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PRODUCTION ENGINEERING MEASURE
Cont.#DA-36-039-SC-86737 CR-(XM-46)/U
FIRST QUARTERLY REPORT
June 10, 1962 - October 31, 1962
U.S. Army Electronics Materiel Agency
Phila., Penna.

E.B. Lewis Co., Incorporated
East Hartford, Conn.

PRODUCTION ENGINEERING MEASURES
Crystal Unit CR-(XM-46)/U

FIRST QUARTERLY REPORT
June 1962 to October 1962

Production Engineering Measure (PEM)
in accordance with Step I of Signal Corps
Industrial Preparedness Procurement
Requirement. (SCIPPR) No. 15, dated 1,
October 1958 for Overtone Filter Crystal
Units, 30 - 60 MC's, CR-(XM-46)/U Per
Specification SCS-135 dated 20, February
1962.

Contract #DA-36-039-SC-86737

Order #19059-PP-62-81-81

E.B. Lewis Co., Incorporated
East Hartford, Conn.

Prepared by

Approved by

Approved by

Robert P. McComb
Robert P. McComb

Ernest B. Lewis
Ernest B. Lewis

Charles G. Robb
Charles G. Robb

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FIRST QUARTERLY REPORT

Contract #36-039-SC-86737
Order #19059-PP-62-81-81

OR-(XM-46)/U

Purpose:

The purpose of this study is to design and carry out the production engineering necessary for the manufacture of quartz crystals for filter applications operating on the third overtone in the frequency range of 30 to 60 MC/s in accordance with Signal Corps Specification SCS-135 dated 20 February 1962.

It is also the purpose of this program to carry out Step I of the Production Engineering Measures as specified in Signal Corps Industrial Preparedness Procurement Requirements #15 dated 1 October 1958.

ABSTRACT

Design data for AT Cut Quartz Crystals for filter applications operating on the third overtone at 30 MC/s is presented.

An evaluation of forty-four crystal units with two electrode sizes and two mounting positions is given.

A comparison of the electrical parameters between the crystals fabrication and the ultimate design goal is also given.

NARRATIVE

It was originally decided that the first units would be made on the frequencies of 30, 45, 60 MC/s respectively. However, after a discussion with Mr. Ed Mason and Mr. Ermon Jones on 2 October 1962, it was decided to fabricate all of the initial units at the 30 MC/s frequency.

The crystals were to be essentially the same design as those used by Hermes Electronics on Contract #DA-36-039-SC-78242 as described in the Third Quarterly Report.

The masks were made up to give electrode areas of .046 inches and .064 inches respectively. All work was to be done using our standard production methods and techniques. Fig. 12 is a copy of the work order issued to our shop for 44 crystals.

The crystals were catalogued in such a way that they could be readily identified as to frequency, electrode diameter and orientation of the blank in the holder. The designations are as follows:

- SC-1330, .064" electrode diameter mounted with the springs on Z, Z' axis
- SC-1430, .064" electrode diameter mounted with the springs on X, X'
- SC-1130, .046" electrode diameter mounted with the springs on Z, Z'
- SC-1230, .046" electrode diameter mounted with the springs on X, X'

All blanks were semi-polished in a VanConey Lapp. They were flat to one light fringe when examined under a monochromatic light with an optical flat. The surface finish was 3 micro-inches measured with a Brush Surfindicator Model BL-110.

The crystals were then examined under a 15X microscope, some scratches were observed. It was also noted at this point that the outer edge of the crystals seemed to have a lesser degree of polish than the center, which would tend to make one believe that the crystals were slightly convex.

The crystals were base plated at a pressure of at least 5×10^{-5} MM of Mercury or better. They received a flash coat of aluminum followed by an evaporated coat of fine silver, sufficient to bring them within +90 KC/s of the finished frequency. At this point we encountered some difficulty in making the plating adhere to the blanks with sufficient tenacity, it being common knowledge that aluminum electrodes are quite necessary when plating polished crystals.

We felt it advisable to use a combination of aluminum and silver rather than go to an all aluminum electrode, the reason for this being that it would entail introducing new techniques of finishing which are different from that with which we are familiar, since much of our experience has been with unpolished crystals and silver electrodes. We further believe that by using the silver aluminum combination that we will be able to take advantage of certain techniques which will allow us to increase the electrode area without causing deleterious effects on the mode configuration and will at the same time allow us to more fully realize the other parameters of the crystal.

of the 200 lots of crystals processed only the SC-1430 units were found to meet the requirements of the specification. This was due to the overall objectives of the program.

The SC-1430 units while not meeting the requirements of the specification were worth a comparison as to what should be expected of this particular design and what we actually achieved.

The design of the SC-1430 is shown in Figure 13.

The mean value of the parameters for the SC-1430 design are compared with the parameters as taken from the SCS-135 Specification.

<u>SC-1430</u>		<u>SCS-135</u>	
Fo	= 30 MC/s	Fo	= 30 MC/s
Co	= .989 pf	Co	= 1.5 pf
R	= 250 ohms	R	= 100 ohms
df	= 95 cps	df	= 200 cps
C ₁	= 1.33×10^{-4}	C ₁	= 3×10^{-4} pf
r	= 7439	r	= 5000
Q	= 200×10^3	Q	= 200×10^3
L	= .250 henry	L	= .100 henry

The examination of these parameters will show that at 30 MC/s a slightly larger diameter spot will be necessary to meet the requirements of C_1 , C_0 and df . The resistance should show great improvement with the increased electrode area and a finer finish on the crystal.

Unwanted Modes

The SC-1430 crystal units were all scanned for unwanted modes and X Y plots made for seven units.

Fig. 14 shows the arrangement of the test equipment used in the Mode Analysis. Fig. 1 and 2 are X Y plots on a 9.986 MC/s crystal operating on the 3rd overtone, and a 30.0 MC/s fundamental crystal respectively.

Figs. 3 and 4 show the results obtained when the SC-1430 crystals are scanned over the entire frequency range as required in the SCS-135 Specification. It is quite evident upon examination of these curves that some of the crystal responses could possibly go unobserved.

Figs. 5 through 11 are X Y plots of seven SC-1430 crystal units. In each case the Y axis was calibrated with the crystal shorted out.

There was considerable difficulty involved in plotting these curves since the signal generator must be swept manually and at an extremely slow rate so as not to miss any of the responses. quite often there would be a question as to the true amplitude of the responses.

It is felt at this time that the modes observed in the SC-1430 crystals were definitely below the 40 db requirement with respect to the short circuit reference condition.

Further work on the measuring technique with regard to the accuracy of the Mode level measurement is indicated.

CONCLUSIONS

The first lot of crystals processed for this program were not of sufficient quality to meet the requirements of the SCS-135 Specification with respect to all of the parameters except the unwanted modes. It is quite evident that the basic problem was a combination of surface condition of the crystal and poor tenacity of the electrode plating, further it is believed that the selection of the electrode size was not sufficient to meet the capacitance ratio requirement of the SCS-135.

Due to the quality of the SC-1130, SC-1230 and SC-1330 which was not comparable to the SC-1430 units no accurate evaluation of the method of mounting the crystals could be made. However, in the future this will be investigated.

There was also a considerable amount of time spent during the interval covered by this report in setting up equipment to fabricate and test the crystal units.

We experienced several delays in obtaining equipment for the project.

It is felt that these delays should be considered as genuine Lead Time problems in considering future programs. We are presently about 30 days behind schedule.

PROGRAM FOR THE NEXT INTERVAL

Immediate plans call for the processing of approximately 50, .312 diameter blanks and 50, .250 diameter blanks.

A more rigorous investigation of the polishing technique and plating adherence problems will be undertaken if it is necessary to go to an all aluminum electrode we will.

The electrode area will be increased to allow us to meet the requirements of the SCS-135 Specification.

Any questions regarding the accuracy or technique of measuring the crystal parameters will be resolved during this period. Another conference with Dr. Bechmann is being planned for the near future.

CONFERENCES

On 13 September 1962 a conference was held at Fort Monmouth with Dr. Rudolph Bechmann, Mr. Frank Priebe and Mr. Heinz Wasshausen of the U.S. Army Electronics Research and Development Laboratory of Fort Monmouth.

The discussion covered the measurement of crystal parameters as specified in the SCS-135 Specification.

On 2 October 1962 a conference was held at E.B. Lewis Co., Inc. with Mr. Ed Mason of USAEMA and Mr. Ermon Jones of USASIMSA. The following points were discussed:

- a. The initial work and first engineering samples would be at the 30 MC/s frequency.
- b. The surface condition of the crystals will be analyzed with the Brush Surfindicator.
- c. Crystals will be processed in both .312 and .250 diameter.
- d. We will evaluate both silver and aluminum electrodes.
- e. An evaluation of need for a Teflon liner will be made.
- f. The 5 G at 5 crip vibration requirement will have to be evaluated in that the M B Electronic Co. Model C-11 vibration equipment as specified in the SCS-135 Specification will not specifically meet this requirement.

IDENTIFICATION OF TECHNICAL
PERSONNEL

ROBERT P. McCOMB

Mr. McComb's duties at E. B. Lewis Co. are primarily concerned with the design of Quartz Crystals for filter applications. Mr. McComb attended Public Schools in Springfield, Massachusetts.

He served in the United States Navy in World War II.

Mr. McComb graduated from the Ward School of Electronics Division of University of Hartford in 1952.

From 1952 to 1955 he was associated with Andersen Laboratories. Primary duties were the development of test equipment to measure the parameters of solid ultrasonic delay lines.

From 1955 to 1959 he was associated with Sturup, Inc. of Middletown, Connecticut. As an Engineering Assistant his duties included the design and development of complete multiple delay systems employing solid ultrasonic delay lines and the associated electronic circuitry.

From 1959 to 1960 he was associated with E. B. Lewis Co. His duties were in the design of prototype crystals.

From 1960 to 1962 Mr. McComb was associated with Hartford Hospital, Hartford, Connecticut where he was engaged in Medical Electronic and Bionic Instrumentation. During this time he was also a consultant to the E. B. Lewis Co., Inc.

ERNEST B. LEWIS

Mr. Lewis attended the Public School System of Meriden, Connecticut.

He is a graduate of Wesleyan University, Middletown, Connecticut. While at Wesleyan he majored in Physics studying under Dr. K.S. Van Dyke and Dr. Walter Gady.

Upon graduation Mr. Lewis entered the advertising field for a period of four years. Two years of which he operated his own agency.

In 1941 Mr. Lewis became associated with the Crystal Research Laboratories of Hartford, Connecticut in the capacity of General Production Manager.

In 1948 Mr. Lewis founded the E.B. Lewis Co. in East Hartford, Connecticut. In addition to operating the E. B. Lewis Co. he has acted in a consulting capacity to several crystal manufacturers and also to allied industries concerned with Piezoelectric Phenomena.

CHARLES G. ROBB

Mr. Robb is Chief Engineer at the E.B. Lewis Co., Inc.

He studied Civil Engineering at Pennsylvania State College and has had extensive experience in the Quartz Crystal field.

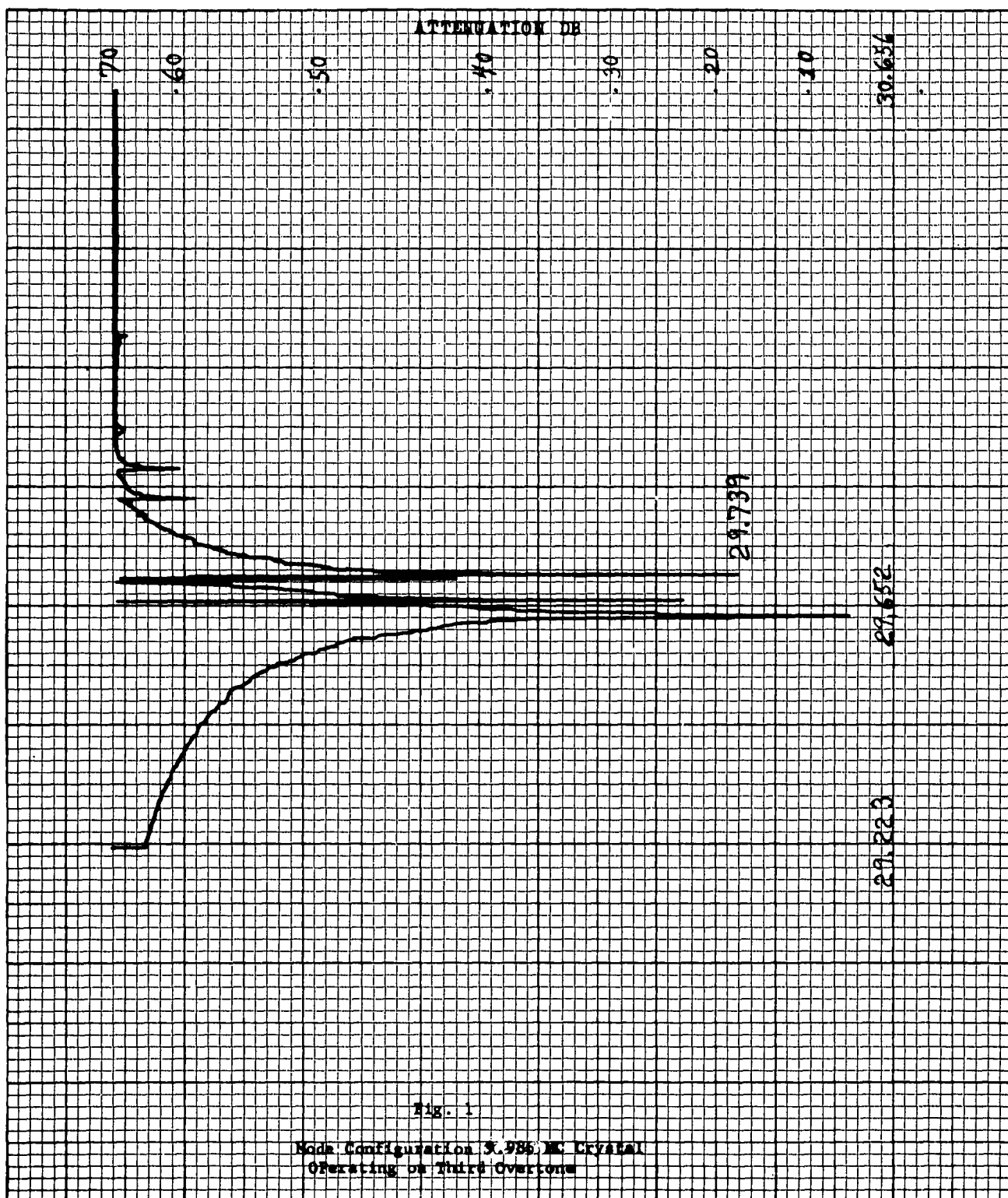
During his association with the E.B. Lewis Co., Inc. for the past five years he has in addition to his engineering duties served in both Management and Production Engineering capacities.

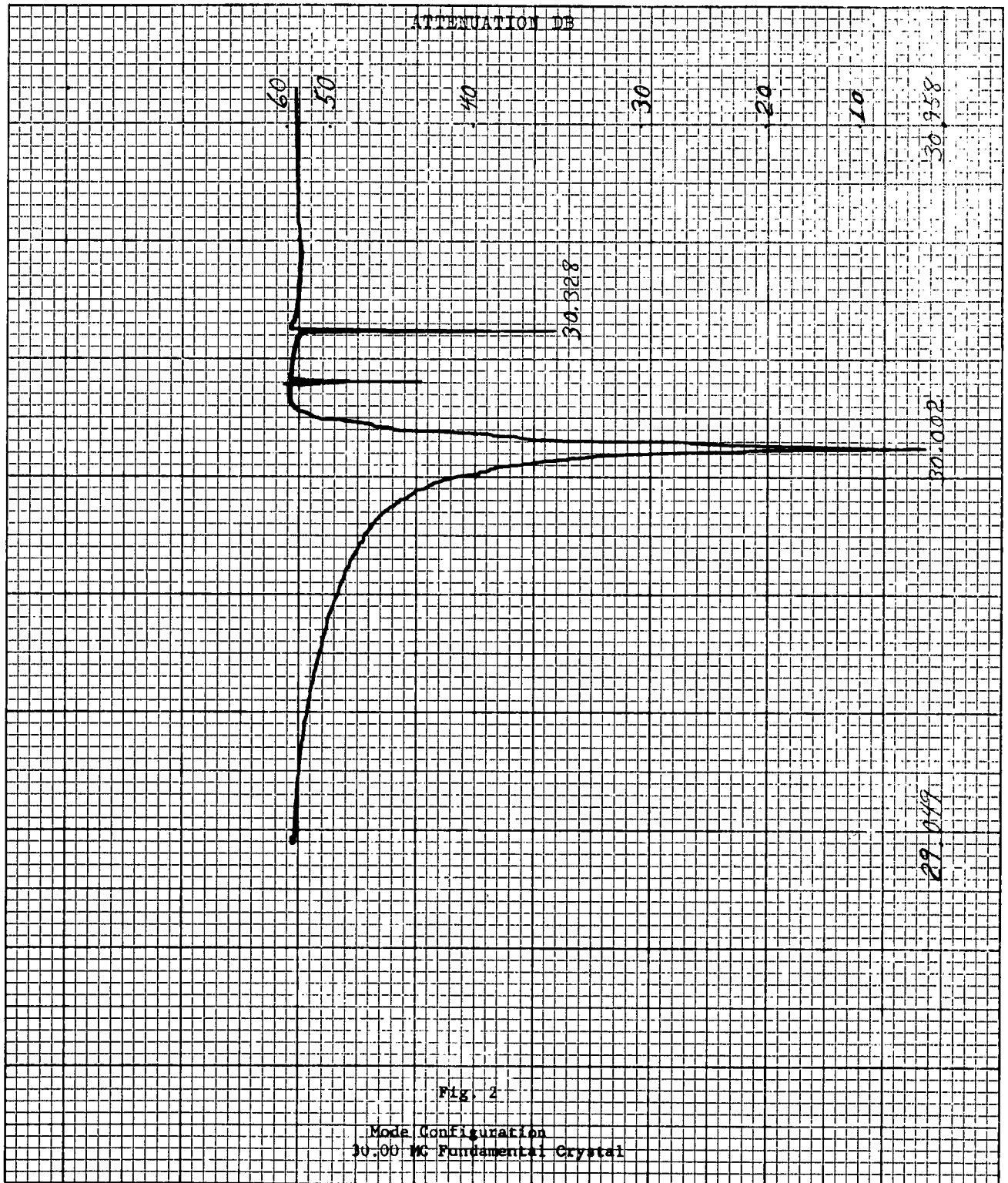
Prior to his association with E.B. Lewis Co., Mr. Robb was a Technical Director for General Scientific Equipment Co. where he was concerned with the instrumentation for laboratories in both industry and institutional organizations.

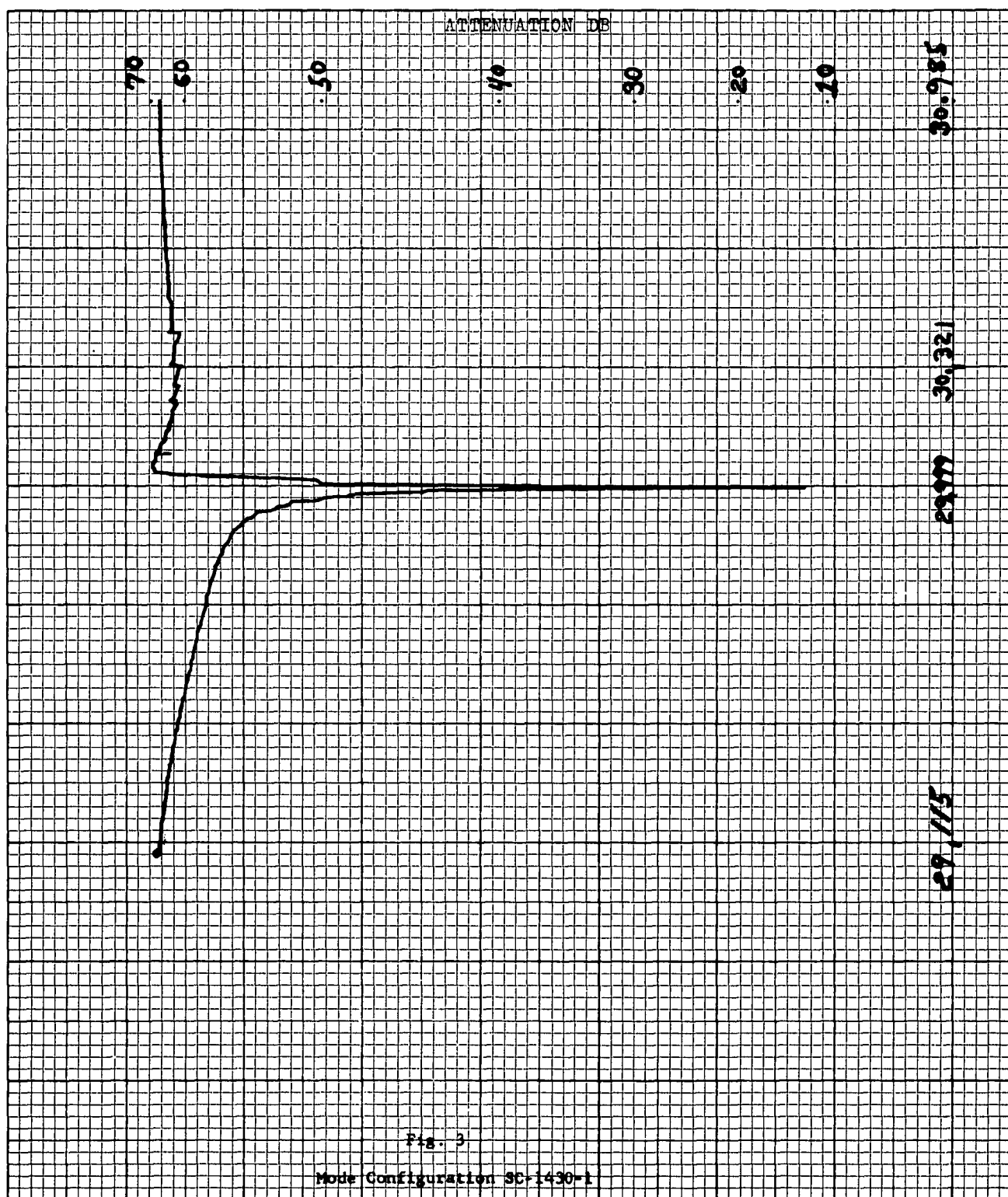
Before joining General Scientific Mr. Robb was on the Research and Engineering Staff of Crystal Research Laboratories, Hartford, Connecticut, where he did much work in the field of thin film deposition. He has several patents and patent applications relating to Quartz Crystals.

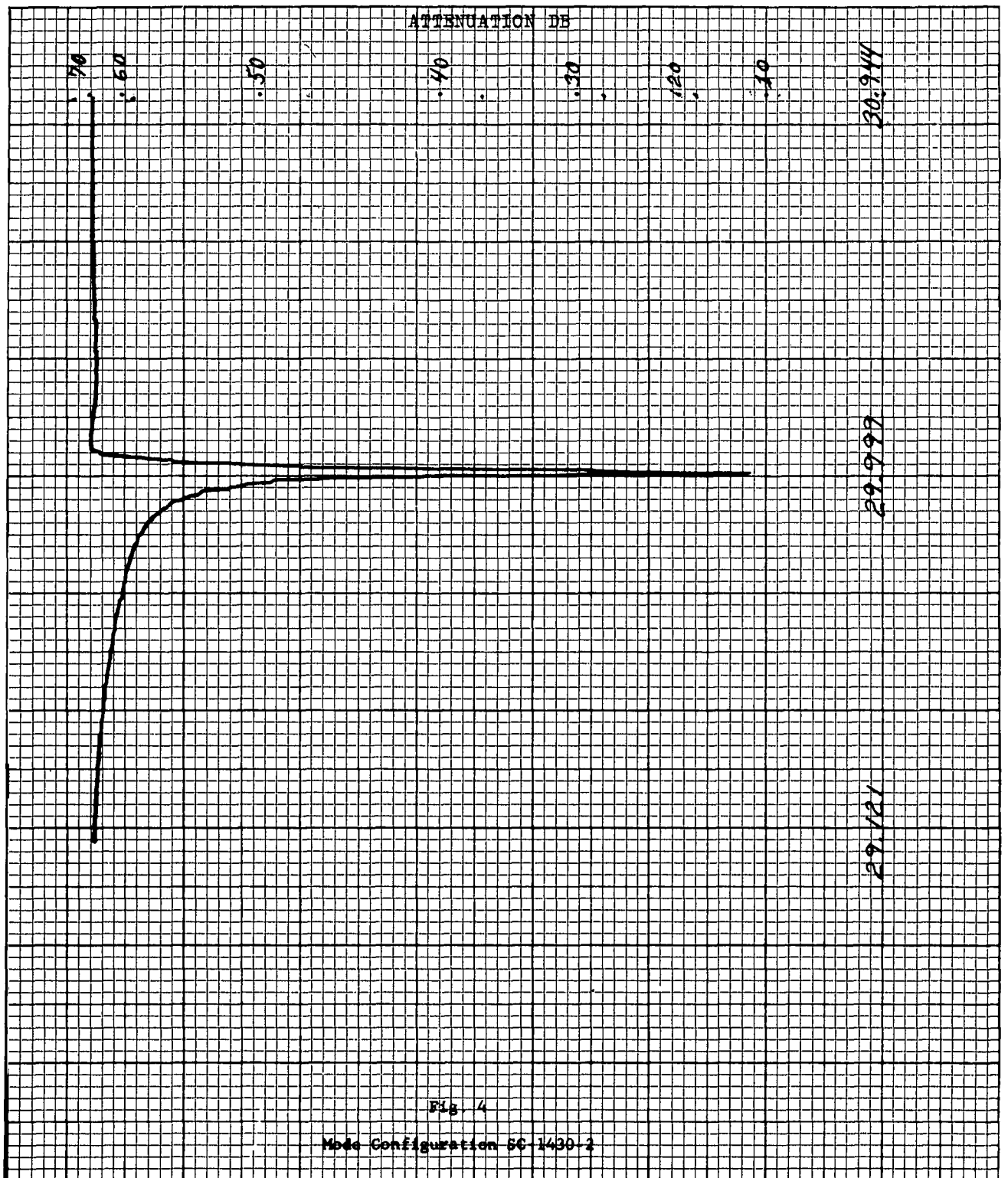
MAN HOURS

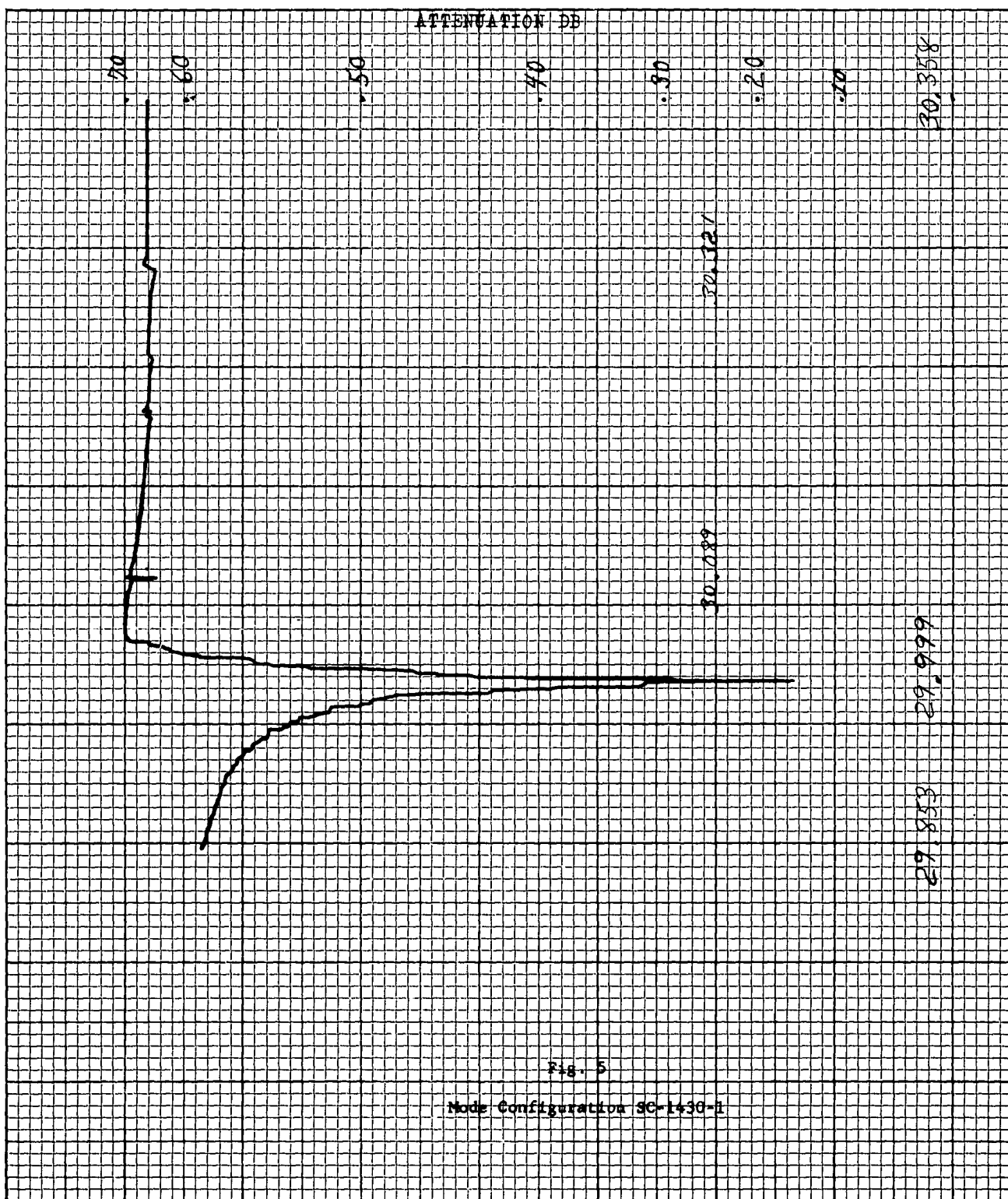
Ernest B. Lewis	40.0
Robert P. McComb	248.0
Charles G. Robb	12.5
Raymond Moore	56.0
Thaddeus P. Kubiak	2.0
Crystal Fabrication	<u>8.5</u>
TOTAL	367.0

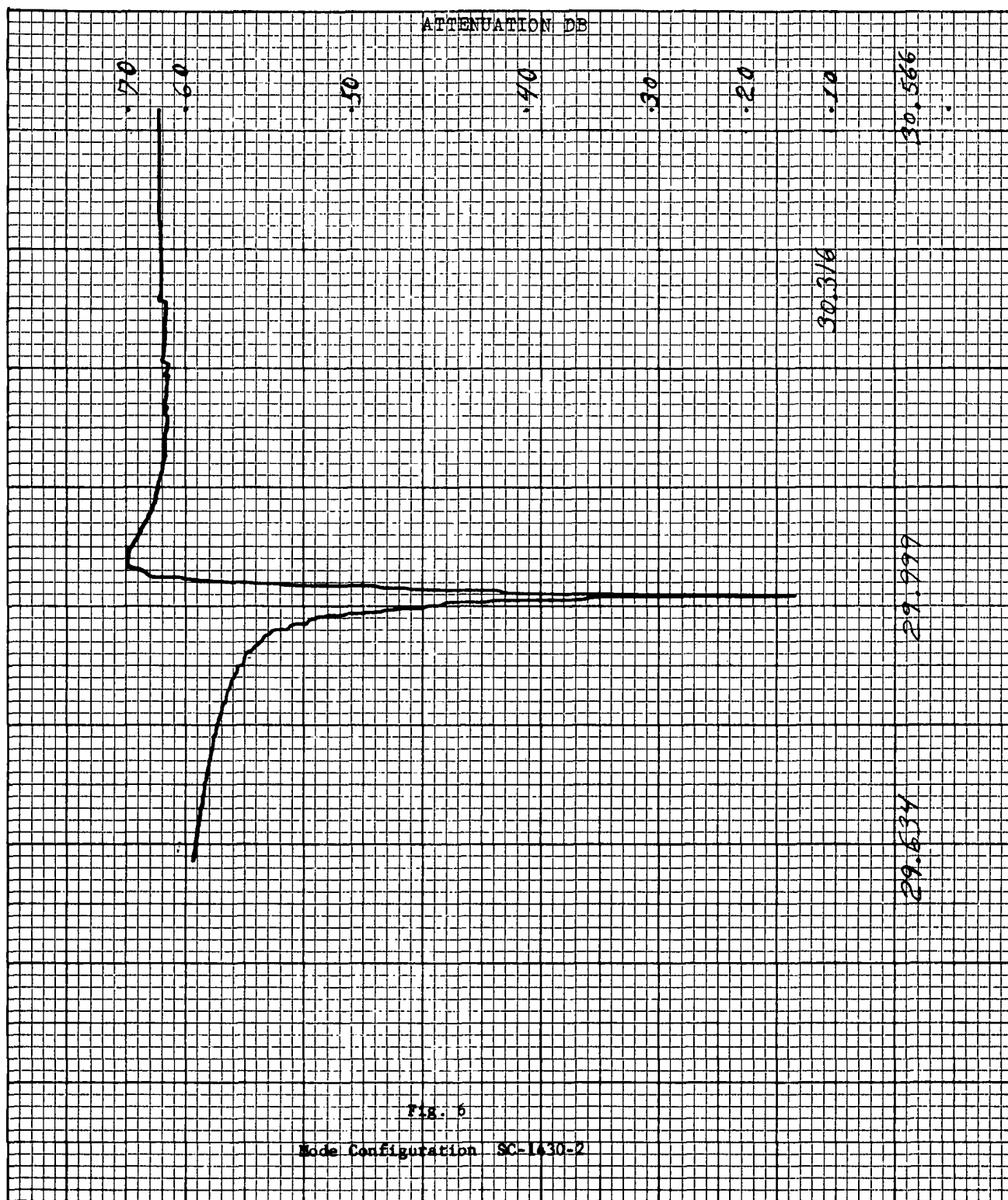


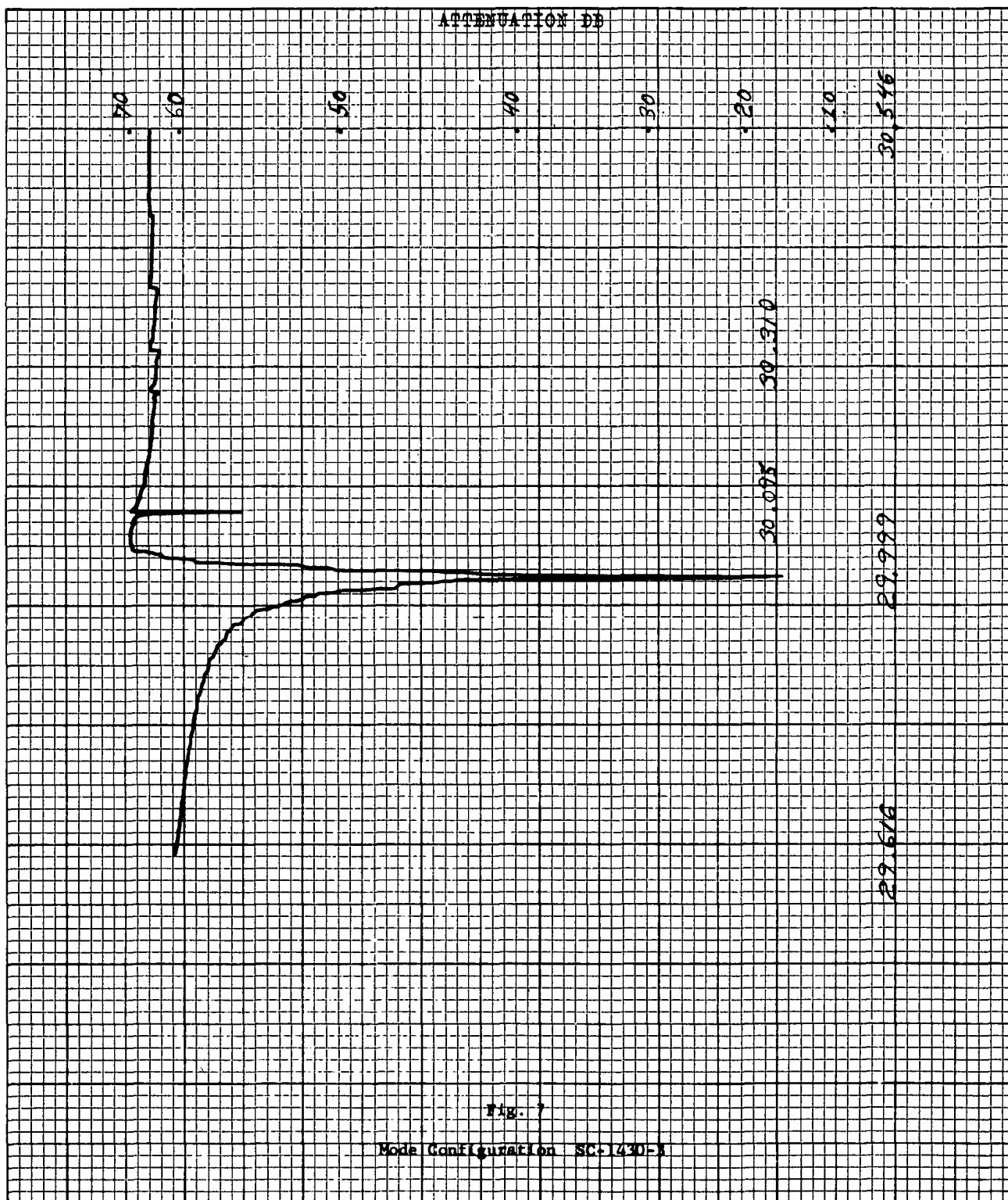


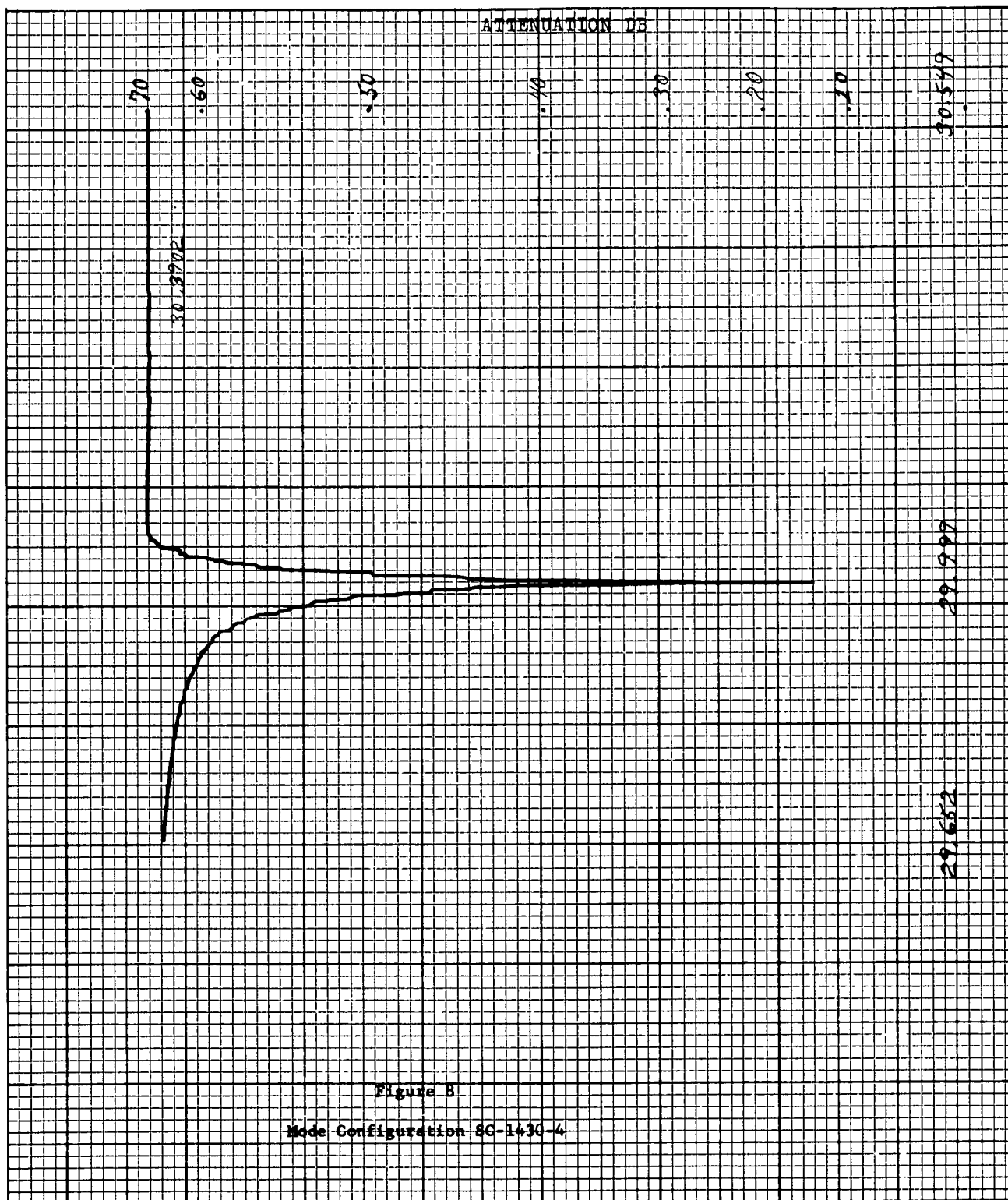


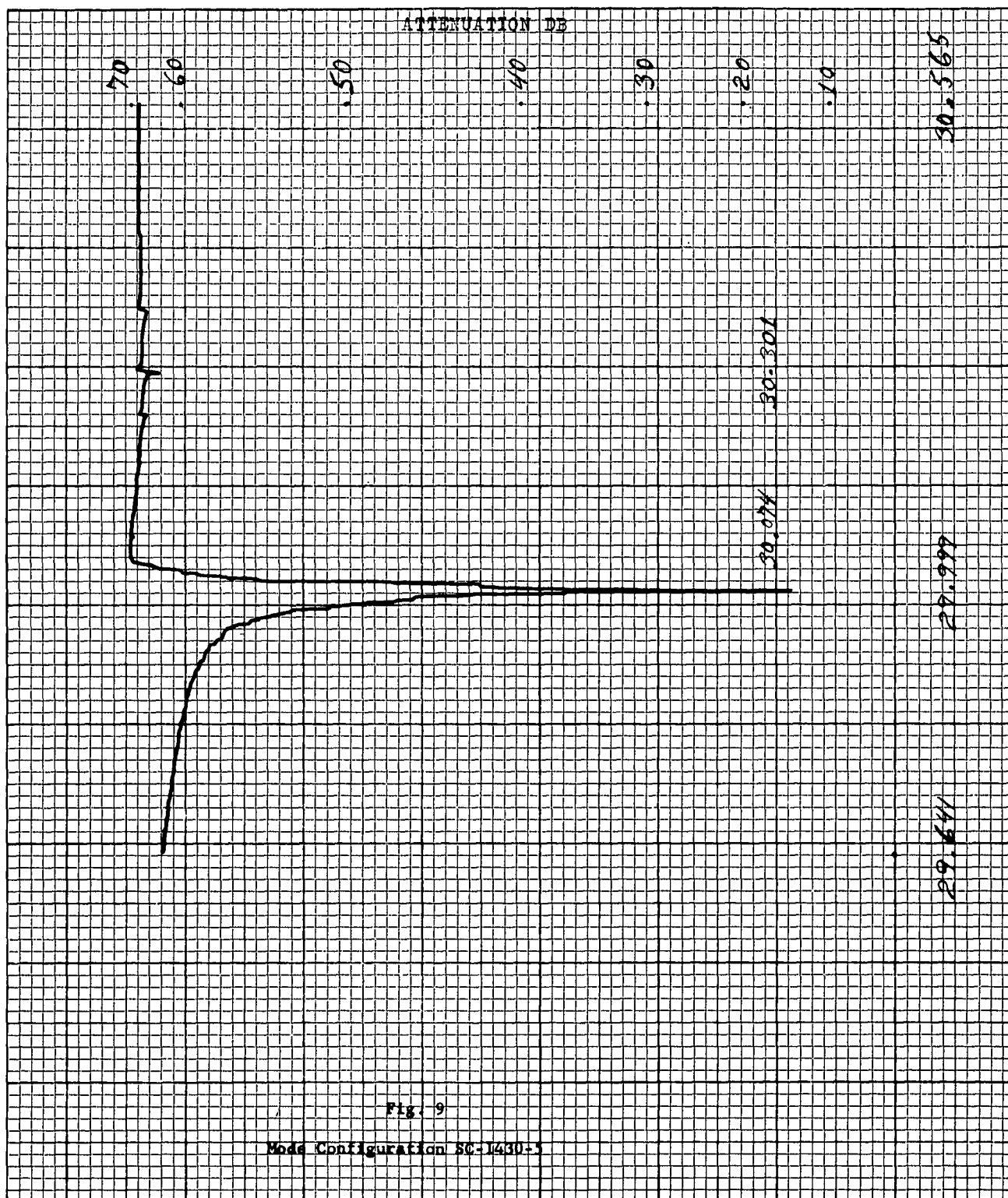


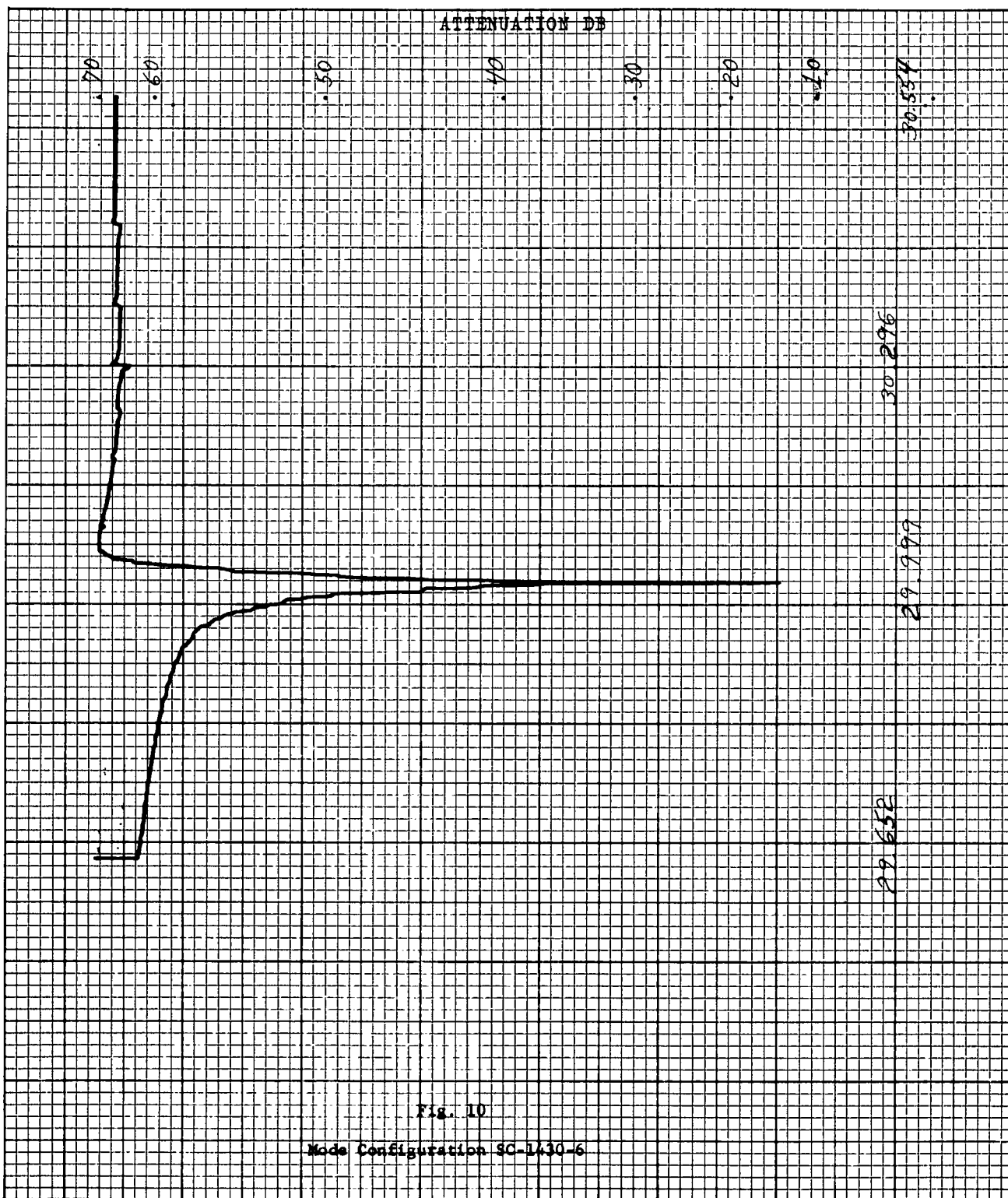


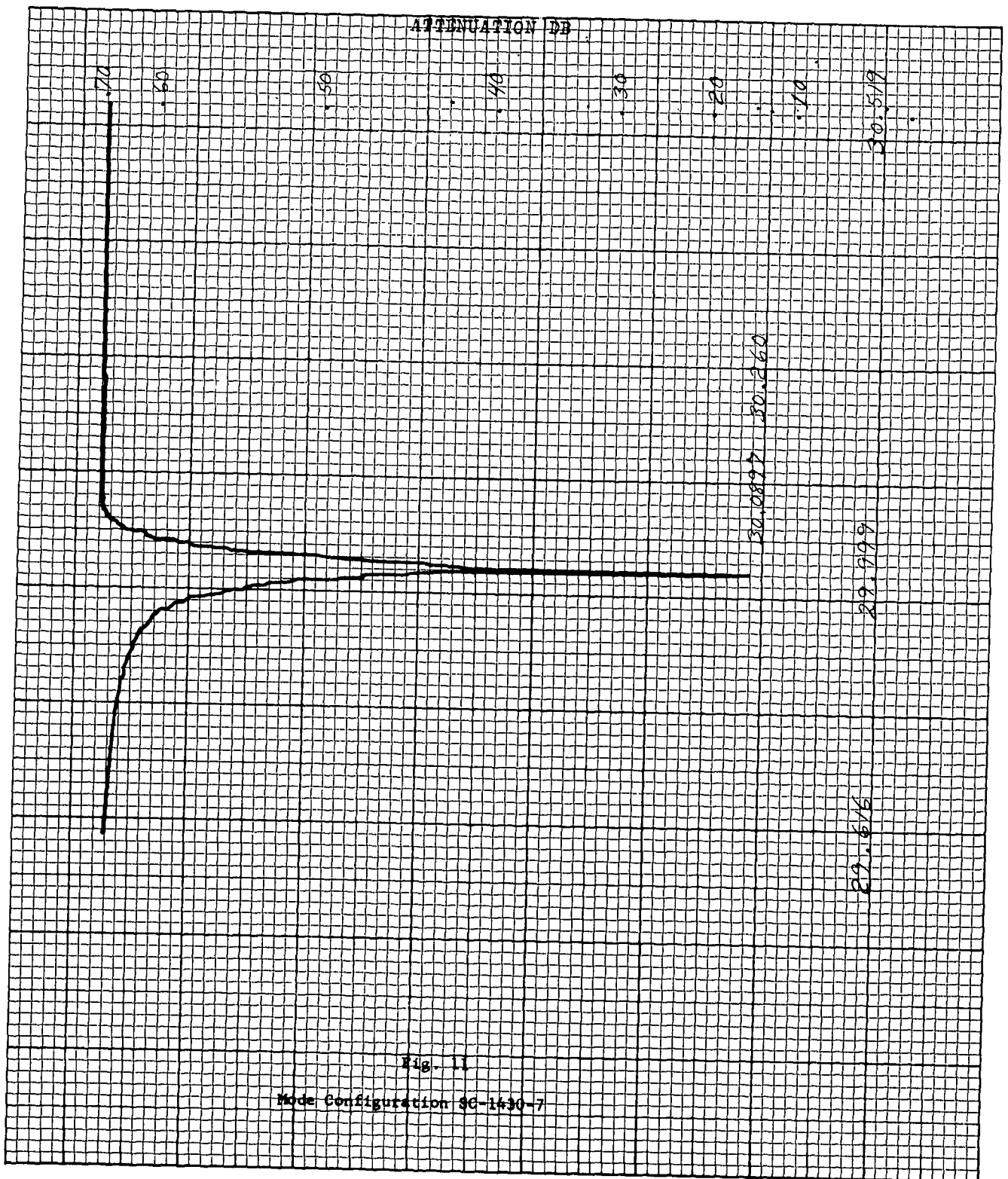












E. B. LEWIS CO., INC. EAST HARTFORD, CONN.

FOR **U.S. Army Signal Corps**
Philadelphia, Penna.

SHIP TO

PROMISED DELIVERY DATE

DESCRIPTION:

1-1-1 Engineering samples
44-pcs. (a) 30 MO (Natural Quartz)

Contract # **KL 6843-A**
DA-36-079-80-88737
Order # **19059-PF-62-81-81**

DATE **Oct. 2, 1962**
REV. 1

How Shipped _____

SC-1

HC-18/4 Wire Leads.	
Cutting	35° 27' ± 2
Squaring	.310 +.002 -.000 dia 1/16" flat on Z Z'
Lapping	Semi Polish Very flat, finish to be checked with Brush Analyzer
	Replate Freq + 60 KC + 10 KC (Fundamental) -0.000 KC
Plating	.064 spot .046 spot 8 pcs clamped on Z (sc1350) 8 pcs clamped on Z (sc-1130) 8 pcs clamped on X (sc-1145) 8 pcs clamped on X (sc-1230)
Finishing	
Oscillator	TS-683
Correlation	
Testing	SCS-135
Shipping	RPM 2/oct/62

FINISHING DEPT.

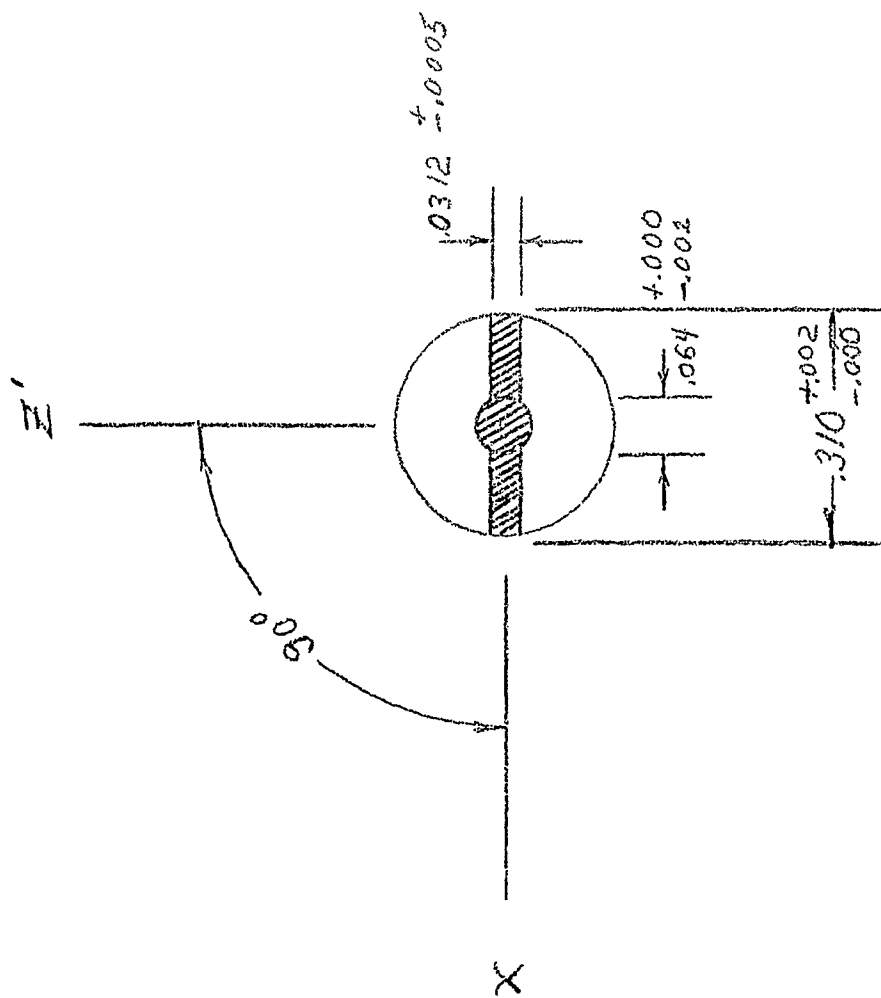


FIG. 13

DESIGN SC-1430 CRYSTAL

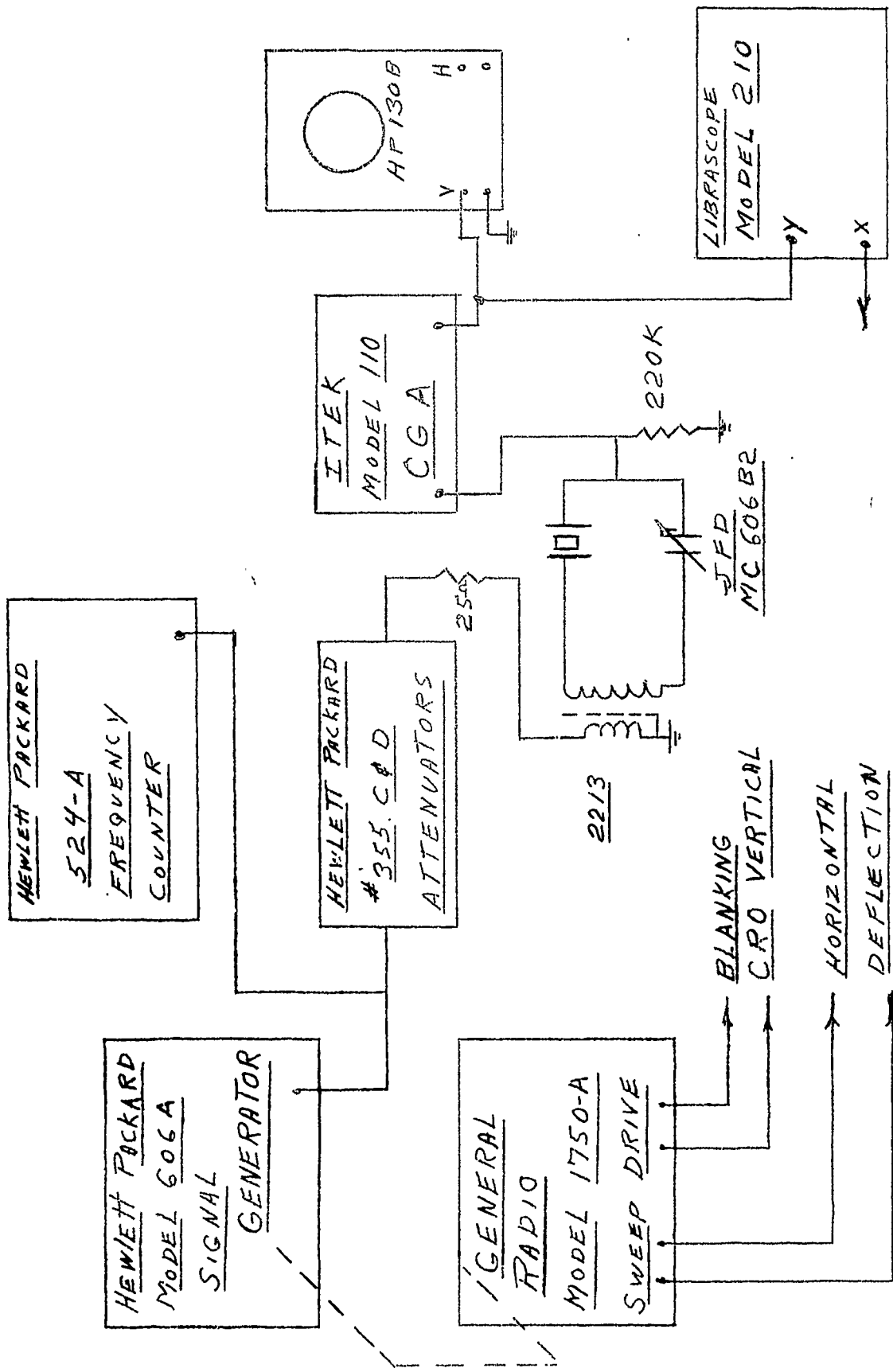


FIGURE 14

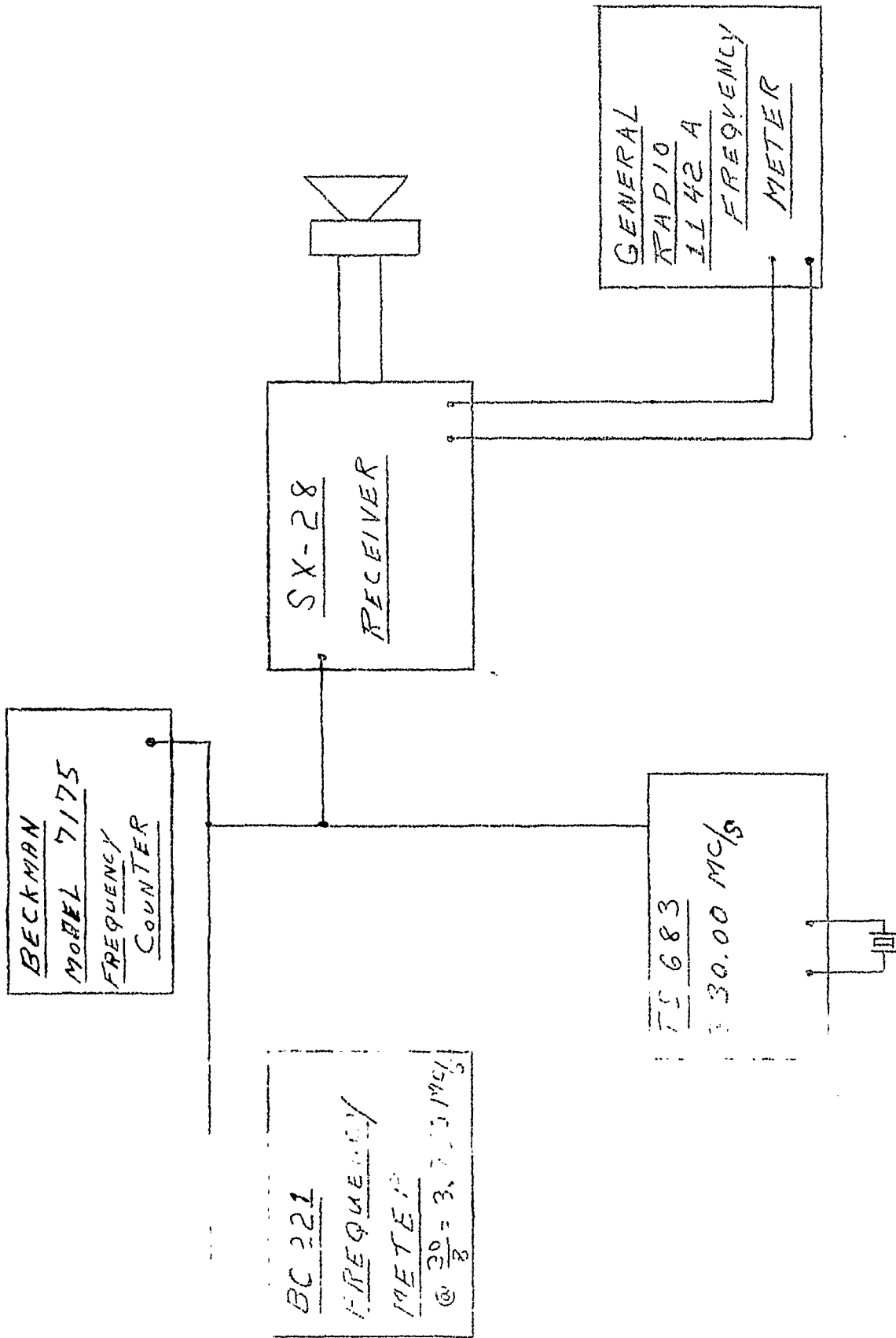


FIGURE 15