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NAVY DEPARTMENT

BUREAU OF ENGINEERING

Report on

Test of Model TAV-2 Equipment

SECTION I

Transmitter, Generators, Antenna

and

Transportation Equipment

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AUTHORIZATION

1. The tests herein reported were authorized by the Bureau of Engineering in letter S67/52/TAV-2(1-25-W8) of 29 January 1934 to Director, Naval Research Laboratory.

OBJECT OF TESTS

2. The object of the tests is set forth in detail in ref.(a). Briefly, it is to supply information for the use of the Bureau of Engineering in the analysis of bids for additional equipment, to determine the compliance with requirements of the contract under which the equipment was manufactured and to obtain complete performance data to be used as a basis for any necessary corrective action or in the preparation of revised specifications for new equipment.

REFERENCES

3. Reference:
(a) BuEng let.S67/52/TAV-2(1-25-W8) of 29 January 1934 to Naval Research Laboratory.
(b) Specifications RE 13A 399D.
(c) Westinghouse Electric and Manufacturing Company descriptive specifications R674 of May 1933.
(d) Westinghouse Electric and Manufacturing Company Preliminary Instruction Book.

MATERIALS UNDER TEST

4. The materials under test consist of one complete Model TAV-2 portable radio equipment, Serial No. 2, consisting of the following component parts:

- Transmitter-receiver unit.
- Gas engine generator unit.
- Hand-driven generator unit.
- Antenna assembly.
- Battery case with receiver batteries.
- Connecting cables, filter and accessories.
- Transportation cart.
- Spare parts.

5. The frequency range of the transmitting equipment is 2000 to 4525 kilocycles and the power rating is 20 watts. The frequency range of the receiving equipment covers two bands; namely, 300 to 600 and 2000 to 4525 kilocycles.

6. The equipment was designed for the use of landing parties ashore or in small boats.

7. A complete description of the power equipment, the master oscillator power amplifier transmitter circuits, receiver circuits and

antenna system with drawings is contained in refs.(c) and (d).

ABSTRACT OF TESTS

8. The Model TAV-2 portable radio equipment is similar in many respects to the Model TAV-1 equipment. The former constitutes, however, a decided advancement in this class of radio equipment. Many of the faults and deficiencies noted in previous tests of similar apparatus have been corrected in this model. The deficiencies noted during the tests herein described may be attributed to the choice of a rather inferior type of vacuum tube for the transmitter, the poor adjustment of the antenna loading coil taps and minor faults in the design of parts rather than any fundamental errors in circuit design, arrangement of parts or choice of materials with the possible exception of the failure on the part of the manufacturer to eliminate receiver and transmitter interaction.

9. The difficulties encountered in the tests of this equipment, including electrical and mechanical defects and failures are given below in abstract form. A more complete description of these tests with conclusions and recommendations may be found elsewhere in this report. The performance tests of the receiver unit are contained in Section II of this report.

(a) The failure of all the type 38110 vacuum tubes furnished led to a direct comparison test between these tubes which were manufactured by Eveready Raytheon and three RCA Radiotrons of the same type number. The latter proved to be superior, one set of tubes being used throughout the remainder of the tests without a failure. The fundamental difference is in the type of filament used. The former uses an oxide coated filament which renders the tube inherently subject to primary grid emission, while the latter uses a thoriated tungsten filament which is free from this defect.

(b) The failure to obtain required output from the transmitter on all the frequencies included in the specified band, using an antenna of specified height and length, is attributed to an error in the adjustment of taps on the antenna loading coil resulting in a gap between range four and range five, when a sufficiently tight coupling is employed to give maximum output. There is a second gap between the high frequency limit of range five and the high frequency end of the specified frequency band when adjusted for maximum output. The fact that range one is not usable at all in this particular set in covering the specified frequency band and further, that the required overlap is not provided between any of the bands suggests the need of a complete rearrangement of taps to fulfill the specifications.

(c) The presence of serious interaction between transmitting circuits and receiving circuits when adjusted to the same or adjacent frequency prevents the operation of either the transmitter or the receiver at maximum efficiency. This condition is particularly serious when the receiver is in operation and the transmitter is not but is tuned to the same or an adjacent frequency within the band covered by transmitter antenna range five which is the highest frequency band provided.

(d) The failure of the transmitter relay key to operate properly at speeds up to 40 words per minute led to an inspection of the relay. It was found that the plunger was binding against the inner surface of the solenoid and that the pin which limits the side movement of the contact arm rubbed and limited the speed of its vertical motion also. By replacing the pin with one of smaller diameter and turning down the plunger until it was perfectly smooth, the action was improved. The maximum speed at which the relay will operate with the most favorable adjustment is 30 words per minute. At 40 words per minute the dots do not record.

(e) The voltmeter supplied for use with the generators for determining when the proper generator speed is being maintained is connected to the generator by means of small plugs which fail to make proper contact due to continuous vibration. A heavier plug should be substituted.

(f) While no difficulty was experienced in setting up the antenna supports or the transmitter-receiver unit on firm soil, it is believed that the supporting legs of this unit and the foot of the masts would sink into loose sand or mud, either of which might be the only available type of soil in a locality where a rapid set-up is desired. A base of the proper type in the case of the masts and flanges near the ground end of the legs of the transmitter-receiver unit would remove the possibility of this difficulty.

(g) Considerable difficulty was experienced in loading the equipment on the transportation cart due, first, to the absence of any markings to indicate where the various units should be placed and the failure to enclose photographs referred to in the instruction book and, second, to the unsteadiness of the supporting legs of the cart. The second difficulty was also experienced while unloading the equipment prior to setting it up in the field. Properly designed supporting legs with braces for use while the cart is not in motion would correct this difficulty and improve an otherwise well designed transportation cart. Markings on the frame would indicate to the untrained operator the proper space in which the respective units should be placed on the cart for proper balancing of the load.

(h) On dismantling the antenna assembly after having stood in the weather for a period of approximately one month, the hardware in the case of the antenna guy snaps and the antenna blocks was found to be quite rusty. Hardware of a non-ferrous material should be substituted. The masts themselves were found to resist the effect of the weather very well indeed. No difficulty was experienced in disassembling or reassembling the sections.

METHOD AND RESULTS OF TESTS

10. The equipment was first unpacked and assembled indoors for a preliminary test to determine, as far as possible in the limited time allotted, the general merits of this model in comparison with other models previously tested. The results of this preliminary test were on the whole very favorable. They were communicated to the Bureau verbally in order that the information might be used immediately.

11. Since the results of the preliminary test are fully covered in the more exhaustive tests which followed they will be omitted from this report.

12. The apparatus was then turned over to the Receiver - Direction Finder Section for tests in accordance with refs.(a), (b), and (c) insofar as they were related to the receiving equipment. Section II is a complete report of the tests conducted on this part of the equipment.

13. The complete equipment was later loaded onto the transportation cart and transported from the laboratory building to a point in the field north of the laboratory building where operation was reasonably free from interference of a nature which would be expected not to exist under service conditions.

14. The apparatus was unloaded and set up by two engineers. Each piece of equipment was examined during the procedure. The time consumed is not recorded since a landing party would normally consist of several men, more or less trained, and with special duties assigned. It is believed that the requirements of par.6-15 of ref.(b), when given a liberal interpretation, have been met. That is, under favorable wind, weather, and soil conditions, the complete antenna system can be set up and the equipment put into operation within ten minutes by a crew of not more than four men who are more or less trained in the procedure and whose efforts are well directed.

15. The equipment was first checked to ascertain the measure of compliance with the specifications as contained in refs.(a), (b), and (c) as they relate to the complete equipment except that the receiver specifications were considered only as they affected actual operation of the equipment in the field, laboratory tests of the receiving equipment having been previously conducted.

16. The introductory and general specifications of ref.(b) as amended by correspondence reviewed in ref.(a) have been met as nearly as can be judged under the conditions existing during the tests and with the test equipment available, except clauses 1 - 2, covering the frequency range required; 2-5 and 6, regarding the use of ferrous materials; 2-31, as it relates to possible keying speed, endurance and corona; and 2-32, referring to operation in accordance with specifications with the antenna arrangements laid down in Section IV of the same reference.

17. The only corona detected during the tests was in the antenna series capacitor. This condition was not noticed after bending the terminal strip of one plate so that the clearance was increased between this point and the opposite plate.

18. The other clauses mentioned as being not fulfilled are stated more specifically in other sections of the same reference and will be treated in the discussion of these other sections.

19. The general requirements contained in Section III of ref.(b), insofar as they relate to the power, transmitting, and radiating systems, have been met with the following exceptions:

(a) Paragraph 3-1 requires satisfactory operation over a frequency range of 2000 to 4525 kilocycles when either of the three specified antenna arrangements are in use. Compliance with this clause hinges upon the interpretation of the word "satisfactory". The specific requirements are contained in paragraphs 4-2 to 4-9 inclusive. The points in question are:

(1) whether a maximum of power has been provided at frequencies in the neighborhood of 3300 kilocycles and between 4400 and 4525 kilocycles which is specified as being essential;

(2) whether the rated output of 20 watts is obtainable at the highest frequencies in the specified band; and

(3) whether, where band adjustments have been used, an overlap of not less than 10% has been provided.

(b) It would appear from an examination of Tables 5 and 6 that the frequency band required has been fully covered. It must be noted, however, that when the large antenna was in use, it became necessary to reduce the antenna coupling and power output to obtain a frequency overlap between bands 4 and 5 or to adjust the transmitter to any frequency above 4400 kilocycles. Therefore, a maximum of power is not obtainable at 3300 kilocycles or above 4400 kilocycles. The normal function of the antenna coupling adjustment which is to provide a means of obtaining an optimum value of coupling, a value which will give the maximum transfer of energy without objectionable reaction, has been changed to a means of obtaining the required frequency range. It is believed that this condition cannot be termed "satisfactory".

(c) The question as to whether the rated output of 20 watts is obtainable at the highest frequencies in the specified band is not easily answered. Table 2 shows the power output using a dummy antenna of specified characteristics to be quite sufficient. The question is whether the characteristics of the dummy antenna approach those of the actual antenna. The table was prepared from data obtained during a test conducted in accordance with sub-paragraph 13-3-(3) of ref.(b) supplemented by sub-paragraphs 2-b(6)(a) and (b) of ref.(a), authorizing the power output tests to be conducted with a dummy antenna of 10 and 20 ohms resistance and 80 mmf capacitance. Due to the impracticability of measuring the resistance of the antenna at the highest frequencies, it is impossible to say just what the power output is. Since practical tests have demonstrated the superior performance of the transmitter at the higher frequencies over the required distance of twenty-five miles, as described later in this report, the determination of the exact power output is considered important only insofar as the fulfillment of the contract is concerned. The power output at the higher frequencies will doubtless be increased to the extent that it will be quite satisfactory by the alteration of the antenna circuit to meet the maximum power and frequency overlap requirements.

(d) The frequency overlap requirements as they apply to the antenna circuit where band adjustments have been used have not been met and the operation is not considered satisfactory. It has been noted that in paragraph 4-7 of ref.(c) the specification contained in paragraph 4-7 of ref.(b) has been interpreted to mean "10% of the band coverage of each tap". The usual interpretation of this clause is that the overlap shall be 10% of the mean frequency of the overlap, which is slightly less than 10% of the maximum frequency of the lower of the two overlapping bands. Meeting the requirements under this interpretation is considered entirely practical should the full range of all five bands be utilized. It is interesting to note that even with the liberal interpretation placed on this clause by the manufacturer, it has not been met.

Tables 3 and 4 show the band coverages of the master oscillator and power amplifier to be entirely adequate. Tables 5 and 6 show the limitations of the present adjustment of taps on the loading inductance and Table 7 shows what may be expected of the antenna circuit altered and properly adjusted. With the present arrangement there are twelve turns on the loading coil which are never used. Probably ten of these could be removed without reducing the inductance below the value necessary to cover the frequency band required.

(e) The removal of ten turns from the loading coil and the rearrangement of taps in such a way that the full range of all the bands would be utilized would doubtless bring the transmitter within the requirements of all of the paragraphs mentioned above.

20. In this equipment as in all high frequency transmitters provided with the "break-in" feature, the rapid transfer of the antenna from transmitter to receiver and back again for alternate transmission and reception presents quite a complex problem. Paragraph 3-11 of ref.(b) is a general statement of the requirements and paragraph 4-10 of the same reference specifically states that the transfer from the transmitter to the receiver must be effected directly and not through loading inductors or capacitors. The circuit used does not violate the wording of this clause as the current which produces the received signal does not necessarily pass through the transmitter loading inductance or capacitor when the antenna is connected for reception; however, the presence of the transmitter antenna tuning system, which remains directly connected to the receiver, causes a diminution of the received signal when the transmitter is tuned to the same or an adjacent frequency. This is discussed at length in Section II and curves are given to illustrate the effect of tuning the transmitter circuits to the frequency on which the receiver is operating.

21. The purpose for which the clause was inserted is doubtless to exclude a circuit which would permit reaction to exist, but due to the wording of the clause it does not exclude the circuit used in this equipment. A clause definitely requiring freedom from interaction between transmitting and receiving circuits would prevent the use of such a circuit under future contracts.

22. Instructions should be included with the present equipment warning the operator to detune the transmitter while receiving weak signals. Received signals are further improved by disconnecting the power transmission cable. This indicates failure to comply with paragraph 3-11 of refs.(b) and (c). Signals from the radio truck at 25 miles distance when the truck transmitter was operating at reduced power on 4107 kilocycles were readable with the transmitter tuned to 4400 kilocycles and the gas engine shut down or cable disconnected but not with the transmitter in operation with key up. Interaction between the transmitter and receiver had not been noticed at the time of this test

but a later test with signals from the truck demonstrated the diminution of signals when the transmitter was tuned to the frequency of the received signal and also the decrease in the output of the transmitter when the receiver was tuned through resonance with the transmitter frequency. This last effect would indicate reaction between the circuits due to inadequate shielding of circuits or leads, covered in paragraphs 3-8 and 4-11 of refs.(b) and (c).

23. It is noted that compliance with paragraph 3-12, ref.(b), is not guaranteed in paragraph 3-12 of ref.(c) regarding frequency stability with varying antenna characteristics and generator speeds. The liberal interpretation of the latter reference is probably met but not the rigid requirements of the original specifications, ref.(b). No mention of frequency stability is noted in ref.(a). Applying the usual test of adjusting the transmitter for a given frequency, 3000 kilocycles, and detuning the antenna circuit until it no longer changed the master oscillator frequency disclosed a change in master oscillator frequency of approximately 3000 cycles or one-tenth of one percent. This is considered excessive although no direct comparisons can be drawn due to the differences which exist between this and other standard Navy equipment.

24. The requirements of Sections IV, VI, VII, VIII, and X of ref.(b) not covered in the general specifications of I, II, and III have been met with the exceptions contained in the discussions that follow. Sections V and IX containing the specifications relating to receiving equipment and receiver batteries are covered in Section II of this report.

25. Paragraph 4-1 of ref.(b) approves the use of the Navy type 38110 vacuum tube. The manufacturers of Eveready Raytheon vacuum tubes have type approval on the Navy type 38110 vacuum tube so the use of this tube has been definitely approved by the Bureau. The fact remains, however, that after a few hours strenuous use these tubes become inoperative and show the effect of primary grid emission while the RCA Radiotrons bearing the same Navy type number withstand the strenuous key locked tests with no signs of weakness or failure. Table 15 was prepared from data obtained by the Vacuum Tube Section from tests comparing the three Eveready Raytheon vacuum tubes used in the early tests, the three unused tubes provided as spares and one of the RCA Radiotrons chosen at random from the three tubes used during the tests that followed the failure of all the tubes shipped with the Model TAV-2 equipment under test.

26. This fault of tubes of the Eveready Raytheon class employing an oxide coated filament as compared with tubes in which the thoriated tungsten filament is used has been reported to the Bureau. Briefly, this fault is an inherent tendency toward primary grid emission. The effect as noted in the present transmitter was a gradual falling off of grid bias during a key locked test and an accompanying rise in plate current until a certain point was reached, about 200 milliamperes total plate current, when the plate current would rise very rapidly to a value beyond the scale of the plate milliammeter necessitating the lifting of

the key. After ten minutes running idle with key up the same cycle could be repeated. Since one probable use of this equipment is for compass calibration where an approach to a key locked test is necessary this fault would render the equipment useless where the Eveready Raytheon type of tube is the only one available.

27. Paragraph 4-16 of ref.(b) has not been complied with in the case of the master oscillator frequency control where a Navy standard reversible worm gear control is used with no means for locking in position.

28. Table 8 shows the variation of frequency per division of marking. The accuracy of calibration as shown in Table 9 is well within the tolerance required by paragraph 4-25 of ref.(b).

29. The accuracy of reset as shown in Table 11 is satisfactory although the apparent backlash given in Table 12 seems excessive. If the instructions to always approach the setting from the low frequency side in a clockwise direction on the main dial are followed, reasonably accurate settings can be obtained.

30. The time required for reset to a given frequency is within the tolerance of one man minute specified in paragraph 4-20 of ref.(b) and the number of controls is the minimum number required for accurate and flexible adjustment.

31. The first key speed tests were a complete failure, alternate hand and machine keying methods being employed. The relay was later removed from the transmitter, a new pin for limiting the side motion of the plunger contact arm substituted for the one furnished which limited the vertical motion and speed as well, and the plunger turned down smooth to prevent friction against the inside wall of the solenoid. After these alterations and a careful adjustment of contacts the action of the relay was greatly improved. A speed of 30 words per minute was obtainable with a clear note and solid copy. Above this speed the dots do not record. The requirement of paragraph 4-17 and 4-23 of ref.(b) are not met but in its present condition the transmitter keying circuit is considered quite satisfactory for the uses for which the equipment is designed.

32. Table 1 is compiled from data obtained in a test conducted to demonstrate the capability of either the gas engine generator unit or the hand driven generator, propelled by two persons, to supply the necessary electrical power to satisfactorily operate the radio transmitting equipment and simultaneously charge the receiver storage battery. This was carried out in accordance with the specifications as contained in paragraph 7-13 of ref.(b) except that the battery charging current was only 2.6 amperes which was the charging rate limited by the degree to which the battery in use happened to be discharged and the value of the charging line resistor, which is a fixed unit.

33. The equipment supplied with RCA Radiotrons and with no other alterations except the readjustment of the keying relay was set up at a point approximately 100 yards north of the Laboratory annex building for two-way break-in communication tests. The radio truck outfitted with a "Hammarlund Comet Pro" superheterodyne receiver and a 50 watt crystal controlled transmitter with an antenna 20 feet high and 35 feet long for use when the truck was not moving was used as the second station for communication purposes and as observer of signal strength under different antenna, dimensional, and directional arrangements. Two trips were made necessary by transmitter difficulties with the truck equipment on the first trip. The first was successful from the point of view of transmission alone, and the second was entirely satisfactory from every point of view. The antenna changes made on the first trip were not repeated on the second since the data on this phase of the test was completed during the first trip. Table 13 covers the results obtained during the first trip and Table 14 covers the second trip.

RECOMMENDATIONS

34. It is recommended that steps be taken to correct the faults pointed out in this report, notably the use of inferior vacuum tubes, the use of fittings which have a tendency to corrode, the poor adjustment of taps limiting the frequency bands in the antenna circuit, the presence of serious reaction between transmitting circuit and receiving circuits and the failure of the keying relay to comply with the specification requirements.

35. The use of inferior vacuum tubes may be eliminated by the withdrawal of type approval on vacuum tubes employing an oxide coated filament and supplying spares from other stock to vessels already supplied with this equipment.

36. The removal of ten turns of inductance from the antenna loading coil and the complete rearrangement of taps in such a way that the full range of all the bands will be utilized with at least one of the three standard antenna arrangements would correct a number of the faults noted in connection with the transmitter. This alteration may be accomplished aboard ship if the Bureau concurs in the opinion that the sets which have been issued should be tested for frequency continuity at maximum output and altered when this difficulty is found to exist. It would no doubt be advisable to make the proposed alterations in the set assigned to the Laboratory for test and to prepare the proper instructions for issue to the service where required.

DISCUSSION

37. In general, it may be stated that the Model TAV-2 equipment reflects excellent workmanship and the materials used are of good quality. This equipment represents a decided improvement over previous equipment of a similar nature. Such points in the design as do not comply completely with the governing specifications can undoubtedly be corrected in future equipment and can be corrected in the present equipment without a great deal of difficulty.

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Table 1

Power Output of the Gas Engine Generator Unit

Conditions of test: (1) transmitter operating, key locked, at full power output; (2) battery charging circuit in operation, charging a six volt storage battery similar to receiver "A" battery furnished.

	Key opened	Key closed
Low potential voltage	12 volts	12 volts
Low potential current		
Transmitter	4.4 amps.	4.4 amps
Battery charging	2.6 "	2.6 "
Total	7 "	7 "
Low potential power	84 watts	84 watts
High potential voltage	520 volts	500 volts
High potential current	.01 amps.	.145 amps
High potential power	5 watts	72.5 watts
Total power	89 "	156.5 "

Note: The above results could be obtained for a short length of time when two men operated the hand driven unit.

Table 2

Determination of Power Output

Conditions of test: (1) transmitter operating, key locked, at full power output; (2) battery charging circuit in operation, charging a six volt battery at 2.6 amperes; (3) a dummy antenna in use made up of a General Radio precision capacitor and ten Ward Leonard 2 ohm units in series for 20 ohms and five such units in series for 10 ohms.

Frequency	2000	2000	3000	3000	4500	4500
Ant. Coup. Tap.	3	3	3	3	3	3
Ant. Capacity	80	80	80	80	80	80
Ant. Resistance	10	20	10	20	10	20
Ant. Current	1.58	1.05	1.73	1.26	1.50	1.21
Ant. Power	25.0	22.0	29.9	31.8	22.5	29.3

Table 3

Continuity of Frequency, Frequency Ratio and Overlap

Master Oscillator

Conditions of test: (1) transmitter circuits resonated except at lowest and highest frequency limits; (2) transmitter operating key locked at maximum power output; (3) maximum and minimum settings 50 and 950 divisions respectively.

	Freq.bands in Kcs.			Freq.radio
Specified low frequency limit	2000			
Range 1	1800 - 3150			1.75
Range 2		2850 - 4900		1.75
Specified high frequency limit			4525	
Overlap in Kcs.	200	300	375	
% overlap	10%	10%	8.3%	

Table 4

Continuity of Frequency, Frequency Ratio and Overlap

Power Amplifier

Conditions of test: (1) transmitter circuits resonated except at highest frequency observed; master oscillator and power amplifier resonated at all observed frequencies; (2) transmitter operating, key locked, at maximum power output; (3) maximum and minimum settings 1 and 100 divisions respectively.

	Freq.band in Kcs		Freq.ratio
Specified low frequency limit	2000		
Range	1950 - 4825		2.49
Specified high frequency limit		4525	
Overlap in kilocycles	50	300	
% Overlap	2.5%	7%	

Table 5

Continuity of Frequency, Frequency Ratio and Overlap

Antenna Circuit, Large Antenna

Conditions of test: (1) transmitter circuits resonated on all frequencies observed; (2) transmitter operating, key locked, at maximum power output obtainable on the frequency observed; (3) frequencies chosen to obtain the most favorable frequency ranges; (4) maximum and minimum settings 5 and 95 divisions respectively, except range 2 is 35 and 95 divisions; (5) antenna supports 6 feet and 24 feet high, distance between masts 40 feet.

	Freq. bands in Kcs.	Freq. ratio
Specified low frequency limit-2000		
Range 1		
Range 2	1910-2250	1.18
Range 3	2080-2750	1.32
Range 4	2590-3430	1.32
Range 5	3370-4550	1.35
Specified high frequency limit	4525	
Overlap in kilocycles	90 170 160 60 25	
% overlap	4.5 8.1 6.0 1.8 0.5	

Table 6

Continuity of Frequency, Frequency Radio and Overlap

Antenna Circuit - Small Antenna

Conditions of test: (1) transmitter circuits resonated on all frequencies observed; (2) transmitter operating key locked at maximum power output; (3) maximum and minimum settings 5 and 95 divisions respectively; (5) antenna supports 6 and 18 feet high, distance between masts, 25 feet.

	Freq.bands in Kcs.					Freq.ratio
Specified low frequency limit	2000					
Range 1						
Range 2	1990-2493					1.25
Range 3		2315-3071				1.33
Range 4			2833-3804			1.34
Range 5				3594-4758		1.32
Specified high frequency limit					4525	
Overlap in kilocycles	10	178	238	210	233	
% Overlap	5.0	7.4	8.2	5.7	5.2	

Table 7

Continuity of Frequency, Frequency Ratio and Overlap

Antenna Circuit, Large Antenna - Calculated Values.

Conditions of test: (1) 5% overlap at extremities of required frequency range; (2) 10% overlap between frequency bands; (3) ratios used are conservative as compared with those obtained in Table 5.

	Freq.band in kcs.	Freq.ratio
Specified low frequency limit	2000	
Range 1	1900-2510	1.32
Range 2	2270-2970	1.31
Range 3	2685-3510	1.31
Range 4	3170-4130	1.30
Range 5	3680-4750	1.29
Specified high frequency limit	4525	

Overlap in kilocycles	100	240	285	340	450	225
% Overlap	5.1	10.0	10.1	10.2	11.5	5.0

Table 8

Variation of Frequency per Division of Marking

Master Oscillator

Conditions of test: Calculated from calibration with crystal calibrator.

Freq. Band 1		Freq. Band 2	
Frequency	Cycles change per whole div.	Frequency	Cycles change per whole div.
1800	675	2900	1050
1900	715	3000	1150
2000	953	3100	1280
2100	1052	3200	1425
2200	1175	3300	1570
2300	1360	3400	1710
2400	1575	3500	1550
2500	1785	3600	2220
2600	2000	3700	2270
2700	2130	3800	2500
2800	2500	3900	2780
2900	2780	4000	2940
3000	3030	4100	3050
3100	3225	4200	3230
		4300	3450
		4400	3700
		4500	3900
		4600	4100

Table 9

Accuracy of Calibration

Conditions of test: (1) the master oscillator calibration chart furnished with the transmitter was checked against a calibration chart constructed from data obtained by recalibrating the master oscillator using a 50 kilocycle and 500 kilocycle crystal calibrator as a standard; (2) tolerance, 1%.

Freq. Band 1			Freq. Band 2		
Freq. in kcs.	Error in kcs.	% Error	Freq. in kcs.	Error in kcs.	% Error
2000	+ 12	0.60	3000	0	0
2250	+ 9	0.40	3250	0	0
2500	- 3	0.12	3500	0	0
2750	0	0.00	3750	0	0
3000	- 10	0.33	4000	-3	0.08
			4250	-25	0.59
			4500	-30	0.67

Table 10

Locked Key Tests

Conditions of test: (1) transmitter operating, key locked, at maximum power output; (2) frequencies measured by comparison with NRL primary standard; (3) short antenna in use, antenna supports 6 and 18 feet high, distance between masts 25 feet; (4) frequency of transmission approximately 4600 kilocycles, 3300 kilocycles, and 2000 kilocycles; (5) Eveready Raytheon vacuum tubes in use.

Time	Filament Voltage	Total plate Current	Antenna Current	Frequency
0945	7.5	200	1.3	4605.00
48				05.23
50	7.5	200	1.25	05.96
54	7.5	200	1.25	07.05
56				07.96
58				08.02
1000	7.5	200	1.23	08.44
05				09.08
10				09.57
15	7.5	200	1.23	10.05
		Greatest deviation in kilocycles -		5.05
		% deviation		0.11%
1025	7.5	99.0	.40	1986.04
28				.02
30				.02
35	7.7	99.5	.40	.02
40				.02
45	7.4	100.0	.45	.02
50				.04
55	7.3	100.0	.45	.05
		Greatest deviation in kilocycles -		.03
		% deviation -		.0015%
1400	7.5	125	.90	3325.10
07				.13
12				.33
16				.43
19				.53
21				.56
26				.80
30				.86
		Greatest deviation in kilocycles -		.76
		% deviation -		.023%

Table 11

Accuracy of Reset

Conditions of test: (1) transmitter was carefully adjusted and frequency measured by comparison with NRL primary standard. Master oscillator was detuned and returned to the same setting by each of two operators and measured after each reset; (2) adjustment was made each time in a clockwise direction approaching from the low frequency side.

Approximate frequency - 2000 kilocycles.
Master oscillator setting, Step 1 - 300 divisions.

	Freq. in Kcs	Freq. Dev. in kcs
Original frequency	1986.47	
Operator #1 reset	85.91	-0.56
Operator #2 reset	86.39	-0.08
Operator #1 reset	86.18	-0.29
Operator #2 reset	86.78	+0.31
		1.24

Average deviation .31
Average % deviation 0.016%

Approximate frequency - 3000 kilocycles
Master oscillator setting, Step 1 - 910 divisions.

	Freq. in Kcs.	Freq. Dev. in kcs.
Original frequency	2998.28	
Operator #1 reset	97.25	-1.03
Operator #2 reset	98.33	+0.05
Operator #1 reset	99.07	+0.79
Operator #2 reset	97.66	-0.62
		2.49

Average deviation .62
Average % deviation 0.021%

Approximate frequency - 4500 kilocycles
Master oscillator setting, Step 2 - 860 divisions

	Freq. in Kcs	Freq. Dev. in kcs.
Original frequency	4490.45	
Operator #1 reset	88.11	- 2.34
Operator #2 reset	90.57	+ .12
Operator #1 reset	90.99	+ .54
Operator #2 reset	90.26	- .19
		3.19

Average deviation .80
Average % deviation 0.018%

Table 12

Backlash - Master Oscillator

At 200 divisions	1.0 divisions
" 500 "	2.0 "
" 800 "	1.0 "

Table 13

Two-way Communication

Conditions of test: (1) Model TAV-2 equipment set up north of laboratory buildings; (2) antenna east and west with transmitter at west end of antenna. Antenna oriented about transmitter from east to southeast and south and then back to southeast and east; (3) observations made on signal by radio truck using "Hammarlund Pro" superheterodyne receiver; (4) radio truck at 3 miles distance and underway for preliminary tests and 25 miles south of the Laboratory for the final tests; (5) weather cloudy and moderate temperature; (6) grid lead found to be disconnected in amplifier circuit of truck transmitter after test which rendered data obtained from observations of truck signals by Model TAV-2 receiver useless; (7) final tests carried out on prearranged time schedule and not by call and answer or break-in communication.

Preliminary Tests

Test No. 1 - At 3 miles distance signals were excellent. Two way"break-in" communication established with ease on all the test frequencies in the 2 to 4.5 megacycle band. Signal strength was 5 on all frequencies.

Test No. 2 - Truck underway. Readable signals were received on truck from Model TAV-2 transmitter up to 8 miles distance. Beyond this point the signal to noise ratio was unfavorable and solid copy was not obtainable.

Test No. 3 - At 25 miles distance. Two-way communication was established with difficulty due to weak signals from the truck as explained under conditions of test.

Test No.	Height of masts	Distance between masts	Direction of antenna	Antenna Freq.	Antenna Curr.	Reception Signal in DB	Reception Noise in DB
1	6 & 18 ft.	25 ft.	E	4400	1.6	*18 & 10	6
2			SE	"		*18 & 10	6
3			S	"		*10 & 10	6
4			S	2000	0.5	18	14
5			SE	"		18	14
6			E	"		19	14
7	6 & 24 ft.	40 ft.	E	"	1.0	20	12
8			SE	"		22	14
9			S	"		22	14
10			S	4400	1.35	*14 & 10	- 4
11			SE	"		*14 & 10	- 4
12			E	"		*11 & 10	- 4

Note: * Sensitivity of receiver was 10 DB down for 4400 kilocycles as compared with 2000 kilocycles.

Table 14

Two - way Communication

Conditions of test: (1) Model TAV-2 equipment set up north of the Laboratory building; (2) antenna east and west with transmitter at west end of antenna; (3) observations made on Model TAV-2 transmitter signals by radio truck using "Hammarlund Pro" superheterodyne receiver; (4) radio truck at 3 miles distance for preliminary test and 25 miles south of the Laboratory for final tests; (5) break-in method of communication used both in preliminary and final test; (6) height of masts 6 and 25 feet with 40 feet between masts; (7) truck transmitter power 50 watts, crystal controlled; (8) truck antenna single wire inverted L 20 feet high, 35 feet long.

Preliminary Test - At 3 miles distance two-way break-in communication was established with ease on all the test frequencies in the 2 to 4.5 megacycle band. Signal strength was steady at 5 on all frequencies observed.

At 25 miles distance two-way, break-in communication was again established with ease and the prearranged time schedule was dispensed with.

Final Tests - Radio truck observed signals from Model TAV-2 transmitter for strength and fading and then tested for two-way break-in communication on each test frequency.

Transmitter Frequency Model TAV-2	Radio Truck	Model TAV-2 Signal	Noise	Strength	Two-way break-in reception
2000	3300	+ 10 DB	0 DB	2	Excellent
3000	3300	+ 21 DB	-2 DB	4	"
4400	3300	+ 20	+4	4	"
4525	3300	+22	+6	4	"
2000	4107				"

Table 15

Comparison of Vacuum Tubes

Conditions of test: Eveready Raytheon vacuum tubes received as a part of the Model TAV-2 equipment compared with one RCA Radiotron used in the tests subsequent to the failure of all tubes supplied.

Tube No.	At start	Reverse grid current after 2 mins.	Reverse grid current after 3 mins.	Time required to reach 100 ua
ER 1	0 ua	20 ua	100 ua	3 mins.
2	0	0	5	-
3	0	100	-	1.25
4	0	100	-	1.5
5	0	15	100	3.0
6	0	100	-	1.5
RCA 1	3	5	5	-