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Fourth Bimonthly Report on the Miniature IF Amplifier Program

Period: 1-Jan-'60 to 1-Mar-'60

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Table of Contents

I Purpose

See Bimonthly Report No. 1.

II Abstract

Measurements have been made to determine the behavior of the ceramic transformers as a function of load capacitance and temperature. Curves are included in this report which show the variation of center frequency and bandwidth of the individual transformers as well as the variation of power gain of the complete amplifier over the temperature range from -40°C to +40°C.

The schematic diagram of the high IF (2.281 mc) amplifier is shown with the associated crystal oscillator and mixer stages. Results are included showing overall power gain, impedance levels, etc.

In preparation for the arrival of the crystal filter for the second IF amplifier, design work has been started on the transistor circuitry required for this unit. A brief description is given in this report of the work carried out so far on this portion of the program. Results are given of the various measurements which have been made to determine the characteristics of the ferrite material to be used for interstage coupling transformers. Curves are also shown indicating the impedance measurements made on the 2N274 drift transistor.

III Factual Data

1. Ceramic Resonator Program

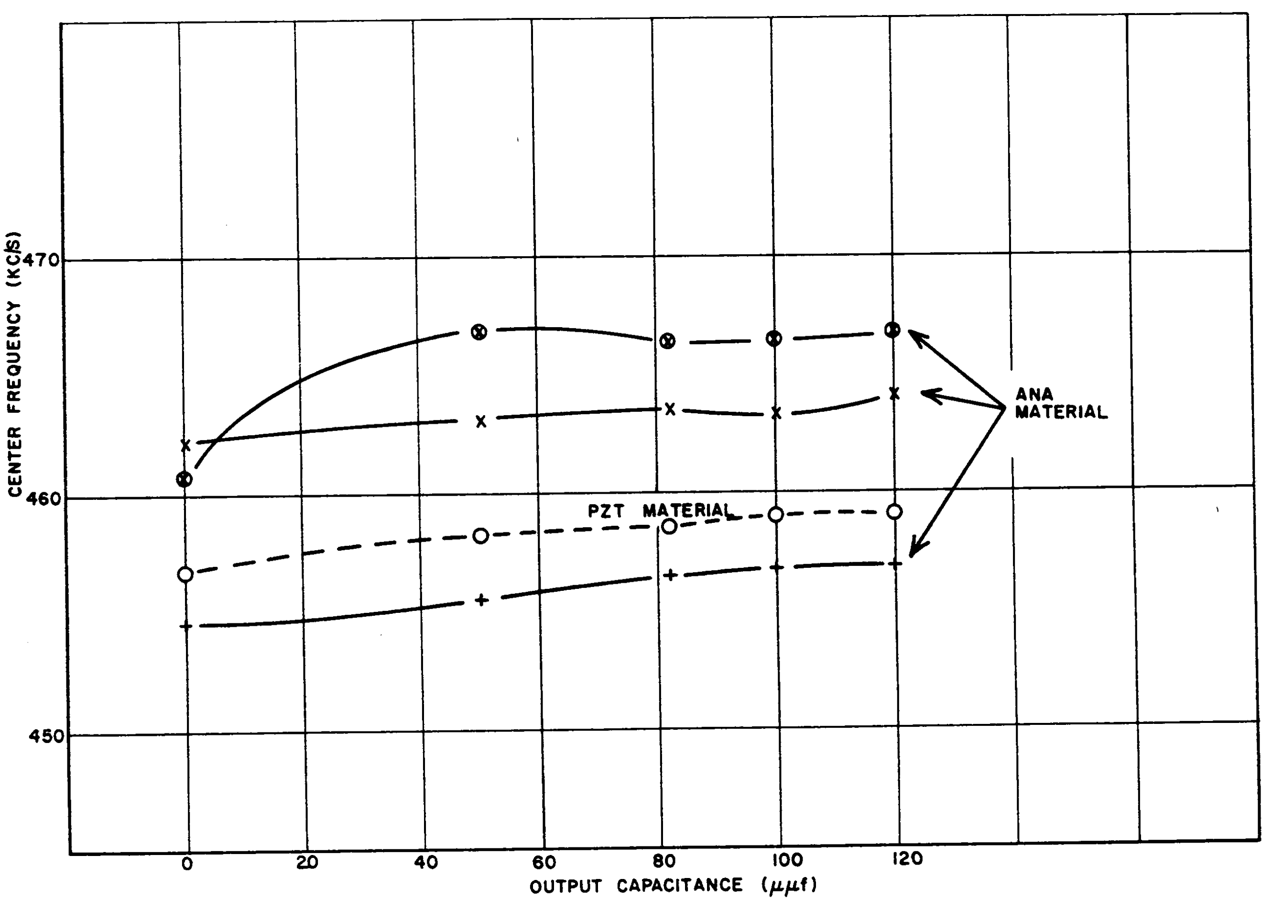
Complete environmental testing of representative samples of PZT and ANA type ceramic resonators has been completed.

Individual resonators have been tested in the test circuit shown in Figure 1 of the Second Bimonthly Report for center frequency variation versus load capacitance (Figure 1), bandwidth versus load capacitance (Figure 2) and center frequency and bandwidth versus temperature (Figures 3 and 4).

The latest ceramic resonators made of the ANA material have the required bandwidth of approximately 20 kc per individual resonator in order to insure the overall amplifier response will be in the neighborhood of 5 kc.

The schematic diagram of a three stage 455 kc amplifier is shown in Figure 5. The circuit is essentially the same as Figure 6 of the Third Bimonthly Report except for better power supply decoupling and slightly increased bias on the last stage to prevent overloading.

The variation of power gain over the temperature range of -40°C to +40°C is shown in Figure 6 to be -3 db, +2 db from the room temperature value of 77 db. The shift in center frequency is approximately +2.5 kc at -40°C and +1.5 kc at +40°C (Figure 7). The change in bandwidth from the room temperature value of 9.2 kc is +1.0 kc, -3.0 kc over the temperature range of -40°C to +40°C. The shape of the response curve of the three stage amplifier at various temperatures is shown in Figure 8. It should be noted



CENTER FREQUENCY OF CERAMIC RESONATORS VS. OUTPUT CAPACITANCE

FIGURE 1

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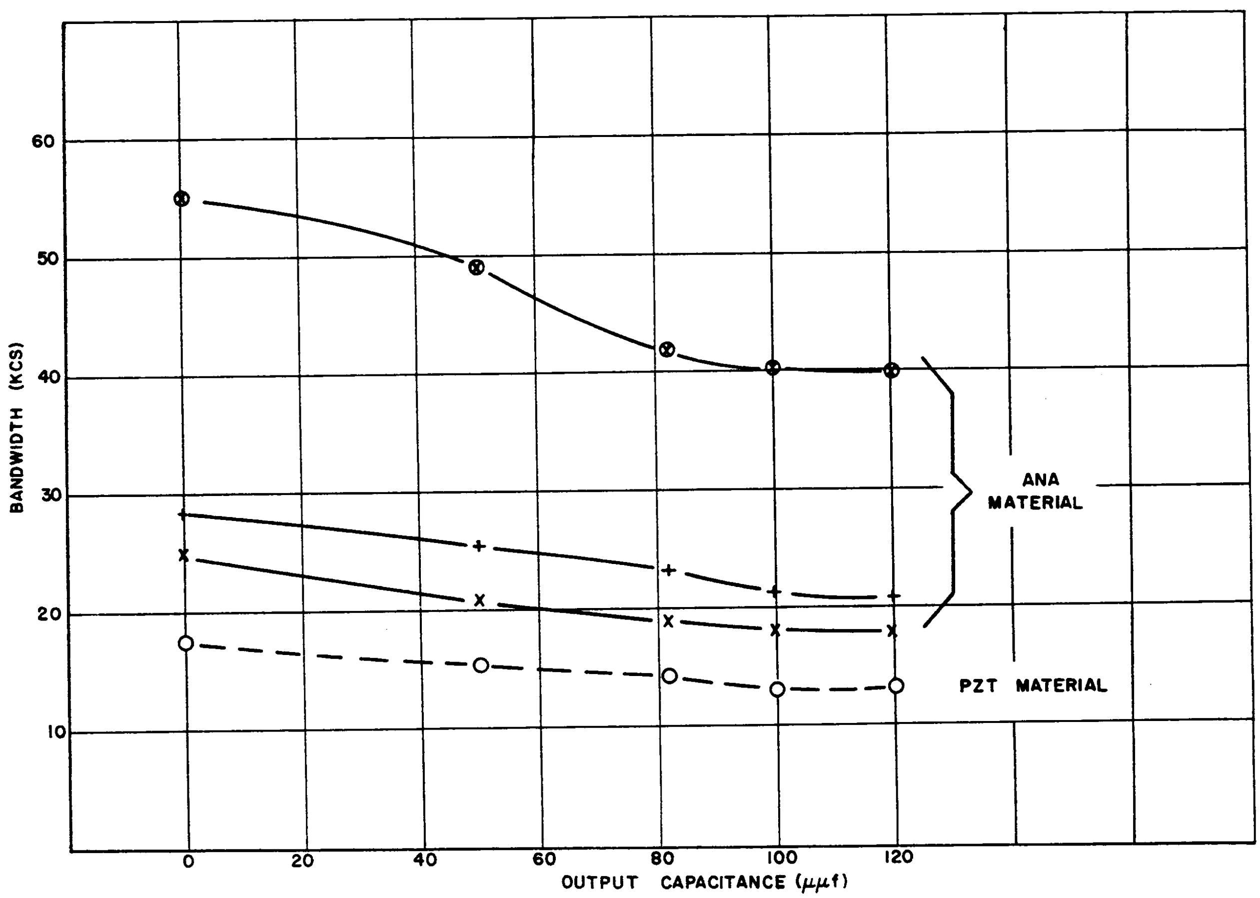
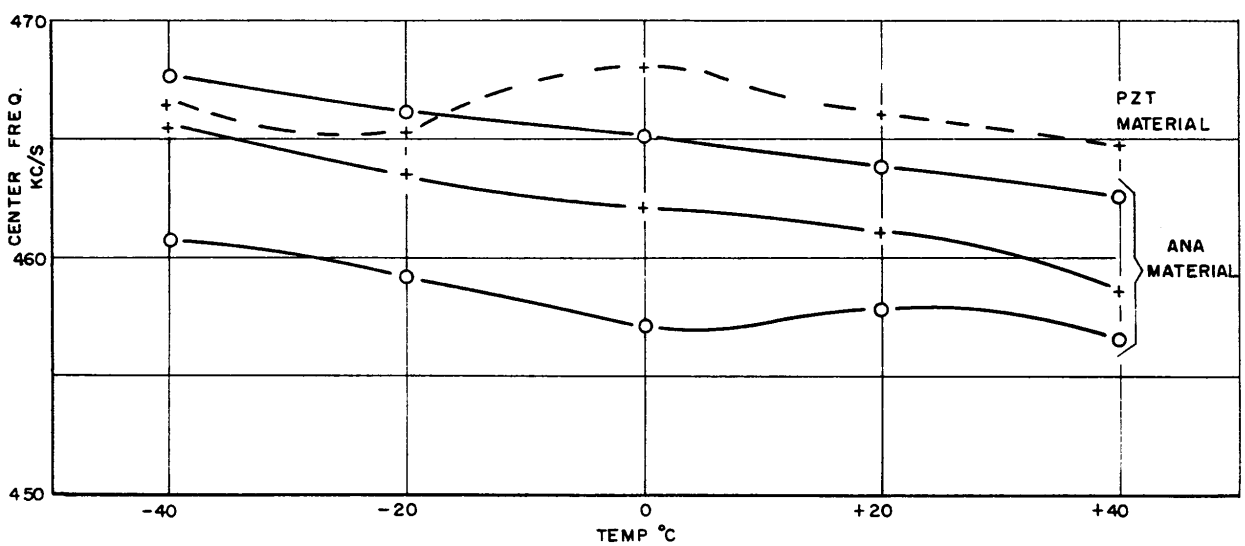


BANDWIDTH OF CERAMIC RESONATORS VS. OUTPUT CAPACITANCE

FIGURE 2



CENTER FREQUENCY VS. TEMP. OF CERAMIC RESONATORS

FIGURE 3

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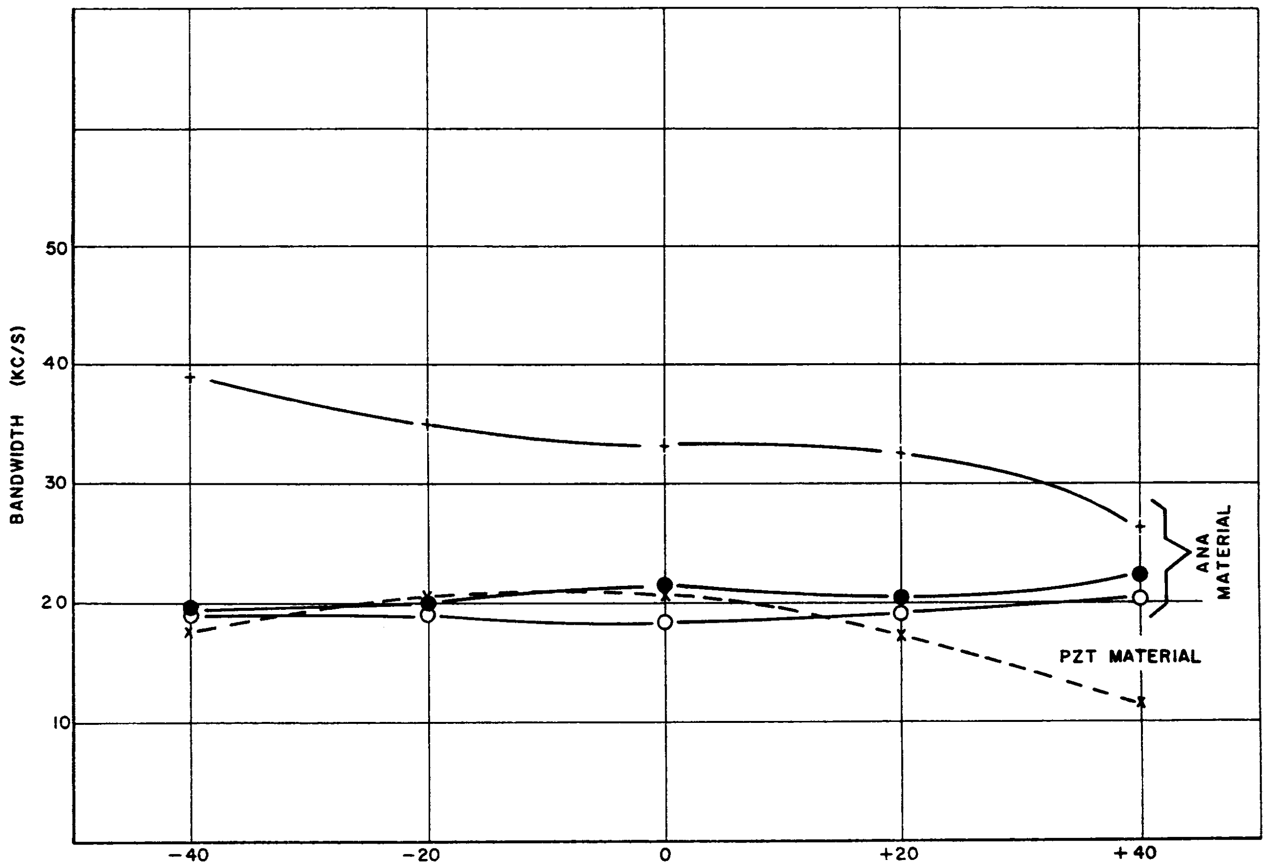
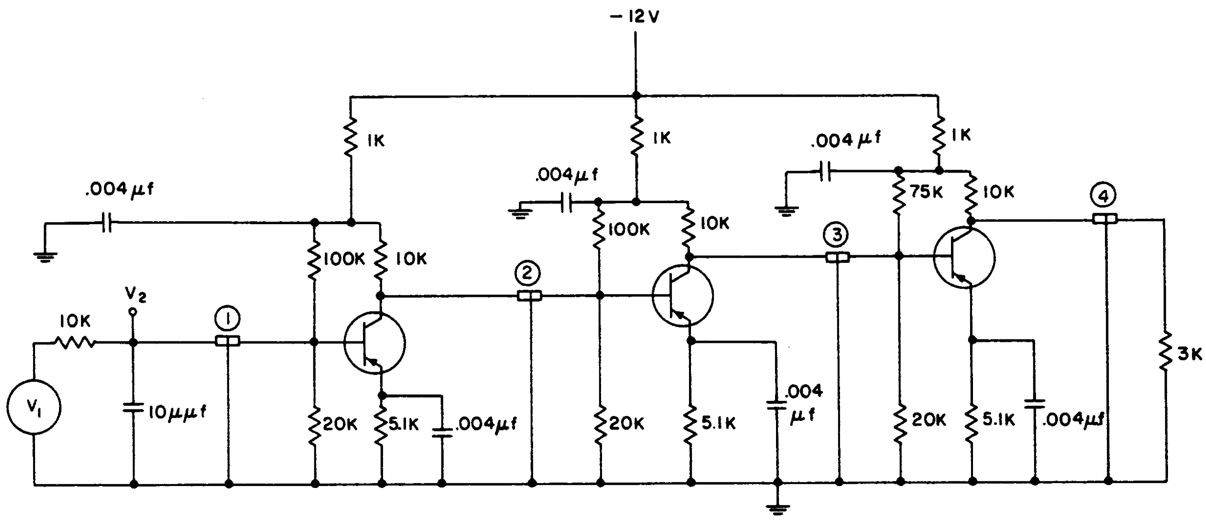


BANDWIDTH VS. TEMPERATURE OF CERAMIC RESONATORS

FIGURE 4



ALL TRANSISTORS 2N274
TRANSFORMER # 1 - PZT # 2
TRANSFORMER # 2 - ANA # 3
TRANSFORMER # 3 - ANA # 7
TRANSFORMER # 4 - ANA # 6

SCHEMATIC OF THREE STAGE 455 KC AMPLIFIER

FIGURE 5

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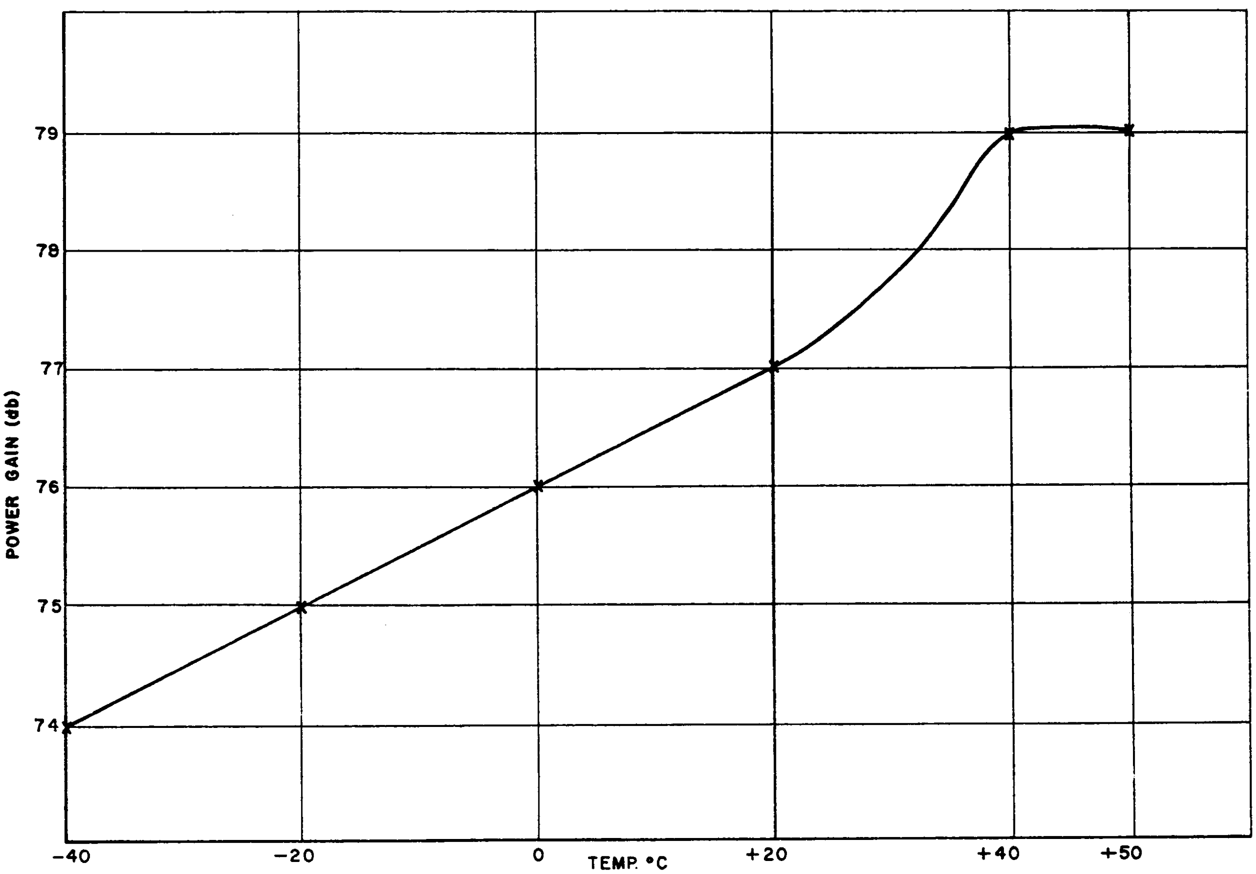

POWER GAIN VS. TEMPERATURE OF A 3 STAGE AMPLIFIER

FIGURE 6

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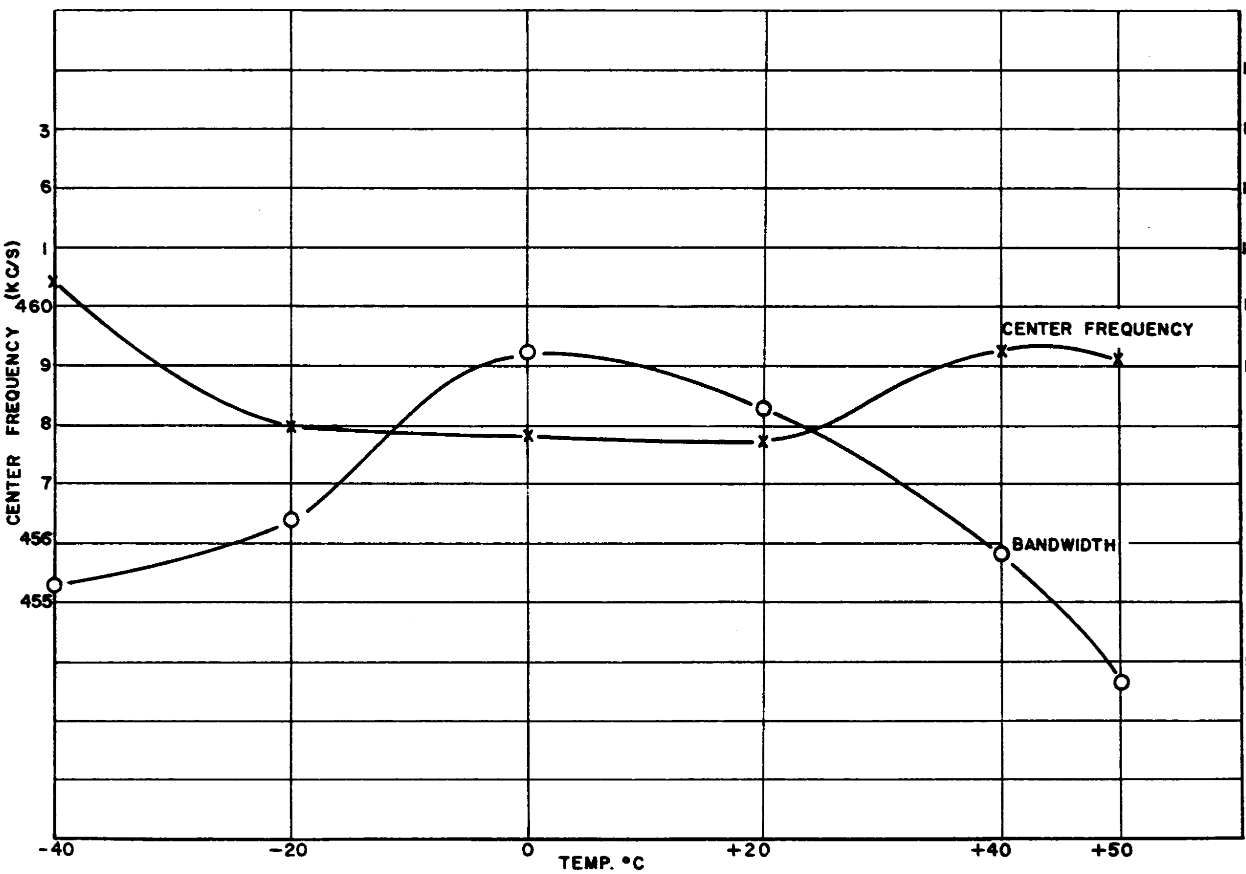

BANDWIDTH AND CENTER FREQUENCY OF A 3 STAGE AMPLIFIER VS. TEMPERATURE
FIGURE 7

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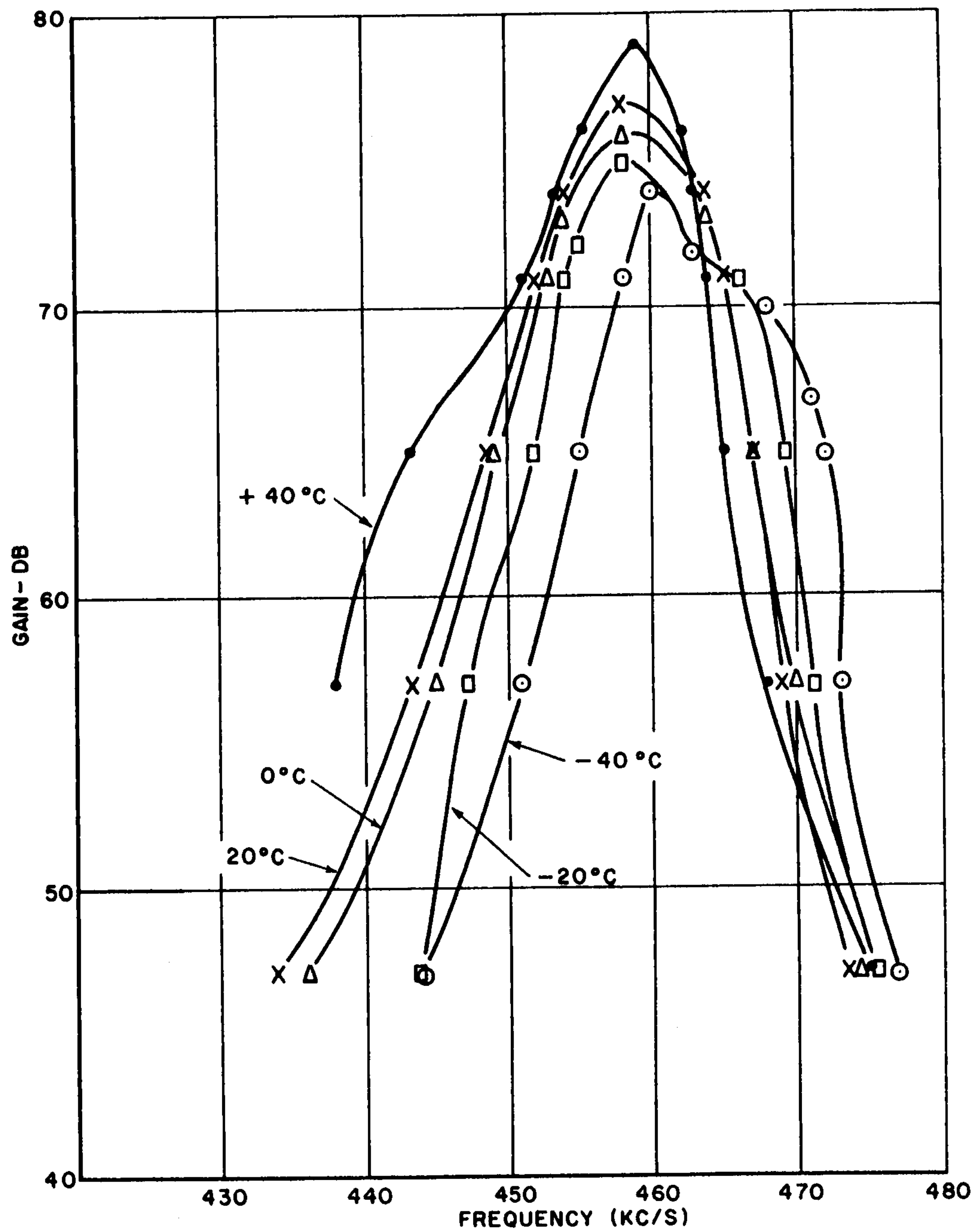


GAIN VS FREQUENCY OF A 3 STAGE AMPLIFIER

FIGURE 8

that there is a tendency for the response to show a double peak on the low side at the higher temperatures and on the high side of resonance at the lower temperatures.

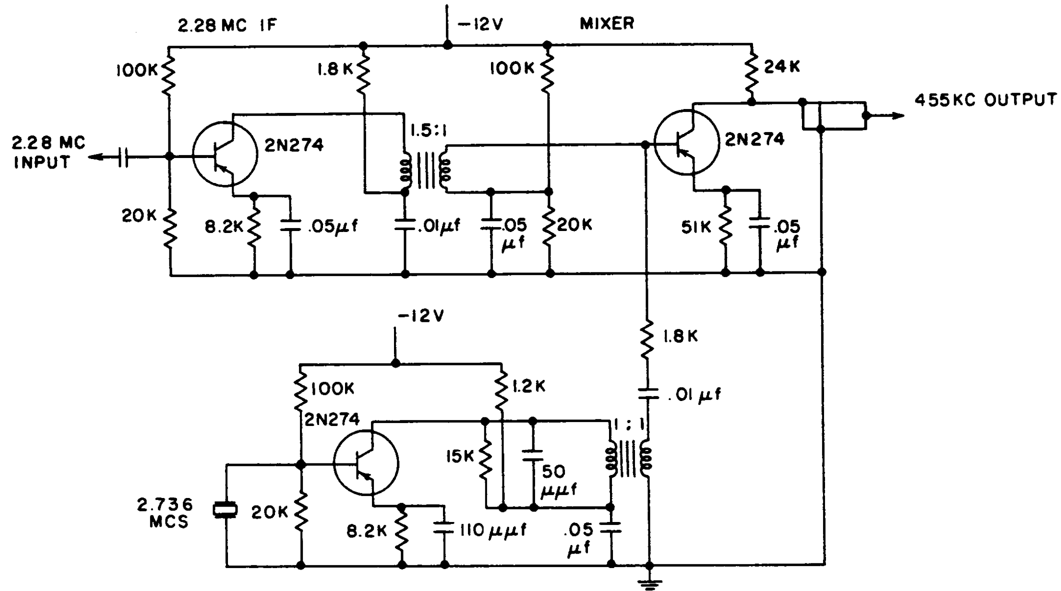
The schematic diagram of the 2.281 mc IF amplifier, the 2.736 mc crystal oscillator and the mixer stage is shown in Figure 9. A lumped element LC filter will precede the 2.281 mc amplifier stage. This is inserted in order to provide adequate image frequency rejection in a double conversion system.

The two interstage transformers feeding the base of the mixer are wound on ferrite, toroidal cores of .25 inch OD of CQ-64 material. The optimum oscillator voltage of 70 mv is injected in parallel with the signal input to the mixer stage. The output of the mixer is fed directly to the first ceramic resonator in the three stage 455 kc amplifier.

The overall power gain of the complete amplifier is 111 db without the 2.281 mc input filter. It is expected that the insertion loss of this filter will be about 6 db so the required gain figure of 100 db can be obtained. The input impedance of the 2.281 mc amplifier is 6.8 K ohms.

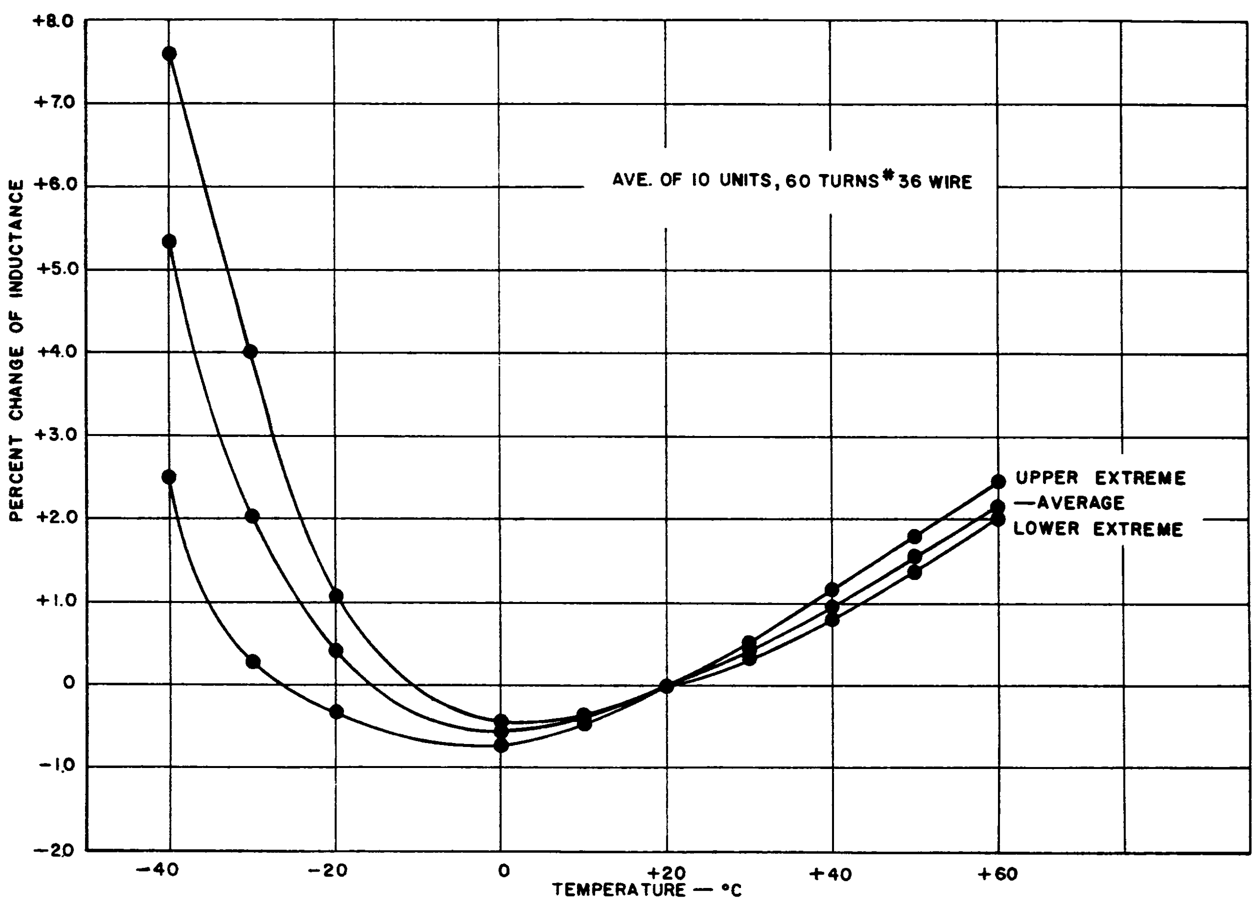
2. Crystal Filter Amplifier

Preliminary design work for the 2.281 mc crystal filter amplifier is now being completed. A satisfactory ferrite core material (CQ-64) has been found (see Figure 10). Since the bandpass of the amplifier is to be entirely determined by the narrow band 2.281 mc crystal filter, each amplifier stage may be designed to be wideband so that any shift in center frequency due to the ferrite core interstage transformers can be tolerated.



HIGH FREQUENCY AMPLIFIER AND MIXER

FIGURE 9



INDUCTANCE STABILITY OF CQ-64 CORES AT 2.28 MCS.

FIGURE 10

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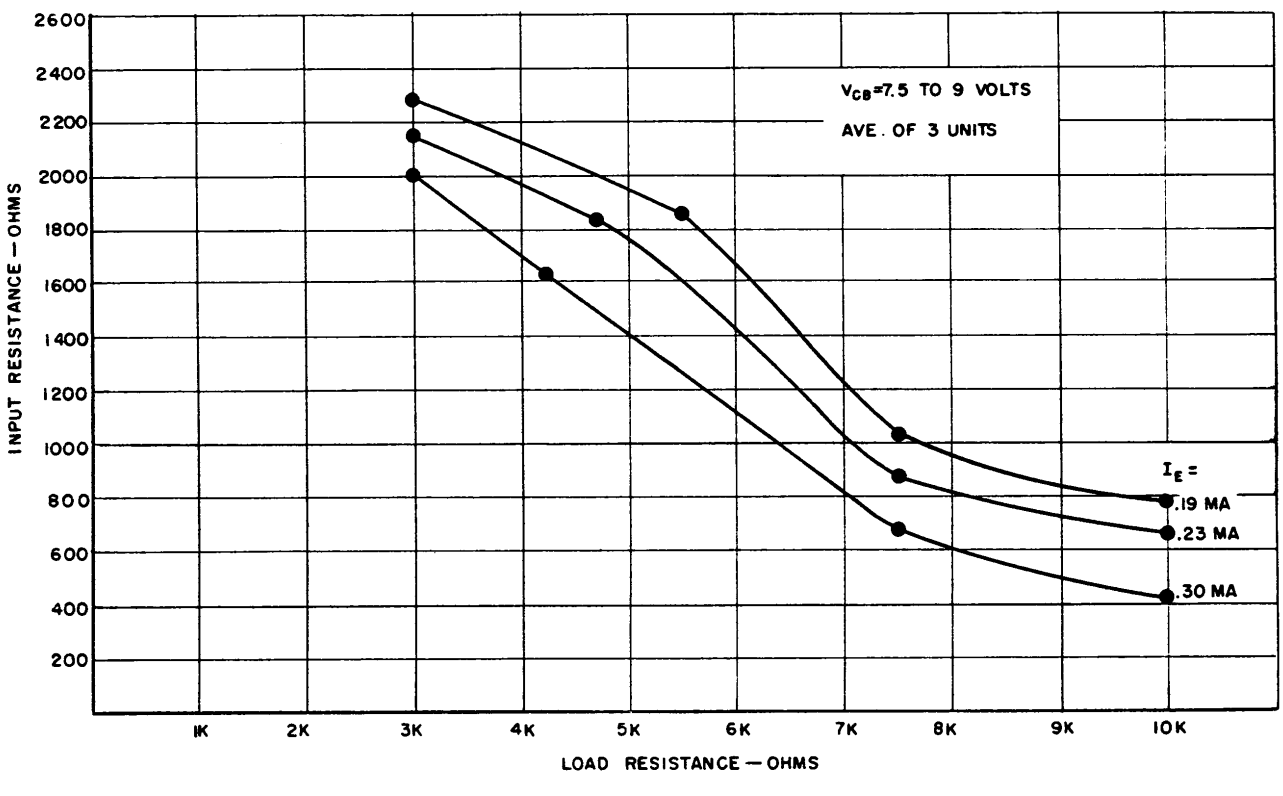
Four amplifier stages will be required to provide 100 db overall gain. A restriction on the gain per stage arises from the necessity of conserving battery power. Curves of input and output resistance and capacitance are shown in Figures 11 - 14 for the 2N274 drift transistor. The individual interstage transformers will be designed for optimum match on the basis of the material presented in these graphs.

A breadboard design will be available for preliminary testing in the next report period.

IV Conclusions

The electrical design of the ceramic transformer amplifier is essentially complete. Some difficulty is being encountered due to feed through of the 2.736 mc oscillator frequency which appears at the output of the 455 kc section. While this phenomenon does not directly effect the performance of the amplifier, efforts are being made to reduce the amplitude of this frequency component at the output due to its undesirable effects on any AGC detector that might ultimately be used in conjunction with an amplifier of this type. In other respects the behavior of the amplifier appears to be quite satisfactory.

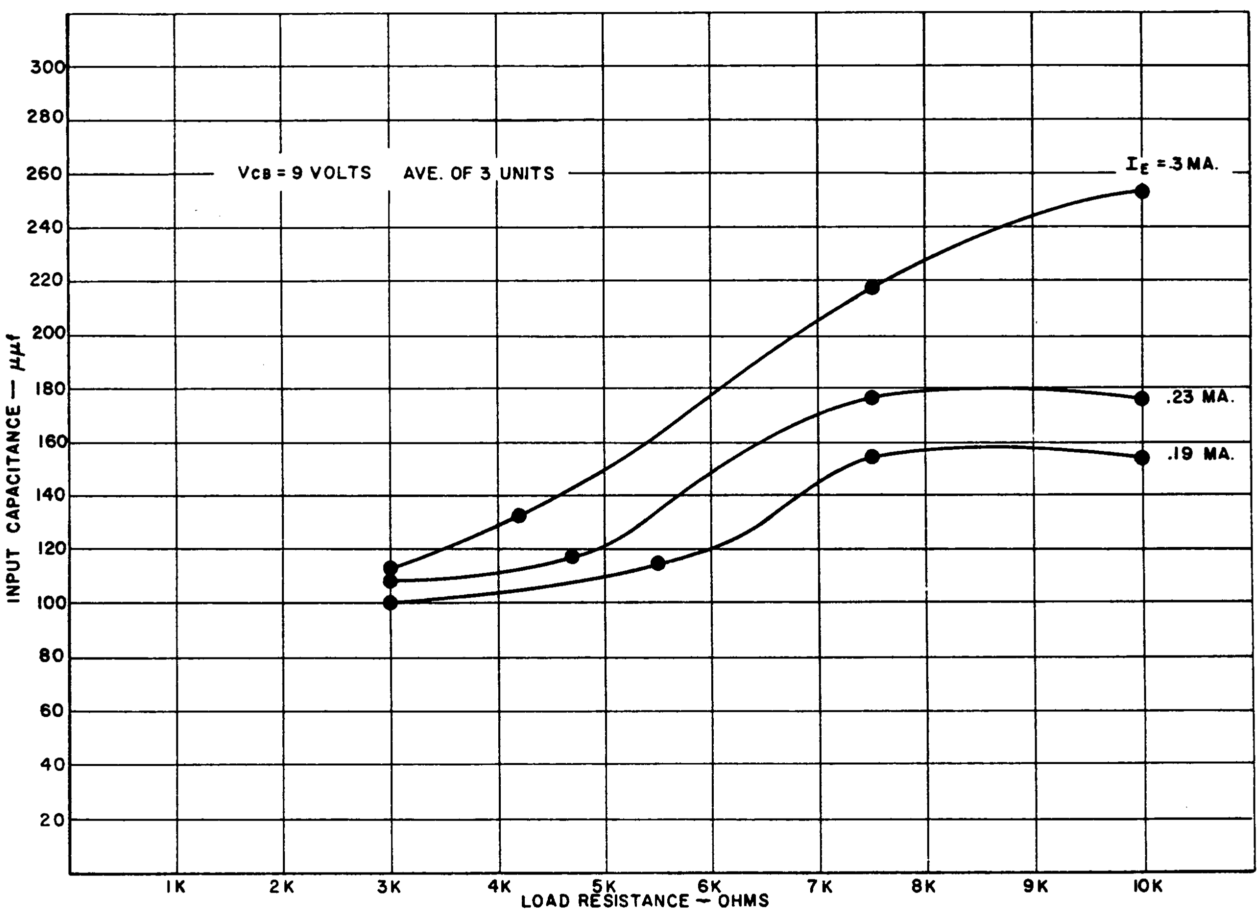
The start to be made on the design of the circuitry for the crystal filter amplifier was delayed due to difficulty experienced in packaging the filter in a very small volume, without adversely altering the electrical characteristics due to the proximity of the metal case. However during the past report period circuit design work for this amplifier was iniated and a suitable ferrite material found for the interstage coupling transformer.



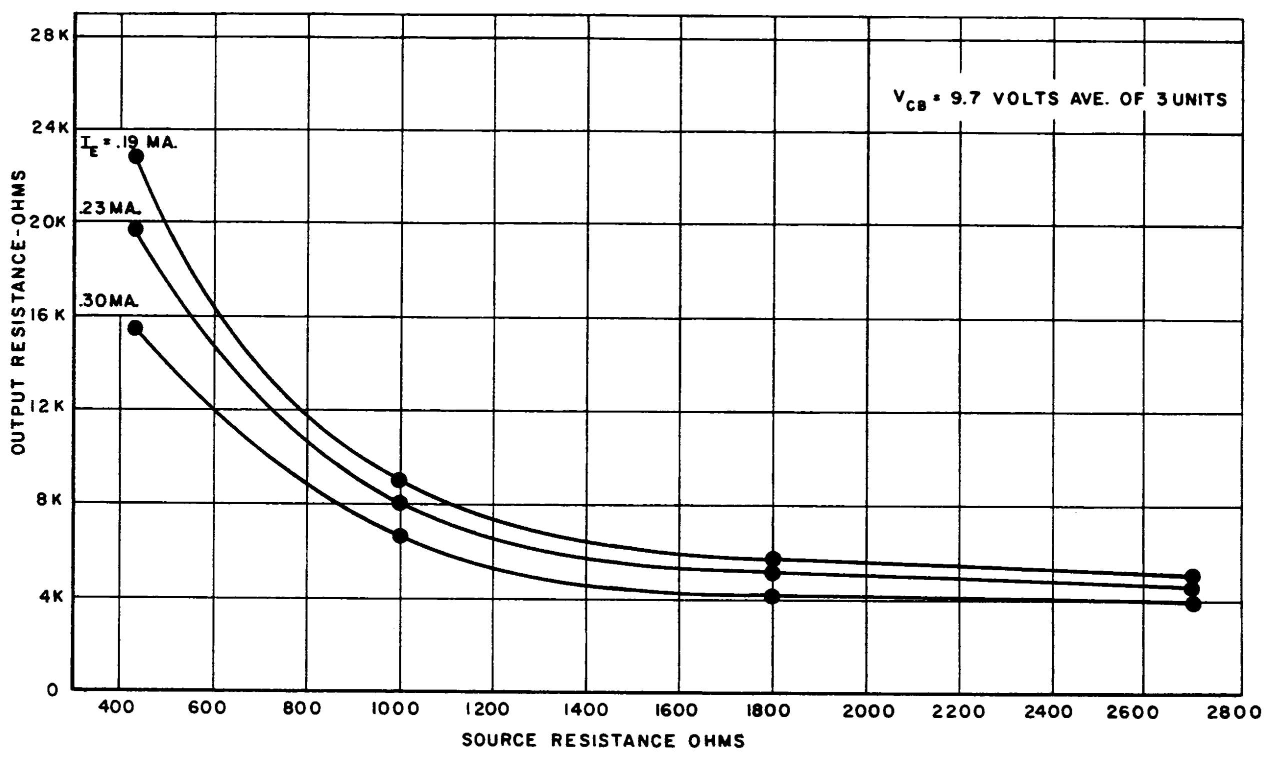
INPUT RESISTANCE OF 2N27V4

VS. LOAD RESISTANCE AT 2.28 MCS.

FIGURE 11



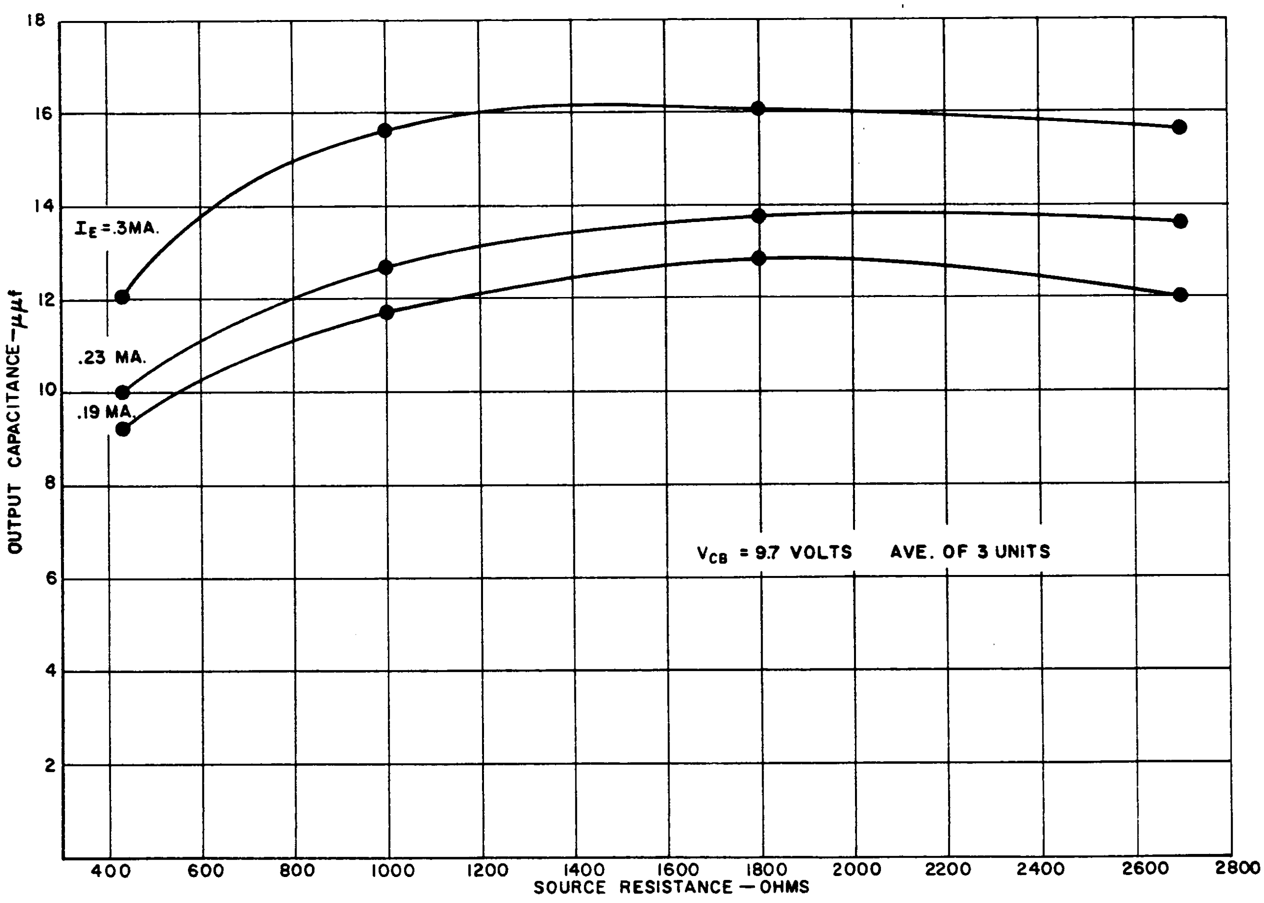
INPUT CAPACITANCE OF 2N274 VS. LOAD RESISTANCE AT 2.28 MCS.
FIGURE 12



OUTPUT RESISTANCE OF 2N274

VS. SOURCE RESISTANCE AT 2.28 MCS.

FIGURE 13



OUTPUT CAPACITANCE OF 2N274 VS. SOURCE RESISTANCE AT 2.28 MCS.

FIGURE 14

V Future Plans

The local oscillator signal is presently not being attenuated adequately in the ceramic resonator interstage coupling and is appearing at the output of the amplifier. The oscillator signal is amplified by each transistor along with the 455 kc signal. Several approaches are being and will be investigated to reduce the oscillator signal level at the output.

It is felt that further testing of the amplifier should await the final packaging of the three stage 455 kc amplifier section. It is intended to package each stage in an individual shielded block in such a fashion as to allow the section to be removed after final assembly for testing and evaluation.

Future work on the crystal filter program will be concerned with completing the electrical design and packaging the complete amplifier.

VI Identification of Key Technical Personnel

See previous reports.