DP -164

Metallurgy and Ceramics

AEC Research and Development Report

A NONBOND DETECTOR FOR HOLLOW SLUGS

by

J. D. Ross and R. W. Leep

Instrument Development Division

October 1956

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E. I. du Pont de Nemours & Co.
Explosives Department - Atomic Energy Division
Technical Division - Savannah River Laboratory

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ABSTRACT

A tester was developed to detect nonbonded areas between the cladding and the core of hollow slugs. These slugs are one inch in diameter and eight inches long, and have a 3/8 inch axial hole. The tester employs an ultrasonic detector previously developed at the Savannah River Laboratory. A transducer 5/16 inch in diameter was developed to pass down the inside of the slug and a mechanical feeder was constructed to provide an automatic inspection cycle.

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A NONBOND DETECTOR FOR HOLLOW SLUGS

INTRODUCTION

Reactor fuel elements can be tested for nonbonded areas between the cladding and the core by transmitting ultrasonic pulses through the element.[1] Nonbonded areas are detected by their attenuation of the ultrasonic pulses. Solid cylindrical fuel elements, or slugs, may be rotated as they pass between the transmitting and receiving transducers to provide a complete inspection.

It was not possible, however, to detect nonbonds by passing an ultrasonic beam along a diameter of a cylindrical fuel element one inch in diameter containing a 0.375 inch axial hole. Refraction and interference effects that were due to the hole made the ultrasonic transmission information unintelligible. It was necessary therefore to develop an instrument that would be suitable for testing these hollow slugs.

SUMMARY

An ultrasonic instrument was developed that inspects hollow slugs for nonbonded areas. A small receiving transducer of barium titanate was designed that passes down the inside of the slug so that the ultrasonic pulses traverse the wall only once. A mechanical feeder was constructed to rotate the slug and translate the transducer assembly to provide complete inspection.

The inspection time for a hollow slug eight inches long is approximately ten seconds. The inspection rate is about four slugs per minute when allowance is made for manual handling.

DISCUSSION

The additional interfaces introduced by the coaxial cavity in the hollow slug shown in Figure 1 reduce the ultrasonic energy that can be transmitted directly through both sides of the element. As a result, the ultrasonic energy that passes through the slug by indirect routes may be more intense than the direct signal. However, it was found possible to make the direct signal predominate by placing the receiving transducer inside the hole so that the slug wall was traversed only once by the ultrasonic beam. This finding formed the basis for the successful development of the desired instrument that is shown in Figure 2.

TRANSDUCER ASSEMBLY

Figure 3 is a sketch of the transmitting and receiving transducers and their positions relative to the slug under inspection. The barium titanate transducers were supplied by the Erie Resistor Corporation and have a natural frequency of approximately 900 KC. The disc-shaped transmitting transducer was cemented in a stainless steel holder with epoxy resin. The receiving transducer was cut to a rectangular shape and cemented in the end of a tube 5/16 inch in diameter as shown in Figure 3.

ELECTRONIC CIRCUIT

The detector circuit was developed at the Savannah River Laboratory and was described in a previous report.[1] The output of the detector is fed to a counter which is preset for a count that represents the maximum nonbonded area that is permissible. If this count is exceeded, an alarm is sounded to notify the operator. Figure 4 is a photograph of the back of the electronic chassis showing its general arrangement.

FEEDER

The feeder mechanism is sketched in Figure 5. It consists of two rollers to rotate the slug and a device to translate the transducer assembly. The feeder, with the exception of the motor package, is mounted in a tank and the testing is performed under water. Figure 6 is a photograph of the rollers and the transducer assembly.

The rollers are 1-3/4 inch rubber, bonded to stainless steel shafts that are mounted on 1-15/16 inch centers. "Purebon No. 9," manufactured by the Pure Carbon Co., was used as bearing material for the rollers and drive shaft. One roller is driven by a shaft that passes through the end of the tank to the motor package.

The transducer assembly is mounted on two guide rails and is moved by a cable attached to a drum. The drum is driven in either direction by the motor package.

The motor package consists of an 1800 RPM, 1/12 HP drive motor coupled to a gear box. The gear box has a 5 to 1 reduction and a double shaft extension on the output. One end of the output shaft drives the rollers and the other output is coupled through a magnetic clutch to the armature of the return motor. The return motor is a 1750 RPM, 1/70 HP gear head motor with a 60 to 1 reduction. The cable drum is mounted on the output shaft of the gear reducer. The hub of the drum contains a slip clutch to protect the gears in case the probe assembly runs into an obstruction during a test.

OPERATION

The operator places a slug on the rubber rollers and presses the start button to energize the drive motor and magnetic clutch, which rotate the test piece and translate the transducer assembly. The return motor is not energized at this time and serves only as a gear reducer to advance the transducer assembly 1/8 inch for each revolution of the fuel element. When the transducers have entered the end of the slug, a microswitch is automatically depressed to start the counter. When the transducers reach the far end of the slug, another switch is automatically depressed to stop the counter and initiate the return sequence. The drive motor and clutch are cut off and the return motor energized to return the probe assembly to the initial position. The entire inspection cycle requires ten seconds. The probe return is accomplished in three seconds. The tested slug may then be exchanged for a new one and the test cycle repeated.

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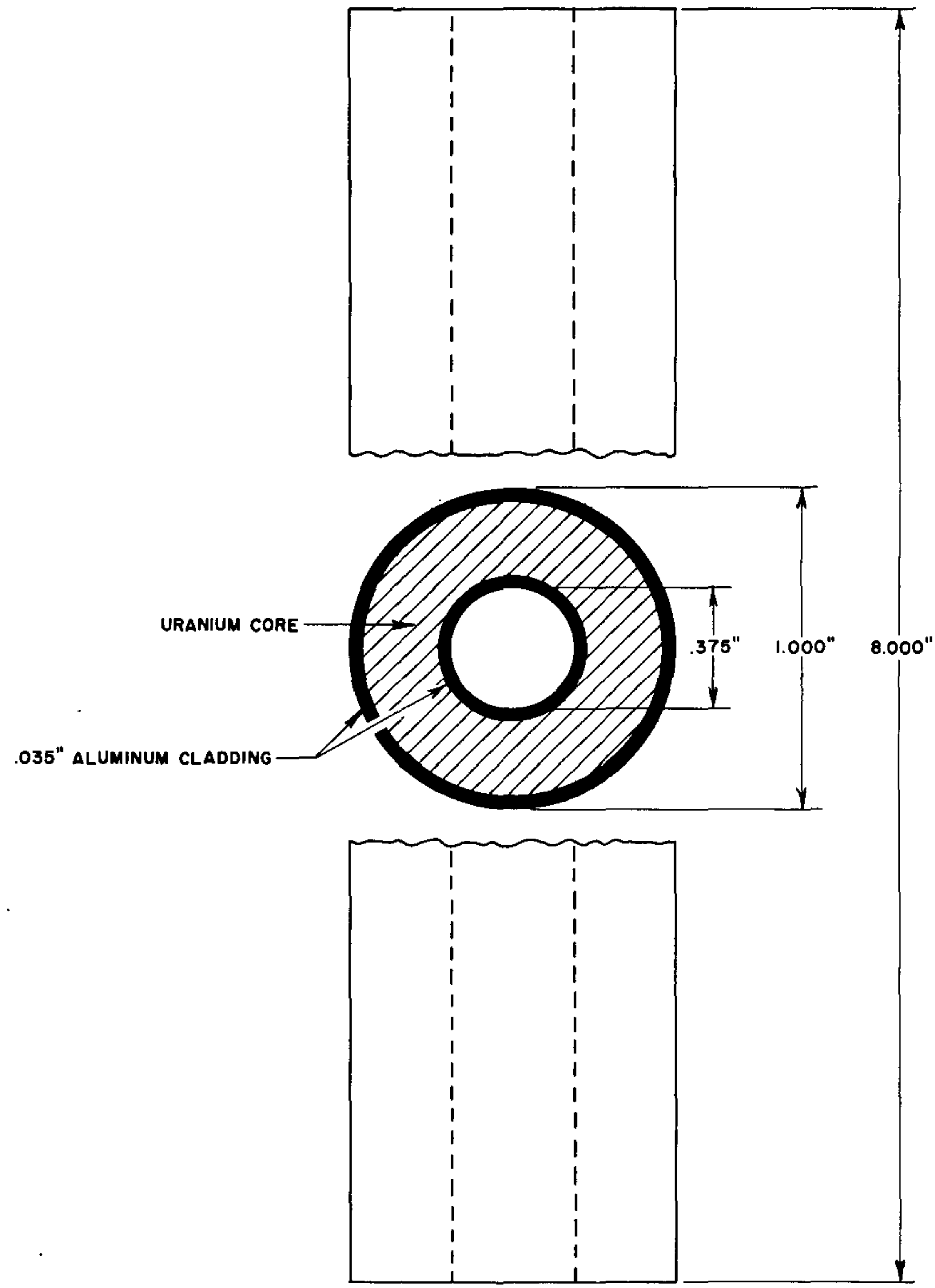
BIBLIOGRAPHY

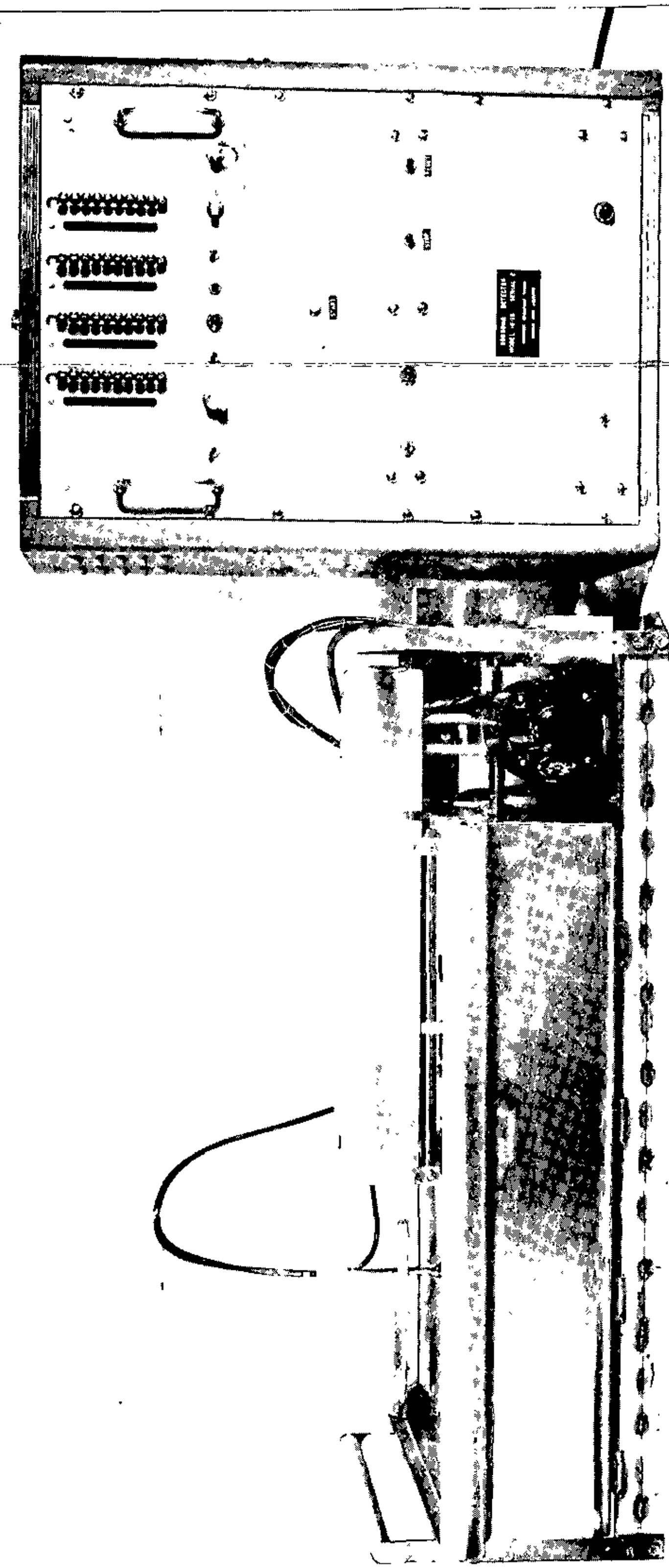
1. Ross, J. D. and Leep, R. W. A Simplified Electronic Circuit for Ultrasonic Inspection. E. I. du Pont de Nemours and Co., DP-120, January 1956.

FIGURE 1



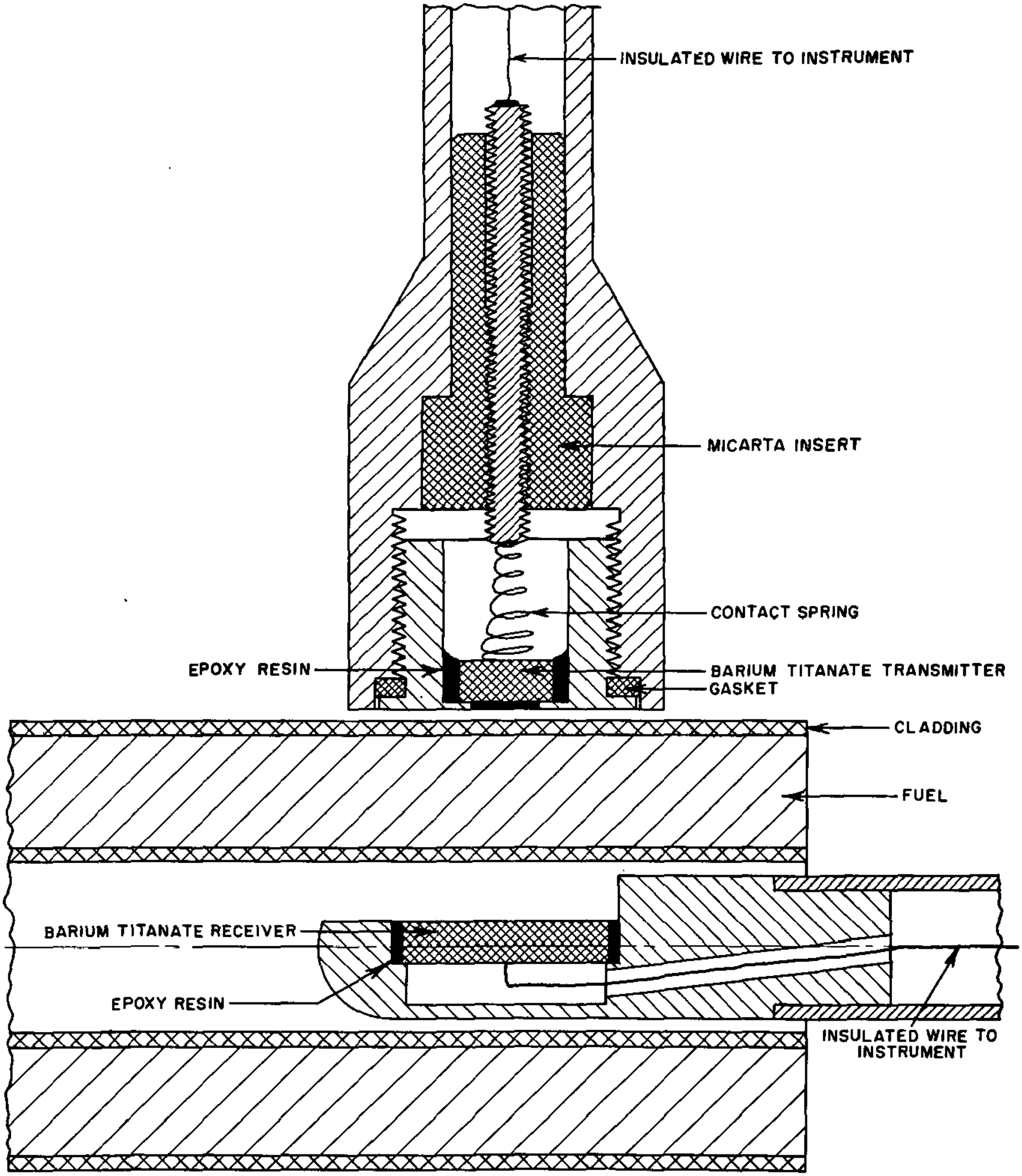
CROSS SECTION OF A HOLLOW SLUG

FIGURE 2



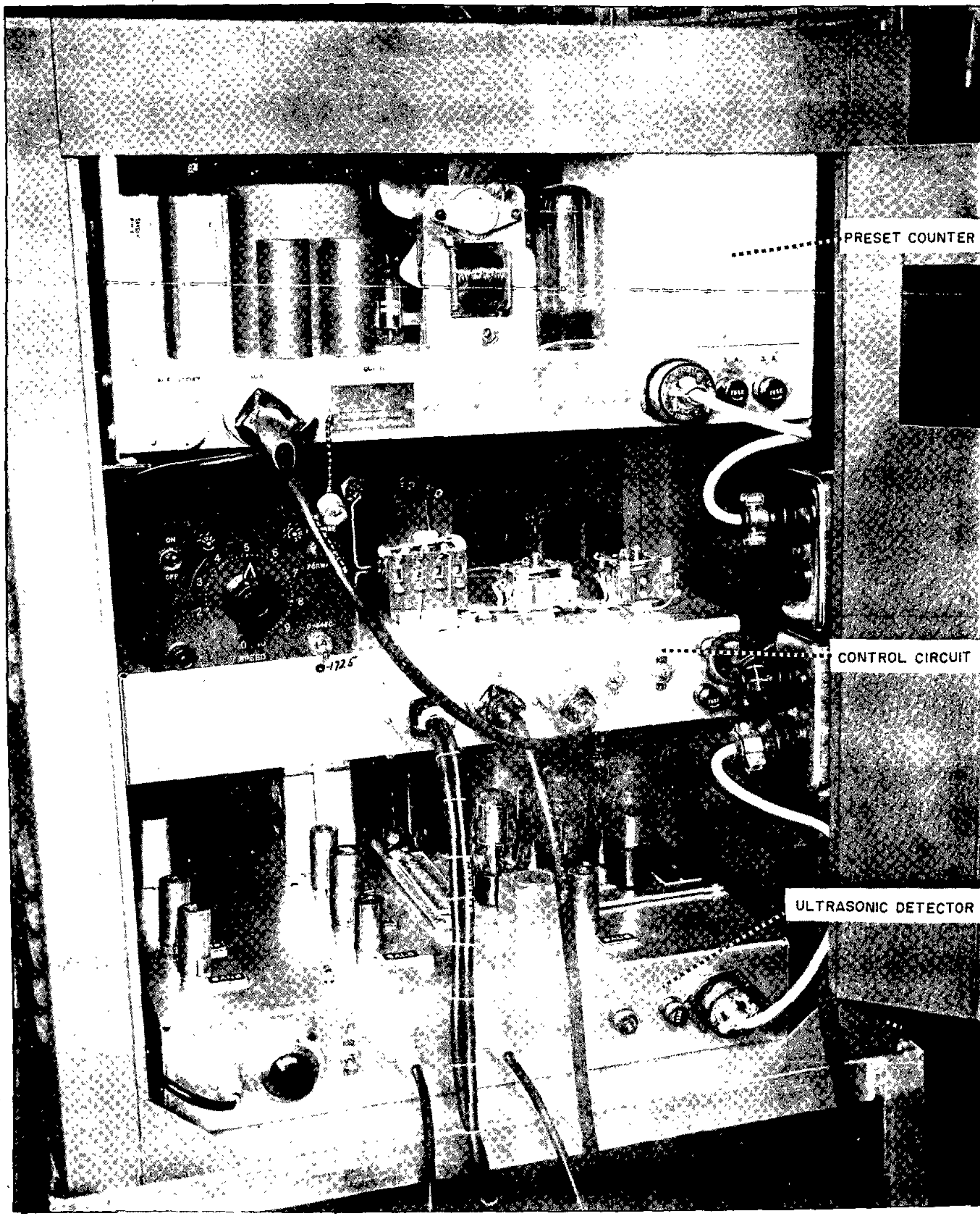
COMPLETE TESTER

FIGURE 3



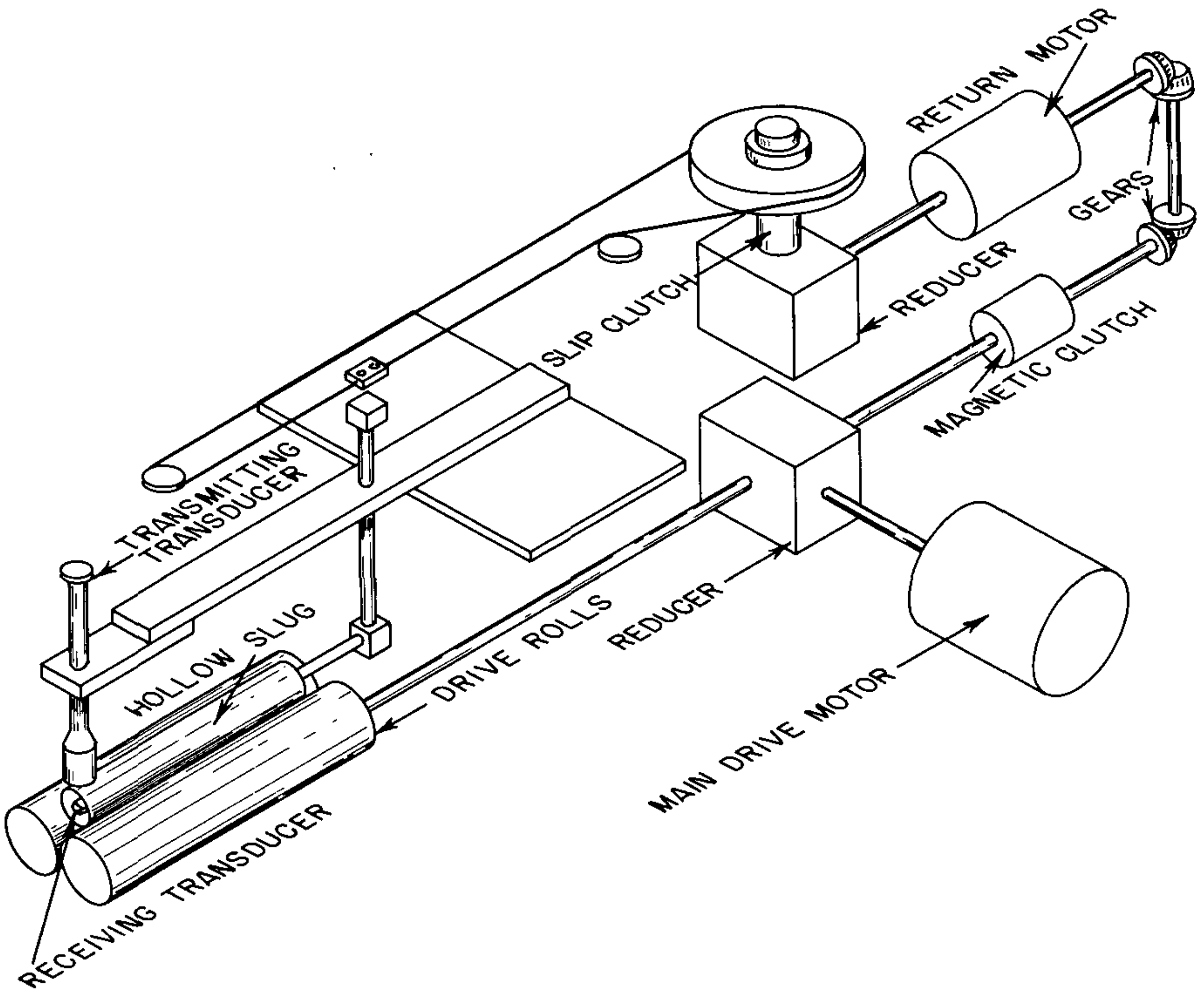
TRANSDUCER ASSEMBLY

FIGURE 4



ARRANGEMENT OF ELECTRONIC CHASSIS

FIGURE 5



FEEDER MECHANISM

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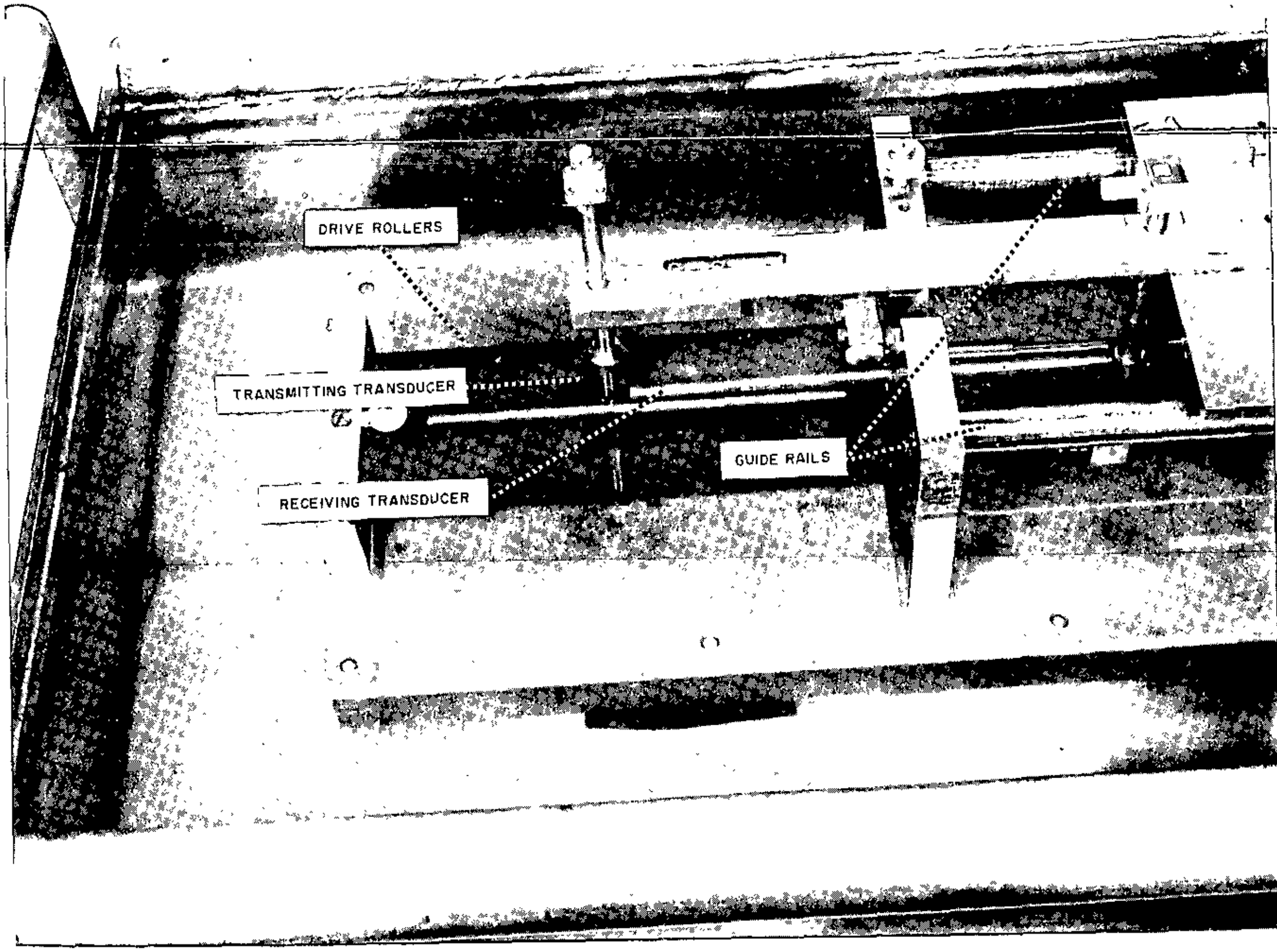
FIGURE 6



DRIVE ROLLERS AND MOUNTED TRANSDUCER ASSEMBLY

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