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AN IMPROVED TUBULAR ELECTRIC FURNACE FOR THE CLOSED-TUBE DISTILLATION OF OIL FROM OIL SHALE

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Geological Survey

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AN IMPROVED TUBULAR ELECTRIC FURNACE FOR THE CLOSED-TUBE DISTILLATION OF OIL FROM OIL SHALE

By

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ABSTRACT

The single unit, tubular electric furnace used in the closed-tube distillation of oil from oil shale has been modified to increase its capacity, compactness, ruggedness, and general utility. With this furnace four oil distillations can be completed in the same length of time formerly required for one. The new furnace gives results similar to those obtained by the single-tube furnace. When used with a variable autotransformer, the temperature of the aluminum core furnace can be controlled from room temperature to 550 C. Detailed shop drawings are given for the construction of the furnace.

INTRODUCTION

In the course of chemical investigations in the Geological Survey it is frequently necessary to carry out heating operations where the heating units required are not available commercially. This led to the construction of the single-unit furnace described by Cuttitta (1951). This furnace found its principle application in the closed-tube distillation of oil from oil-bearing rock, but there are many other uses to which this

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Cuttitta, Frank, 1951, A photometric method for the estimation of the oil yield of oil shale: U. S. Geol. Survey Trace Elements Inv. Rept. 152.

furnace may be put such as boiling, evaporations, and ignitions.

The single-unit tubular electric furnace has been in constant use at the Geological Survey for over a year and proved to be very useful. When it became increasingly apparent that a more rugged and greater capacity furnace would better meet our needs, an improved furnace for use in the closed-tube distillation of oil from oil shale, prior to its colorimetric estimation, was constructed. The new furnace has the following advantages over the single-unit furnace: greater capacity, ruggedness, compactness, and greater flexibility as a general laboratory tool. In addition, with the present furnace four oil distillations can be completed in the same length of time formerly required for one.

We are indebted to J. F. Abell who did all of the machine work and to R. C. Kellagher who made the shop drawings.

This work was done on behalf of the Division of Raw Materials of the U. S. Atomic Energy Commission.

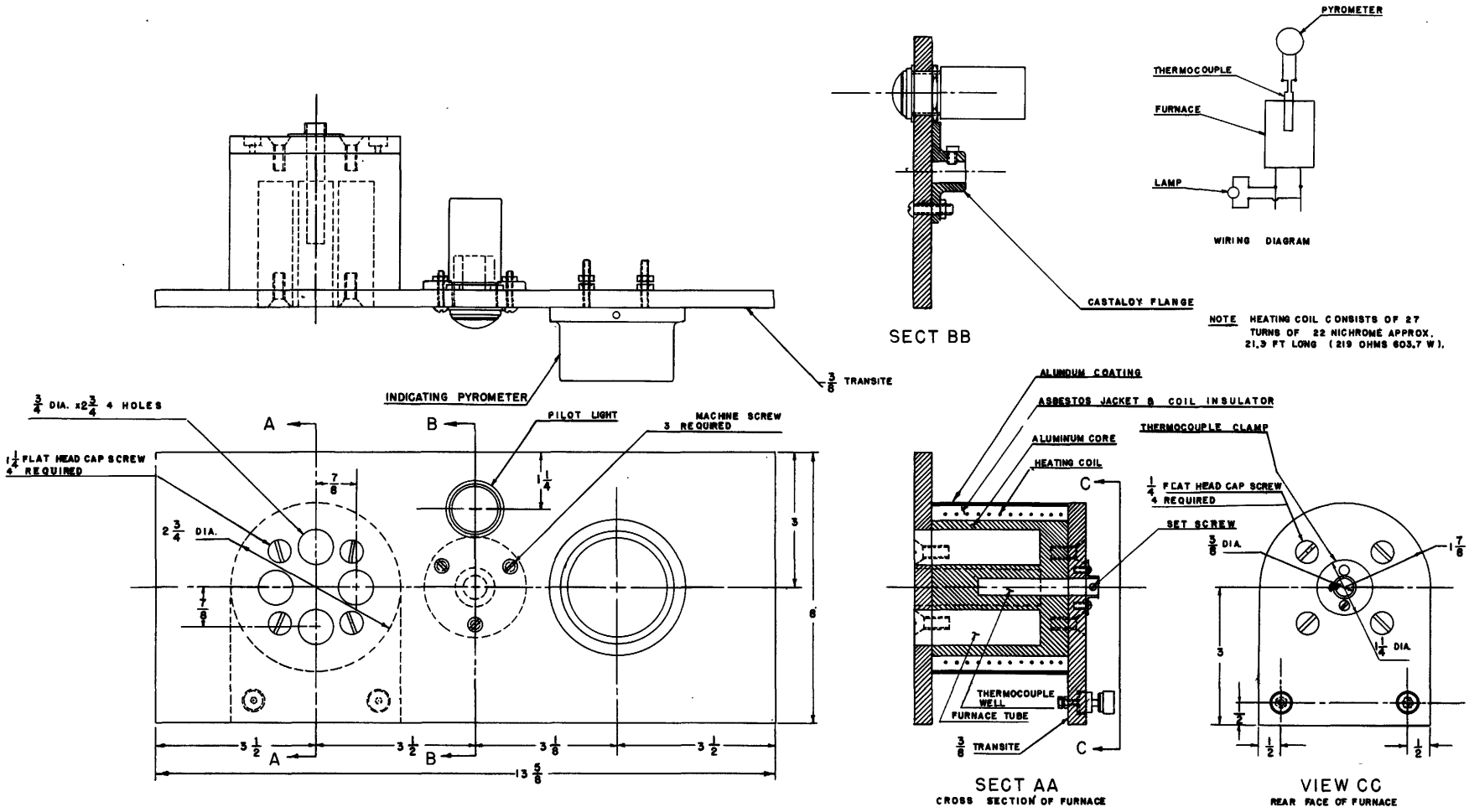
DESCRIPTION OF FURNACE

The new tubular furnace (figs. 1, 2, and 3) is housed in a cylindrical alundum-asbestos shell. The core of the furnace is made from a cylinder of high melting point aluminum alloy 3 in. in diameter and 3 in. long. Four holes 3/4 in. in diameter and 2 in. deep were drilled for heating chambers.

The furnace core is heated by a winding of no. 22 B and S nichrome wire wound around the aluminum cylinder and insulated from the core by asbestos. The various turns are spaced and held in position by embedding in asbestos so that the coil is free to radiate directly to the chamber.

The multiple-unit furnace is fitted with a small indicating pyrometer to provide a convenient means of reading the chamber temperature at any

FIGURE 1. ELECTRIC FURNACE FOR THE DISTILLATION OF OIL FROM SHALE



R.C. KELLAGHER

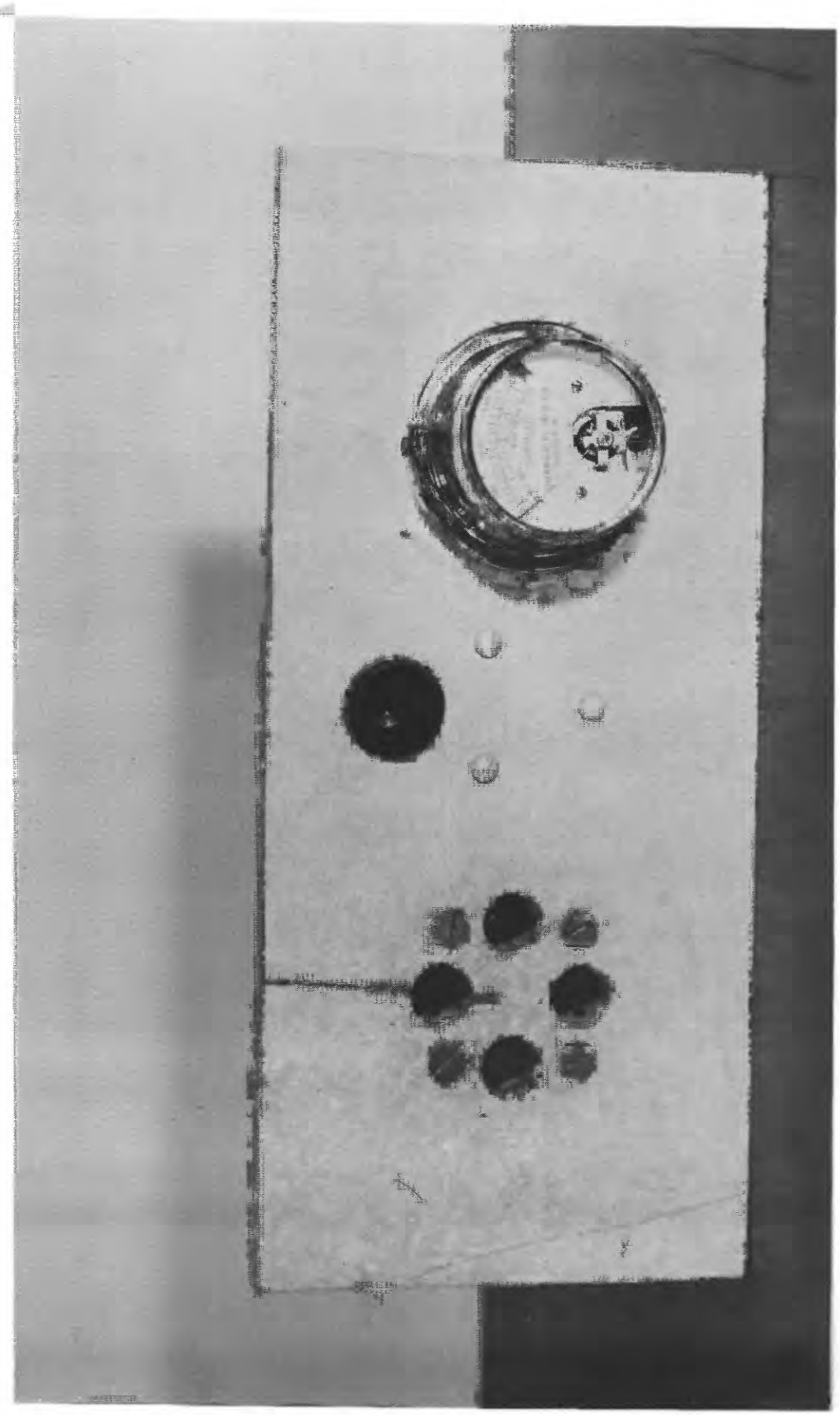


Figure 2.—Front view of improved tubular electric furnace

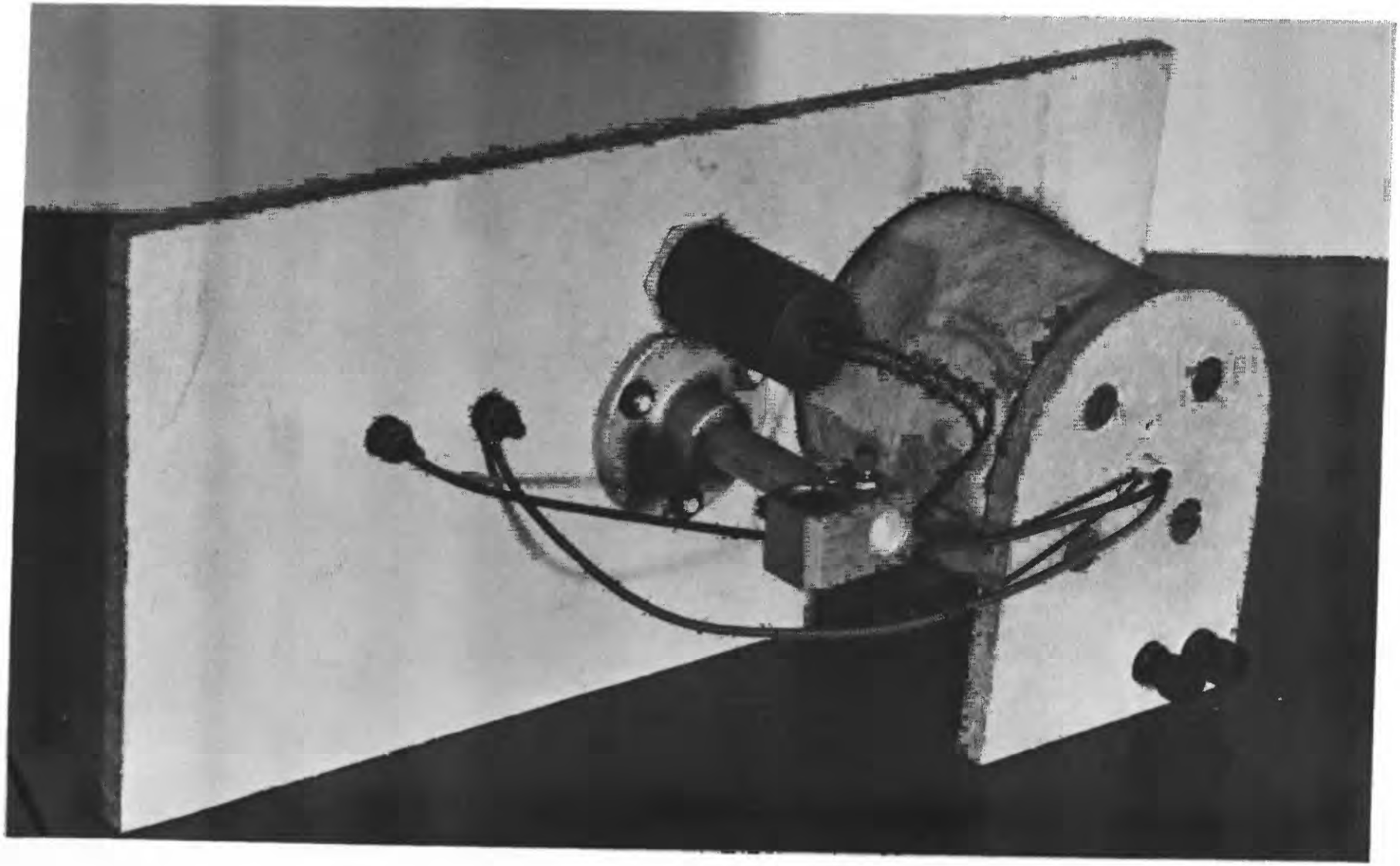


Figure 3.--Rear view of improved tubular electric furnace

time. The pyrometer is permanently installed in the furnace with its chromel-alumel thermocouple extending into the thermocouple well through the rear wall of the furnace core. The pyrometer was checked against a potentiometer and was found to be accurate over the range used.

Temperatures are indicated by the pyrometer and are regulated by a variable autotransformer. The variable transformer used has a capacity of 1 kva with a 115-volt input, a 0-135 volt output, and a maximum output amperage of 7.5. With these controls it is possible to maintain a constant temperature to within $\pm$ 5 C. The voltage supplied to the unit should not be much greater than that needed to produce a temperature of 550 C because the aluminum alloy used in the core softens at 600 C. Replacement of the aluminum heating core with a higher melting alloy can increase the temperature maximum to over 900 C. Aluminum was chosen because of its relative light weight and good heat conduction. Complete detailed shop drawings for the construction of the furnace are given in figure 1.

Specifications of multiple-unit furnace

Maximum operating temperature	550 C
Rating	344
Voltage	115, a-c 60 cycles
Gauge of wire (B and S)	no. 22
Resistance	32 ohms
Length of nichrome wire	30.5 ft
Aluminum core dimensions	3 in. diameter x 3 in. long
Unit heating chamber dimensions	3/4 in. diameter x 2 in. deep
Insulation	3/8 in. asbestos
Variable transformer	1 kva
Pyrometer accuracy	$\pm$ 5 C
Pilot light	115 v

PERFORMANCE OF ELECTRIC FURNACE

The watt rating of the furnace is 344 and care must be taken not to exceed this wattage because the aluminum core softens at about 600 C.

The temperature-time and the temperature-power relation charts shown on the following pages (figs. 4, 5, and 6) will assist in deciding the proper power input for a selected temperature. It should be borne in mind that line voltage may differ somewhat in various localities or on the same line at different times of the day and under varying load conditions. This may cause some variation in the temperature readings at any specific transformer dial position.

Thus it can be seen from the data shown in figures 4, 5, and 6 that performance of the furnace is adequate for average laboratory needs. The sensitivity of the tubular electric furnace is such that temperatures can be maintained to within $\pm$ 5 C.

REPRODUCIBILITY OF RESULTS

The work in the development of the photometric method for the estimation of the oil yield of oil shale was done with a single-unit tubular electric furnace. In order to compare the performance of the multiple-unit furnace under actual operating conditions with that of the single-unit furnace, 42 oil shales were run through the procedure for the photometric determination of oil. Comparative results of the oil determinations are shown in table 1.

CONCLUSION.

The multiple-unit tubular electric furnace described is a great improvement over the existing furnace in such factors as speed, compactness,

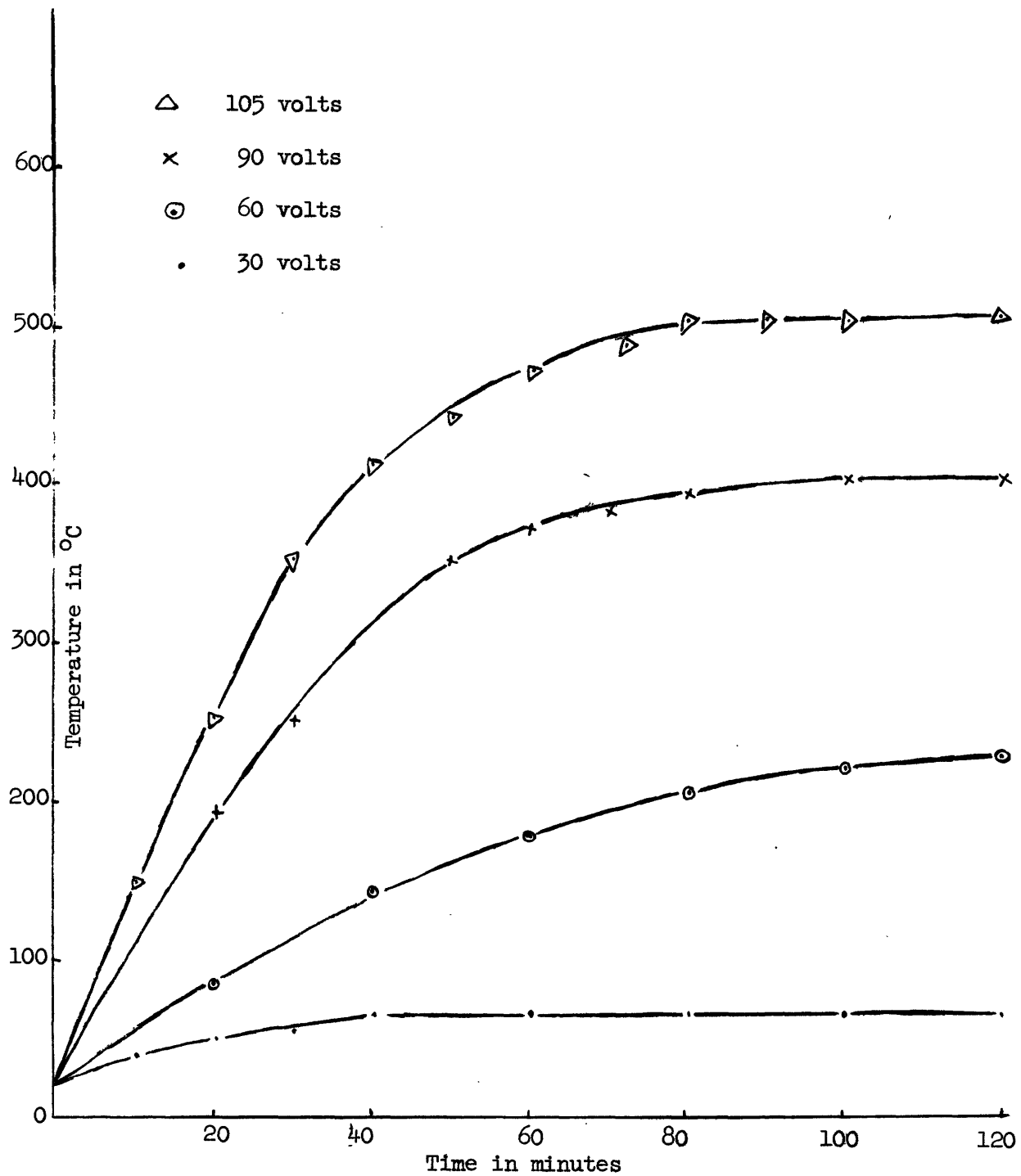


Figure 4.--Temperature-time relation at various voltages (32 ohms)

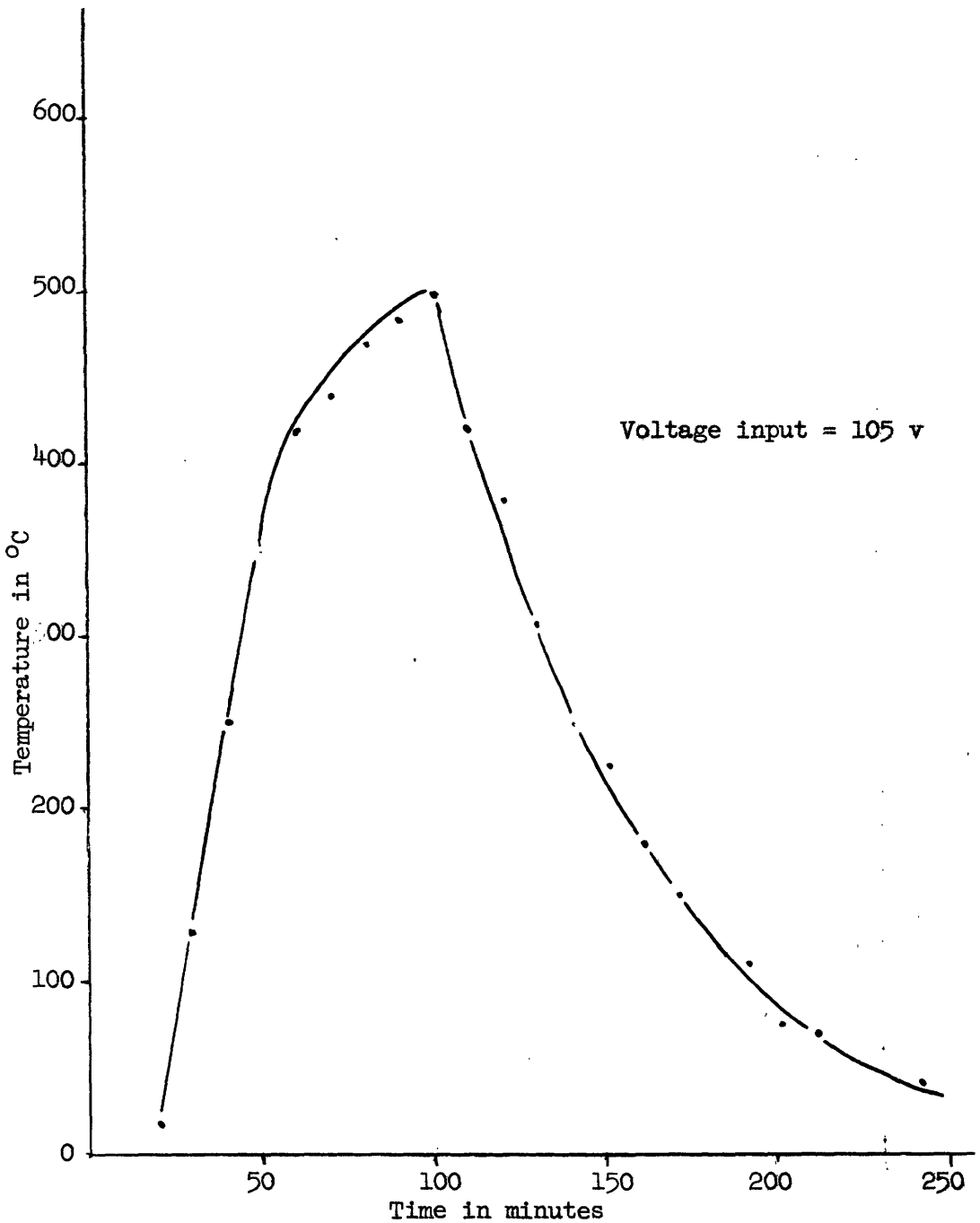


Figure 5.--Heating and cooling curves at 105 volts

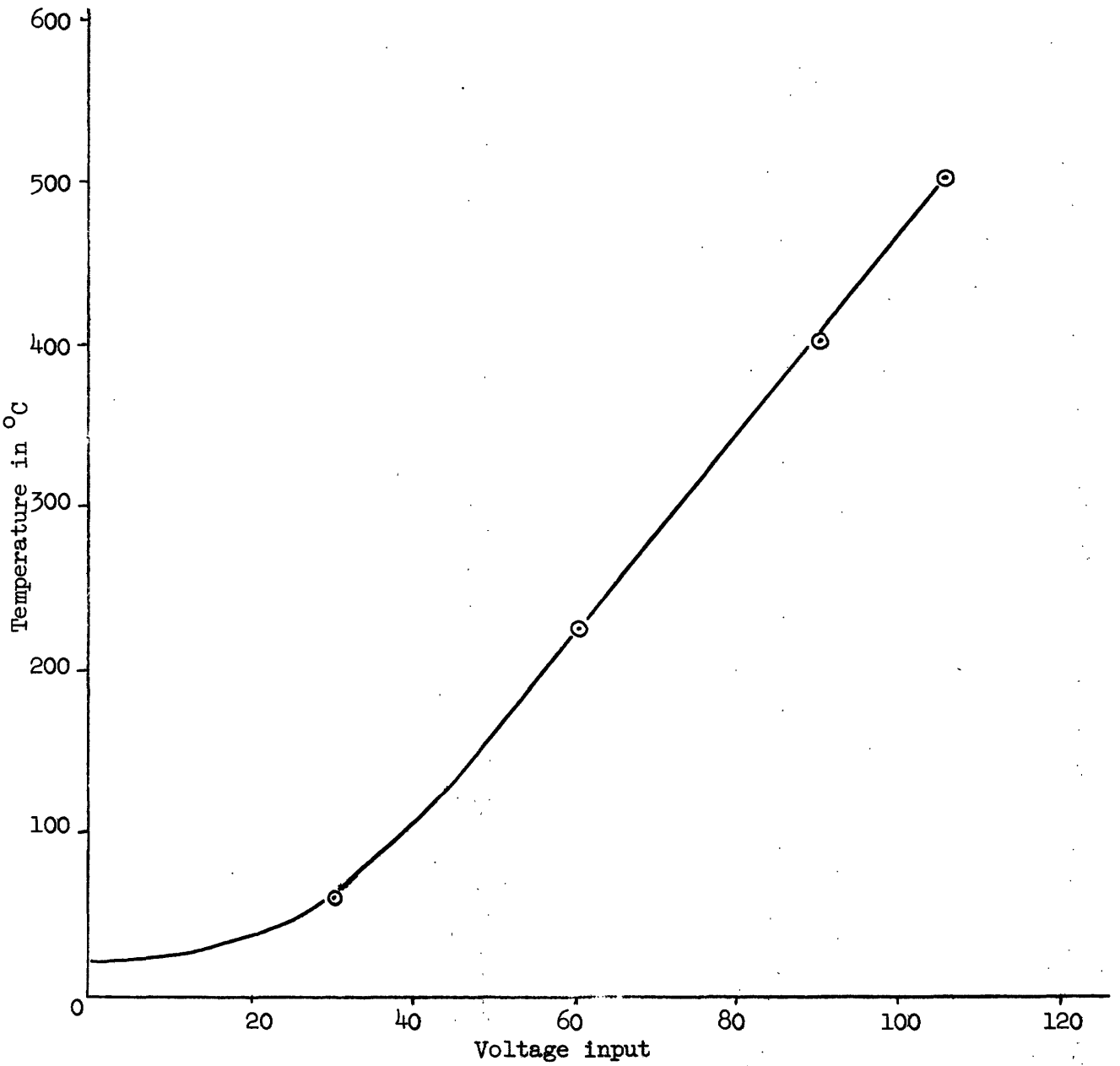


Figure 6.--Temperature-voltage relation

Table 1.--Oil determinations using single-unit and multiple-unit furnaces.

Number	Percent oil (single-tube furnace) 1/	Percent oil (multiple-tube furnace) 2/	Number	Percent oil (single-tube furnace) 1/	Percent oil multiple-tube furnace 2/
59505	1.0	1.1	59526	2.2	2.4
59506	0.9	1.0	59527	1.7	1.6
59507	1.0	0.9	59528	1.5	1.7
59508	1.1	1.2	59529	1.9	2.0
59509	1.1	1.1	59530	1.7	1.9
59510	0.9	0.8	59531	2.7	2.8
59511	1.2	1.3	59532	2.7	2.6
59512	1.3	1.2	59533	2.3	2.2
59513	1.3	1.4	59534	3.2	3.3
59514	0.8	0.8	59535	2.9	3.1
59515	1.3	1.2	59536	3.0	3.2
59516	1.6	1.5	59553	2.9	3.0
59517	2.2	2.4	59557	5.6	5.8
59518	2.5	2.6	59558	5.5	5.4
59519	3.2	3.4	59559	5.8	5.6
59520	2.9	3.0	59560	5.0	5.2
59521	3.4	3.3	59561	6.4	6.2
59522	2.4	2.6	59562	5.8	5.9
59523	2.5	2.4	59563	3.4	3.6
59524	2.6	2.6	59565	5.4	5.3
59525	2.9	3.0	59592	5.2	5.2

1/ Determinations made by Myra Rosenthal
2/ Determinations made by Frank Cuttitta

ruggedness, greater capacity, and efficient use of electrical energy. The furnace has been in use for over a year and has proved to be very satisfactory.

This furnace provides a means for rapid and controlled heating of materials in test tubes. Although its primary application is the distillation of oil from oil-bearing rock, it may be used for practically any operation requiring rapid and uniform heating in test tubes. Thus, it can be used in the laboratory for drying precipitates, heating and evaporating solutions, distilling, boiling, wet ashing, fusions, and general experimental test work.