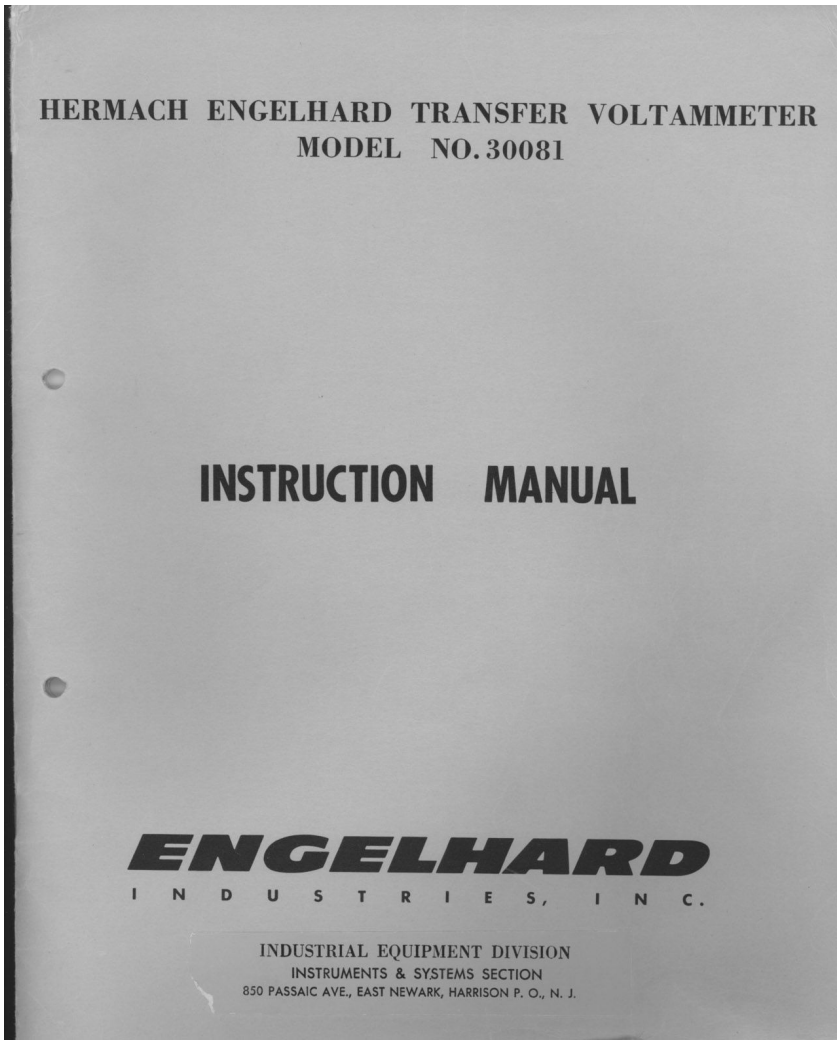
Francis L. Hermach, geboren am 8.1.1917, brachte um 1960 ein Transfer Volt-Am-Meter mit der Firma Engelhard heraus. Er erforschte bei dem Nationalen Amerikanischen Standardlabor (NBS; heute NIST) das Verhalten von Thermalkonvertern. Diese wurden dort für die Rückführung der Wechselspannung und des Wechselstroms benötigt. Er verfasste über die Konverter ab etwa 1952 bis 1986 über 30 wissenschaftliche Berichte, war lange Zeit Mitarbeiter beim NBS und starb 2007.

Die beiden vorgestellten AC-DC-Transfer Messgeräte für Spannung und Strom bestehen aus einem Thermalkonverter, Widerständen, Schaltern, Batterien und einem Spiegelgalvanometer zum Nullabgleich. Bei dem größeren Modell können auch HF-Thermalkonverter bis 30 MHz (0,5%) an der Buchse Nr. 29 angeschlossen werden.

Teil-Copy von Modell 30081


HERMACH ENGELHARD TRANSFER VOLTAMMETER
MODEL NO. 30081

INSTRUCTION MANUAL

ENGELHARD
INDUSTRIES, INC.

INDUSTRIAL EQUIPMENT DIVISION
INSTRUMENTS & SYSTEMS SECTION
850 PASSAIC AVE., EAST NEWARK, HARRISON P. O., N. J.

SAFETY PRECAUTIONS

This instrument, with external accessories, can be operated at potentials which are hazardous. The operator should observe the proper precautions, both for personal safety and protection of equipment.

The metal input terminal marked "G" is connected to the internal shield and should always be grounded.

"Since the thermal converter can be damaged by overloading, the selector switch should be in the rectifier instrument position until the range switch setting has been determined. The selector switch shall be kept in the #2 position between readings."

Caution

The maximum current that can be applied to the thermal converter filament is 7 ma. care should be taken not to exceed this value when checking continuity of same.

METER SPECIFICATIONS

Frequency Range 20 to 50,000 Cps.

Accuracy ± .05% of Full Scale on any Range

RANGE	IMPEDANCE	
15 V	2.000 Ohms	
30 V	4,000 Ohms	
75 V	10,000 Ohms	All ranges 133 Ohms per volt
150 V	20,000 Ohms	
300 V	40,000 Ohms	
5 A	0.1 Ohms	
2.5A	0.2 Ohms	
1.0A	0.5 Ohms	All ranges 0.5 volts drop at
500 MA	1.0 Ohms	rated current
250 MA	2.0 Ohms	
100 MA	5.0 Ohms	

GENERAL DESCRIPTION

The Hermach-Engelhard transfer instrument is a precision A-C multi-range unit with an accuracy of 1/20 of 1% (.05%) through a frequency range from 20 to 50,000 cps. It employs the transfer technique which has been established as standard procedure in making high precision A-C measurements. It does not require a D-C source identical to the rms A-C measured. The circuit design enables power from a small battery to match a large value of alternating current or voltage. The voltage drop in a portion of the D-C circuit is measured with a potentiometer. This potentiometer reading is multiplied by appropriate factors, conveniently located on the range switch to provide the rms A-C measurement.
Basically, the circuit consists of a thermal converter, (Fig. 1), which is shunted to obtain several current ranges, or used in series with appropriate resistors to obtain voltage ranges, (at 133 Ohms per volt).

As shown, (Figs. 2A and 2B) the heater of the thermal converter is switched in series with appropriate resistors, or in parallel with current shunts. The resulting emf of the thermal converter is balanced by an adjustable internal D-C circuit as indicated by the built in galvanometer. The heater is switched to an internal variable D-C source which is adjusted to give the same thermal converter emf and, therefore, the same heater current as the A-C source. The voltage across a portion of this circuit is measured with an external potentiometer. The measured potential is multiplied by a simple factor to obtain the unknown voltage or current. This method of equalizing the D-C produced temperature and the A-C produced temperature eliminates the thermal efficiency factor of the converter, except that it must be stable for at least the duration of the reading and the output must be great enough to obtain the required sensitivity.

The voltage measurement formula is given in Fig. 2A. Please note that the measured A-C voltage depends only on the product of the potentiometer reading and the ratio of the resistance (R_v and R_s).

The current measurement formula is given in Fig. 2B. The value of the measured current is simply the potentiometer reading, divided by the resistance of the four terminal shunt and is independent of the converter temperature vs. resistance characteristic. This is another reason why this instrument is capable of high accuracy.

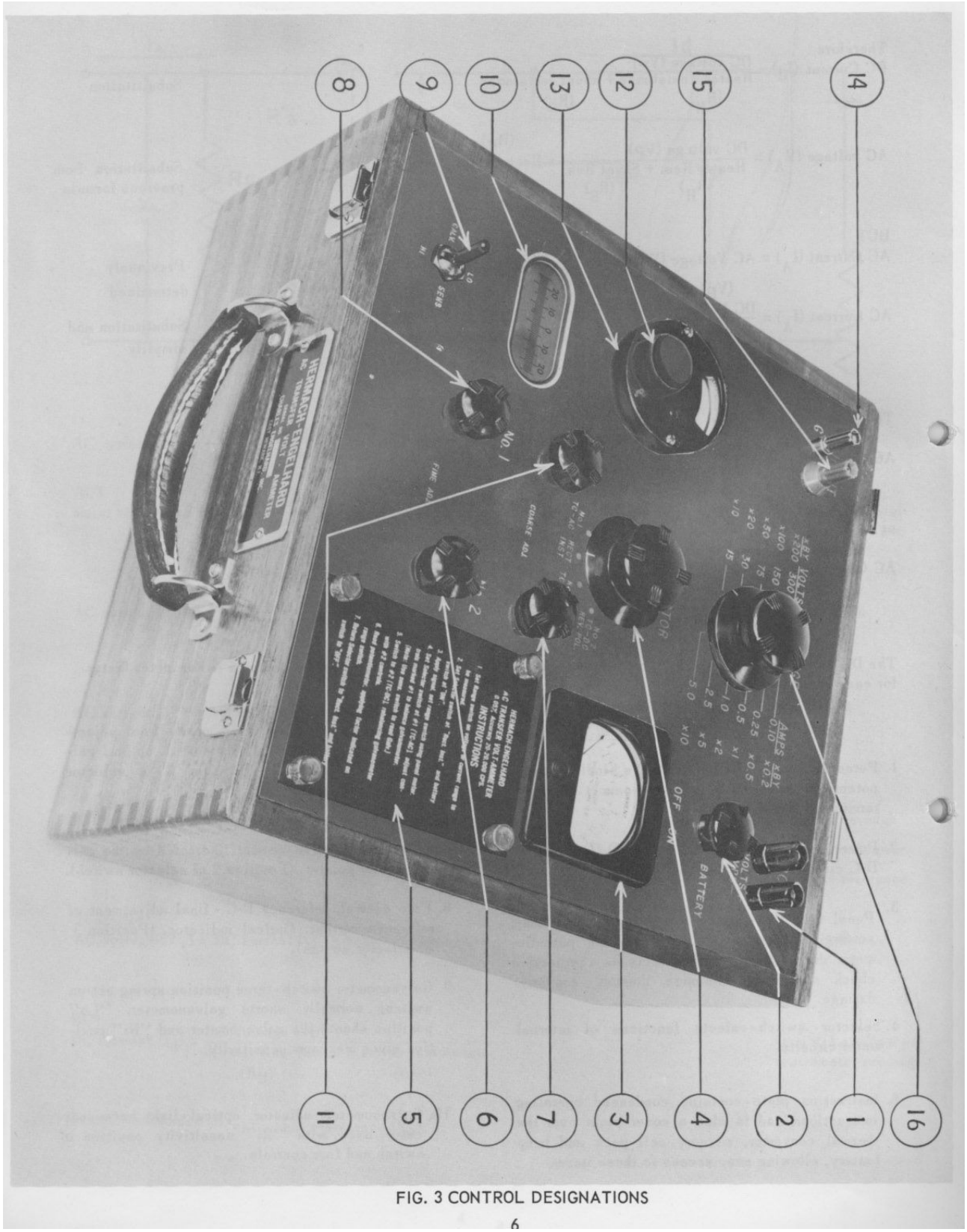


FIG. 3 CONTROL DESIGNATIONS

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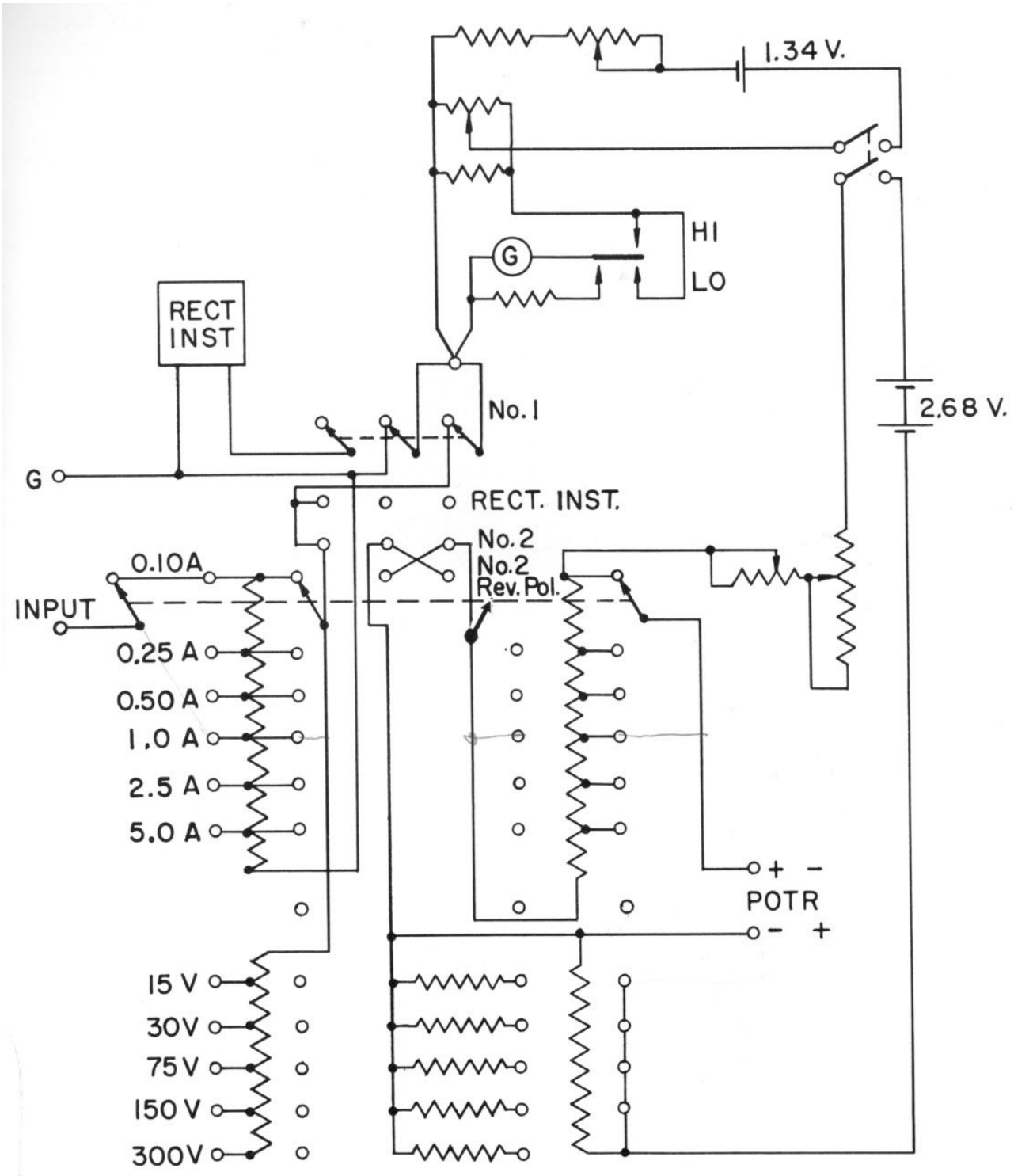
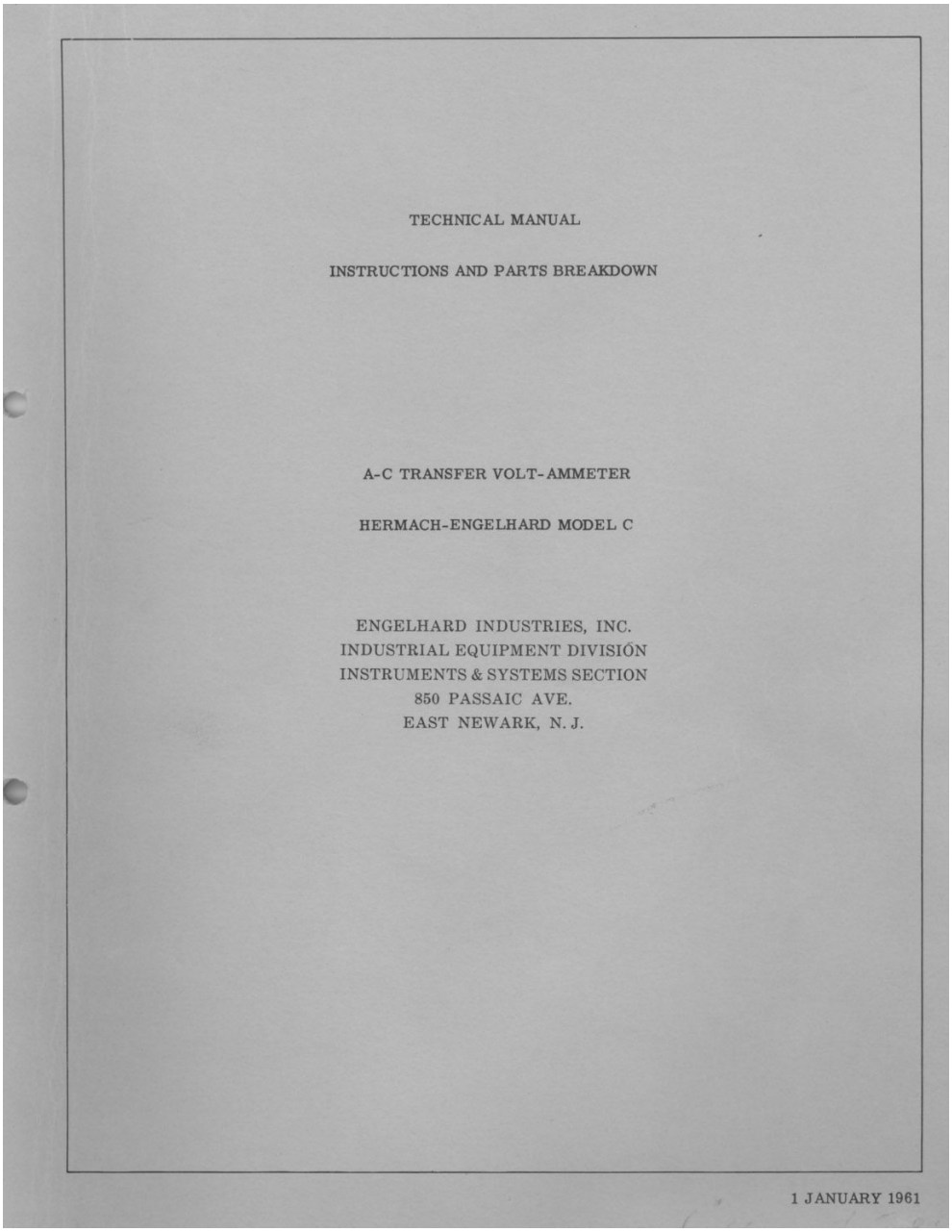


FIG. 6 BASIC SCHEMATIC DIAGRAM

Teil-Copy von Modell - C



TECHNICAL MANUAL

INSTRUCTIONS AND PARTS BREAKDOWN

A-C TRANSFER VOLT-AMMETER

HERMACH-ENGELHARD MODEL C

ENGELHARD INDUSTRIES, INC.
INDUSTRIAL EQUIPMENT DIVISIÓN
INSTRUMENTS & SYSTEMS SECTION
850 PASSAIC AVE.
EAST NEWARK, N. J.

1 JANUARY 1961

SECTION I

USE AND MAINTENANCE

1. GENERAL.

2. This manual describes the use, maintenance, and parts breakdown for AC Transfer Volt-Ammeter, Hermach-Engelhard Model C, figure 1, manufactured by Engelhard Industries, Inc., Industrial Equipment Division, Instruments and Systems Section, 850 Passaic Avenue, East Newark, New Jersey.

3. The AC Transfer Volt-Ammeter Hermach-Engelhard Model C referred to in this manual as volt-ammeter is a very precise a-c and d-c voltage and current measuring instrument. The accuracy of the volt-ammeter is such that it can be used not only to measure voltages and currents but to calibrate other a-c and d-c measuring instruments. The volt-ammeter uses the transfer principle to measure a-c voltages or a-c and d-c currents. The transfer principle is to heat a thermocouple with the unknown voltage or current and reheat the thermocouple to the same temperature with an internal d-c source, and then measure the d-c with a potentiometer. To measure d-c voltages, the volt-ammeter is used as a volt-box.

4. DESCRIPTION.

5. The volt-ammeter is enclosed in a wooden case approximately 9 inches high, 19 inches wide, and 15 inches deep, including the handle. The volt-ammeter weighs 32 pounds. All controls and indicators are located on the front panel, which is protected in transit and storage by the hinged wooden cover. No external power is required and no test leads are supplied with the volt-ammeter. Power for the volt-ammeter is supplied by internal batteries. The batteries and thermal converter, which are under the instruction plate, can easily be replaced by removing the four thumb screws securing the instruction plate.

6. ASSOCIATED EQUIPMENT.

7. The equipment listed in figure 2 is used in conjunction with the volt-ammeter, but is not furnished with the volt-ammeter. Only the potentiometer is essential for all measurements. The galvanometer and milliammeter are needed only when determining a-c - d-c difference of other measuring instruments.

8. LIST OF SPECIFICATIONS.

9. ELECTRICAL SPECIFICATIONS.

a. Voltage Ranges: 1500, 600, 300, 150, 60, 30, 15, 6, 3, 1.5, 0.5 volts.

b. Current Ranges: 25, 10, 5, 2.5, 1.0 amperes. 500, 250, 100, 50, 25, 7.5 milliamperes.

c. Frequency Range: The frequency range of the volt-ammeter on all ranges except the 1500 volt, 10, and 25 ampere ranges is from 5 to 50,000 cps. On the 1500 volt, 10 and 25 ampere ranges, the frequency range is from 5 to 20,000 cps. All scales are capable of measuring d-c.

d. Accuracy: The accuracy of the volt-ammeter is ±0.05 percent of full scale on all ranges without any correction factors.

e. Burden: Voltage Ranges - 7.5 ma (133 ohms per volt).
Current Ranges - 0.5 volt.

10. POWER REQUIREMENT. All power for the volt-ammeter is supplied by one size D flashlight battery and one mercury cell pack (Engelhard Part No. 30004).

11. PHYSICAL SPECIFICATIONS.

a. Size: 19 x 15 x 9 inches.

b. Weight: 32 lbs.

12. PRINCIPLE OF OPERATION (figure 3).

13. The a-c voltage or a-c or d-c current to be measured is proportionally reduced by precision multipliers or shunts selected by the voltage and current range switches and checked by the panel meter for magnitude. The accurately known proportional voltage or current is then used to heat a resistance wire which is part of a thermal converter. The thermal converter is essentially a resistance wire which is heated proportionally to the applied voltage or current and a thermocouple which, when heated by the resistance wire, develops a voltage proportional to the resistance wire temperature. The voltage from the thermocouple is now balanced out on a galvanometer by an internal voltage. This internal voltage acts as a memory or reference while the unknown voltage is removed and a second internal voltage is applied to the thermal converter resistance wire. This second internal d-c voltage is adjusted to balance out the first internal d-c voltage, which acted as the memory or reference voltage. Null is indicated on the galvanometer. This second internal voltage is then equal to the unknown reduced value of the a-c voltage or a-c or d-c current. Then the second internal d-c voltage is measured, using the external potentiometer. The value on the potentiometer dial times the range switch scale factor will be the actual value of the unknown voltage or current.

14. For d-c voltage measurements the thermal converter is not used. The voltage is proportionally re-

duced by a voltage divider and this reduced voltage is then applied to the potentiometer, and the value of the potentiometer reading times the range switch scale factor will be the value of the unknown d-c voltage.

15. If it is desired to extend the frequency range of the volt-ammeter an external thermal converter can be connected to the HFTC jack. The frequency range can thus be extended into the megacycle range at a somewhat reduced accuracy.

16. THEORY OF OPERATION (figure 4).

17. The volt-ammeter is a thermoelectric transfer instrument using a thermal converter as a transfer element. The thermal converter consists of a heater

Description	Use
Precision potentiometer with a scale 0 to 1.5 volts. Accuracy 0.01 to 0.05%.	Determines the value of current or voltage being measured.
Galvanometer: galvanometer with a sensitivity of approximately 1.5 microvolts per millimeter with a critical damping resistance of approximately 30 ohms. With a galvanometer of this sensitivity, a-c - d-c differences as small as 0.02 percent can be detected.	Increases the accuracy when determining the a-c - d-c difference of other measuring instruments.
Milliammeter: milliammeter to measure to 1.5 milliamperes d-c at 2 percent accuracy.	Increases the ease of determining the a-c - d-c difference of other measuring instruments.
High Frequency Thermal Converter: Engelhard Industries Part No. 34970.	Extends the frequency range of the volt-ammeter into the megacycle region. Used only for voltage measurement above 50 KC.

Figure 2. Associated Equipment Required but not Supplied

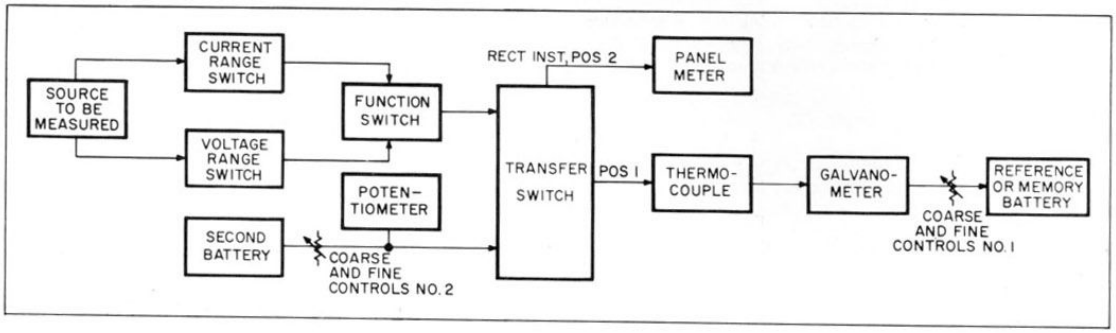
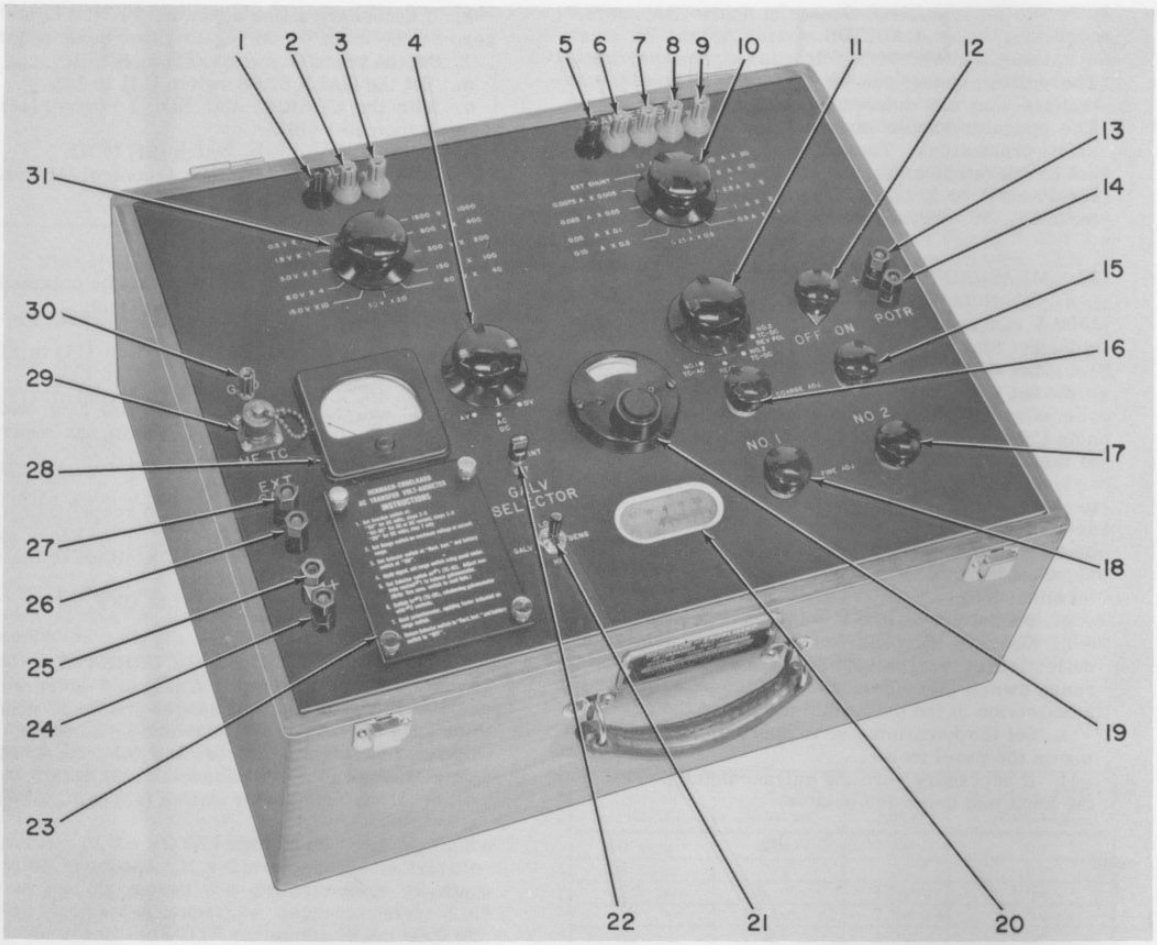
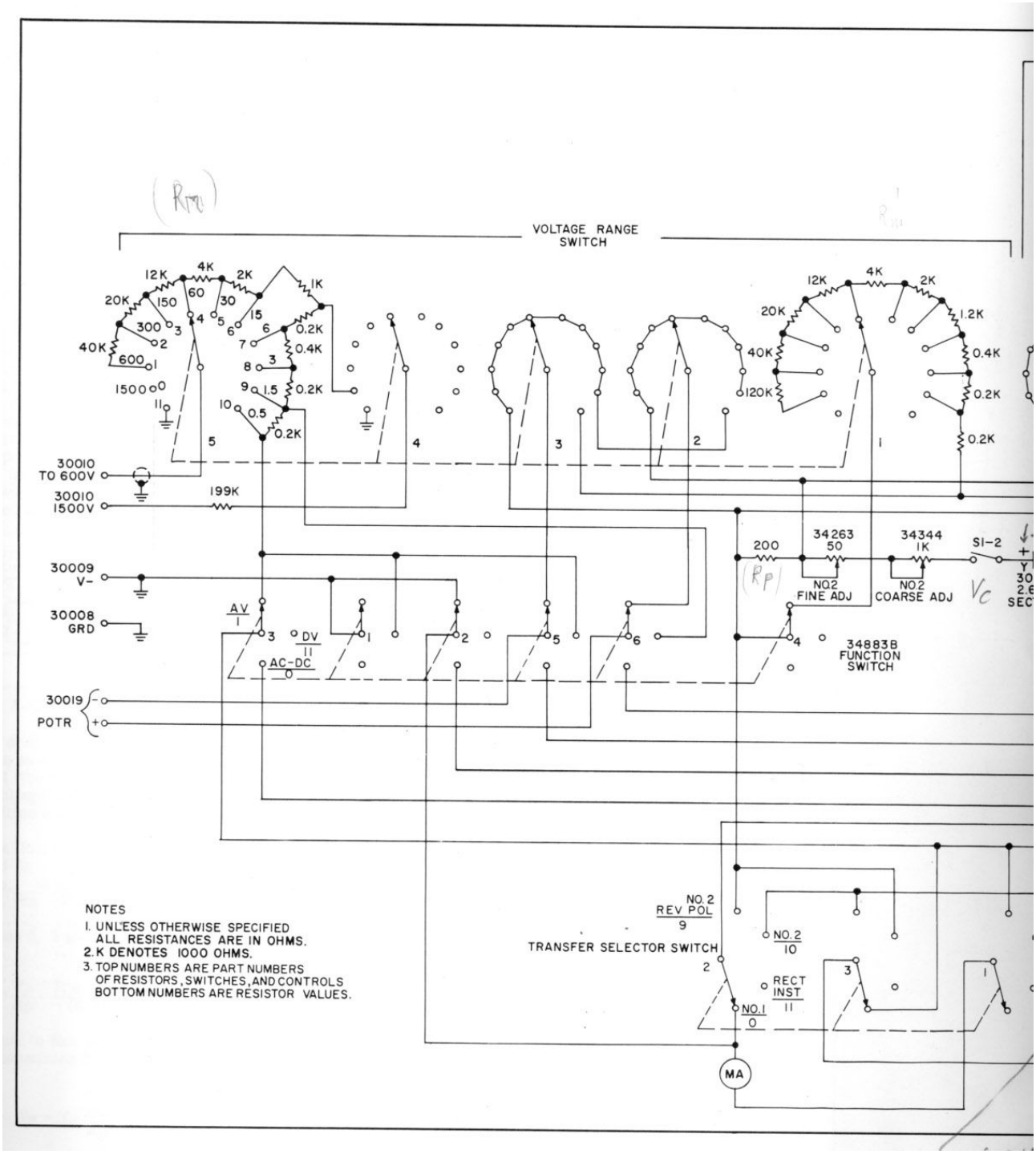


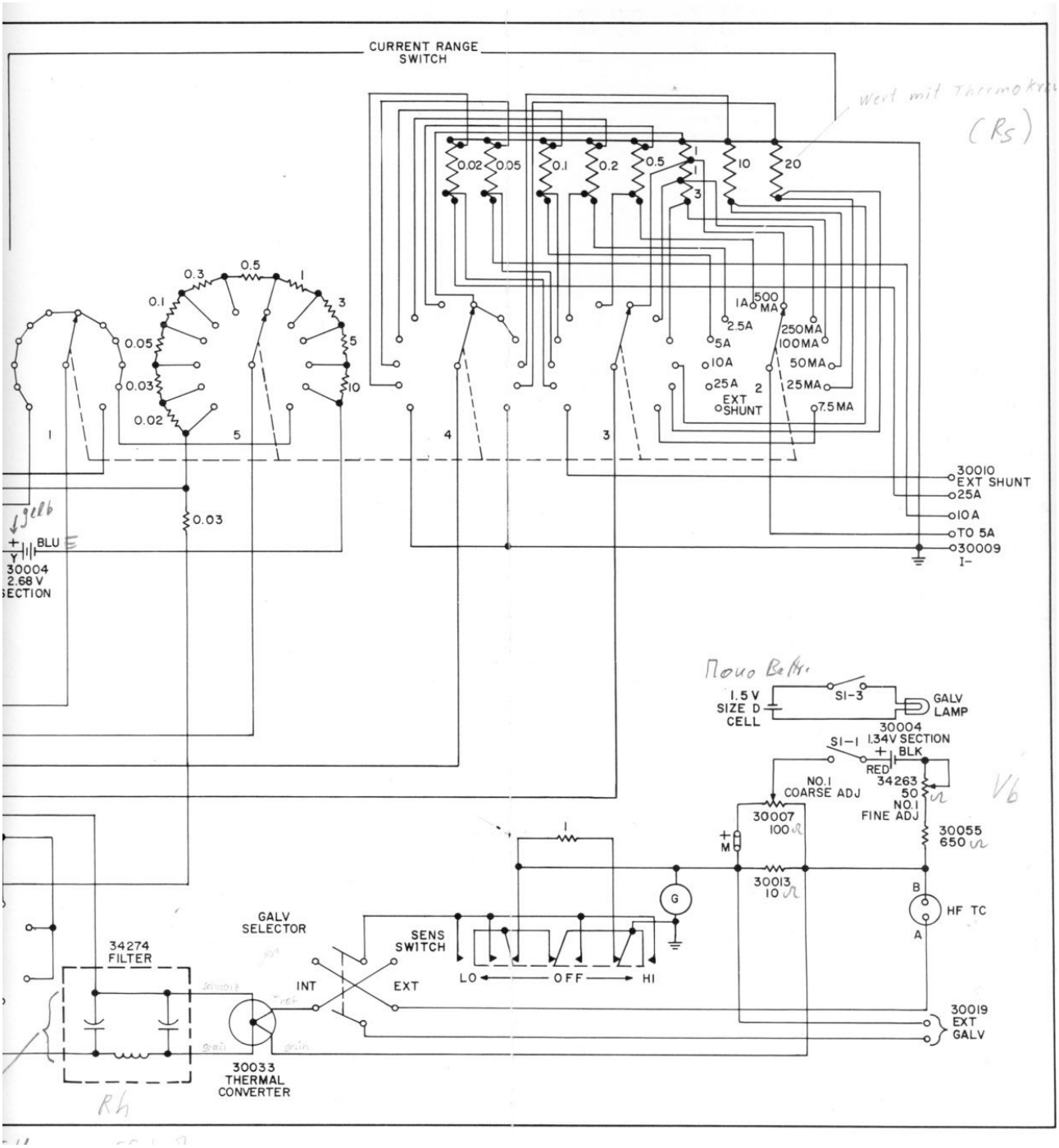
Figure 3. Volt-Ammeter Block Diagram



1. VOLT V- Terminal
2. VOLT TO 600 V Terminal
3. VOLT 1500 V Terminal
4. Function Selector Switch
5. AMPERES I- Terminal
6. AMPERES TO 5A Terminal
7. AMPERES 10A Terminal
8. AMPERES 25A Terminal
9. AMPERES EXT SHUNT Terminal
10. Current Range Switch
11. Transfer Selector Switch
12. Battery Switch
13. POTR + Terminal
14. POTR Terminal
15. COARSE ADJ NO. 2 Control
16. COARSE ADJ NO. 1 Control
17. FINE ADJ NO. 2 Control
18. FINE ADJ NO. 1 Control
19. Galvanometer
20. Galvanometer Optical Vernier
21. GALV SENS Switch
22. GALV SELECTOR Switch
23. Condensed Instruction Plate
24. Milliammeter M Terminal
25. Milliammeter M+ Terminal
26. EXT GALV Terminal
27. EXT GALV Terminal
28. Panel Meter
29. HFTC Jack
30. GRD Terminal
31. Voltage Range Switch

Schaltplan in zwei Teilen




CURRENT RANGE SWITCH
0.02
0.05
0.1
0.2
0.5
1
3
10
20
0.3
0.5
1
0.1
3
0.05
5
0.03
10
0.02
1
5
4
3
1A
500 MA
2.5A
250MA
5A
100MA
10A
50MA
25A
EXT SHUNT
2
25MA
7.5MA
30010
EXT SHUNT
25A
10A
TO 5A
30009
I-
0.03
BLU
30004
2.68 V
1.5 V
SIZE D
CELL
SI-3
GALV
LAMP
30004
1.34V SECTION
SI-1
BLK
RED
NO.1
COARSE ADJ
34263
50
NO.1
FINE ADJ
30007
100
30055
650
30013
10
M
G
B
HF TC
A
GALV
SELECTOR
SENS
SWITCH
34274
FILTER
INT
EXT
LO
OFF
HI
30019
EXT
GALV
30033
THERMAL
CONVERTER

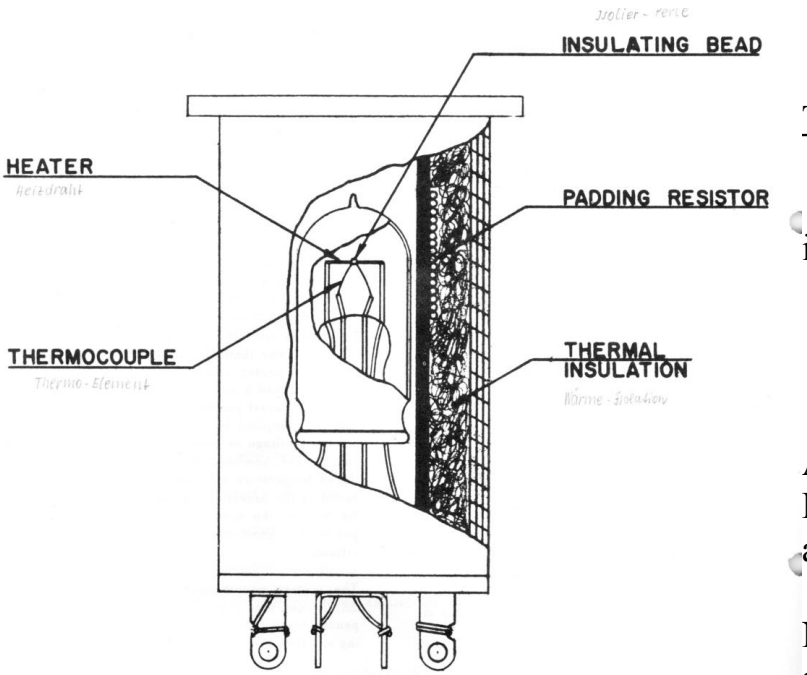


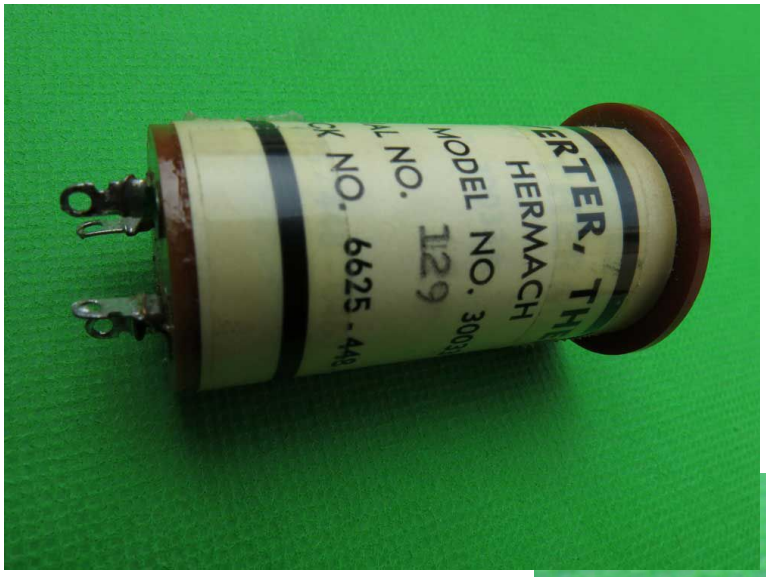
FIG. I THERMAL CONVERTER

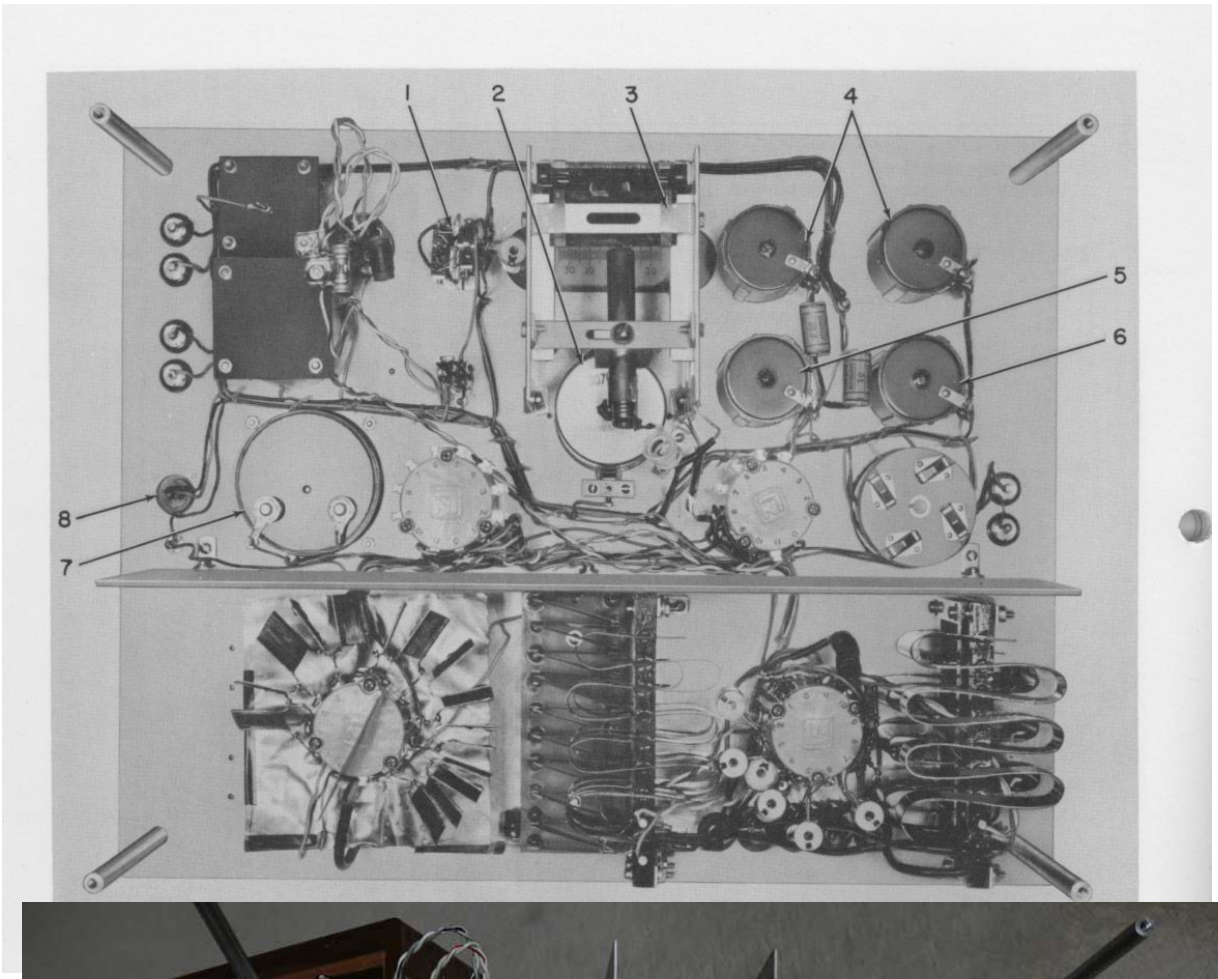
Thermalkonverter

im Prinzipbild

Als Orginalersatzteil
Modell: 30033
austauschbar unter Nr.23

NF-Thermal-Pille
als Beispiel

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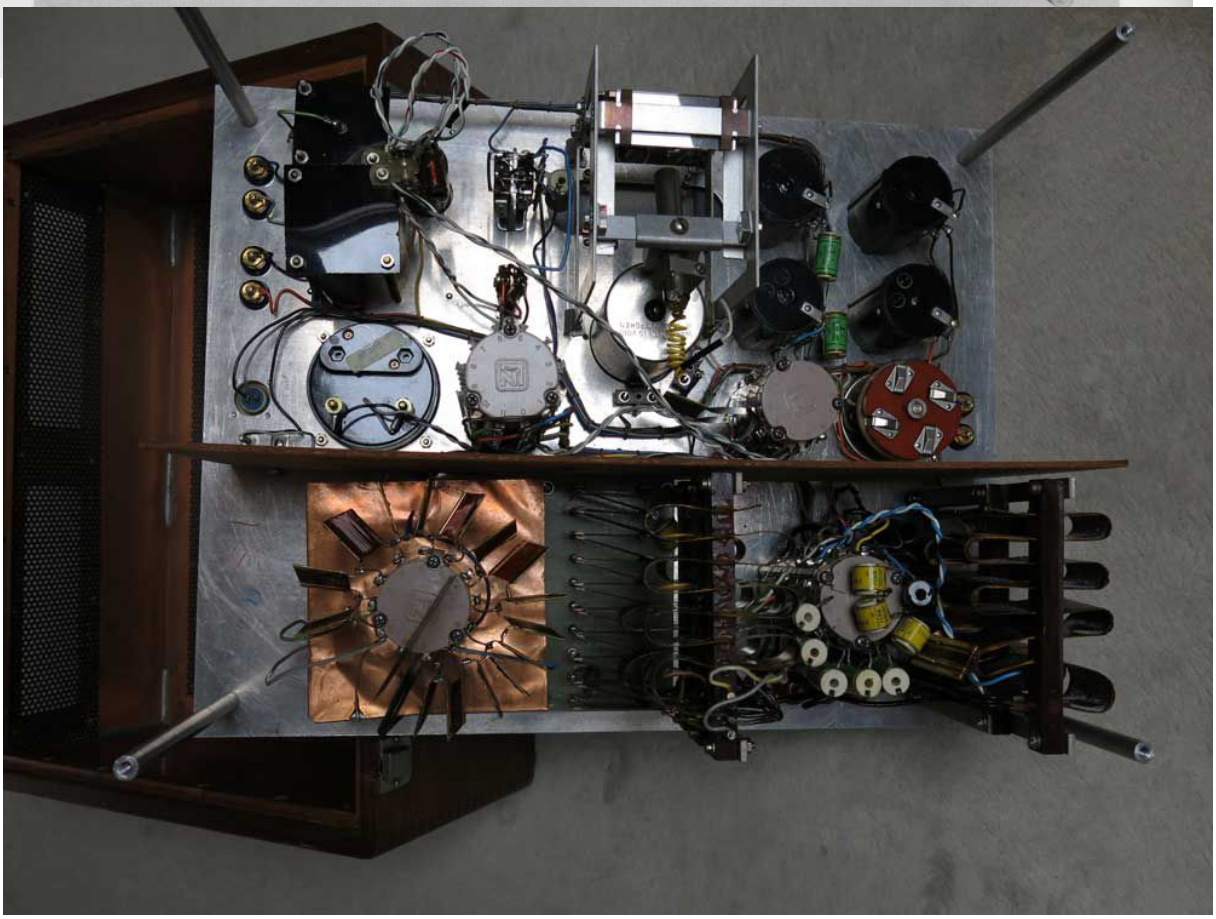

Francis L. Hermach Engelhard A-C Transfer Volt-Am-Meter