the equipment when subjected to humidities from 47 to 97% is shown in Table 17. The equipment performed satisfactorily under these conditions.

CONCLUSIONS

12. In its present condition the equipment is not entirely satisfactory for the use for which it is intended.

13. Electrically the equipment meets the requirements of the specifications, reference (b), except on the following: receiver frequency range and overlap, accuracy of the calibration chart, sensitivity and audio fidelity, transmitter frequency range and overlap, accuracy of the calibration chart, power output and audio distortion of the power output.

14. The equipment has an undesirable characteristic in that the full output of the side tone is applied to the telephone receiver when the key is pressed with the equipment in the receive condition and the crystal calibrator switch either on or off, and in the transmit condition with the crystal calibrator switch on.

15. Another undesirable feature is the presence of voltages of the order of 125 to 150 volts inside the case when the battery is in place and the power switch is in the off position. There is a warning of this condition in the instruction book. Removing this voltage near its source by means of a switch when in the power-off position would greatly facilitate changing of tubes.

16. Several mechanical defects were encountered in the equipment. The backlash of the tuning controls is excessive. The contacts of the band changing mechanism and the relay gave considerable trouble due mainly to poor alignment. Keying the transmitter for MCW telegraph was difficult due to binding in the key bearing. The arrangement of the acorn type tube sockets is such that they do not hold the tubes securely in place. Accessibility to the detector tube of the receiver is very difficult. The general construction of the knapsack is satisfactory, but the arrangement of the carrying straps is not conducive to the most comfortable load distribution for transportation on a man's back. The batteries are not sufficiently protected to prevent damage from moisture. The hand telephone of the so-called French type and the chest microphone described in the specifications were not supplied. There was supplied a Navy Type RS-38 hand microphone modified so that the push button is non-locking. This type of microphone is considered satisfactory. The head telephones have not the Navy Type A9028 head bands but are equipped with an adjustable webbing band and an adjustable chin strap. The latter is not of a comfortable design. The cords supplied with the key, head sets and microphones are not satisfactory. The snap fasteners for securing the cover of the transmitter-receiver unit in place are not sufficiently rugged. The design of the filament rheostat control knobs is not entirely satisfactory.

TABLE 1

MODEL TBP EQUIPMENT

WEIGHTS AND DIMENSIONS

Units	Item	Weight
2	Headphones, microphone and cords (per unit 1.0 lb.)	2.0 lbs.
1	Key, switchbox and cord	.25 "
1	Instruction book	.35 "
1	Antenna (10 sections)	.5 "
1	Knapsack	2.3 "
1	Battery, Burgess	14.2 "
1	Battery, General	12.5 "
1	Transmitter-Receiver unit	9.7 "
	Weight of complete equipment with Burgess battery	29.3 "
	Specification allowance	32.0 "

	Height	Width	Depth
Transmitter-Receiver Unit including all projections	8-3/8 in.	10-1/2 in.	7 in.
Specification allowance	12 in.	15 in.	7 in.
Burgess battery	4-5/8 in.	9-1/2 in.	6-7/8 in.
General battery	4-1/4 in.	9-1/2 in.	6-7/8 in.

Antenna (10 sections) length, maximum 13-1/2 in., minimum 12 in.

Specification allowance 24 inches.

TABLE 2

MODEL TBP EQUIPMENT

RECEIVER

Frequency Range

	Rec.Dial Setting Min.	Rec.Dial Setting Max.
Band 1	26.83 mc	39.80 mc
Band 2	35.02 mc	51.45 mc
Band 3	48.05 mc	71.45 mc

Specification requirements, 28.0 mc to 65.0 mc.

Overlap

Range	Overlap mc	Percentage overlap
Min. to 28.0 mc	1.17	4.18
Band 1 to Band 2	4.78	13.64
Band 2 to Band 3	3.4	7.08
65.0 to Max.	6.45	9.9

Specification requirements, 5% overlap.

[redacted]

TABLE 3

MODEL TBP EQUIPMENT

CALIBRATION ACCURACY OF RECEIVER

Freq. mc	Rec. Setting by chart	Rec. Setting by LM-1	Rec. Setting by XTAL
30	410	420	411
35	857	855	855
40	480	485	487
45	830	835	832
50	1085	1085	1085
55	490	485	485
60	742	745	739
65	940	940	942

TABLE 4

MODEL TBP EQUIPMENT

SENSITIVITY OF RECEIVER

Freq. mc	Input MCV	Output with Mod. MW	Percent Modulation
28.0	5.3	.5	20.9
33.0	1.4	.4	19.7
37.0	5.0	.32	20.7
37.5	4.0	1.2	20.7
45.0	3.0	.7	20.9
50.0	3.1	.7	21.5
50.5	4.5	1.25	21.5
60.0	5.0	.8	19.4
65.0	6.2	.75	20.0

The noise level (without modulation) was held constant at .250 MW. The percent modulation column is the actual percentage of modulation of the microvolter by measurement.

[redacted] DECLASSIFIED

TABLE 5

MODEL TBP EQUIPMENT

SENSITIVITY OF RECEIVER AT 38 mc.

Modulation Input MCV	30 percent at 1000 cycles Output MW No. resistance in input	Full Gain Output MW 100 ohms in input
1.0	.888	.817
10.0	.938	.770
100.0	.770	.770
1,000.0	.560	.450
10,000.0	.580	.560
50,000.0	4.7	1.6
60,000.0	6.7	2.56
80,000.0		5.1
100,000.0		7.33

TABLE 6

MODEL TBP EQUIPMENT

SENSITIVITY OF RECEIVER AT 33 mc.

Input Freq.	MW output at the following percentages of modulation						
∿	10	20	30	40	65	75	100+
200	.250	.4	.6	1.0	3.0	5.0	12.0
300	.4	.9	1.8	3.5	10.0	16.0	40.0
400	.35	.7	1.5	3.0	8.0	13.0	25.0
600	.3	.4	.65	1.0	3.0	5.0	12.0
800	.250	.325	.45	.6	1.8	2.8	6,0
1,000	.250	.3	.38	.5	1.2	2.0	4.0
1,500	.250	.270	.3	.4	.8	1.2	2.5
2,000	.250	.250	.28	.35	.6	.9	2.0
3,000	.250	.270	.3	.35	.7	.85	1.5

The output of the microvolter is leakage with the attenuator controls at zero. The receiver adjusted for full gain the noise level without modulation was .250 MW. The output for 10 percent modulation at 800 and 1,000 cycles was nearly all signal with little noise in background. In all other cases where the values are .250 and .270 MW, the output was mostly noise with the signal weak in background.

DECLASSIFIED

[redacted]

TABLE 7

MODEL TBP EQUIPMENT

SELECTIVITY OF RECEIVER

Freq. mc	X Resonance Input	Microvolter setting below resonance	Microvolter setting above resonance	Band width Div.	Kcs. per Div.	Band width Kcs.
33	2	17.1	18.2	1.1	221	243
33	10	16.6	18.6	2.0	221	442
33	100	16.0	19.0	3.0	221	663
33	1000	15.6	19.5	3.9	221	862
45	2	72.4	74.1	1.7	210	357
45	10	71.6	74.7	3.1	210	652
45	100	70.9	75.3	4.4	210	924
45	1000	70.1	76.0	5.9	210	1238
60	2	12.2	13.1	.9	415	373
60	10	11.8	13.4	1.6	415	654
60	100	11.5	13.7	2.2	415	913
60	1000	11.1	14.0	2.9	415	1203

TABLE 8

MODEL TBP EQUIPMENT

AUDIO FIDELITY OF RECEIVER

Input Freq. ~	At 33 mc D.B.	At 45 mc D.B.	At 55 mc D.B.
100	-5.28	-6.02	-7.23
200	-3.32	+5.19	+5.23
400	+8.47	+9.93	+10.46
600	+3.88	+4.66	+4.93
800	+1.48	+1.87	+1.92
1,000	0	0	0
1,500	-2.01	-2.38	-2.55
2,000	-3.54	-3.73	-3.74
2,500	-3.9	-4.15	-4.48
3,000	-3.9	-4.15	-4.48
5,000	-1.08	+ .32	- .15

[redacted]

TABLE 9

MODEL TBP EQUIPMENT

TRANSMITTER

Frequency Range

	Trans. Dial Setting Min.	Trans. Dial Setting Max.
Band 1	27.15	37.9
Band 2	36.65	57.05
Band 3	49.22	77.55

Specification Requirements 28.0 to 65.0 mc.

Overlap

Range	Overlap mc	Pct. overlap
Min. to 28.0 mc	.85	3.035
Band 1 to Band 2	1.25	3.41
Band 2 to Band 3	7.83	15.9
65.0 mc to Max.	12.55	19.3

Specification requirements 5% overlap.

TABLE 10

MODEL TBP EQUIPMENT

CALIBRATION ACCURACY OF TRANSMITTER

Freq. mc	Trans.setting by chart	Trans.setting by XTAL
30	500	476
35	984	975
40	395	385
45	690	690
50	896	904
55	456	456
60	680	674
65	850	845

[redacted] DECLASSIFIED

TABLE 11

MODEL TBP EQUIPMENT

TEMPERATURE COEFFICIENT OF CRYSTAL

Time Min.	Temp. °C.	Freq. Kcs.
0	+22	5000.4
15	+37	5000.8
30	+45	5000.8
45	+49	5000.8
60	+52	5000.7
75	+27	5000.7
90	+14	5000.7
105	+5	5000.6
120	-2	5000.5
135	-6	5000.4
150	-9	5000.3
165	-10	5000.2
180	-11	5000.1
195	+12	5000.1
210	+18	5000.2
225	+22	5000.3

Specification requirements, 5 parts/million/degree. At 5000 KC = 25 ~ per degre

Max.temp.change - 62°C
Max.Freq.change - 700 ~ } = 11.5 ~ per degree.

TABLE 12

MODEL TBP EQUIPMENT

CARRIER POWER OUTPUT OF TRANSMITTER

Freq. mc	Carrier Output watts
28.0	.891
31.5	.855
37.0	.629
37.5	.742
44.0	.694
50.0	.787
50.5	.603
57.5	.670
65.0	.585

TABLE 13

MODEL TBP EQUIPMENT

POWER CONSUMPTION

Continuous operation with alternate 15 min. periods of transmitting (MCW key down) and receiving.

Time hrs.	General Battery Plate E	General Battery Battery E	MCW Power Output watts	Burgess Battery Plate E	Burgess Battery Battery E
0	135	150	1.63	125	135
1	125	142	1.61	113	128
2	120	140	1.57	112	126
3	118	138	1.55	110	125
4	117	136	1.53	108	124
5	114	135	1.51	108	124
6	113	134	1.51	107	122
7	113	133	1.44	107	122
8	113	133	1.44	107	121
9	112	132	1.44	107	120
10	111	132	1.38	105	118
11	111	131	1.38	105	118
12	111	130	1.32	105	118

TABLE 14

MODEL TBP EQUIPMENT

AUDIO FREQUENCY FIDELITY OF THE TRANSMITTER

Modulated 70 Percent

Audio Freq. ∿	33 mc D.B.	45 mc D.B.	55 mc D.B.
200	+1.94	+2.16	+1.72
400	+ .84	+ .98	+ .87
600	+ .25	+ .5	+ .17
800	+ .25	+ .37	0
1,000	0	0	0
1,500	- .06	+ .06	+ .06
2,000	- .06	+ .06	0
2,500	- .12	+ .06	- .06
3,000	- .12	+ .06	0
5,000	+ .49	+ .37	+ .06

TABLE 13

MODEL TBP EQUIPMENT

POWER CONSUMPTION

Continuous operation with alternate 15 min. periods of transmitting (MCW key down) and receiving.

Time hrs.	General Battery Plate E	General Battery Battery E	MCW Power Output watts	Burgess Battery Plate E	Burgess Battery Battery E
0	135	150	1.63	125	135
1	125	142	1.61	113	128
2	120	140	1.57	112	126
3	118	138	1.55	110	125
4	117	136	1.53	108	124
5	114	135	1.51	108	124
6	113	134	1.51	107	122
7	113	133	1.44	107	122
8	113	133	1.44	107	121
9	112	132	1.44	107	120
10	111	132	1.38	105	118
11	111	131	1.38	105	118
12	111	130	1.32	105	118

TABLE 14

MODEL TBP EQUIPMENT

AUDIO FREQUENCY FIDELITY OF THE TRANSMITTER

Modulated 70 Percent

Audio Freq. ~	33 mc D.B.	45 mc D.B.	55 mc D.B.
200	+1.94	+2.16	+1.72
400	+ .84	+ .98	+ .87
600	+ .25	+ .5	+ .17
800	+ .25	+ .37	0
1,000	0	0	0
1,500	- .06	+ .06	+ .06
2,000	- .06	+ .06	0
2,500	- .12	+ .06	- .06
3,000	- .12	+ .06	0
5,000	+ .49	+ .37	+ .06

[redacted]

PLATE I

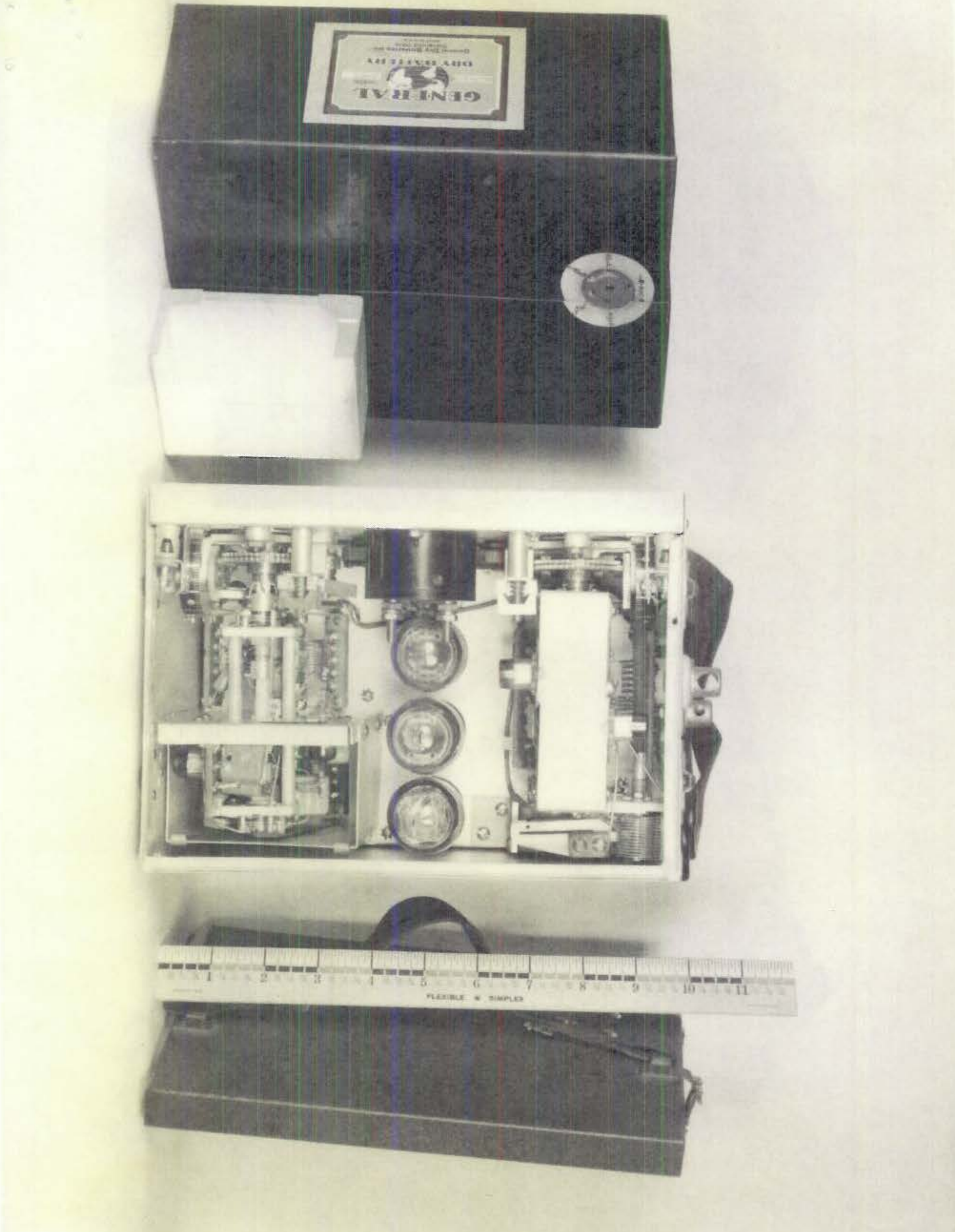
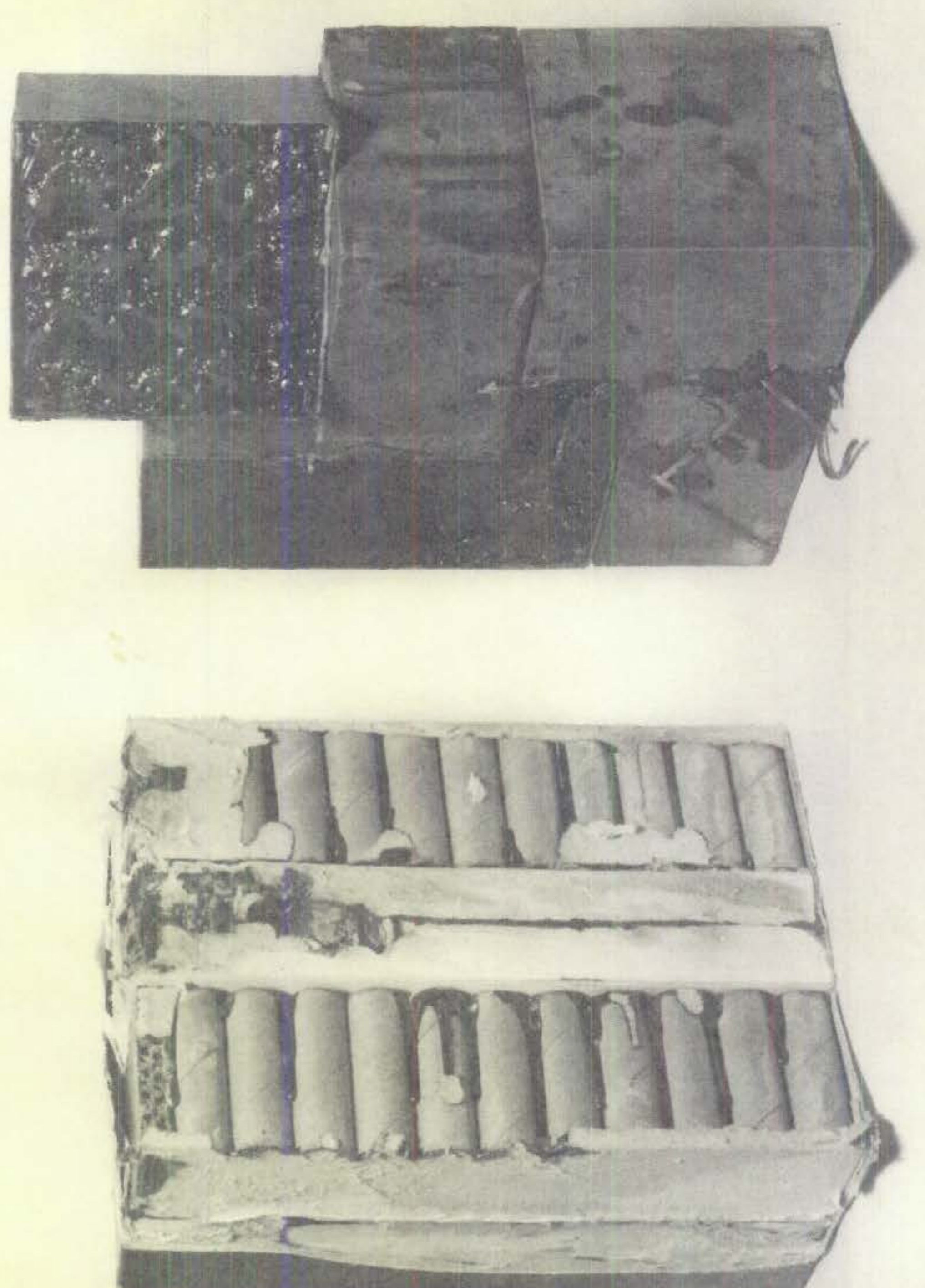
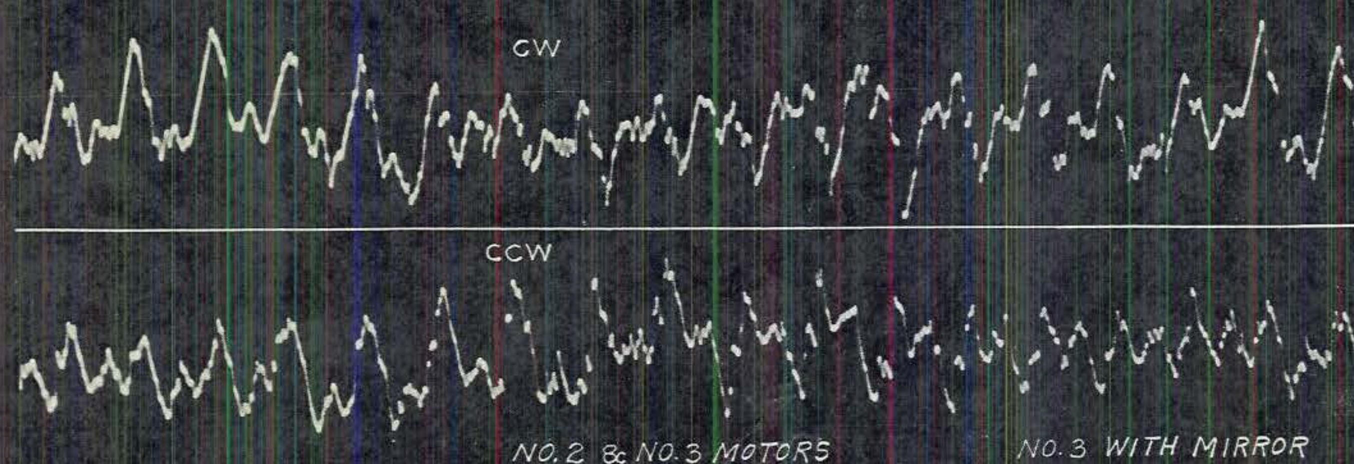


PLATE 2



DECLASSIFIED

PLATE 3


CW
CCW
NO. 2 & NO. 3 MOTORS
NO. 3 WITH MIRROR