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AMC TR 7-652(I)

AMC INTERIM REPORT 7-652(I)
November 1961

ENGINEERING AND PRODUCTION OF AN INTEGRATED
FAMILY OF BACKWARD WAVE OSCILLATORS

James E. Orr

LITTON ELECTRON TUBE CORPORATION

Contract: AF33(600)43396

Interim Technical Engineering Report
7 July 1961 - 7 October 1961

A family of electronically tuned, broad band oscillator tubes has been developed that are physically and electrically similar from band to band. These tubes are being production engineered and productized for system application.

RESEARCH AND DEVELOPMENT BRANCH
MANUFACTURING METHODS DIVISION

AMC Aeronautical Systems Center
United States Air Force
Wright-Patterson Air Force Base, Ohio

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ABSTRACT - SUMMARY
Interim Technical Progress Report

AMC INTERIM REPORT 7-652 (I)
November 1961

ENGINEERING AND PRODUCTIZATION OF AN INTEGRATED
FAMILY OF BACKWARD WAVE OSCILLATORS

James E. Orr
Litton Electron Tube Corporation

Redesign of the tubes in bands 1, 6 and 8 has been completed. Sub assemblies have been undergoing extensive life test to evaluate the designs. Life test consoles were designed and fabrication was started. Thermal drift compensation for these bands was started and the electron optics was checked by calculating electron trajectories. Material improvement and tooling improvement programs were initiated.

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FORWARD

This Interim Technical Engineering Report covers all work performed under contract AF33(600)43396 from 7 July 1961 to 7 October 1961.

This contract with Litton Electron Tube Corporation, San Carlos, California, is administered under the direction of Melvin D. Brown, Ralph B. Brinkman, Arnold H. March and others of the Manufacturing Methods Division, AMC, Aeronautical Systems Division, Wright-Patterson Air Force Base, Ohio.

The primary objective of the Air Force Manufacturing Methods Program is to increase producibility, and improve the quality and efficiency of fabrication of aircraft, missiles, and components thereof. This report is being disseminated in order that methods and/or equipment developed may be used throughout industry, thereby reducing costs and giving "MORE AIR FORCE PER DOLLAR".

Your comments are solicited on the potential utilization of the information contained herein as applied to your present or future production programs. Suggestions concerning additional Manufacturing Methods development required on this or other subjects will be appreciated.

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Objectives of Contract

The purpose of this contract is to conduct an engineering study of a family of M-type backward wave oscillators. Phase I of this study shall be directed toward redesigning and productizing this tube type to the extent necessary to build quantities at a high yield. Phase II shall be directed toward production fabricating a minimum of six tubes of each type with the same design and construction and subjecting these tubes to all environmental and life tests required by the finalized specification data.

The tubes in the family will have the following characteristics:

Band	Tube Type		Minimum Output Power	RF Output Structure
1	L-3721A	1000-1200 Mc 1200-1400 Mc	200 Watts	7/8" Coax
2	L-3722	1400-1575 Mc 1575-1800 Mc	200 Watts	7/8" Coax
3	L-3723	1800-2175 Mc 2175-2550 Mc	200 Watts	7/8" Coax
4	L-3724A	2500-3025 Mc 3025-3550 Mc	180 Watts	7/8" Coax
5	L-3725A	3500-4175 Mc 4175-4850 Mc	180 Watts	7/8" Coax
6	L-3726A	4800-5675 Mc 5675-6550 Mc	165 Watts	DR-19
7	L-3727A	6500-7525 Mc 7525-8550 Mc	150 Watts	DR-19
8	L-3728A	8500-9750 Mc 9750-11000 Mc	150 Watts	DR-19

Two frequency ranges are available within each tube due to the recent advances in wide band sole tuning. Litton will not develop band 2 and 3 at the present time. Figure 1 is a photo of the tubes band 1, 6 and 8 which were worked on during the first quarter.

L-3728A Status

Several L-3728A type tubes were built during the quarter. These tubes had specification power outputs of 150 watts minimum when the output match, line uniformity and attenuator match were of high quality. Deterioration of any of these three parameters due to poorly executed brazes, uninspected parts, etc., resulted in frequency discontinuities and spurious output power. Work is continually in progress to write procedures for the inspection and assembly of parts.

The construction of the interdigital line has been modified from previous practice. The base of each finger is now copper plated for .040" of the .220" finger length. The copper plating covers the gold-copper brazing alloy fillet at the base of each finger. This procedure decreases the r.f. losses in the alloy fillet which results in an increase of about 5% in output power. It is expected that this procedure would not be effective for other tubes where fewer finger and lower frequencies decrease skin effect losses.

Other improvements incorporated are discussed elsewhere in the report under the general topics.

Several parameters need to be evaluated before the tube will be ready for Phase II life test. Beryllia ceramic sole insulators have been incorporated

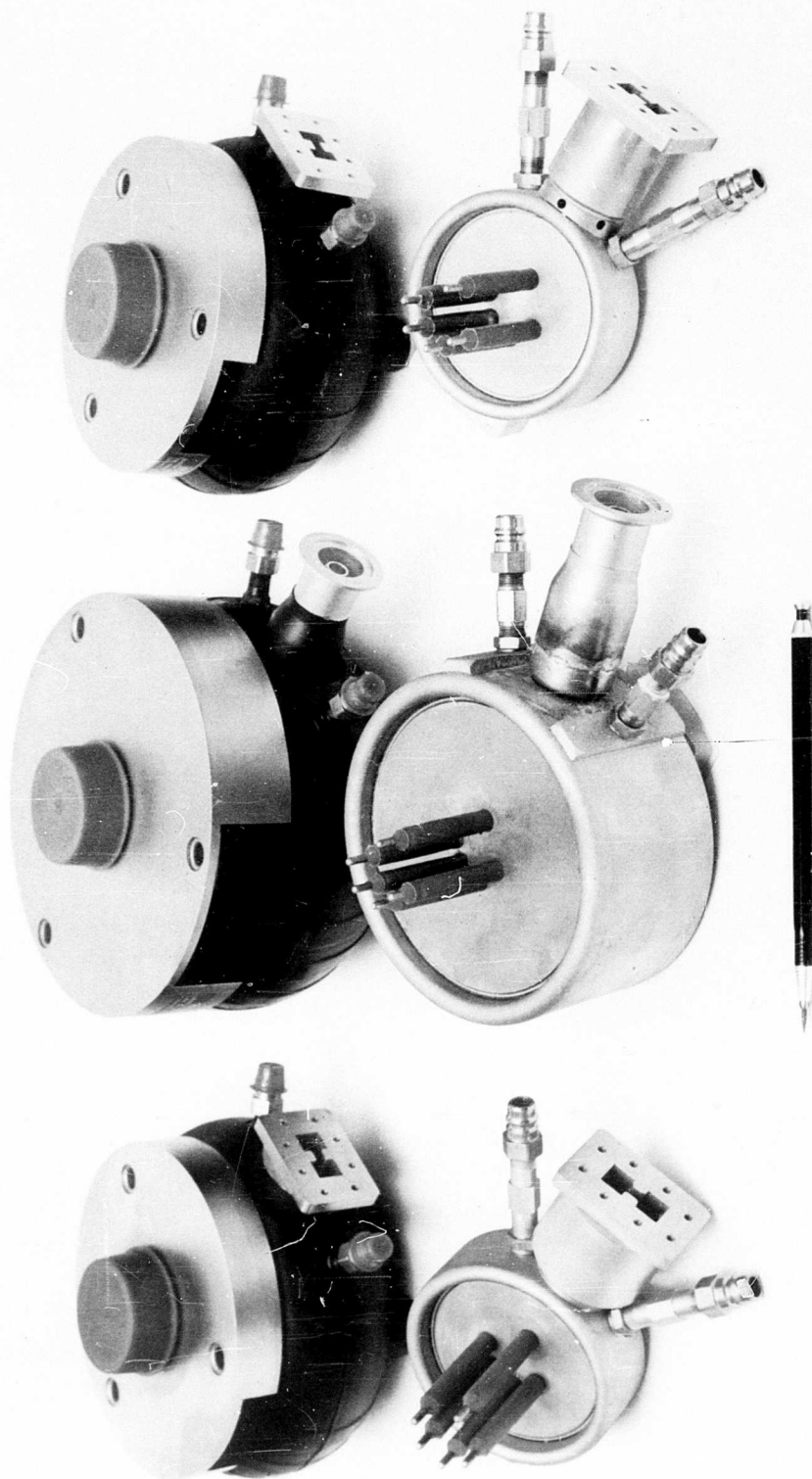


Figure 1 - Packaged & Unpackaged Tubes

in the construction of the sole-end plate sandwich to quickly equalize temperature gradients during turn on. It is expected that transient behavior of the tube will be evaluated during the month of November.

Also scheduled to be evaluated will be (1) thermal drift characteristics for which magnetic compensating shunts are employed and (2) vibration and shock characteristics.

L-3726A Status

Several L-3726A type tubes were built during the quarter. In general the status of the L-3726A is similar to the L-3728A with the exception that thermal drift characteristics have already been evaluated (See Page 10).

L-3721A Status

The problems in designing and building the L-3721A tube type are quite different than the higher frequency tubes in the family. The much larger size of component parts requires new construction techniques and procedures. (See Page 15). Electrical specifications are of the same order of difficulty as the other tubes in the family with the possible exception of the two current operation requirement which applies only to the band 1 tube. The wide dynamic range required to operate from 300 ma to 500 ma requires careful design of the interaction region geometry and gun configurations to decrease frequency pushing effects.

A major portion of our effort on the band 1 tube for the month of August was directed toward a redesigned tube, model K, which would improve pushing

characteristics, and also would have an improved cathode structure.

The first Model K, Band 1 tube was cold tested the last week in September with encouraging results. Match adjustment for the new design was greatly facilitated over the Model J tube by a redesign of the transformer region at the output and a longer attenuator structure.

We redesigned the L Band gun in an effort to improve gun uniformity. The present method of building guns is by positioning the accelerator and grid assemblies on the sole platform with an elaborate assembly jig. They are then spot welded to the platform. The sole assembly is removed from the jig and the assemblies are brazed in position. The cathode and heater are added to the sole assembly last and spot welded in position. This technique has worked quite well in the past but it is believed that a higher yield could be obtained from guns if the brazing operation was eliminated. Also, jigs would not need to be so complicated and therefore small design changes could be made more quickly on tubes which were in the development stage. Since new jigs were required for the latest design of the L band gun, we decided to incorporate new assembly techniques into the redesign. By securely spot welding the cathode grid assembly to the sole platform it is possible to complete the assembly, that is, add the cathode and heater, before it is attached to the sole platform. It was hoped that this procedure would allow the cathode to be more accurately positioned in the assembly. Also the two assemblies could be positioned separately thus simplifying the jiggling and improving the dimensions.

Also incorporated in this new design was a cathode of different geometry and reduced mass. This cathode structure would insure that the cathode temperature was at design value after a sixty-second warm-up time. Filament current in a new design would be considerably reduced from that which was used in the L-Model structure.

Several new type guns were built for the Band 1 tube during October. These guns made use of the new technique of spot welding the accelerator and grid cathode sub-assemblies to the gun platform separately, thus eliminating the brazing operation. This technique speeds up the gun building operation and allows the sub-assemblies to be salvaged if for some reason the gun fails. However, a more accurate positioning of the gun elements has not as yet been achieved by this method.

One of the problems with the new gun building technique lies with the positioning jigs. Although these jigs function satisfactorily they are in no way superior to the old gun jigs except for being easier to build and more adaptable to changing the gun design. The jigs are now being studied and an attempt will be made to improve them.

The second problem with the new method is one of spot welding techniques. Since the spot weld is all that hold the gun elements in their proper position it is very important that unwanted stresses are not set up in the gun support by the weld. If stresses do occur they relieve themselves after the jigs are removed and the gun elements must then be adjusted by hand. This of course, reduces the time saving advantage of the new method. We are reviewing and evaluating these spot welding techniques in order to solve this problem. Also, we are ex-

perimenting with more rigid gun supports in an attempt to eliminate individual adjustment of the gun sub-assemblies.

The hot test results of the K-model tube were quite encouraging. The frequency pushing effects from 300 to 500 ma operation were greatly improved over the J-model. Also the tendency for frequency discontinuities was less. However, the output power was less at 300 ma and about the same at 500 ma. To overcome this problem a new design, L-model, was built. This model had a longer delay line and a larger diameter sole structure.

The L-model was also successful in reducing frequency pushing effects. Specification power output was obtained in each current range for fixed voltage; however, the tube required a high magnetic field for optimum operation. Since the magnetic field was higher than the maximum stable value for the permanent magnets, further redesign was necessary. The L-3721 M-model will have a change in pitch of the interdigital line and a new electron gun configuration. It is expected that this model (or one very similar) will meet the specification in all respects. Adequate thermal drift characteristics were approached on the L-3721 J-model as discussed in Section F. Further work on this problem has been held up temporarily pending final decision on the gauss level of the permanent magnets.

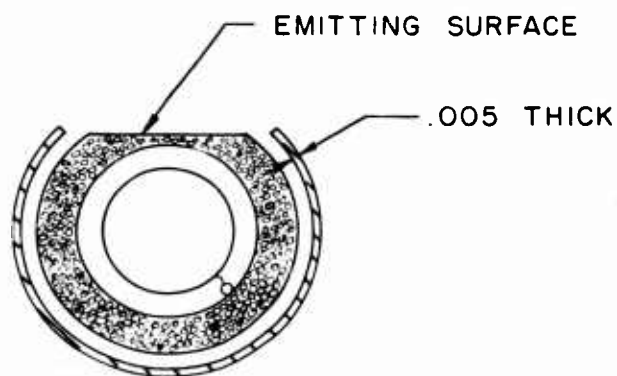
Evaluation of Electron Gun Components with Life Testing

One parameter limiting long life in an MBWO is unstable grid current. Although grid current may be zero during initial testing of a tube it is very likely that an inadequately designed gun structure will develop grid current after many

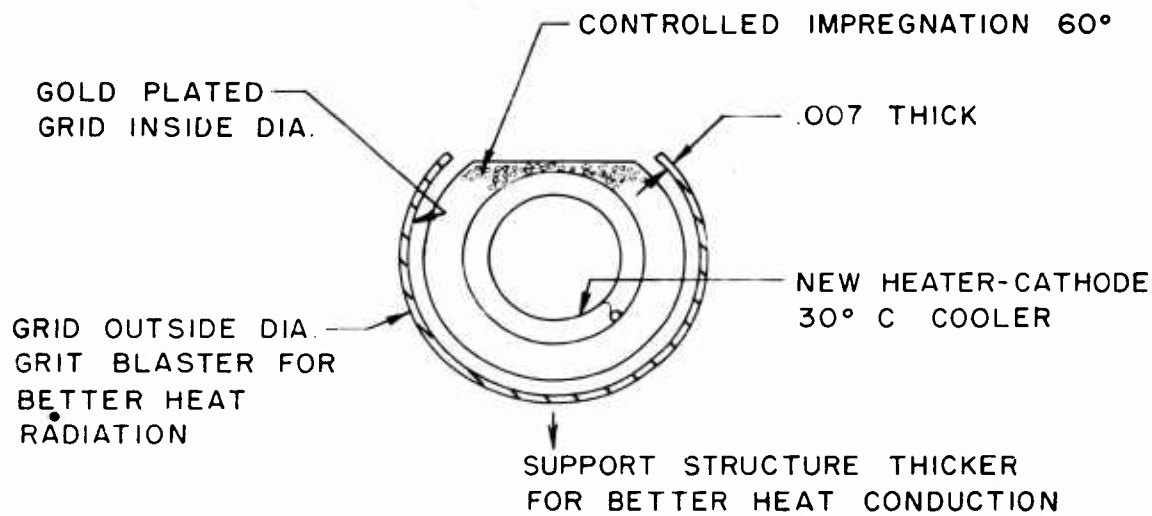
hours of operation. Two main sources of grid current are electrode to electrode leakage across supporting insulators and primary grid emission. The leakage problem on the MBWO's has been eliminated by the use of clean techniques, high quality insulator material and shields which prevent the deposit of materials on the insulators during cathode breakdown and operation of the tube. The elimination of primary grid emission has required a more involved solution.

The first step taken to eliminate grid emission was to gold plate the inside of the grid surface. This proved to be successful but was not adequate long hours after operation because the gold plating was depleted due to vaporization. An abundant coating of emission inhibiting gold was provided by reducing the temperature of the grid during exhaust from nearly 900° to 625°C, which is still hot enough to insure good bakeout. Although the grid operates much cooler during normal tube operation, evaporation does occur at a slow rate which is dependent upon the operating temperature. The next step therefore, was the reduction of the operating temperature of the grid. Heat radiation from the grid was enhanced by grit blasting the outside of the grid. The thickness of the grid, the grid support, and the grid leads was increased to improve the heat flow from the grid by a factor of 1.4.

Barium deposits on the grid were reduced by impregnating the cathode only over 60°, the required area for gun optics, rather than over the total area of the cathode. The improvements in the grid and cathode assembly are summarized in Figure 2.



OLD DESIGN



NEW DESIGN

IMPROVEMENTS IN THE GRID AND CATHODE ASSEMBLY

FIGURE 2
-7a-

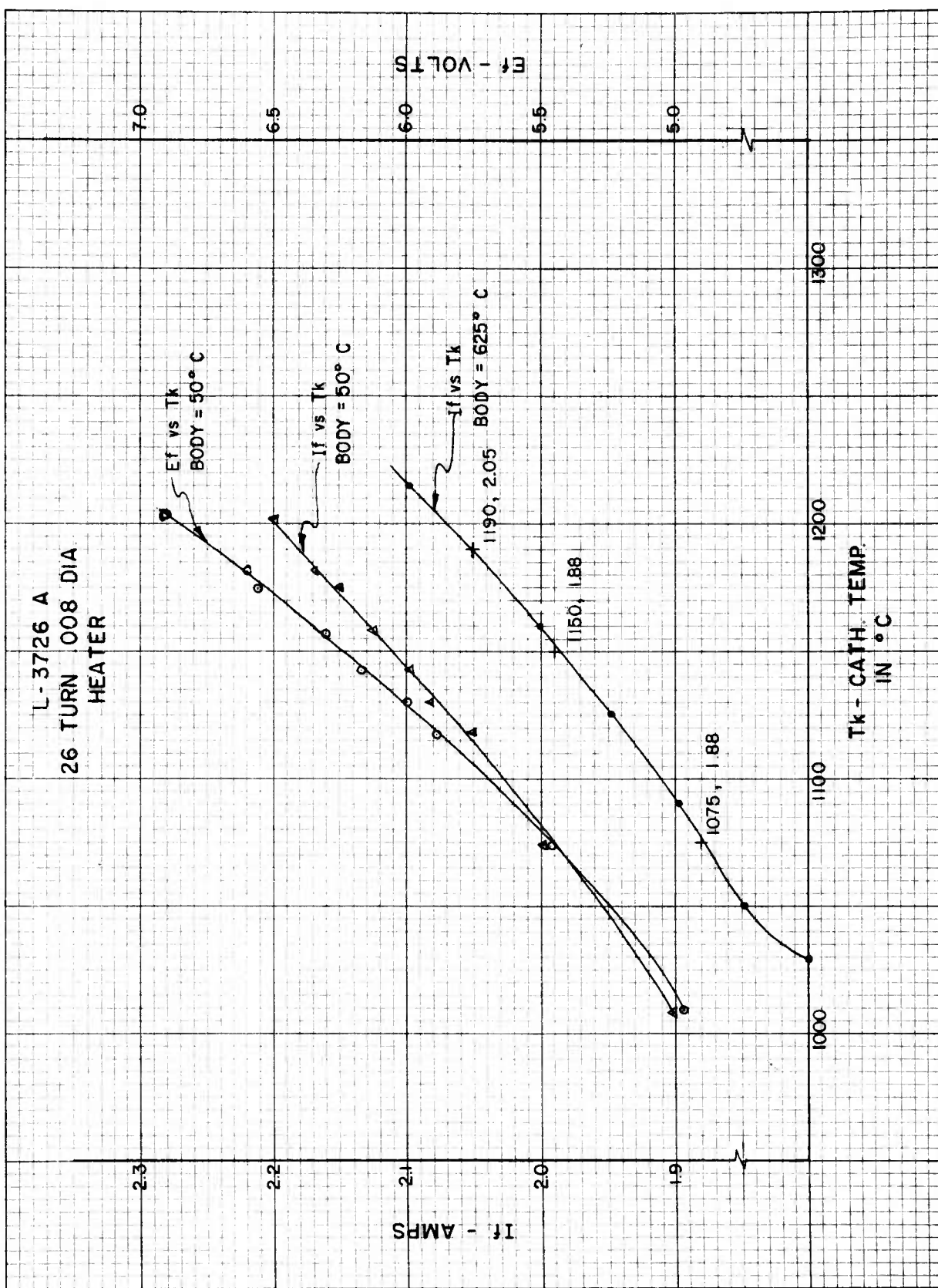
In order to prevent undue vaporization of barium during cathode breakdown and to insure proper breakdown temperatures, gun assemblies are monitored for temperature during the exhaust cycle and later under simulated tube operating conditions. Typical data taken in this manner is shown in Figure 3. This technique allows us to determine the proper exhaust schedule for standard tubes so that cathodes are properly broken down and to evaluate heaters so that we are able to operate with the lowest possible temperature consistent with space charge limited operation. Low operating temperatures also increase the inherent life of the cathode.

In order to evaluate the changes made with respect to life under normal operating conditions bodies were built with a copper block brazed to the tube body in the relative position normally assumed by the accelerator, as shown in Figure 4. The gun assembly is mounted in the same manner as standard tubes and all other factors which effect gun temperature are standard. The dummy accelerator life test tubes are run with the most stringent grid voltage, (700 volts) beam current (300 mA) and heater voltage (6.6 volts) allowed by the specification.

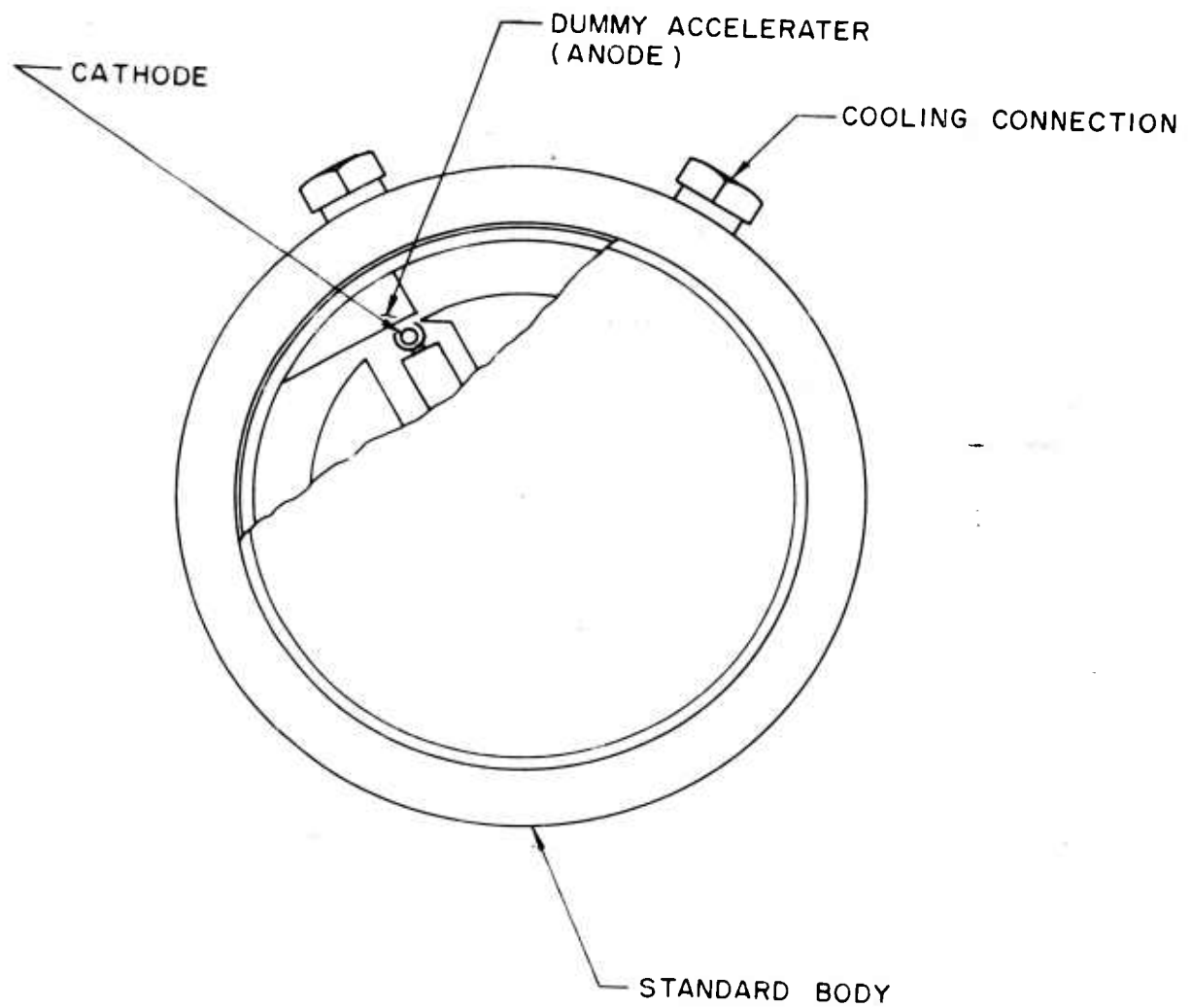
The following tests were run during the first quarter: (Band 4 tests were run first since components were available at initiation of contract)

Band 4 Test No. 1 (Obsolete design because full impregnation of 360°)
Grid current after 400 hours with a filament voltage of 6.3 volts was 0.1 mA.
Filament voltage was then raised to 6.6 volts and component was operated for 92 hours with a resulting grid current of 4.8 mA. Since this grid current is

FIGURE 3



CATHODE TEMPERATURE VERSUS I_f



DUMMY ACCELERATOR TUBE

FIGURE 4

out of specification, this component was taken off life test.

Band 4 Test No. 2 (Impregnation of 60° but obsolete because grid cylinder material too thick) Filament voltage was 6.3 volts. After 409 hours grid current was still zero mA. This component was taken off because of obsolete design.

Band 4 Test No. 3. (Obsolete design because of 180° impregnation and a 24 turn heater which gives a cathode temperature at 6.6 volts of 1190°C brightness. This temperature is considered to be about 30°C too high for long life.) At the end of 2397 hours grid current is still zero.

Band 4 Test No. 4. (This component is latest design. The cathode has a 26 turn heater which gives a cathode temperature of 1160°C brightness which is considered about optimum. Impregnation is 60°.) After 2095 hours grid current is still zero.

Band 4 Test No. 5. (Configuration identical with Test No. 3 and was not run because design became obsolete.

Band 4 Test No. 6. (Latest design with the exception that the grid on this gun has the inside surface plated with a thin layer of platinum.) After 1083 hours grid current has risen to 0.1 mA.

Band 4 Test No. 7. Test body was damaged.

Band 4 Test No. 8. (Latest design in which a check of new batch of cathodes will be evaluated) After 95 hours grid current is still zero.

Band 6 Test No. 1. (Latest Design) After 48 hours grid current is still zero.

Band 8 Test No. 1. (Latest Design) After 96 hours grid current is still zero.

• Band 8 Test No. 2. (Latest Design) Run just started.

In addition to life testing the grid structure for grid emission, we are life testing the heaters with a program of two minutes on and five minutes on and five minutes off. A filament voltage of 6.3 volts is snapped on immediately. This cycling test is performed using standard Band 4 tubes. Two tubes were cycled 4720 times and still showed no signs of weakness.

Improvement of Thermal Drift Characteristics

This specification requires that the tube be stable over all combinations of input oil temperatures from -54°C to $+85^{\circ}\text{C}$. Using the technique developed for our Band 4 tube, which utilized compensating magnetic material placed on the bowl magnet, we have made tests with our Band 6 and Band 1 tubes. Several runs were made in the Litton environmental test chamber tube during the quarter.

There are three main factors which contribute to frequency drift with a change in temperature:

1. The interaction space between the line and sole changes dimensions due to a change in oil temperature or ambient temperature.
2. The gap between pole pieces changes due to the expansion or contraction of the tube body, the pole piece and also the pole piece supporting structure. Therefore, the magnetic flux density which is approximately inversely proportional to frequency decreases for larger gap distances and increases for smaller gap distances.

3. The magnetism of the magnet itself is a function of temperature. The

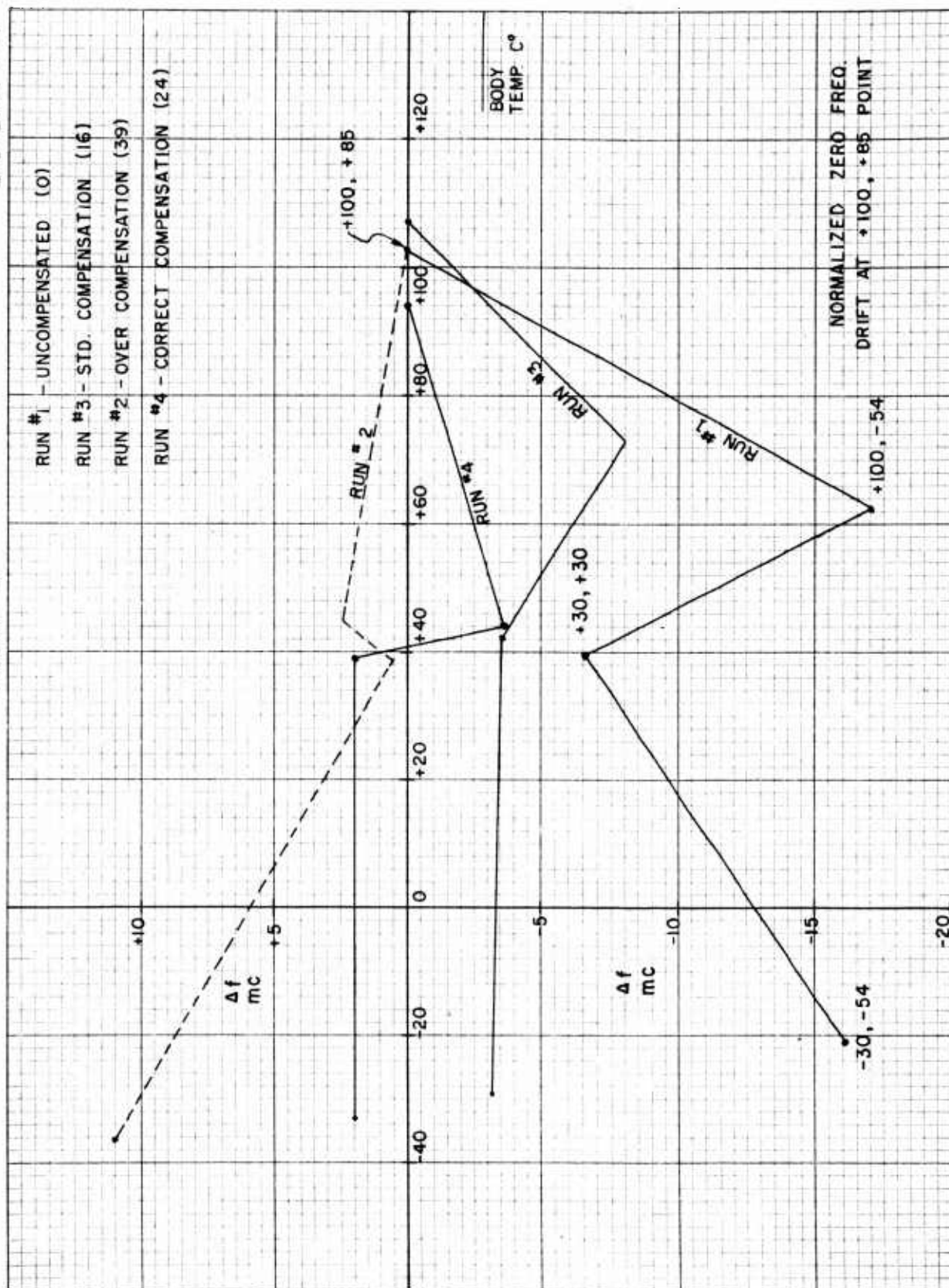
temperature distribution of the magnet is not merely a function of the ambient temperature, since in general, there is some heat contribution from the pole piece supporting structure near the top and the bottom of the magnet.

Four chamber runs were made to determine the optimum compensation required for the Band 1 tube. In Figure 5, Run 1 had no magnetic compensating shunts on the outside surface of the magnet; Run 2 had 39 magnetic shunts; Run 3 had 16 magnetic shunts; and Run 4 had 24 magnetic shunts. For each run a thermocouple was placed on the tube body to monitor the body temperature. By plotting tube body temperature against frequency shift for each stabilized point, one can determine if the compensation is under or over compensated. In the analysis the $+100^{\circ}\text{C}$ ambient and the $+85^{\circ}\text{C}$ oil temperature stabilized point is taken as zero frequency shift reference because the magnetic shunts are not very effective at this temperature. Thus from Figure 5 we see that Run 1 was under compensated, Run 2 quite over compensated, Run 3 slightly under compensated and Run 4, the correct compensation. In Figure 6, Run 4 is replotted as frequency drift versus time and temperature. Further work to decrease the frequency shift by adjusting pole piece gap variation was temporarily halted pending the availability of the new Model M, Band 1 tube. These tests will be made in the next quarter.

In Figure 7 is plotted the frequency drift data for the Band 6 tube. The frequency deviation from the stabilized points was 6.5 megacycles which is well within the specification.

L-3721 A #47

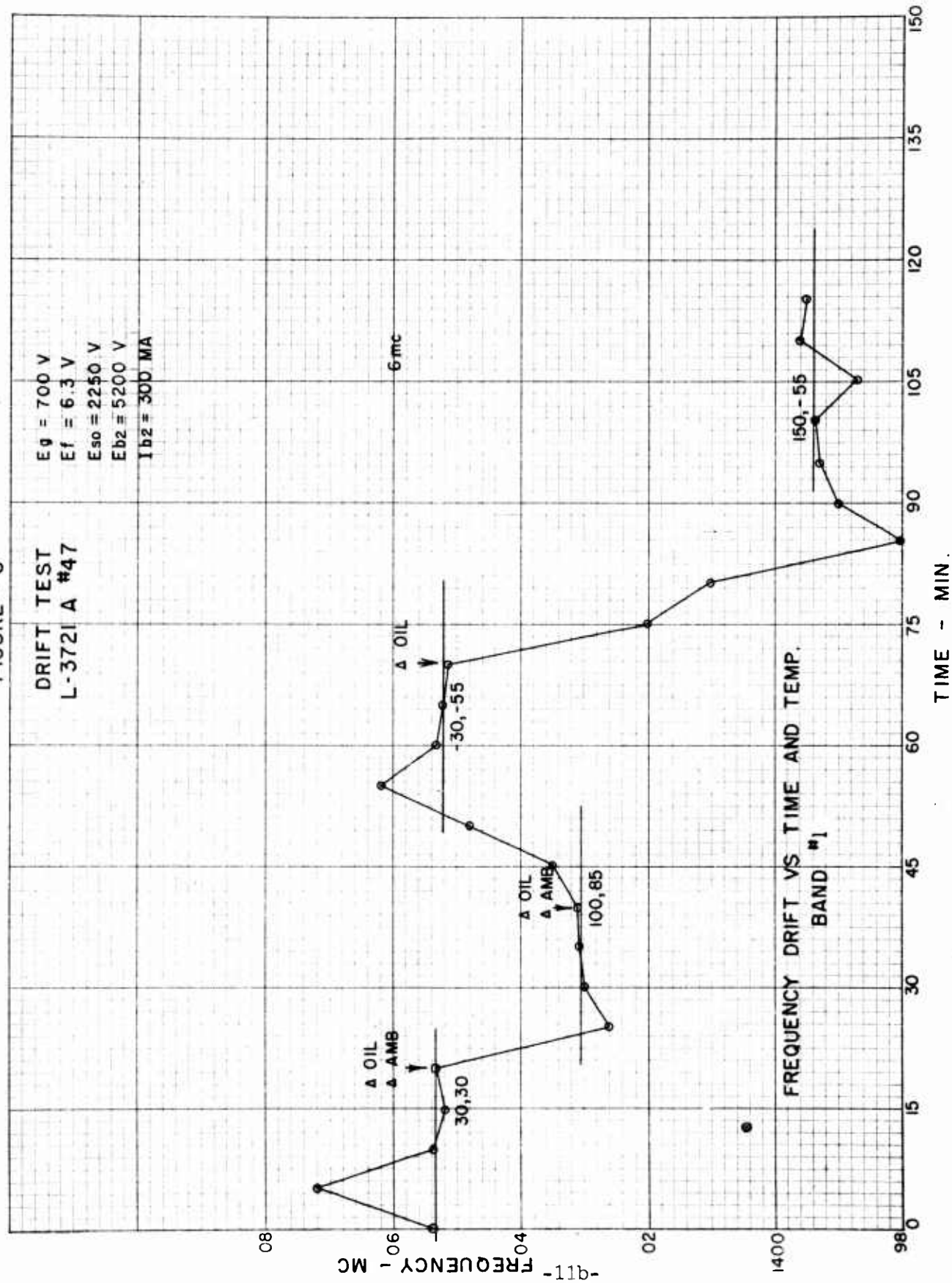
FIGURE 5



MAGNET COMPENSATION CURVES

DRIFT TEST
L-3721 A #47

-11b- FREQUENCY - MC



10 X 10 TO THE INCH
KEUPPEL & ESSER CO.
NEW YORK, N.Y.

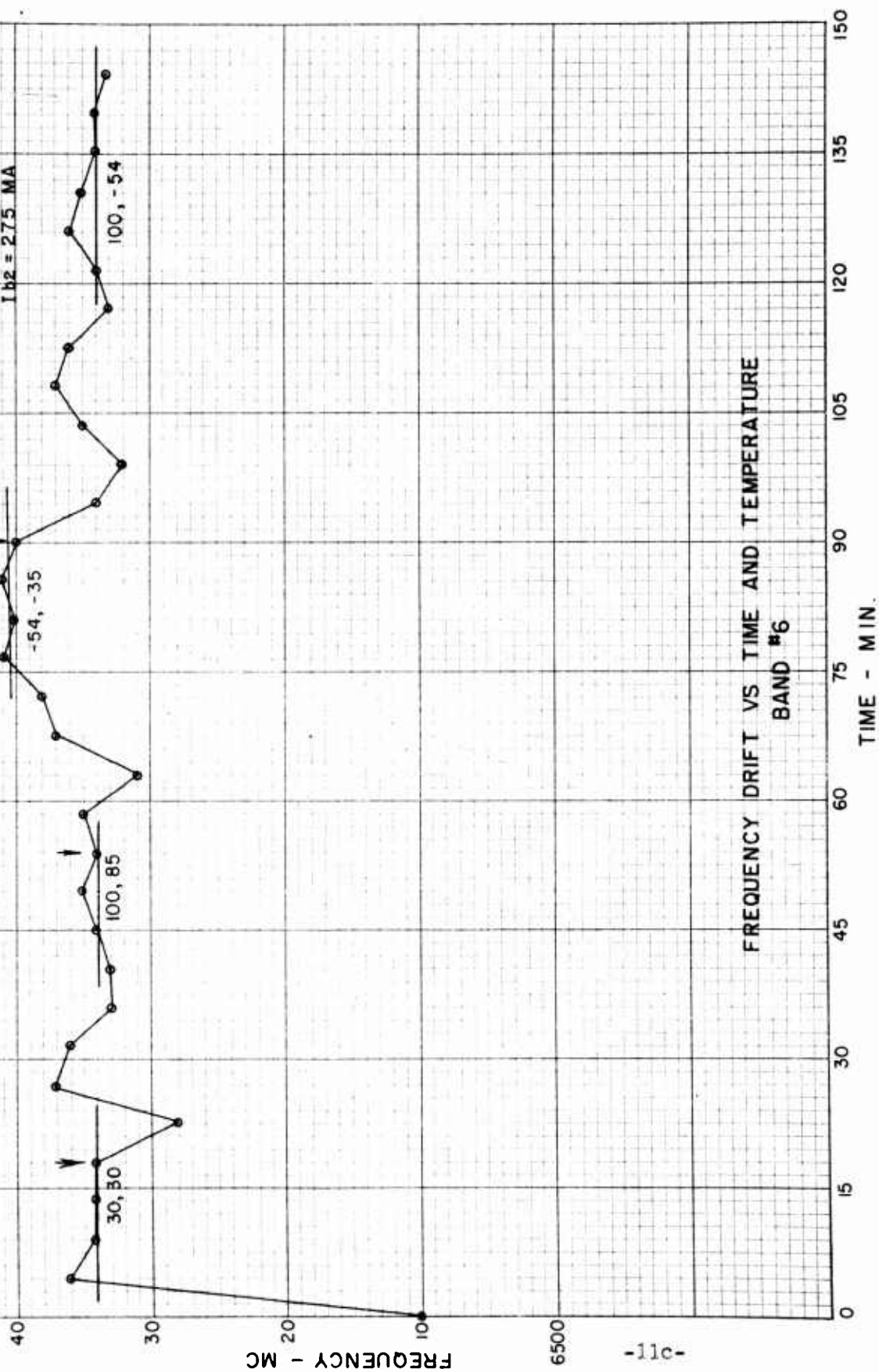
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10 X 10 TO THE INCH
KEUPPEL & ESSER CO.
NEW YORK, N.Y.

FIGURE - 7

DRIFT TEST
3446 A

$E_f = 6.3 \text{ V}$
 $E_g = 700 \text{ V}$
 $E_{90} = 1900 \text{ V}$
 $E_{b2} = 4500 \text{ V}$
 $I_{b2} = 275 \text{ MA}$



FREQUENCY DRIFT VS TIME AND TEMPERATURE
BAND #6

TIME - MIN.

FREQUENCY - MC

-11c-

Studies of the Electron Optics

During the past quarter effort has been directed toward studying and improving the electron gun optics of the MBWO family. Initial studies were begun using an electrolytic tank to find the potential contours and then to manually plot electron trajectories. Toward the end of the quarter, use was made of a resistance board analogue to obtain the potential diagrams and the trajectories were calculated by the use of an IBM 709 digital computer. In Figure 8 plots of three electron trajectories obtained by the analogue are shown for each of three magnetic fields: 1050, 1100 and 1200 gauss. The voltages used were those peculiar to one model of an MBWO and correspond to the voltages applied for operation at the high frequency end of the low range. The design value of the magnetic field was 1100 gauss. As can be seen from the figure the electrons enter at too high a potential to yield a high efficiency tube. A similar observation was noted in the actual operation of the tube. This plot is in good agreement with a similar plot made using the electrolytic tank and hand calculations. Using the information gathered from the trajectory plots and omega-beta diagrams it appears that there are two conclusions which can be drawn..

1. In accordance with emission requirements and voltages specified, the final periodic structure design should be matched to a given gun design and not vice versa.

2. A smoother beam can be obtained if the cathode loading can be increased. This then makes the cathode appear as a point source or rather in our geometry a line source, thus reducing the noise and the scalloping nature of the beam.

1

FIGURE 8
ELECTRON TRAJECTORIES

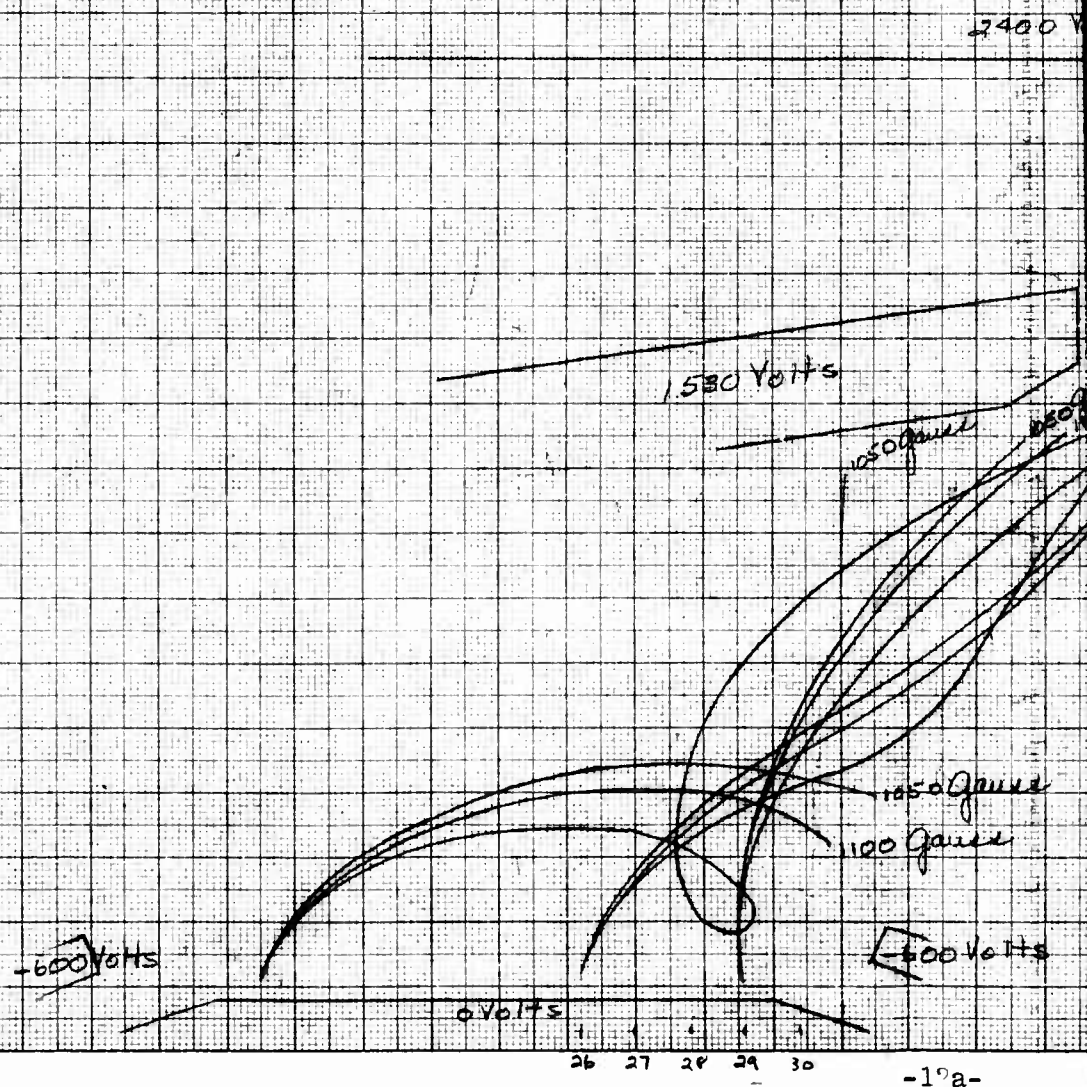
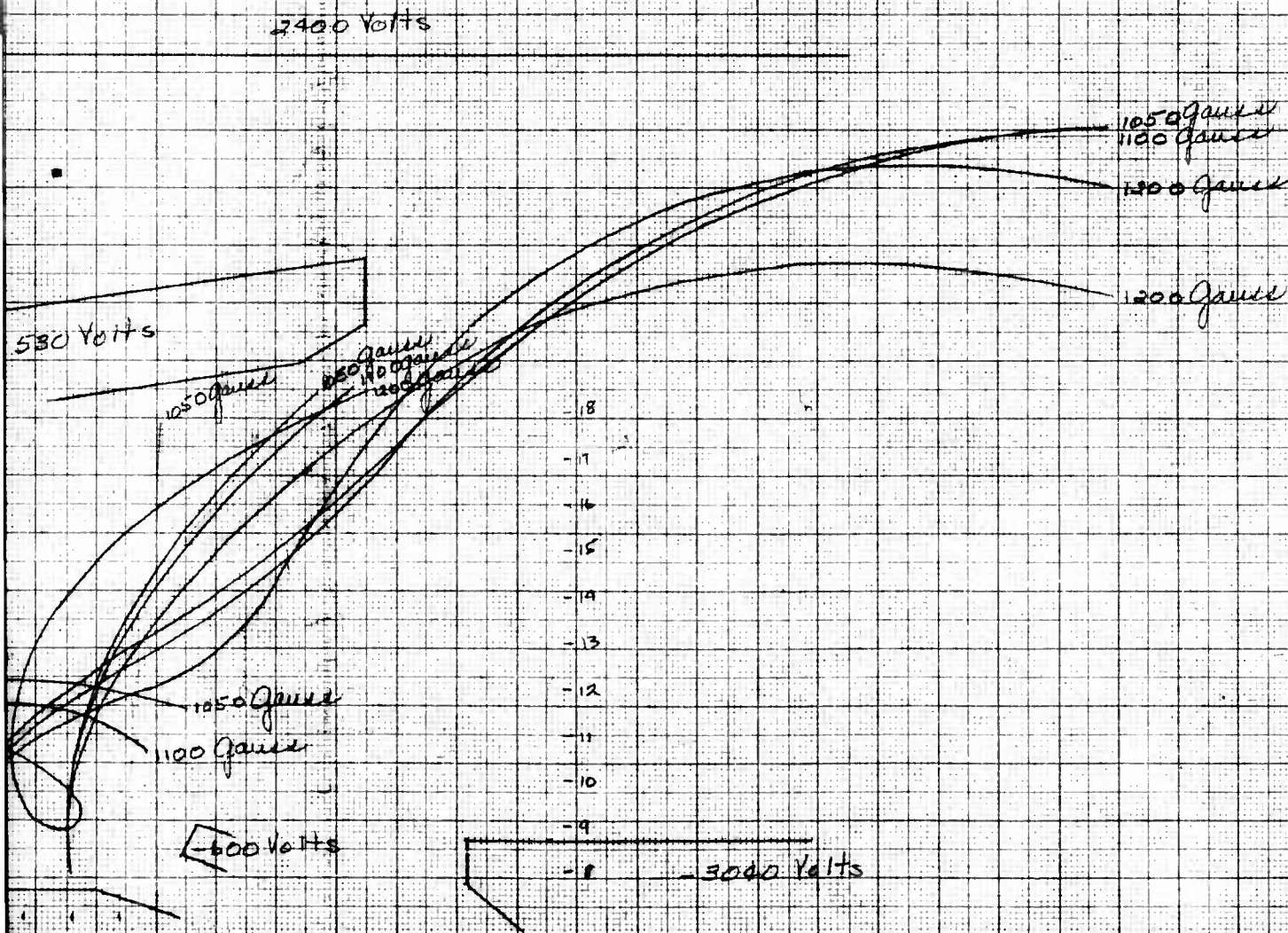


FIGURE 8

IRON TRAJECTORIES



-17a-

It is felt that the wide velocity variations found in a scalloping beam encourage the buildup of spurious oscillations.

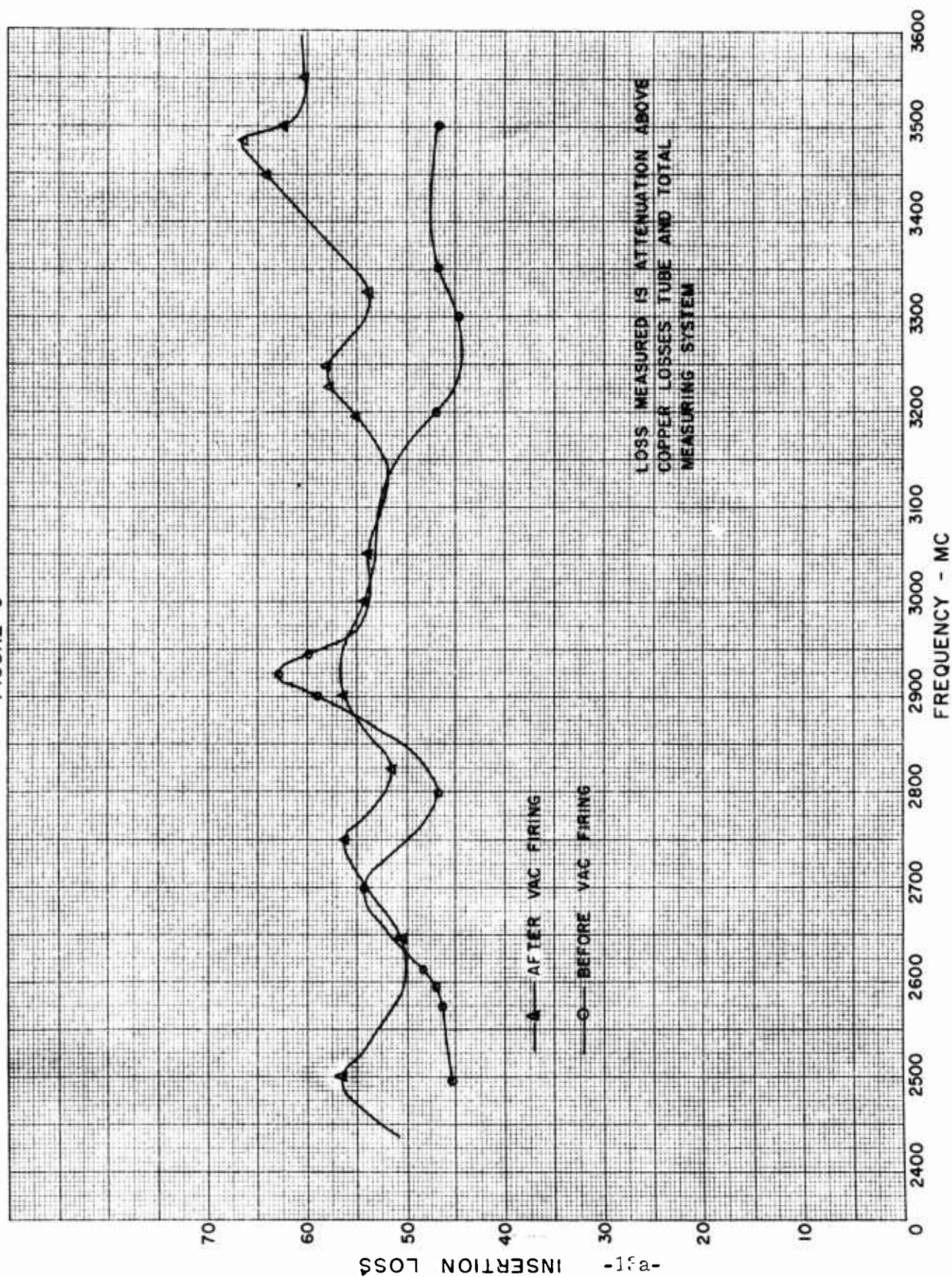
Material Improvement Program

Several lossy ceramic materials are under study for improvement of our attenuator which is used to terminate the slow-wave structure in the MBWO. One method is to impregnate porous ceramic attenuator blanks with water-sugar solution. The attenuator is then hydrogen fired to break down the sugar concentration to carbon.

Several carbon loaded pieces were fabricated into the standard attenuator shape and loaded with various percentages of sugar solution. It was found that a 50% solution gave extremely high attenuation figures and that the VSWR without a profile change was less than 1.5:1. Figure 9 shows a plot of insertion loss through the attenuator versus frequency. The two curves show the result before and after vacuum firing at 650°C. Very little difference is evident, showing that the material would be stable during the bakeout of the tube. This carbon loaded material has an order of magnitude greater loss per unit length than the nickel or tungsten loaded ceramic. Early in the next quarter the first hot test tube will be built utilizing this attenuator material.

Another method of making attenuators is to mix the basic aluminum oxide ceramic mix with metal particles. We are at present experimenting with tungsten or nickel particles. Here again, the best concentration of ceramic-to-metal must be determined, and also we must determine which particle size is the most effective. When the proportion of metal is too high, then the sample becomes conductive, when the proportion of metal is too low, then the sample does not have enough loss per

FIGURE 9



INSERTION LOSS

-18a-

unit length. Previous tests have shown that the nickel lossy ceramic has the advantage of better machineability. However, it has the undesirable property that it is ferro-magnetic in nature. Therefore its lossiness is somewhat dependent upon the relative orientation of the magnetic field and wave propagation direction.

Each sample is cold tested in an input-output tube with the back wall removed for ease of placing the attenuator against the line. With the attenuator removed, insertion loss is measured for the copper loss in the fingers themselves. Samples are then placed in the tube and the loss versus frequency is observed. For the Band 4 tube, a typical nickel attenuator would have a one-way insertion loss at the low frequency end of fifteen db, and at the high frequency end 22 db. These insertion loss measurements are taken with a matched input at all frequencies to take out the losses due to reflections.

Stability of the MBWO Looking into Load Mismatches

Three Band 4 tubes were operated into loads with very high values of VSWR to determine at what values of power output and mismatch permanent damage to the tube would result. All tubes were operated CW at the highest frequency point and therefore the most stringent point as far as thermal dissipation is concerned. Furthermore, beam currents were raised 60% more than normal operating values. Power output was recorded every minute looking into mismatches of VSWR of 1.5:1, 3:1, 4:1, 5:1 and 6:1. All tubes operated satisfactorily at normal operating currents into the highest mismatch of VSWR 6.1:1. Two tubes operated successfully and one tube failed due to a melted

finger where the tubes were operated into a mismatch of 6:1 with beam currents of 500 ma. From the results of these tests it appears that the Band 4 tube would operate with a comfortable margin of safety into loads with mismatches of 4:1 or more. It is planned to make similar tests on all tubes in the family when sufficient samples are available for destructive tests.

Slow Wave Structure Fabrication Improvements

In any microwave tube, the precision at which the resonant or slow-wave structure is fabricated greatly influences the successful attainment of a highly efficient device. At Litton, our approach to the problem of building uniform slow-wave structures for MBWO's has been to press tungsten fingers held by suitable pressing jig with great force into a copper or copper-cupron-copper sandwich disc referred to as a crown. This method has been very successful in the past, and hence we are using our present technique as a framework for further improvement. The pressing jig, which has slots for each finger, must be machined to tolerances of the order of one ten thousandth of an inch. It has been determined during the past quarter that this precision can only be obtained by hardening the basic jig configuration before further operations are made. After hardening the tool steel, the outer diameter is ground, and then the finger slots and indexing slots are ground. Previously, slots were machined in the basic jig configuration for a size change during hardening. However, sufficient tolerance could not be obtained with the old method. Many Band 4, 6 and 8 tube crowns were pressed during the quarter with a total run-out deviation less than 2 thousandths of an inch. Another technique which has kept run-out under

control in a finger-pressing method is the use of a hard rubber confining ring in place of a hardened steel confining ring used previously. During the pressing operation the rubber confining ring bulges out; thereby applying just the right amount of pressure inwardly on the fingers. Thus each finger is held in the pressing jig slots independent of slight differences in radial thickness of the fingers.

A second crown fabrication method is under parallel study. Basically, this method consists of first slotting the crown disc, and then brazing the fingers in the slots, utilizing a suitable precision brazing jig. A major advantage of this second method will be the option to use finger materials other than tungsten. Tungsten finger stock requires a lead time for fabrication of about six weeks, which is ample for a production situation, but not for a development program where one week between design changes would be ideal. A die to punch out fingers from, for example copper alloy sheet stock, could be fabricated in one week using our present magnetron vane know-how. Several trial crowns were brazed with this method using available tungsten finger stock, and were successful. These crowns had runouts of less than two thousandths of an inch. Smooth fillets at the base of the fingers were obtained by placing alloy wire sections in each slot behind the fingers, instead of using a loop of alloy wire around the base of the finger as originally planned. Happily, the difficult problems associated with this slotted crown method have been solved so that a quick reaction from major electrical design change to a tested tube, is now assured.

Also, to avoid distortion of crowns during assembly operations, several crowns were fabricated with sandwich type construction. In this method a disc of monel is brazed between two discs of copper which are then machined to the final crown dimensions. This assembly has great strength and virtually the same thermal conductivity of the solid copper discs used formerly. A sketch of the brazing jig scheme is enclosed as Figure 10. Basically, we use two slotted-crown discs, positioned accurately axially and circumferentially, with the fingers held between the two discs, but brazing alloy used only on one of them. The advantage of this second method is then (1) no need to machine crowns after brazing operation, (2) we can use finger stock other than tungsten rod, (3) there is less tendency for the crown to distort because the copper finger joint is not under stress, and (4) there is a quick reaction from the design to the assembled part.

The crown assemblies for the Band 1 tube are manufactured somewhat differently than the crowns of the other tubes in the family. This is because the fingers are considerably larger and are not made of tungsten; therefore, they are not suited to the finger pressing process. Instead, the fingers are a copper-tungsten alloy which has been pressed and sintered together at high temperatures. The resulting alloy is quite hard and has thermal and electrical conductivities comparable to copper.

The crown assembly is made from three basic parts which are a copper crown blank ring (see Figure 11), a copper finger indexing plate (see Figure 11),

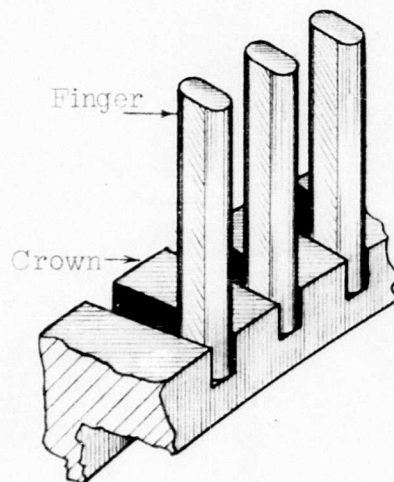
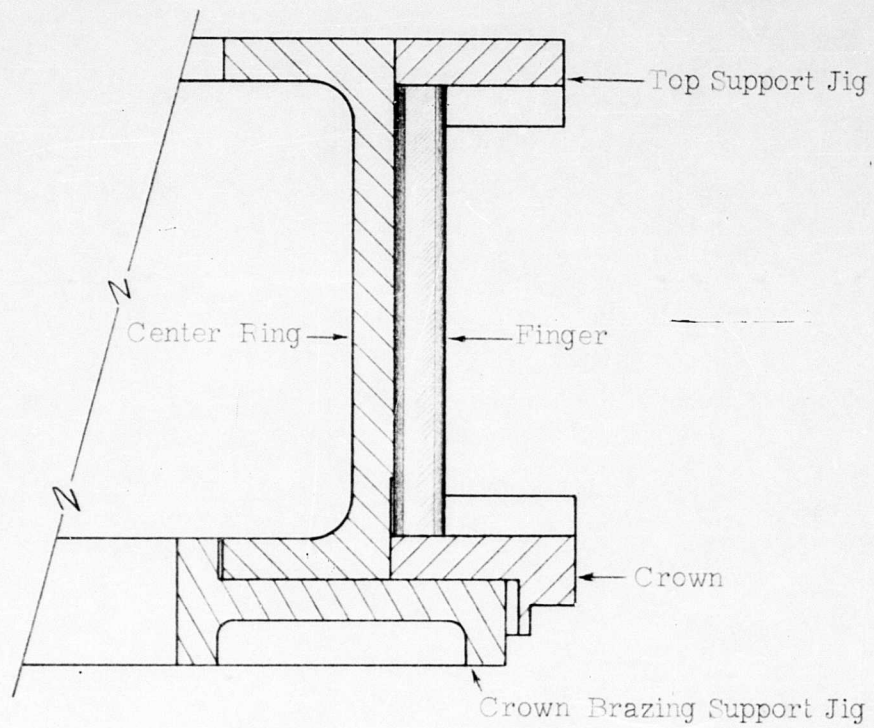


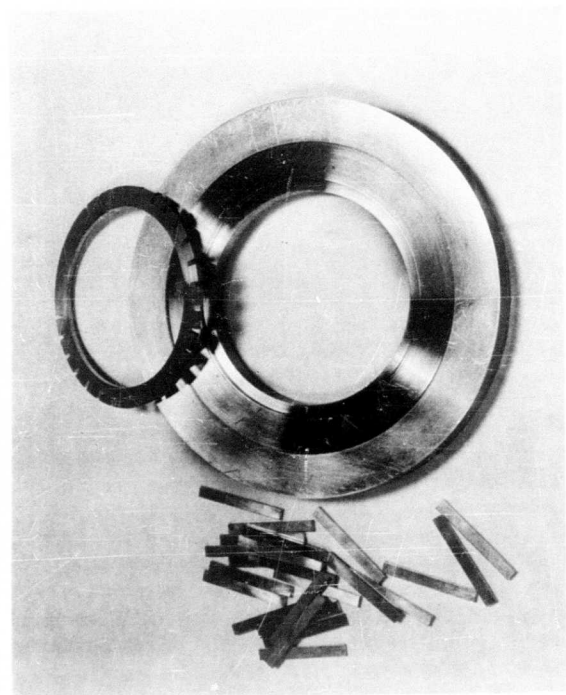
Figure 10
Crown Brazing Jig

and the fingers. The indexing plate is slotted to position the fingers correctly. Note the slots occur on the outside of the ring to facilitate the machining. The crown blank is machined on the inside to fit the indexing plate (see Figure 11). The indexing plate is placed in the crown blank, and the fingers are then inserted in the slots to be brazed (see Figure 11). In order to hold the finger to finger spacing to within .0003 of an inch, a finger brazing jig is placed in the center of the crown blank assembly. This jig is slotted on its outer surface to hold the fingers correctly during the braze.

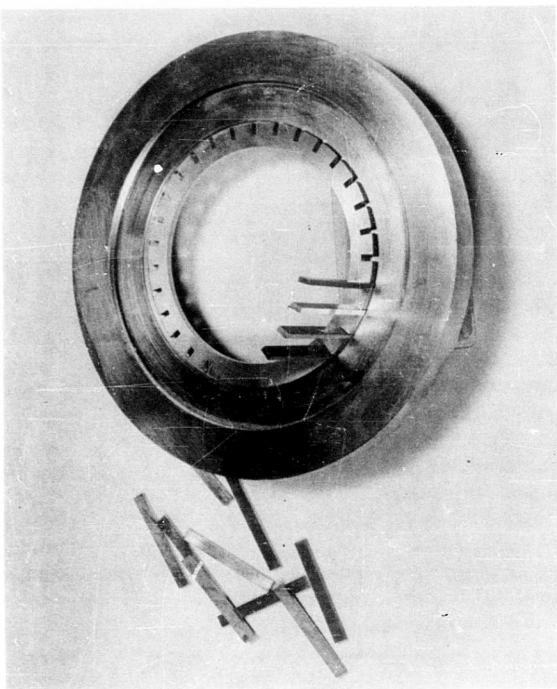
After being brazed (see Figure 11) the crown blank assembly is final machined to fit the tube body (see Figure 11). It is necessary that this machining be done last since a small amount of warping of the crown surface occurs during the braze and this can be corrected by the machining. Also note that the inner portion of the indexing plate is removed during the final machining. The crown assemblies are then ready to be assembled to the body along with the other tube parts for the final braze.

Depressed Collector Program

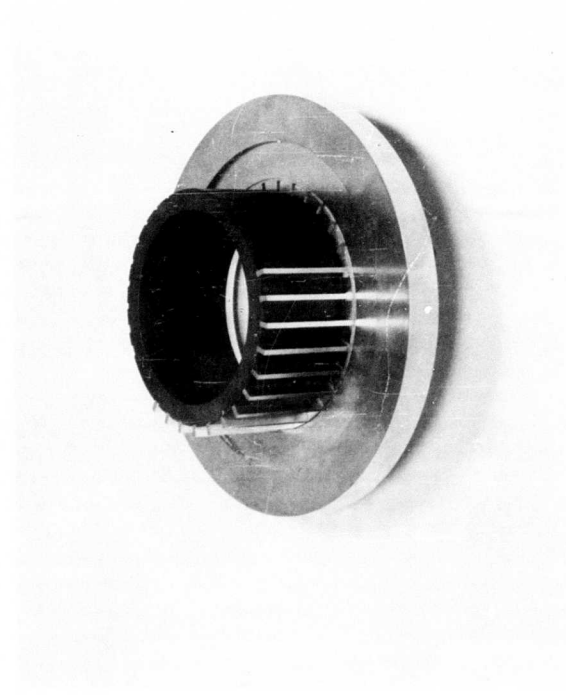
Prior to the initiation of work on this contract, depressed collectors were designed and reduced to practice. Several experimental depressed collector MBWO's were built and tested. Although the additional collector electrode is insulated from other electrodes, this does not complicate the power supply equipment nor change the tube socket because the additional collector electrode is connected internally to the cathode. Feasibility has been established with these experimental tubes. Considerable improvement



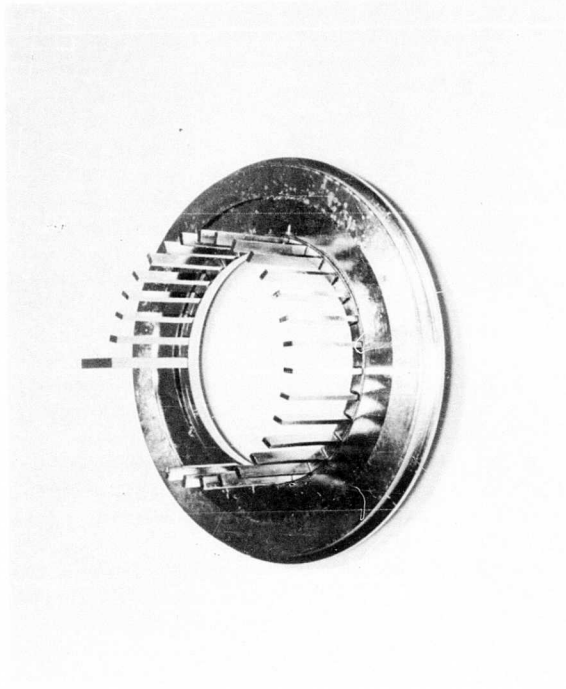
11 a



11 b



11 c



11 d

BAND #1 CROWN CONSTRUCTION

of efficiency resulted from the use of this technique, and hence much less drain of power per tube in the aircraft will result. In order that these collectors can be incorporated in production tubes, reliability, reproducibility, and design parameters must be further evaluated by building several tubes for life test. Furthermore, these life tests must be used to determine the effect of these collectors on the output signal quality. Electrolytic tank studies have been initiated during the quarter which will help to determine the optimum electrodes geometry for the best collection of the spent electron beam. Several of the electron trajectory plots have already pointed out weaknesses in our preliminary collector design.

Life Test Modulators for Phase II of Contract

The first life test modulator has been delivered from the Litton equipment group and is ready for use. It is expected that three additional units will be checked out and ready for use by the first week in December. The associated equipment for the life test modulators such as tube racks, continuously variable phase mismatches and waveguide loads have been ordered and should be on schedule.

Program Next Quarter

Work for next quarter will be directed towards making final adjustments to meet thermal drift and transient drift requirements on Bands 1, 6 and 8 tubes.

Sample tubes of each band will be prepared for life testing under Phase II requirements. Detailed hot test data will be collected for these tubes and com-

pared with specification values.

It is expected that unless unforeseen difficulties are encountered the schedule for initiation of Phase II testing of Bands 1, 6 and 8 tubes will be met.

Work will be resumed on Bands 5 and 7 tubes. This will include incorporating the successful design improvements evaluated during the first quarter on the other bands and new designs to see if they conform to the specification. The first models of the Bands 5 and 7 should be completed and ready for testing during December.

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1961 (Proj.7-652)(AMC TR 61-7-652-I)
Contract AF33(600)43396

Unclassified Report
A family of electronically tuned, broad
band oscillator tubes has been develop-
ed that are physically and electrical-
ly similar from band to band. These
tubes are being production engineered
and productized for system application.

UNCLASSIFIED

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2. Electron Optics
3. Materials Processing

- I James E. Orr
- II Litton Electron Tube Corp.
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