7 July 1936

NRL Report No. R-1286
BuEng. Prob. M6-12

NAVY DEPARTMENT

FR-1286

BUREAU OF ENGINEERING

Report of Test

on

Model LD-3 Combined Heterodyne Frequency Meter and Crystal Controlled Calibrator.

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Number of Pages: Text - 11 Tables - 1 Plates - 4

Authorization: BuEng. ltr. NOs-45269 (12-11-W8) of 9 January 1936.

Date of Test: 1 June to 19 June 1936.

Prepared by:

R.B. Owens, Assoc. Radio Engr., Chief of Section.

R.W. Armstrong, Jr. Physicist.

Reviewed by:

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

Approved by:

L.R. Moore, Commander, USN, Acting Director.

Distribution:
BuEng. (5)

ejj

TABLE OF CONTENTS

APPENDIX

AUTHORIZATION

1. This problem was authorized by Bureau of Engineering letter, reference (a). Other pertinent correspondence is listed as references (b) to (d).

Reference: (a) BuEng. ltr. NOs-45269(12-11-W8) of 9 January 1936.
(b) Specifications RE 13A 401D.
(c) NRL Report No. R-1059.
(d) Contract NOs-45269.

OBJECT OF TEST

2. The object of the test was to determine if the production sample of the Model LD-3 frequency measuring equipment complies with specifications, reference (b), as amended by contract, reference (d), and is suitable for Naval use.

ABSTRACT OF TEST

3. The equipment was given an inspection of mechanical construction and wiring. Its operation was observed as to crystal frequency, multi-vibrator control, frequency stability of heterodyne oscillator with time of operation, with tilting, with change of tubes, and with line voltage change. The audio output on harmonics of 20 and 100 kilocycles was measured. The effect of the extreme ambient temperature on the temperature controlled unit was determined as well as its operation in the presence of a radio transmitter and its use in adjusting the frequency of receivers up to 25 megacycles. The overall accuracy obtainable with the heterodyne oscillator was carefully determined. The effect of severe vibration was noted, both as to its mechanical and electrical effects.

Conclusions

(a) This equipment complies with all requirements of the governing specifications so far as could be determined with certain minor exceptions which are noted under "Recommendations" and which it is believed can be readily corrected.

(b) When these minor changes shall have been made, it is considered that this equipment will be quite suitable for Naval use for the purposes intended.

Recommendations

As a result of the tests the following recommendations are made:

(a) The cause of the change in crystal frequency of nearly two times the allowed tolerance should be determined and steps taken to assure the required crystal frequency accuracy.

(b) Special care should be taken to lock tightly the rotor of the crystal frequency adjusting condenser after standardization of the crystal frequency, to prevent the possibility of its being moved by a stroke from the hand in servicing the equipment.

(c) The desirability of increasing the capacity of the multi-vibrator condenser C-9 to permit maintenance of frequency control when its value is decreased 10% is suggested for the consideration of the contractor.

(d) The coil selector pointer should be permanently fastened to the switch knob to prevent slight rotation after use which might mislead the operator as to the proper switch setting for a given coil range.

(e) The straight, stiff lead connecting the grid capacitor to the tuning capacitor in the heterodyne oscillator should be replaced with a connector which will transmit less flexing force to the terminal lug of the grid capacitor (C-43) as a result of vibration, while guarding against sacrificing heterodyne oscillator frequency stability.

(f) Additional calibration points should be added to the heterodyne oscillator calibration below about 220 kilocycles, such as all multiples of 3.333 kilocycles, in order to increase the per cent frequency accuracy below this frequency and also to permit the use of the interpolation chart upon all coils (the divisions difference between adjacent points in the calibration as given is greater than the number of divisions on the interpolation chart in certain bands on coils 1 to 3).

(g) The feasibility of employing higher current fuses in place of the one ampere fuses in the filament-plate circuit is suggested since three of these became open circuited during test.

(h) The weak-strong coupling switches for all equipments should be carefully checked for positive, low resistance contact, since the switch in the test equipment was intermittently defective in operation.

(i) In order to make complete the test equipment, Serial No. 1, a capacitor to replace C-43 which was damaged in the vibration test and a switch to replace the weak-strong coupling switch should be sent to this Laboratory, if this equipment is to be assigned without return to the manufacturer.

(j) The mountings for resistors R-1, R-2, R-5 and R-6 should be placed so as to give assured spacing from the back removable panel when the panel is screwed tightly in position (see comment on paragraph 2-25)

MATERIAL UNDER TEST

4. The material under test consisted of the Model LD-3 combined heterodyne frequency meter and crystal controlled calibrator Serial No. 1, manufactured by the General Radio Company. The frequency measuring unit bears the type number CAG-74020, and the power unit for operation of the measuring unit from a 110 volt, 60 cycle supply bears type number CAG-20046. The measuring unit contains the heterodyne frequency meter with a fundamental frequency range of 100 to 5000 kilocycles, a crystal controlled calibrator with a fundamental of 100 kilocycles, a multi-vibrator controlled from the calibrator at 20 kilocycles, a detector and two stage audio frequency amplifier and an audio oscillator with fundamental frequencies of 500 and 1000 cycles per second. The measuring unit is temperature controlled at approximately 43°C. and an additional temperature control system maintains the crystal temperature at 50°C. This equipment is practically identical with the Model LD-2 frequency measuring equipment except for certain improvements and minor changes.

METHOD OF TEST

5. The crystal calibrator frequency was determined by comparison with the Navy primary frequency standard, the difference frequency in cycles in 100,000 being recorded on a tape together with seconds intervals. The stability of the multi-vibrator control with change in circuit constants was determined by making large changes in certain circuit elements and noting the effect on the multi-vibrator operation. The frequency drift of the heterodyne oscillator with time of operation was measured by observing the drift in the beat frequency between the heterodyne oscillator and the LD-3 crystal or multi-vibrator harmonic by means of an interpolation oscillator, General Radio Type 617A, the drift in the latter being eliminated by frequent comparison with a precise 1000 cycle source. The effect of the voltage change and of tilting the equipment on the heterodyne oscillator frequency was similarly obtained. The audio frequency output power available as a result of beats between the heterodyne frequency meter and harmonics of the multi-vibrator or crystal was measured by means of a General Radio Type 583A output power meter. The equipment was subjected to ambient temperatures from -1 to +48°C. for the purpose of observing the effect of these extreme temperatures on the controlled temperature of the crystal and heterodyne oscillator compartments. The unit was set up within a few feet of a radio transmitter to note if damage or blocking occurred. It was coupled to the input of Navy standard radio receivers tuned to frequencies up to 25 megacycles for the purpose of determining if the radio frequency output of the equipment was sufficient to permit the adjustment of receivers up to this frequency. A number of frequency measurements were made with the equipment to determine the accuracy obtainable with it at various parts of the frequency range. The equipment was mounted on a vibration test stand and its operation observed while undergoing extreme vibration.

DATA RECORDED DURING TEST

6. The data recorded during the test are given under "Results of Test" and in the table appended.

DISCUSSION OF PROBABLE ERRORS

7. The error in the measurement of the crystal frequency is less than .2 cycle. The error in the measurement of frequency change in the tilting test, the voltage variation test, etc., is not greater than one cycle. The error in measurement of the ambient temperature is not greater than 1°C. The audio output power measurements are accurate to about 5%.

RESULTS OF TEST

8. The following comments cover the results of the tests performed. The sub-paragraph numbers correspond to those in the governing specifications, reference (b).

1-1 to 1-4. The requirements of these paragraphs relating to the fundamental requirements of the equipment are met.

1-5 to 2-2. No comment.

2-3 and 2-4. The equipment is of rugged construction and the workmanship appears to be of the best.

2-5. The equipment was operated in an ambient temperature from -1° to +48°C. with only .2°C. change in crystal compartment temperature and 5°C. change in cabinet temperature from the controlled temperature at an ambient of approximately 25°C.

2-6. Inductance coils of the heterodyne frequency meter are protected from moisture by being coated with a wax which is understood to be that which bears the trade name Superla and which has been tested at this Laboratory and found to be one of the best materials available for this purpose.

2-7 and 2-8. These specifications are met.

2-9. Fuses are provided in the power unit in both sides of the 110 volt, 60 cycle supply line to the power pack and in the heat supply leads as well as in the + plate voltage lead. Two fusable links are provided, one to protect the cabinet proper and the other the crystal compartment from excessive heating in event of the failure of either of the temperature control systems. The cabinet fuse which is not provided in the Model LD-2 equipment is a desirable addition since the link in the crystal compartment is so well insulated from the cabinet heater that damage might result in the cabinet proper before the link in the crystal compartment could become effective as a circuit breaker.

2-10 to 2-14. The equipment complies with these specifications.

2-15. The equipment operates satisfactorily at all inclinations up to 45° in any direction. See comment on paragraphs 4-12 and 4-27.

2-16 and 2-17. The equipment is mounted in a metal angle rack which is provided with 6 shock absorbing mountings for securing it at the bottom and the back of the equipment upon installation. Lock nuts are used as required and r.f. circuit connections are soldered. The crystal holder is clamped in position. After a severe vibration test, in which the equipment was shaken so vigorously for a period of one hour that the tuning capacitor dial numerals could not be distinguished, no damage was observed except that a terminal lug molded into a mica capacitor was broken off close to the molded case. This terminal lug is soldered to a short stiff wire which connects the mica grid capacitor of the heterodyne oscillator (C-43 on the wiring diagram) to the tuning capacitor. The heterodyne oscillator was rendered inoperative due to this open circuit. This trouble was remedied by replacing the defective capacitor with C-43 from the spare parts box.

2-18 to 2-23. Requirements of these paragraphs are met.

2-24. Each item in the spare parts box is marked with a number by which the item may be identified from a list pasted on the inside cover of the spare parts box. This list includes both the item number and the part number which is given in the wiring diagram and marked on the similar item installed in the equipment itself.

2-25. The equipment may be continuously operated without damage. One of the terminal clips of each of four resistor mountings at the rear of the top shelf in the measuring unit has very slight clearance from the back removable panel, in one instance only about 1/32 inch. Even though the shielding panel is coated with a thin non-conducting film, a slightly greater spacing is desirable to guard against the possibility of trouble at this point. See comment on paragraphs 4-13 and 4-23.

2-26. This specification is met.

2-27. No comment.

2-28. Ceramic insulation is used for the r.f. coil forms and in the variable capacitors. The tube sockets are of molded phenolic insulation which is presumed to be in accordance with this paragraph of the specifications since the potentials applied to the tubes are low.

2-29. The wire is color coded. The colors of the covering and of the tracers where used are noted on the wiring diagram.

2-30. The wire used for the several purposes appears to be properly chosen to carry the current required and arranged to minimize the probability of breaking due to vibration.

2-31 and 2-32. No tests were made on the wire or its insulation as outlined in these paragraphs of the specifications since no samples were submitted and it is presumed that the suitability of the wire employed had been determined prior to the wiring of this equipment.

2-33 and 2-34. These specifications are met.

2-35 to 2-43. No comment.

2-44 and 2-45. The finish of the outer and inner surfaces of the cabinets are in accordance with these specifications. A dull black finish is used on the mounting rack instead of wrinkle finish, but no objection is seen to the finish provided.

2-46. The requirements of this paragraph are met. The panel securing screws are of duralumin, polished and not plated.

2-47. The thermostats and thermometers conform in dimensions to Drawings RE 40A 120A and RE 40A 123A except that the diameter of the thermometer stems is considerable less than 1/4 inch, being .225 inch and .231 inch, respectively. However, these instruments were shipped installed in the equipment without damage and while obviously not as strong as if the diameter were .250 inch, they are believed to be satisfactory.

3-1 to 3-4. The equipment consists of the required component parts. Either the power unit or the measuring unit may be mounted above the other. The equipment is shipped with the measuring unit above the power unit and with the connecting cables in place. A shock-proof mounting rack is provided as previously mentioned. The equipment operates from a 110 to 115 volt, 60 cycle supply. In addition to a.c. supply leads the power supply cable contains telephone leads for remote use of the audio output and also d.c. heat supply leads for d.c. heater operation.

3-5. The equipment may be used to measure the frequency of a nearby transmitter up to 25 megacycles without the use of an oscillating receiver. It can be used up to this same frequency as a source of radio frequency power for adjusting Navy standard receivers. For example, with the heterodyne oscillator set at 5 megacycles a Model RAB receiver can be adjusted (with the proper coupling) to any harmonic of 5 megacycles up to 25 megacycles. The heterodyne frequency meter calibration may be checked against the crystal and multi-vibrator harmonics at any multiple of 20 kilocycles from 100 to 5000 kilocycles as well as at a large number of intermediate frequencies if desired.

3-6 to 3-9. The equipment meets these specifications.

3-10. The units are completely removable from the cabinets by means of handles provided, upon loosening the knurled securing screws, without disconnecting any wires; all necessary connections are made on inserting the units into the cabinets.

3-11. The overall dimensions of the equipment with mounting rack assembled are as follows:

Height - 34-3/4 inches.
Width - 17-5/8 inches.
Depth - 15-3/4 inches.

The weight of the total equipment is 175 pounds. These dimensions and the weight comply with the specifications.

3-12. The shielding of the equipment and audio output impedance comply with the requirements of this paragraph.

3-13. The operation of the equipment at extremes of ambient temperature is considered to be quite satisfactory. The crystal temperature was not changed from its normal value by more than .2°C. and the cabinet temperature was not changed from its normal value by more than 5°C. when the equipment was operating in ambient temperature of -1°C. and +48°C.

3-14. The thermostats, heaters, and heater circuits are similar to those used in the Model LD-2 equipment. The operating temperature of the crystal compartment thermostat is 50°C. and that of the cabinet thermostat is 45°C.

3-15. Emergency operation of the equipment in the event of a.c. power supply failure is quite simple. For d.c. operation the power unit is removed from its cabinet and an emergency power supply cable which is packed in the spare parts box is plugged into the multi-jack in the rear of the power unit cabinet; a 6-volt filament battery, a 180-volt plate battery and the 110-volt d.c. supply line are connected to the marked terminals of this cable. If d.c. heat supply is desired with a.c. tube operation, it is necessary only to throw the a.c.-d.c. heat supply switch on the power unit, to the d.c. position, provided the d.c. leads in the power cable are attached to a 110 volt d.c. source.

3-16. Neither side of the power supply line is connected to the cabinet, and the cabinet may safely be grounded upon installation.

3-17 and 3-18. No examination of the inductance switch could be made without considerable disassembling and therefore the operation of this switch was determined merely by adjusting the range changing knob on the panel. With normal operation it was impossible to produce a spurious frequency (due to shorting out a section of a coil) by inadvertently setting the switch contacts on more than one stud at a time, since the switch operates in distinct steps from one contact stud to the next due to the contact aligning device. It is, however, considered to be quite important that the coil selector pointer be permanently attached to the coil changing knob since if the pointer should be rotated slightly after the knob is clamped on the switch shaft, it would assume a position somewhat between the coil numbers and the operator may ignore the switch aligning device and attempt to set the knob so that the pointer will be properly aligned with the coil number. In this manner it is possible to set on two contact studs at the same time, but this is obviously an imporoper use of the switch. To avoid this possibility, the pointer should be rigidly clamped or pinned to the knob.

3-19 to 3-25. These specifications are met.

3-26. See comment on paragraph 2-9.

3-27. The parts are as accessible for replacement as is practicable in an equipment of this type with the space limitations imposed.

3-28. The maximum power input with all circuits operating is approximately 470 watts.

3-29. The heterodyne oscillator calibration consists of a table of frequencies and corresponding condenser settings covering approximately 5-1/2 pages in the back of the instruction book. All multiples of 6.667 kilocycles are given up to 1070 and all multiples of 10 kilocycles up to 1500 kilocycles. Twenty kilocycle points are given up to 5000 kilocycles.

3-30. The frequency of the crystal was carefully determined with three different oscillator tubes and the maximum frequency change resulting from change of tubes was .0008%. The frequency change of the heterodyne oscillator with change in tubes was from .004% to .02%, and the maximum change noted can be readily compensated for by a slight adjustment of the compensating condenser.

3-31. The r.f. leads are such that no appreciable change in frequency occurs with ordinary vibration. The crystal leads pass through fibre insulating sleeves through the walls of the metal crystal compartment. These leads are not bushed where they pass through the balsa wood box surrounding the metal crystal compartment but since the crystal is in the plate feedback circuit of a tuned grid type of oscillator and not in the grid circuit, and since the leads are rubber covered, the existing arrangement is considered satisfactory.

4-1. The frequency range of the heterodyne oscillator (100 to 5000 kilocycles) is divided into 16 bands with considerably more overlap between them than required.

4-2. The change in heterodyne oscillator frequency with a 10% change in line voltage was measured to be .0025%. No measurable change in the frequency of the audio oscillator occurred with a voltage change of 10%. Both the heterodyne oscillator and the audio oscillator are of the voltage compensated type.

4-3. The frequency stability of the heterodyne oscillator with time of operation of the equipment is of a very high order. The observed frequency drift at three radio frequencies taken over a period of 25 minutes is given in Table 1.

4-4 and 4-5. These requirements are met.

4-6. The equipment was operated within 5 feet of a Model TBK transmitter operating at full power without any damage and also without blocking or loss of accuracy in measuring the transmitter frequency. No coupling was required and best results were obtained with the heterodyne coupling switch in the "strong" position.

4-7. A mixer circuit is provided, as required, to permit accurate setting of receivers which can not be adjusted for zero beat reception. The procedure in the use of this mixer circuit is as follows. The heterodyne oscillator is adjusted to the frequency to be received. The receiver is adjusted until a beat note with the heterodyne oscillator is heard. The receiver output is now plugged into the jack labelled "receiver" on the LD-3 equipment and the audio oscillator set to the 1000 cycle position. Telephones are plugged into the adjacent jack marked "telephones" and the mixer volume control is varied to approximately equalize the intensity of the signal from the audio oscillator and the output from the receiver. The receiver is now tuned until its beat note matches the audio oscillator tone. The receiver is now set to receive the desired signal. The frequency of the 500 cycle audio oscillator was measured to be 497 cycles and that of the 1000 cycle oscillator to be 994 cycles.

4-8. The radio frequency output of the heterodyne oscillator is sufficient for tuning standard Navy receivers up to 25 megacycles. The audio output power at all multiples of 100 kilocycles up to 5000 kilocycles for beat notes between 350 and 1100 cycles resulting from beats between the heterodyne oscillator fundamental and harmonics of the crystal oscillator is very large being in excess of 40 milliwatts at 5000 kilocycles, whereas a minimum of 25 milliwatts is required. The audio output up to 3000 kilocycles on multiples of 20 kilocycles when the multi-vibrator is operating is in excess of 5 milliwatts when the beat note lies between 350 and 1100 cycles, whereas a minimum of one milliwatt is required. These values are obtained with strong coupling and high amplifier gain.

4-9. The calibration curve is linear over the range of the instrument. Kilocycles per division are constant to within 2% over the used portion of each band. See Plate 1 for curves of the kilocycles per division for coils 5 and 9.

4-10 and 4-11. A satisfactory compensating condenser is provided for correcting the frequency of the heterodyne oscillator to maintain the accuracy of the calibration with change of tubes, etc.

4-12. The effect of tilting the equipment on the frequency of the heterodyne oscillator was determined at 800 kilocycles. The frequency change with tilting up to 45 degrees was from zero to .0005% which represents a frequency stability of a high order. A precision reference standard external to the LD-3 equipment was used for these measurements of frequency change.

With considerable continuous vibration the frequency stability is such that at 4000 kilocycles it is possible to maintain a matched tone between the audio output of the equipment and the 1000 cycle oscillator. Tests were conducted to determine if the equipment could be used at 4000 kilocycles when the vibration approximates the estimated sustained maximum amplitude likely to be encountered on shipboard (as estimated by a number of experienced Navy radio men). The principal difficulty noted was due to excessive noise in the telephones but frequency measurements could be made with a satisfactory operating accuracy although the zero beat setting was somewhat broad. It is believed that the noise is mostly tube noise; it is not affected by shutting down the heterodyne oscillator but was greatly reduced when the multi-vibrator was turned off. The amplitude of this vibration can not be stated in any definite terms but an approximate idea may be gained from the fact that the tuning capacitor dial numerals could be read only with difficulty due to the frequency and amplitude of the vibration of the whole equipment.

4-13. Frequency measurements can be made to an accuracy of .005% by the use of this equipment at all frequencies above approximately 200 kilocycles with the calibration as given. Below this frequency the length of certain possible interpolations is so great that this accuracy can not be achieved at all points. For example, in order to measure the frequency of 103.33 kilocycles it is necessary to interpolate between 100 kilocycles and 106.667 kilocycles. The difference in condenser settings between these two points is about 416 divisions and the accuracy obtainable is .02% instead of .005%. However, it should be noted that an error of .02% at this frequency represents a frequency error of only 21 cycles and is negligible for practical purposes. It is possible by the inclusion in the calibration data of frequencies and settings for all multiples of 3.333 kilocycles up to about 220 kilocycles to have the equipment conform to the requirement of measuring to an accuracy of .005% at all points.

Since the interpolation chart is adaptable for use only if the number of condenser divisions between adjacent known frequencies is less than 250 divisions, the inclusion of these extra points in the calibration will make the chart suitable for use throughout the range of the instrument. The backlash in the tuning condenser is not more than .2 divisions, which is unusually low. The reset accuracy is quite high and conforms to the requirements of this paragraph of the specifications.

4-14 and 4-16. These specifications are met.

4-17. The audio output is adjustable in 4 steps; high and low audio gain are available with either weak or strong heterodyne coupling. By means of the resulting variations in signal intensity, undesirable beat notes may be eliminated or reduced to a level sufficiently low to avoid confusion on the part of the operator.

4-18 and 4-19. Either the zero beat or the matched tone method may be employed in frequency measurements. An auxiliary dial is provided which may be used to determine directly the mid-point setting when employing the matched tone method.

4-20 and 4-21. A 100 kilocycle crystal controlled calibrator is provided from which usable harmonics are available up to 5000 kilocycles. The crystal oscillator circuit is of the tuned grid type, with the crystal element in series with the plate feed-back coil. In parallel with the fixed grid circuit condenser is a midget variable condenser which is adjusted at the factory to bring the crystal calibrator frequency to exactly 100,000 cycles, at which time the rotor shaft is locked in position by means of a lock-nut.

4-22. The multi-vibrator control is not affected by 10% change in the value of the resistor elements, by change of tubes of the same type, by change of 15% in tube supply voltage, or by a 50% reduction in the controlling voltage. It was found possible to double the value of the coupling condenser between the first and second tubes of the multi-vibrator (C-9 in the wiring diagram) without affecting control, but a 10% reduction in the value of this capacity destroyed control at 20 kilocycles. The investigation of the feasibility of increasing the capacity of this condenser somewhat is suggested.

4-23. The crystal frequency was measured to be 99,998.1 cycles before any change had been made in the crystal frequency adjusting condenser and after the heater systems had been turned on for approximately four hours. The crystal thermometer indicated a temperature of 50.1°C. One week later, after the tilting tests, the frequency was 99,998.8 cycles. It will be observed that the frequency error was .0019% and .0012% on these two occasions, while the specification tolerance is ±.001%. It is assumed that the crystal frequency was adjusted to exactly 100,000 cycles before shipment. The cause of the calibrator frequency error is not known, but since the change in crystal frequency after extreme vibration was only .0002%, it is probably due to a change in the inductance or capacity of the tuned grid crystal oscillator circuit or to some change inside of the crystal holder. As to the effect of the change in the grid circuit on the crystal frequency, it was determined that a change of 3.3 mmfds. in the capacity of this circuit produced a change of .001% in the calibrator frequency. This capacity change was accomplished by varying the setting of the crystal adjusting midget condenser approximately 6 degrees by the use of a screw-driver without loosening the lock-nut (see comment on paragraph 4-20 above). The total capacity in the tuned circuit is approximately 300 mmfds., about 250 in a mica condenser and 50 in the variable midget condenser when set at 1/2 capacity.

4-24. No comment.

4-25. The temperature coefficient of frequency of the crystal controlled calibrator (determined between 28 and 50°C.) was measured to be 10 parts in a million per degree Centigrade which is quite a low value.

4-26 and 4-27. The crystal holder was not opened but it appears to be moisture-proof. The change in crystal frequency with tilting up to 25 degrees in any direction was wholly negligible, but at a tilt of 45 degrees the change was from .0002 to .001%. While this frequency stability is considered quite good, yet an investigation as to the cause of the frequency change with excessive tilting may indicate the cause of the crystal frequency error mentioned under paragraph 4-23 above. As previously stated, severe vibration caused only .0002% change in the crystal frequency as determined by measurements made before and after this test.

4-28. No controls are provided for adjusting the crystal frequency after it is once standardized. The midget condenser for adjusting the crystal frequency at the factory may be used to change the fundamental frequency approximately ± 6 cycles.

4-29. The coupling switch installed in this equipment would not function properly; in some instances the beat note strength in the "strong" position was the same as in the "weak" position until the switch had been operated a number of times.

4-30 to 5-1. These specifications are met.

5-2. No comment.

5-3. The power consumption is never greater than 470 watts and the average value is considerably less.

5-4 to 5-6. The equipment complies with these specifications.

5-7. The heat selector switch on the power unit permits the use of either a.c. or d.c. supply to the heaters (see comment on subparagraph 3-15 for provision for emergency operation).

5-8 and 5-9. These specifications are met.

5-10. All supply leads are suitably protected by fuses. On three different occasions during the tests a one ampere filament-plate fuse became open circuited at the instant the tube power was applied, although the line voltage was not excessive. The voltage regulator was set for normal tube supply voltage.

5-11. No comment.

5-12 and 5-13. The equipment will operate satisfactorily with proper potential when the line voltage is as low as about 101 volts. A small "Variac" or auto transformer is employed to adjust the tube voltage to the proper value as indicated by a red line on the input voltmeter.

CONCLUSIONS

9. This equipment complies with all requirements of the governing specifications so far as could be determined with certain minor exceptions which are noted under "Recommendations" and which it is believed can be readily corrected.

10. When these minor changes shall have been made, it is considered that this equipment will be quite suitable for Naval use for the purposes intended.

TABLE 1

Frequency Drift of Model LD-3 Heterodyne

Oscillator.

Minutes After Tubes "On"	Frequency Drift in Per Cent.					
	120 Kcs.		800 Kcs.		4500 Kcs.	
	Observed	Spec. Limit	Observed	Spec. Limit	Observed	Spec. Limit
5-10	.0017	.0017	.0011	.0019	.0017	.0018
10-15	.0013	.0017	.0008	.0011	.0011	.0011
15-20	.0013	.0008	.0004	.0005	.0005	.0005
20-25	.0002	.0008	.0004	.0005	.0005	.0005

NOTE: Probable error at 120 kcs. = ± .0005%.

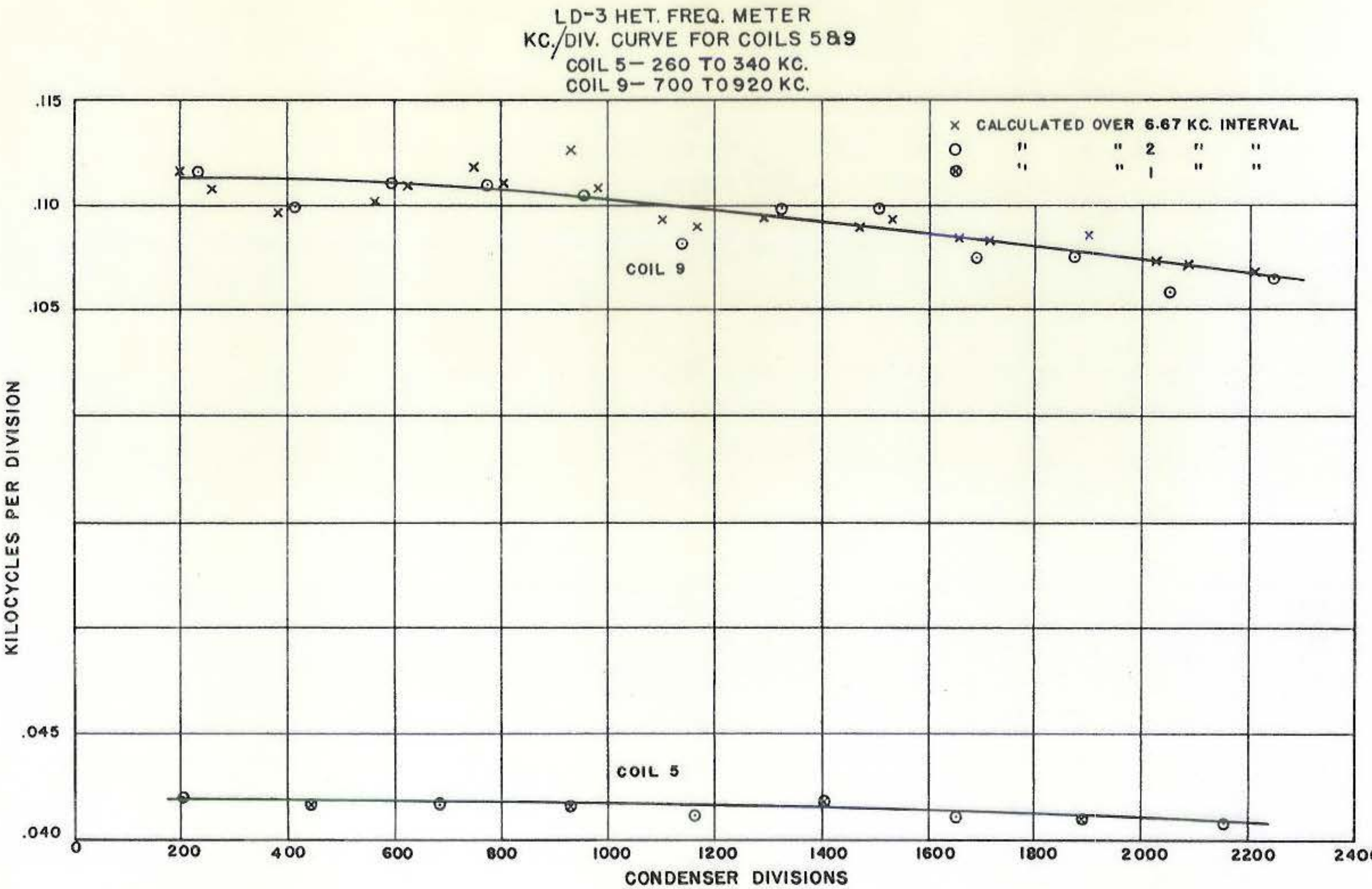
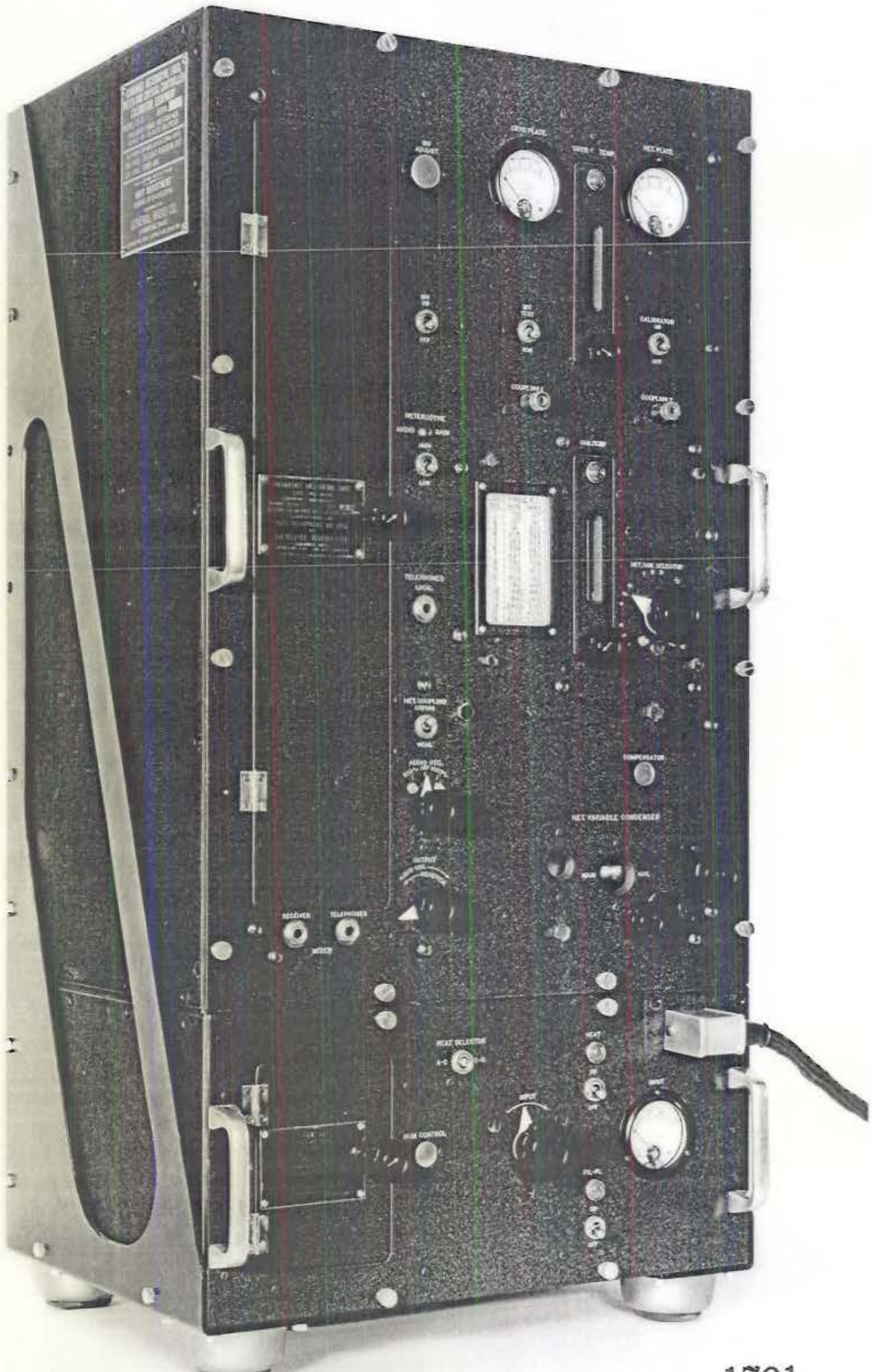

LD-3 HET. FREQ. METER
KC./DIV. CURVE FOR COILS 5&9
COIL 5— 260 TO 340 KC.
COIL 9— 700 TO 920 KC.
× CALCULATED OVER 6.67 KC. INTERVAL
" " 2 " "
" " 1 " "
COIL 9
COIL 5
KILOCYCLES PER DIVISION
.115
.110
.105
.045
.040
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
CONDENSER DIVISIONS

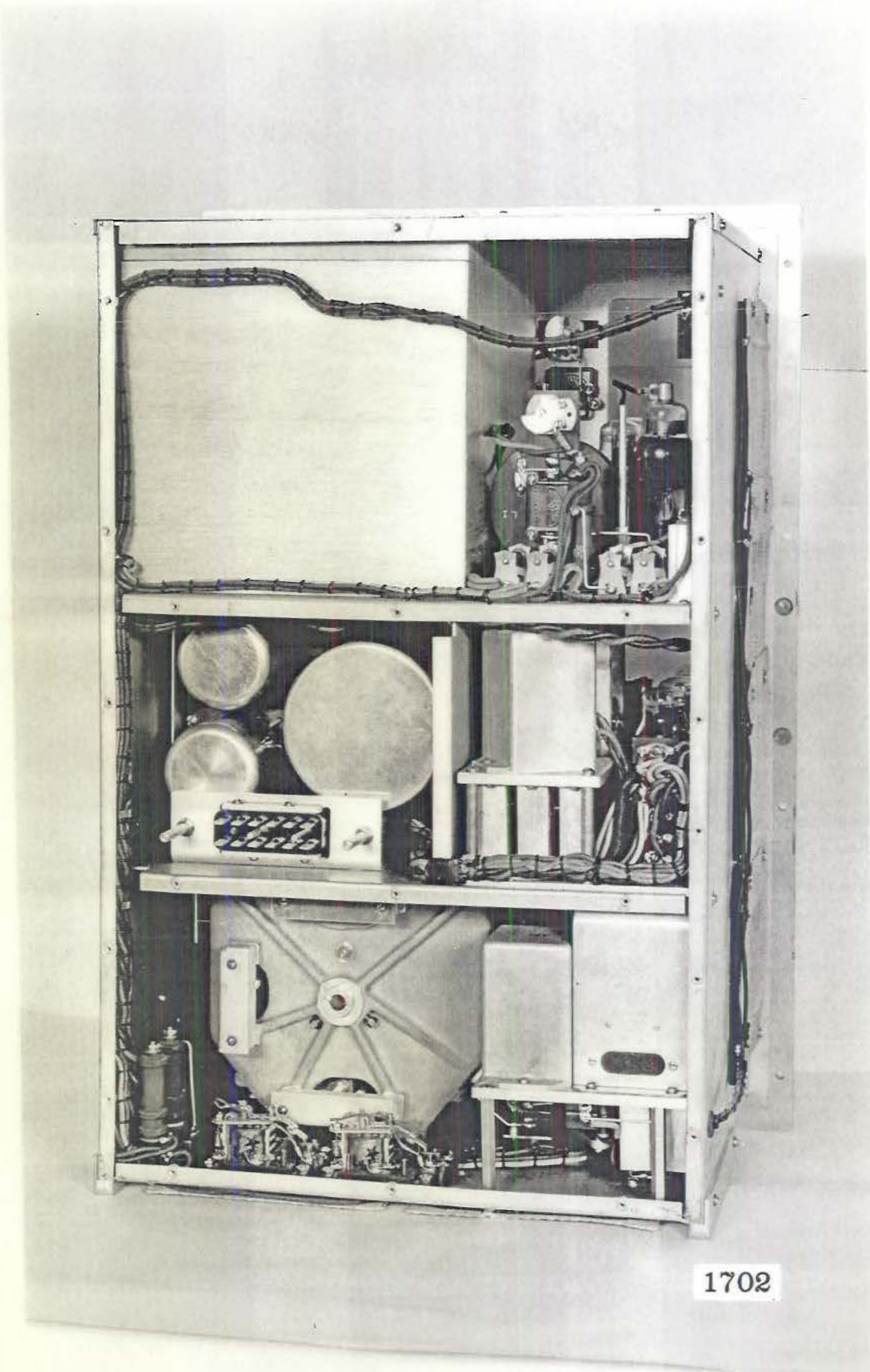
PLATE I



1701

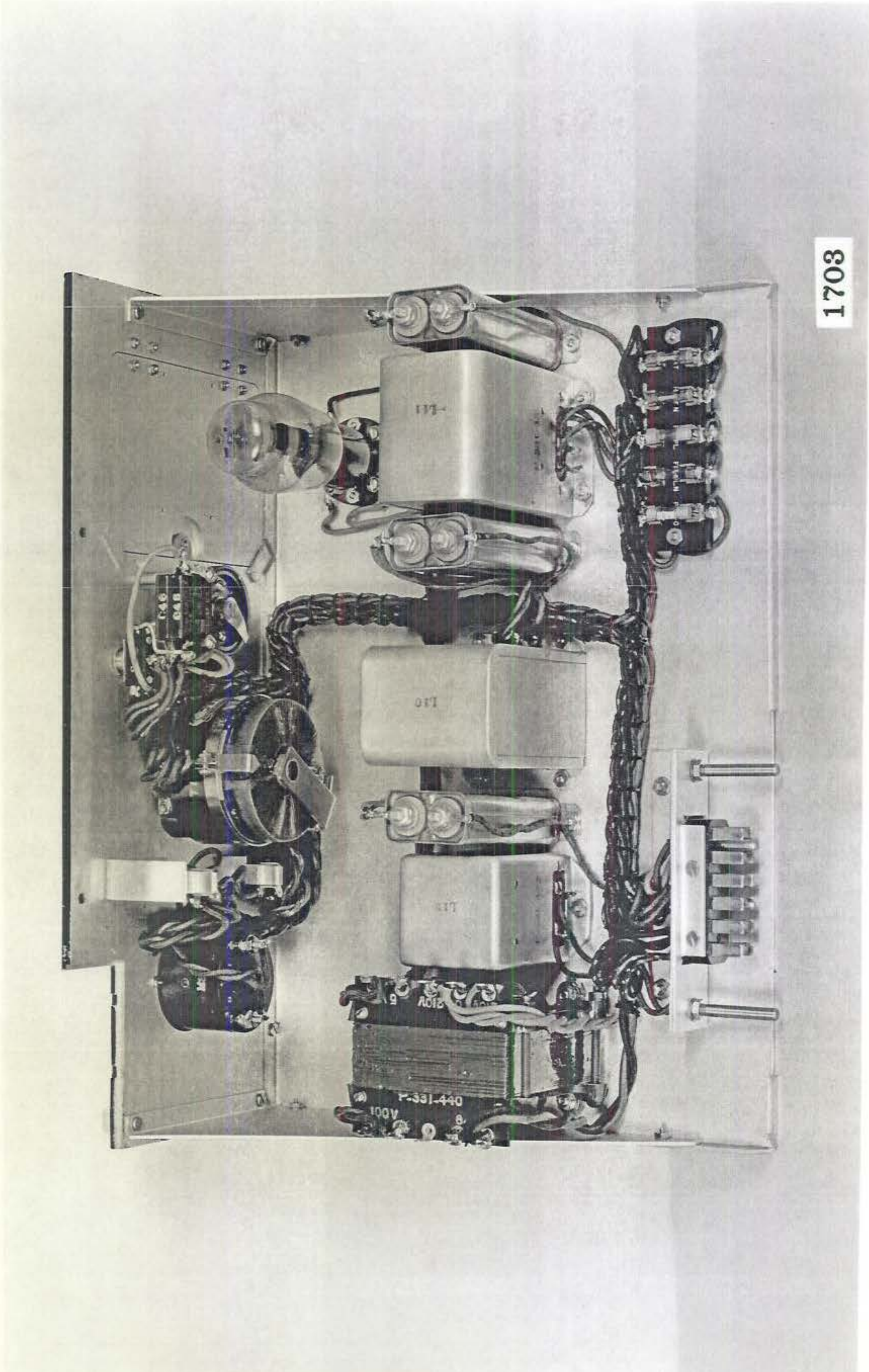
Front view of Model LD-3 equipment

Plate 2



Rear view of measuring unit (panel removed)

Plate 3



NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D.C.

Power unit

Plate 4