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THE CONSTRUCTION AND OPERATION OF A ROTARY BURNER FOR FLUORIMETRIC URANIUM ANALYSIS

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THE CONSTRUCTION AND OPERATION OF A ROTARY BURNER FOR FLUORIMETRIC URANIUM ANALYSIS

by

A. W. Ashbrook*

ABSTRACT

The construction and operation of a rotary burner, for use in the fusion of uranium-containing samples with sodium fluoride flux prior to the fluorimetric determination of uranium, is described. The burner consists essentially of an arrangement of LPG burners providing a circular flame through which dishes containing sample and flux are rotated. This arrangement results in even and reproducible heat distribution to the dishes, and provides good precision between individual fusions, and between replicate analyses.

The burner is fitted for semi-automatic operation, which also increases the reproducibility of the fusion technique.

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Direction des mines

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INSTALLATION ET FONCTIONNEMENT D'UN BRÛLEUR ROTATIF POUR LE TITRAGE DE L'URANIUM PAR FLUORIMÉTRIE

par

A. W. Ashbrook*

RÉSUMÉ

L'auteur décrit l'installation et le fonctionnement d'un brûleur rotatif destiné à réaliser la fusion d'échantillons uranifères à l'aide d'un fondant au fluorure de sodium avant le titrage de l'uranium par fluorimétrie. L'appareil consiste en un ensemble de brûleurs utilisant du gaz en bouteille et produisant une flamme circulaire à l'intérieur de laquelle on fait tourner des coupelles contenant l'échantillon et le fondant. Cette disposition permet une répartition de la chaleur dans les coupelles uniforme et reproductible et assure une bonne fidélité d'un bain de sels à l'autre et entre analyse et contre analyse.

Le brûleur est prévu pour un fonctionnement semi-automatique et ceci améliore la reproductibilité de la technique de fusion.

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INTRODUCTION

The general method for the determination of small amounts of uranium is a fluorimetric procedure. This involves the fusion of the uranium-containing sample with a sodium fluoride-lithium fluoride flux in a platinum dish[1]. Uranium in the 'bead' so produced is determined by the fluorescence produced when the bead is subjected to irradiation in the ultra-violet region of the electromagnetic spectrum. For many years, fusion of the sample and flux has generally been carried out using a Fletcher burner[1], although other apparatus has been designed and used in some cases[2].

Normally, several (generally 4 or 5) aliquots of the sample solution, a standard uranium solution, and two blanks are run per fusion, giving a total of 22 fusions per set. One major factor in the precision of the results is, then, the reproducibility of the fusion technique. Such reproducibility involves, among other factors, subjecting each dish to the same amount of heat.

One way of accomplishing this is to rotate the dishes through a circular flame. Obviously the flame temperature will not be constant around the circle, but by rotation through such a flame each dish should be subjected to an average temperature. This is the principle of the rotary burner described here. One other important factor is that this type of apparatus lends itself well to semi-automatic operation, thus increasing the reproducibility of the fusion cycle. The burner described here is a modification of one used at Panel Consolidated Uranium Mines Ltd., Ontario.

CONSTRUCTION OF THE BURNER

General

The burner consists essentially of a stationary arrangement of 12 LPG burners. These are slotted into holes in a circular metal frame, which is supported on four legs attached to a metal base. A perpendicular shaft, driven by an electric motor and turning at 9.6 rpm, runs through the center of the apparatus.

Attached to the top of the shaft is a turntable carrying 24 wire supports, fitted radially and in the plane of the turntable, to hold the fusion dishes.

The gas supply is controlled by a solenoid valve. An electrical timer operates both the solenoid and the motor, so that fusion time can be accurately controlled. Ignition of the gas is by spark from a Tesla coil, which is operated by a push-button switch. The motor can be operated independently of the gas solenoid valve, to facilitate loading of the dishes on the wire supports.

Views of the assembled burner are shown in Figs. 1 to 3.

Turntable

The turntable is cut from a piece of ¼-in.-thick stainless steel, and is 3¾ in. in diameter. From one face of the turntable is cut a ½-in.-wide by 1/8-in.-deep section. A piece of stainless steel is turned to fit the section cut out (see Fig. 4). V-grooves are cut radially in the slotted section of the turntable (Fig. 4) at 15° intervals, to take No. 19 gauge wire, giving a total of 24 grooves. Grooves of this size have been found suitable for holding No. 17 or 18 gauge wire firmly. The turntable and ring are drilled and threaded, at equal intervals, to take 8 small screws by which the wire supports are clamped (Figs. 1 and 4). The center of the turntable is tapped to take a threaded 3/8-in.-diameter drive-shaft.

Wire Supports

Wire supports for the dishes are made from No. 17 or 18 gauge Chromel A or AA wire. The wire is formed into a loop (approximately 9/16-in. diameter) into which the platinum dishes fit, with the lip of the dish resting on the wire. The stem of the wire is cut to a suitable length such that the loop is centered on the ring of burners (Fig. 1). The wire supports last about 6 months when the burner is used regularly.

Burner Support Ring

The burner support ring and legs are constructed from

1/8-in.-thick mild steel. The ring is 8 in. in diameter and is drilled at 30° intervals with 12 x 1¼ in. holes on centers 1 in. from the edge of the support. The burners are fitted into the holes.

Four portions of the support ring are cut out and a bearing is fitted to the center of the ring to take the drive-shaft. The ring is supported by four pieces of 1/8-in.-thick mild steel, 1 inch wide, welded to the support ring and bolted to the corners of the burner base (Fig. 1) so that the ring is held 8 in. above the base. Burners are fitted into the support ring (after removing their caps) by inserting them in the holes from below, and refitting the caps from above the ring.

Gas Manifolds

Gas manifolds (two) are clamped to opposite sides of the base of the apparatus, and each supplies gas to 6 burners. They are constructed from 1¼-in.-OD copper pipe, 8 in. long, and capped at one end. The other end is reduced to ¾-in. OD by a reducer. Copper tubing, ¼-in. ID, is brazed into 6 holes drilled at suitable intervals along the pipe. These are connected via brass couplings and ¼-in. copper pipe to the appropriate burners (Fig. 2).

The reduced ends of the manifolds are connected by a 90° elbow and a T-piece. The open end of the T-piece is connected, through a suitable length of flexible tubing (optional), a manual gate valve, and a solenoid valve, to the gas supply line (Fig. 2).

Base

The base is made from a sheet of 1/8-in. mild steel, 18 x 9 in., bent to form the stand (Fig 2). The dimensions of the top are then 9 x 9 in. and the sides are 4¼ in. high. A hole is drilled in the center of the base to take a suitable bearing for the turntable drive-shaft.

Motor and Turntable Drive-Shaft

The motor is a Bodine electric motor operating at 9.6 rpm. This is bolted diagonally to the underside of the base and mounted on rubber grommets in such a way that the motor drive-shaft points vertically into the center of the base (Fig. 3). The motor drive-shaft can be rotated, if necessary, to the required position.

The turntable drive-shaft is a 3/8-in. stainless steel rod, threaded at one end to fit the turntable. It is coupled to the drive-shaft of the motor by a suitable coupling, such as a stainless steel sleeve and set-screws. In order to reduce vibration of the turntable to a minimum, the shaft is split between the base and burner ring support, and connected with a short length of hard rubber tubing.

Control Panel and Controls

A control panel for the burner, fitted into the front of the burner base (approx. 9 x 4 in.), accommodates the master and motor switches, high-voltage sparker switch, indicator lamp, and fuse (Fig. 1). A relay, required for the independent operation of the motor, is fitted to the back of the panel, together with a connector strip.

The high-tension source (Tesla coil) is clamped to the rear of the base (Fig. 3). An external timer is used to switch the burner on and off.

A diagram of the electrical circuit is shown in Fig. 5.

OPERATION

The dishes containing the samples and sodium fluoride pellets are placed, in order, on the support rings. Generally, two rings will be vacant and can be used to indicate the order of the dishes. The timer is set for the required time, and the motor switch is switched on, activating the motor. The master or operating switch is then switched on, opening the gas valve and starting the timer. By pressing the sparker switch immediately afterwards, the gas is ignited.

When fusion is complete, the gas is automatically switched off. The motor continues to rotate the dishes until they are cool, and is then switched off. After removal of the dishes the apparatus is ready for the next set. To facilitate loading the dishes, the motor can be switched on and off independently of the timer and gas valve.

DISCUSSION

The main advantage of the rotary burner over the static types, e.g. Fletcher burner, is that each dish is heated to essentially the same temperature. This eliminates problems due to hot and cold spots which are inherent in a burner of the Fletcher type.

This apparatus is easy to load, unload, and manipulate. There is no air supply to be regulated, and once the gas supply is adjusted by means of the needle valves on the burners, no further adjustment is necessary.

Variation of the height of the dishes above the burners is easily accomplished by rotation, up or down, of the turntable on the threaded drive-shaft. Thus the position of maximum heat can be readily fixed. All the wire loops should be in the same plane. Occasional adjustments may be necessary to ensure that this is so.

Incorporation of a flexible gas line enables the whole apparatus to be operated in an inclined position, allowing the melted flux to "wipe" the entire dish, thus providing a more even distribution of uranium and decreasing the formation of bubbles in the bead [2].

The rotary burner was constructed in the workshops of the Technical Services Section of the Mines Branch.

PARTS LIST

A list of parts for the rotary burner which were obtained from suppliers is given below. All other parts were constructed in the workshop.

Motor: Bodine Electric, Chicago. Model 332TL Type NS1 - 12 RA1, 115 V, 0.6 amp., 1/70 HP, 180/1 ratio, 9.6 rpm.

Relay: Allen and Bradley No. 700 C 110A1

High frequency coil: CENCO, Cat. No. 80730.

LPG Burners: Fisher Scientific Ltd., Cat. No. 3-907 P.

Solenoid: Automatic Switch Co. (ASCO), 115 V, 20 W, ½-in. pipe, Cat. No. 6030A42.

Timer: Fisher Scientific Ltd., Cat. No. 6-656.

Toggle switches (2); push-button switch (1), and indicator light (1).

Approximate cost of the above parts was $220.00.

ACKNOWLEDGEMENTS

I wish to thank Mr. D. M. Norman, Mr. E. J. Trudeau, Mr. C. R. Jermy and Mr. R. J. Binette of the Technical Services Division for construction of the rotary burner.

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2. Stevens, R. E., Wood, W. H., Goetz, K. G., and Horr, C. A., Anal. Chem. 31, 962 (1959).

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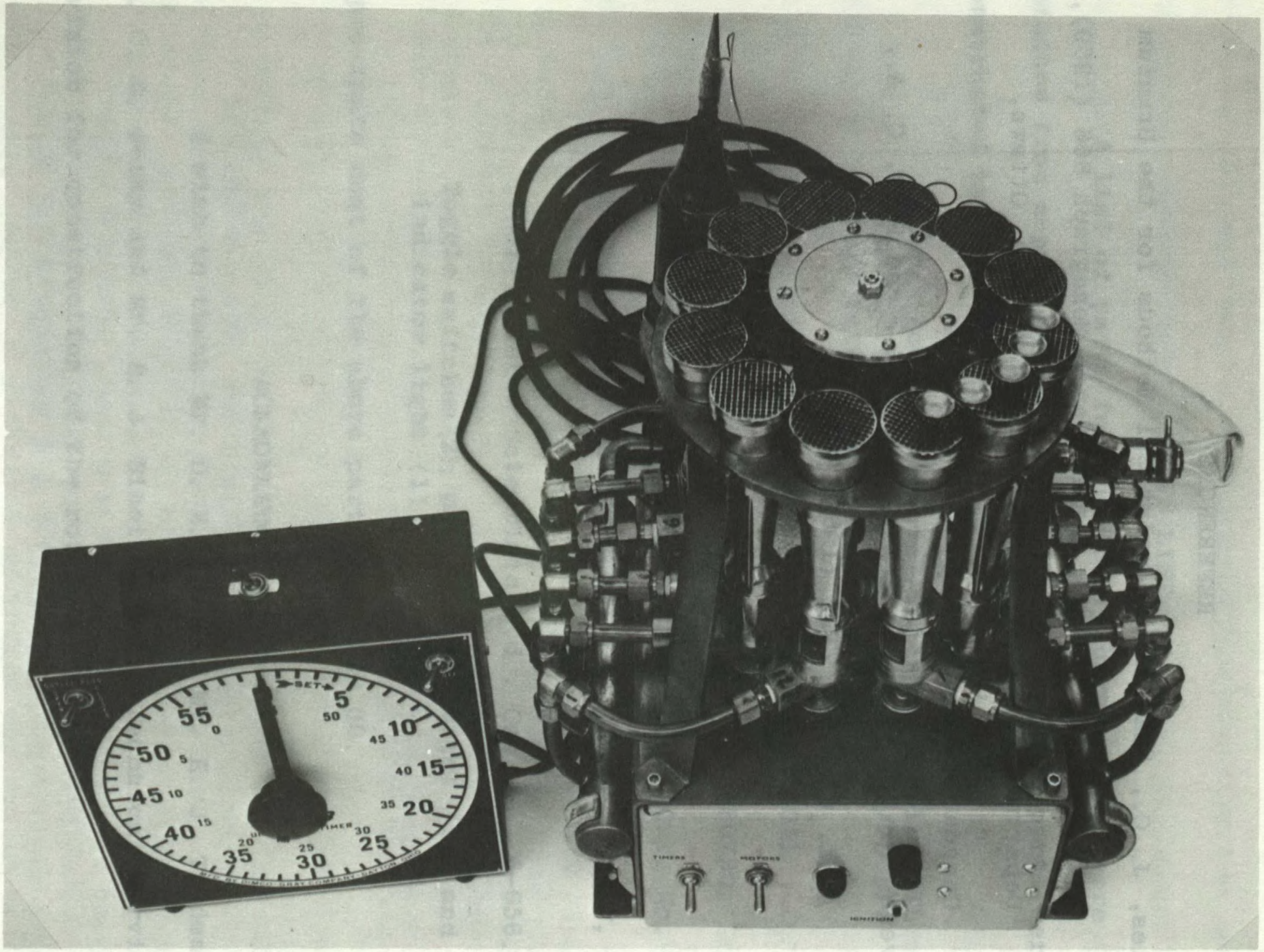


Figure 1, General view of the rotary burner.

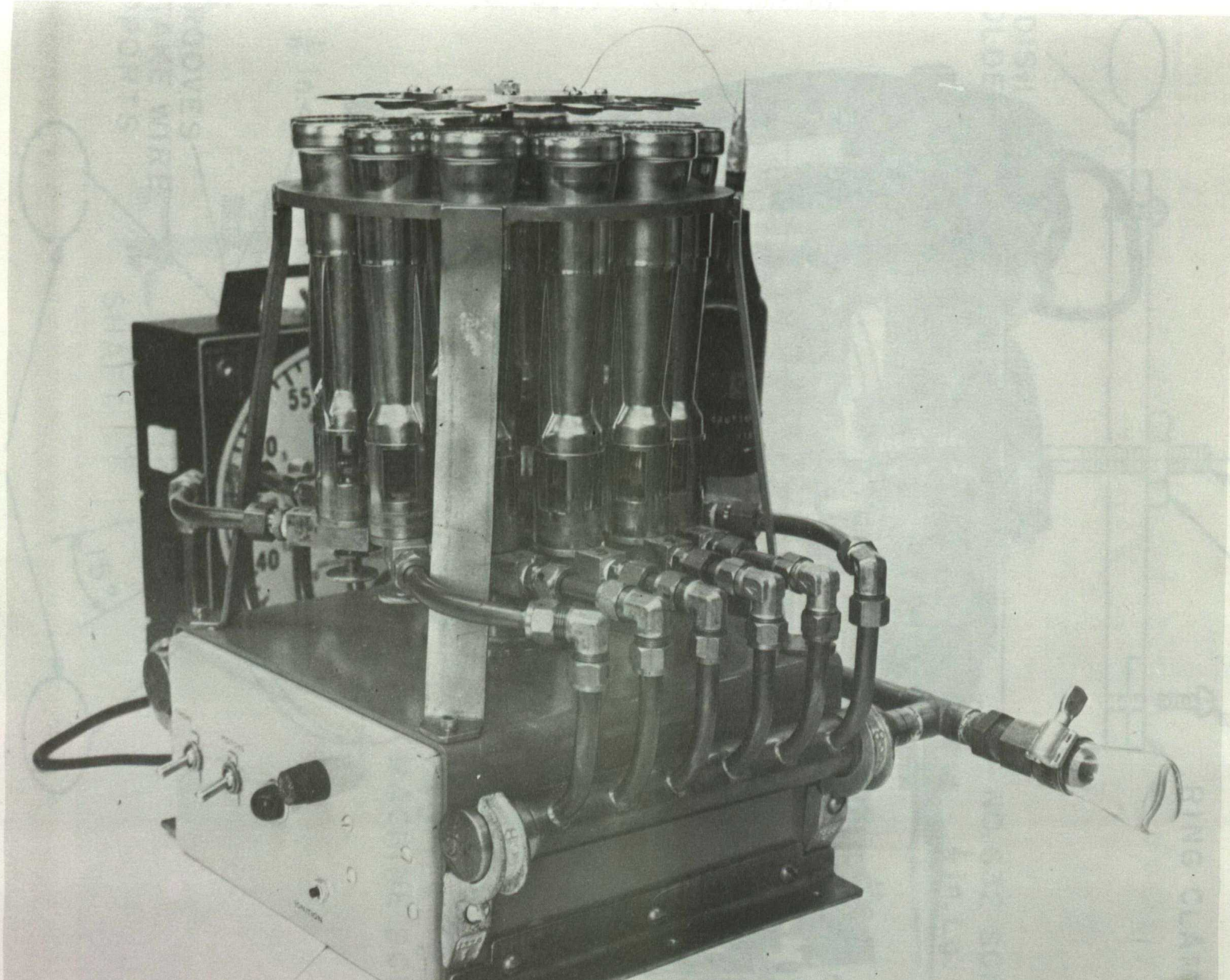


Figure 2. Side view of burner, showing construction of the manifold.

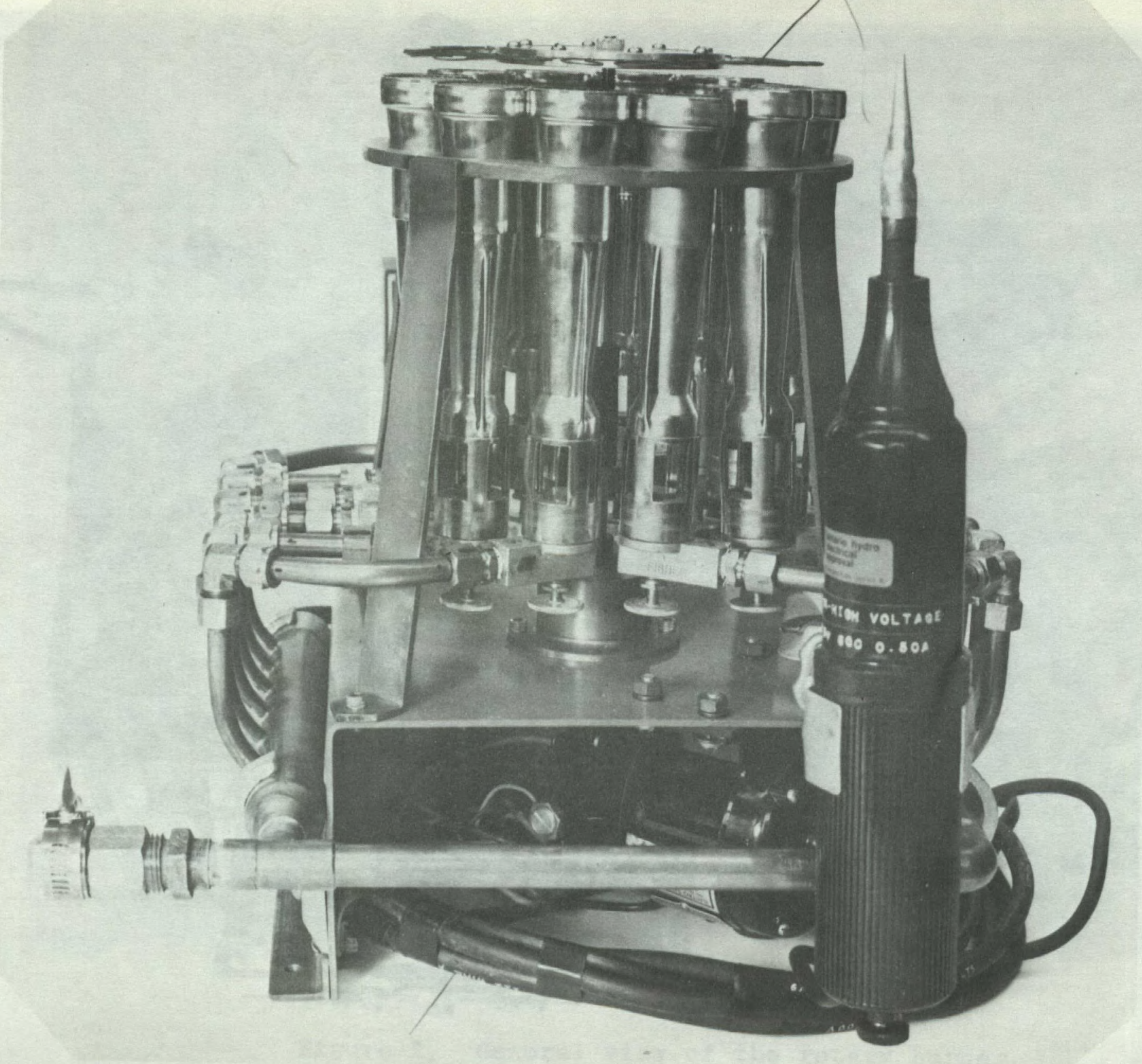
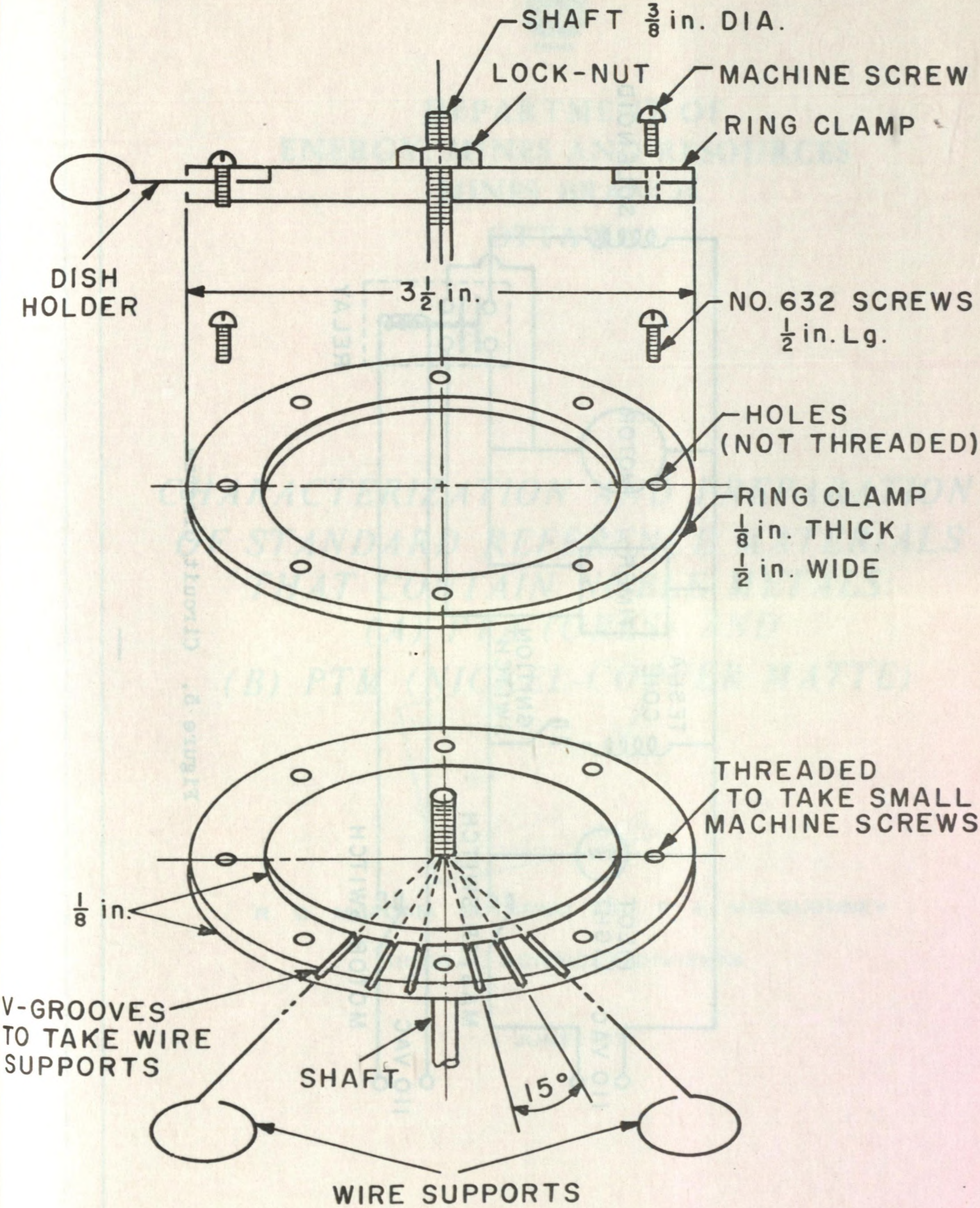


Figure 3. Rear view of the rotary burner.


SHAFT $\frac{3}{8}$ in. DIA.
LOCK-NUT
MACHINE SCREW
RING CLAMP
DISH HOLDER
$3\frac{1}{2}$ in.
NO. 632 SCREWS $\frac{1}{2}$ in. Lg.
HOLES (NOT THREADED)
RING CLAMP $\frac{1}{8}$ in. THICK $\frac{1}{2}$ in. WIDE
THREADED TO TAKE SMALL MACHINE SCREWS
$\frac{1}{8}$ in.
V-GROOVES TO TAKE WIRE SUPPORTS
SHAFT
15°
WIRE SUPPORTS

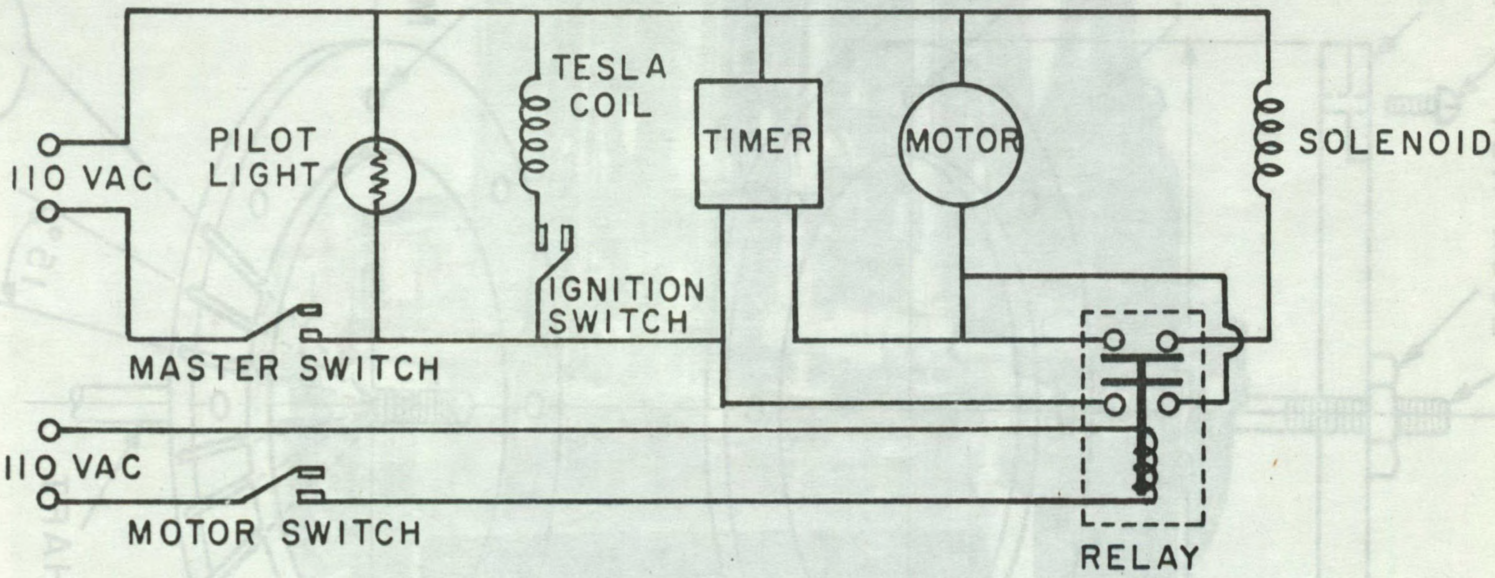


Figure 5. Circuit diagram.