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AUTOMATIC EXTENSOMETER FOR ELASTOMERS

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AUTOMATIC EXTENSOMETER FOR ELASTOMERS

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ABSTRACT

An extensometer has been designed to measure accurately the elongation of any elastomer or similar material and to record electronically this data on the chart of the testing instrument. This instrument, which may be used by operators with a minimum of experience, results in reproducibility of data from laboratory to laboratory since the extension is measured by a semi-automatic process.

Although it was designed for accuracy (from 0 to 1000 percent using a one-inch original gauge), the instrument is rugged enough to require no special handling. It is relatively simple to fabricate in a standard machine shop and can be adapted to almost any tension testing instrument (conforming to ASTM or Military Specifications for testing elastomers) at a very low cost when compared to other commercial laboratory equipment.

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PROPULSION AND VEHICLE ENGINEERING LABORATORY
RESEARCH AND DEVELOPMENT OPERATIONS

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AUTOMATIC EXTENSOMETER FOR ELASTOMERS

SUMMARY

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An extensometer was designed for measuring accurately the elongation of elastomers and similar materials and recording this data (by an electronic process) on the chart of the testing instrument. The instrument, which may be used by technicians with a minimum of experience, yields data which are reproducible from laboratory to laboratory since the extension is measured by a semi-automatic process.

Although it was designed for accuracy, it is also rugged enough to require no special care in handling, which makes it ideal for operations where numerous routine control tests are conducted. The instrument is adaptable to almost any tensile testing machine conforming to ASTM (ref. 1) or Military Specifications (ref. 2) and can be fabricated in a normally equipped machine shop at a relatively low cost when compared to most commercial laboratory equipment. Information relative to the design, fabrication, and operation of the extensometer is included in this report, along with photographs and illustrations of the entire unit and components.

Author

INTRODUCTION

In physical property evaluations of rubber and similar materials, the values of tensile strength and elongation are essential to the chemist and engineer. These properties serve as an almost universal means of evaluating the quality or uniformity of the compound and as a convenient index of quality where numerous control tests are conducted. Also, the modulus (tensile stress) of the compound, which is of particular importance in the design of a product where rubber is subjected to tensile stress, may be readily obtained from these values.

Unlike metals or rigid plastics, which fail at relatively low extension, one of the most distinguishing characteristics of rubber is its great extensibility and deformability. Consequently, special clamping devices, specimen configuration, and high test speeds become significant factors in accurately measuring these high extension values. ASTM and Military Specifications have outlined certain procedures which control many of these factors for determining tensile properties. However, there is still a significant lack of "standard procedures" or practical commercial instruments available for measuring rubber elongation. Current methods vary from laboratory to laboratory and usually employ a manually operated apparatus or instruments that are too complex for routine control tests.

Current manual techniques are generally grouped into one of three categories: the "hand rule technique," the "sliding bar technique," and the "tape method." The "hand rule technique" is simply a measurement of the change in length of the test specimen from two reference points by manually following these with a standard scale graduated in one-inch increments. The degree of accuracy which is obtained depends upon operator experience and usually results in fatigue of the operator and subsequent inaccuracy after a relatively short period of time. Data obtained by this method may periodically vary daily in the same laboratory and usually varies in different laboratories. The "sliding bar technique" (of which there are numerous variations) also is dependent upon operator skill for the accuracy obtained. The operator must follow manually two reference points on the specimen from the start of the test to the moment of failure. Although this method is considered superior to the hand rule, it too can result in operator fatigue, and, consequently, a significant number of inaccuracies may occur. Two photographs, FIG 1 and 2, of the technique formerly used in this laboratory are included in this report. The most accurate of the visual methods is probably the "tape method" where a thin, graduated film is bonded or clamped to the test specimen. The principal disadvantage of this method is the construction of the film and follower units which must be kept light and flexible, resulting in occasional broken tapes. At the present time, these films are expensive, and limited experience indicates that they should be replaced periodically due to wear and damage.

It was apparent from the results obtained by each of the above methods that an automatic device was needed to accurately measure rubber elongation and yet remain simple and rugged enough for extended routine tests. Several trial and error procedures were attempted which resulted in a somewhat crude device with certain potential qualities desired in a practical extensometer. After numerous modifications and additional trials, a "pilot" model was developed and studied extensively using elastomers which varied in elongation from 200 to 800 percent. It was from this model that the present extensometer was designed; it is now being used as a "standard procedure" for measuring rubber elongation in this laboratory. The instrument is simple to operate, durable enough for routine tests, accurate to within ± 10 percent total elongation at moment of failure, and automatic once it is clamped to the specimen. Its design allows the extensometer to exert essentially no weight on the specimen and produces no significant friction during the test to cause erroneous values. The design and operation of the extensometer are discussed in the following paragraphs with photographs and drawings to illustrate the simplicity and versatility of the instrument.

DESIGN AND OPERATION

The basic design of the extensometer may be noted in FIG 3 and 4. These illustrations are referenced by numbers (1) through (10) in the following paragraphs to give the reader a more concise understanding of each component and its use in the assembly.

A stainless steel mounting rod (1) is employed for locating the assembled instrument between the top and bottom sections of the testing instrument. This rod is equipped with a "screw type" height adjustment, providing a two-inch "up or down" variable which can be modified to fit other types of rubber testing instruments. Two V-grooved stainless steel rollers (2) are centered in roller guides (3) and attached to the mounting rod. The guides are designed with a one and one-half inch adjustment slot for varying the "in-out" position of the rollers and may be adjusted to any point on the mounting rod by means of recessed set screws.

The rollers are equipped with precision ball bearings to eliminate friction in the roller assembly. A flexible stainless steel wire (4) is positioned under and around the rollers and attached to each end of the extensometer shaft (5). This shaft is a stainless steel rod that has been pregrooved in 0.2-inch increments (which may be varied to produce more or less "pips" during tests), potted with a nonconductive resin, and machined to a mirror finish. On this shaft are located two self-releasing, spring-loaded clamps, the top (6) being in a stationary position. This clamp rotates the assembly in correlation with the upper gauge location of the test specimen. The lower clamp (7) is equipped with precision recirculating bearings and follows the lower gauge of the specimen. These horizontal bearings allow the clamp to move freely down the shaft with no significant friction throughout the duration of the test. This entire shaft and clamp assembly is then carefully counterbalanced (8) to remove all weight from the specimen (9) when the instrument is in operation.

A spring-loaded steel sphere, which is inside the bearing housing, rolls freely down the shaft with only enough pressure to insure contact as it passes over the grooved metal contacts. This spring and sphere are activated by a one and one-half volt battery that charges a condenser which, when the contacts are closed by the sphere passing over the metal contacts, causes a momentary pulse of current through a series resistor located in the testing instrument recorder. The voltage across this resistor is applied to the input of the recorder and results in a rapid "pip" at the pen. This produces a small disturbance on the chart at each contact point; consequently, the strain (elongation) at any stress value may be observed directly on the chart.

When the test specimen ruptures, the quick contraction of the specimen ends releases the clamps, and the lower clamp falls to a foam rubber cushion (10) which absorbs the shock from the bearing assembly. The counterbalance allows the extensometer to rest in a free position, thus making it ready for attachment to the next test specimen.

Detailed illustrations of the lower clamp and housing assembly may be noted in FIG 5 and 6. These include an artist's cutaway of the recirculating bearings and the activated contact sphere (FIG 5), as well as a close-up photograph of each of the clamp components prior to assembly (FIG 6). Figure 7 shows a typical chart section removed from the testing instrument, which illustrates the "pips" produced from a specimen having approximately 600 percent elongation. Figure 8 illustrates the simple electronic schematic of the circuit which causes the "pip" disturbance on the chart.

Figures 9, 10, and 11 should be observed in their numbered sequence: FIG 9 illustrates the instrument in a free position, ready for attachment; FIG 10 shows the simplicity of placing the extensometer on the specimen; FIG 11 illustrates a typical test in operation with a standard ASTM dumbbell elongated approximately 450 percent.

EXPERIMENTAL AND CONCLUSIONS

Table I shows a typical correlation of data obtained with the extensometer and data obtained from tests with the "slide-bar" technique. A series of carefully selected NBR rubber specimens, uniform in thickness and quality, was used for these tests. Although there is no significant variation in the data, it is important to note that the manual "slide-bar" in these tests was operated by a skilled technician with years of experience with this apparatus, and the extensometer was placed on the specimen by an operator with only a minimum of experience. It is further evidenced by this data that the extensometer caused essentially no change in the tensile or elongation properties of the material being tested. Numerous tests were made using elastomers of various hardness and elongation, and, from 30 Shore A through 80 Shore A hardness, no significant damage was noted to specimens during the tests. The test instrument crosshead speeds were varied from 1 inch to 20 inches per minute with no effect on the operation of the extensometer. With very slight modification, the instrument can be adapted to almost any rubber testing instrument conforming to ASTM or Military Specifications and can record the specimen extension in increments of 10 to 100 percent, or as required. After weeks of use, the instrument shows no sign of wear or damage; it should give years of service with only a minimum amount of care and maintenance.

TABLE I

COMPARISON OF NBR RUBBER DATA MEASURED
WITH "SLIDE-BAR" AND EXTENSOMETER

A. "Slide-Bar" Used to Measure Elongation

Specimen No.	Modulus (psi) @ 100%	200%	300%	400%	500%	600%	Tensile @Break (psi)	Ultimate Elongation (%)
1	490	1017	1423	1963	2137	2399	2414	610
2	507	934	1458	1835	2212	2360	2449	620
3	465	895	1440	1864	2150	2355	2425	610
Avg.	487	949	1440	1887	2166	2371	2429	613

B. Extensometer Used to Measure Elongation

Specimen No.	Modulus (psi) @ 100%	200%	300%	400%	500%	600%	Tensile @Break (psi)	Ultimate Elongation (%)
1	525	940	1495	1840	2219	2354	2426	625
2	495	905	1505	1825	2167	2327	2438	620
3	510	918	1487	1813	2129	2367	2461	620
Avg.	510	921	1496	1826	2173	2349	2442	622

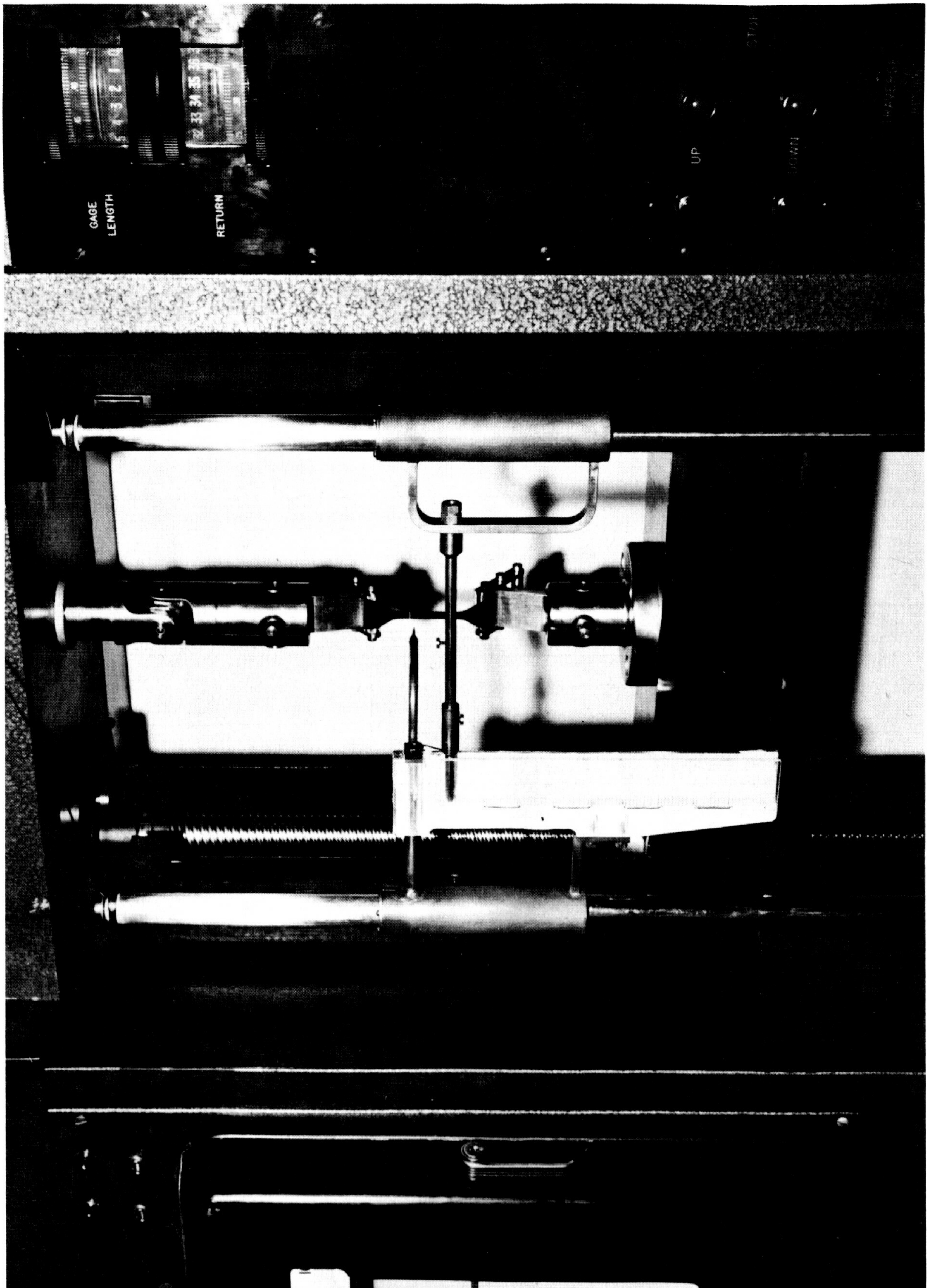

FIGURE 1.– MANUAL "SLIDE BAR" IN POSITION FOR TEST

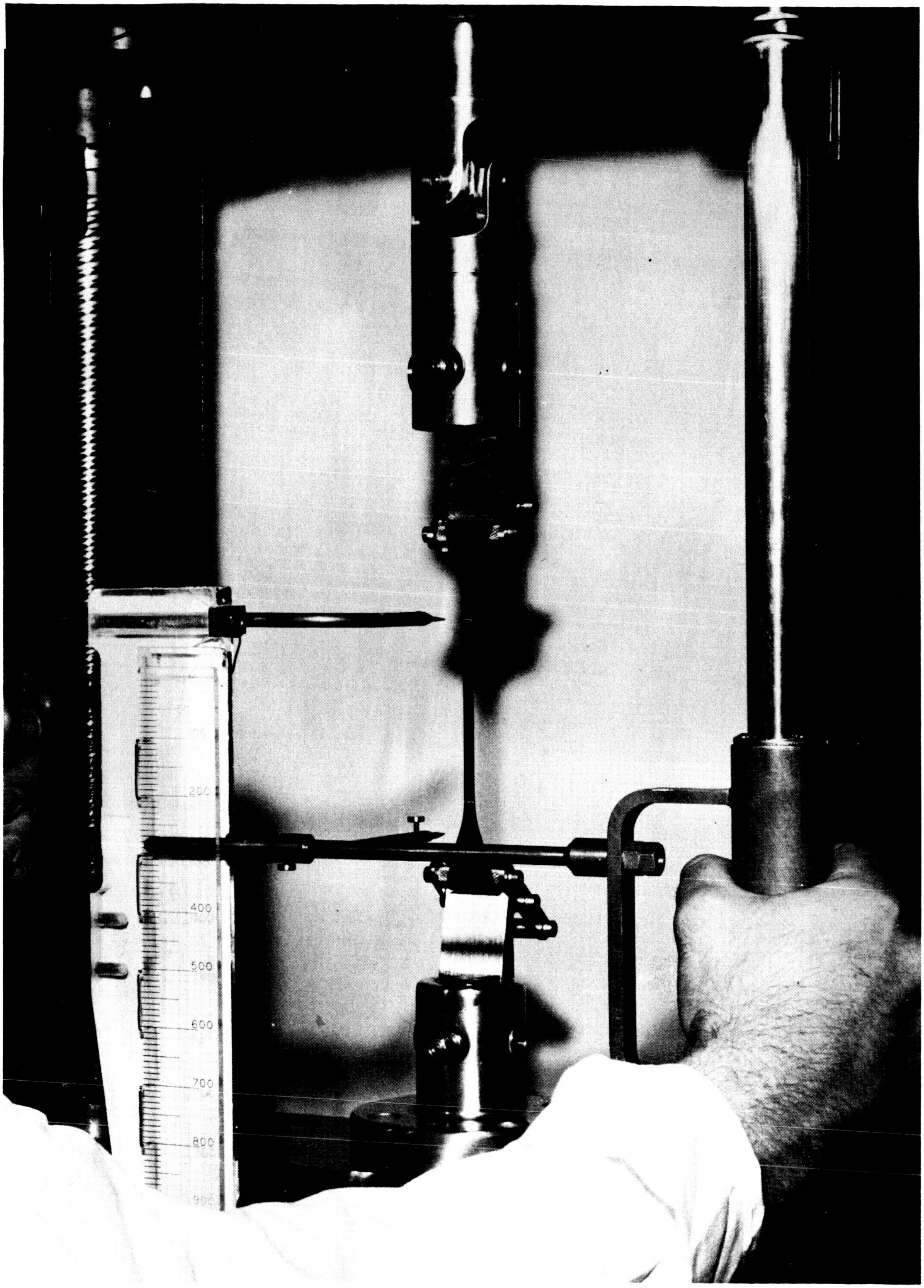

FIGURE 2. -TEST IN PROGRESS USING MANUAL "SLIDE BAR" TECHNIQUE

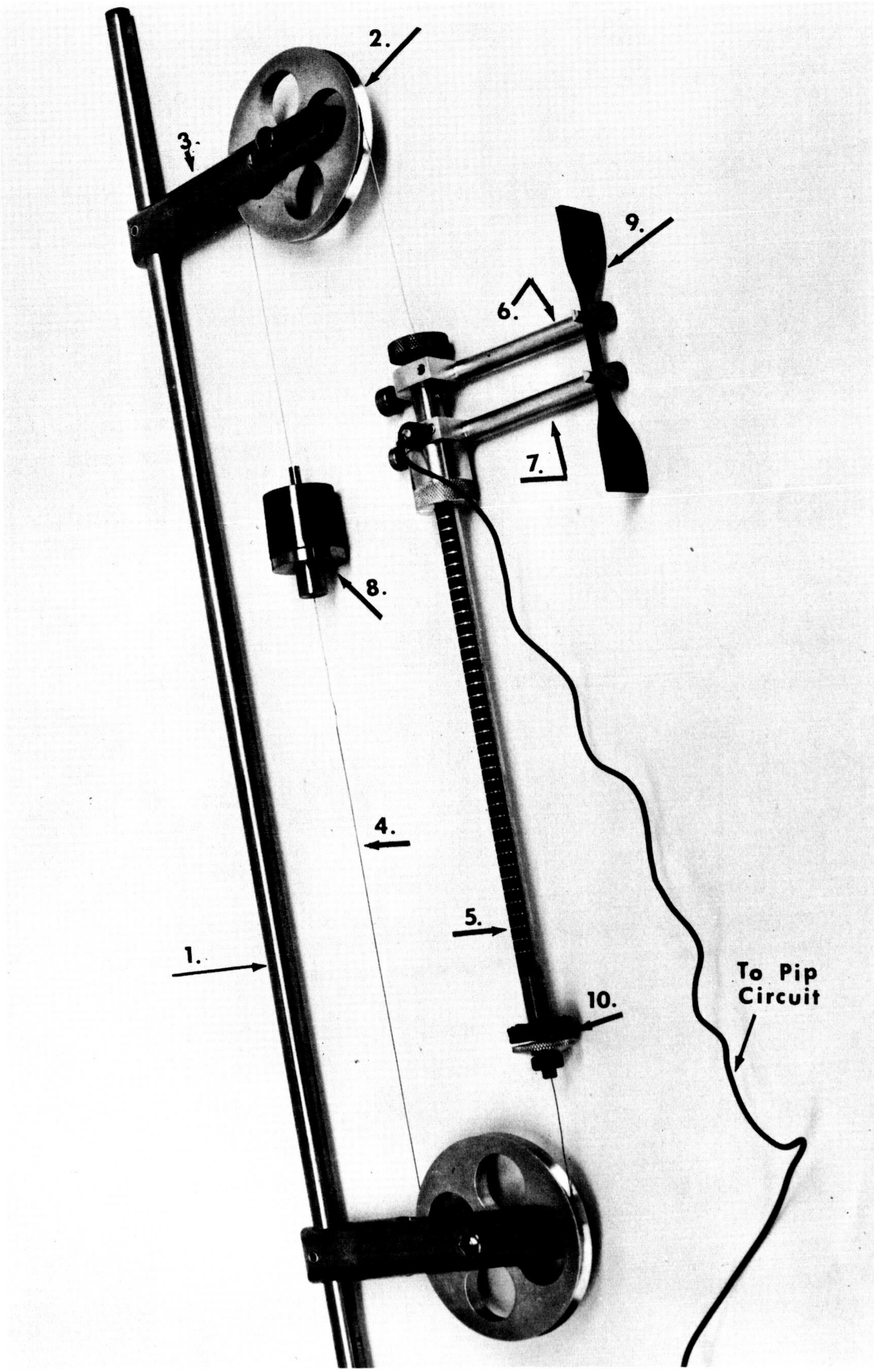

FIGURE 3.-ASSEMBLED AUTOMATIC EXTENSOMETER

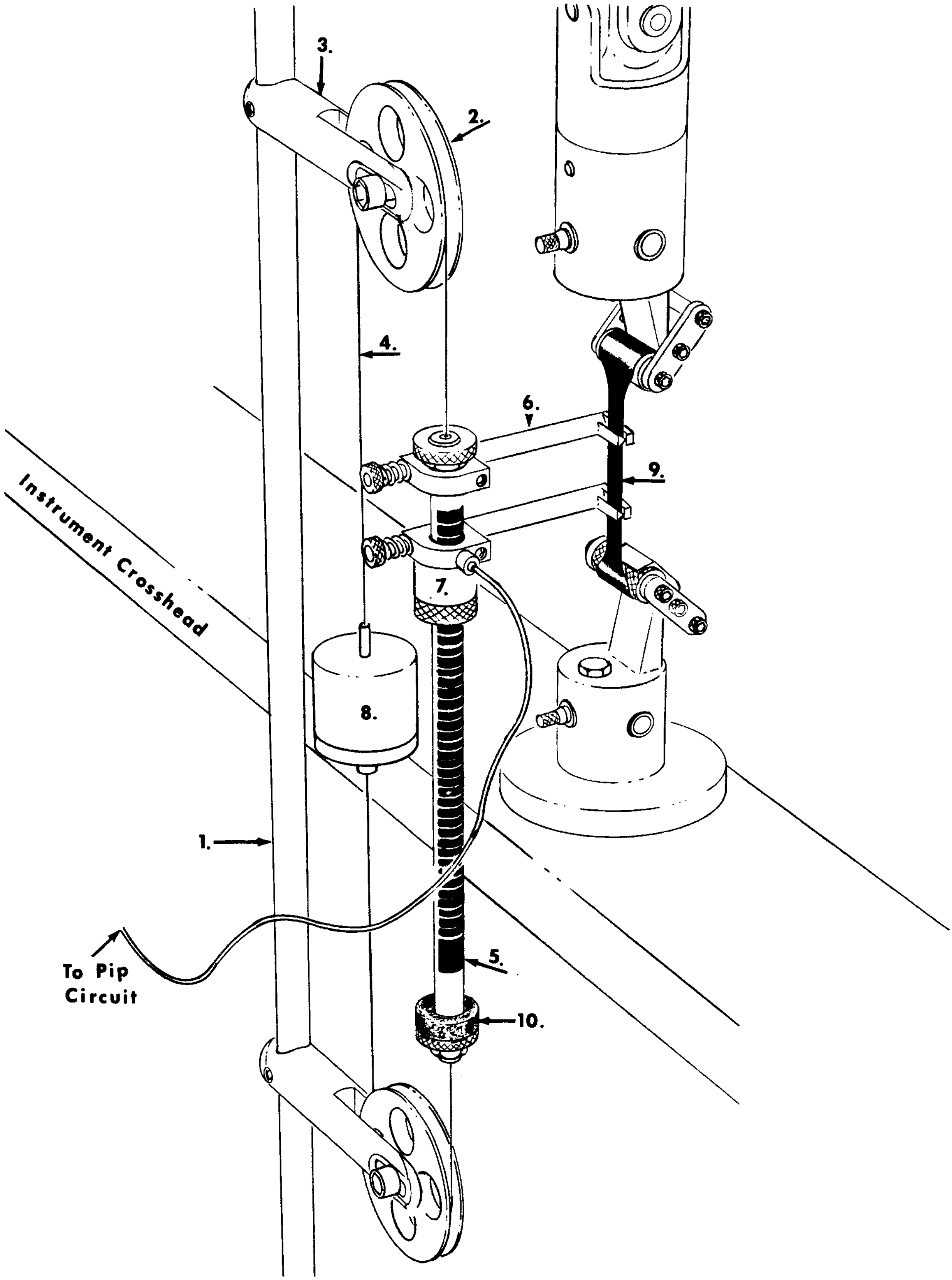

FIGURE 4.-ASSEMBLED AUTOMATIC EXTENSOMETER (ARTIST'S DRAWING)

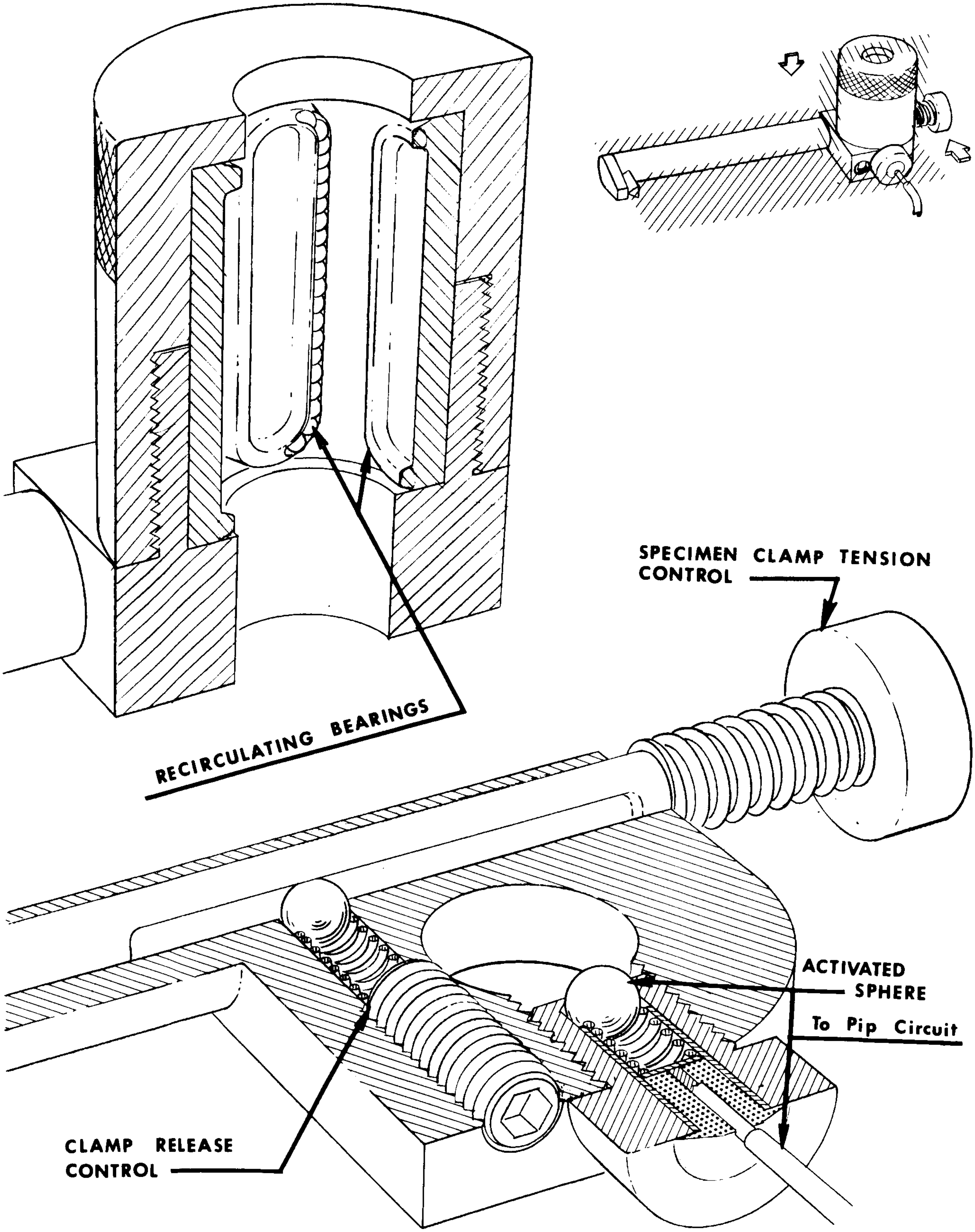

FIGURE 5.-LOWER CLAMP BEARING AND SPRING ASSEMBLY (ARTIST'S DRAWING)

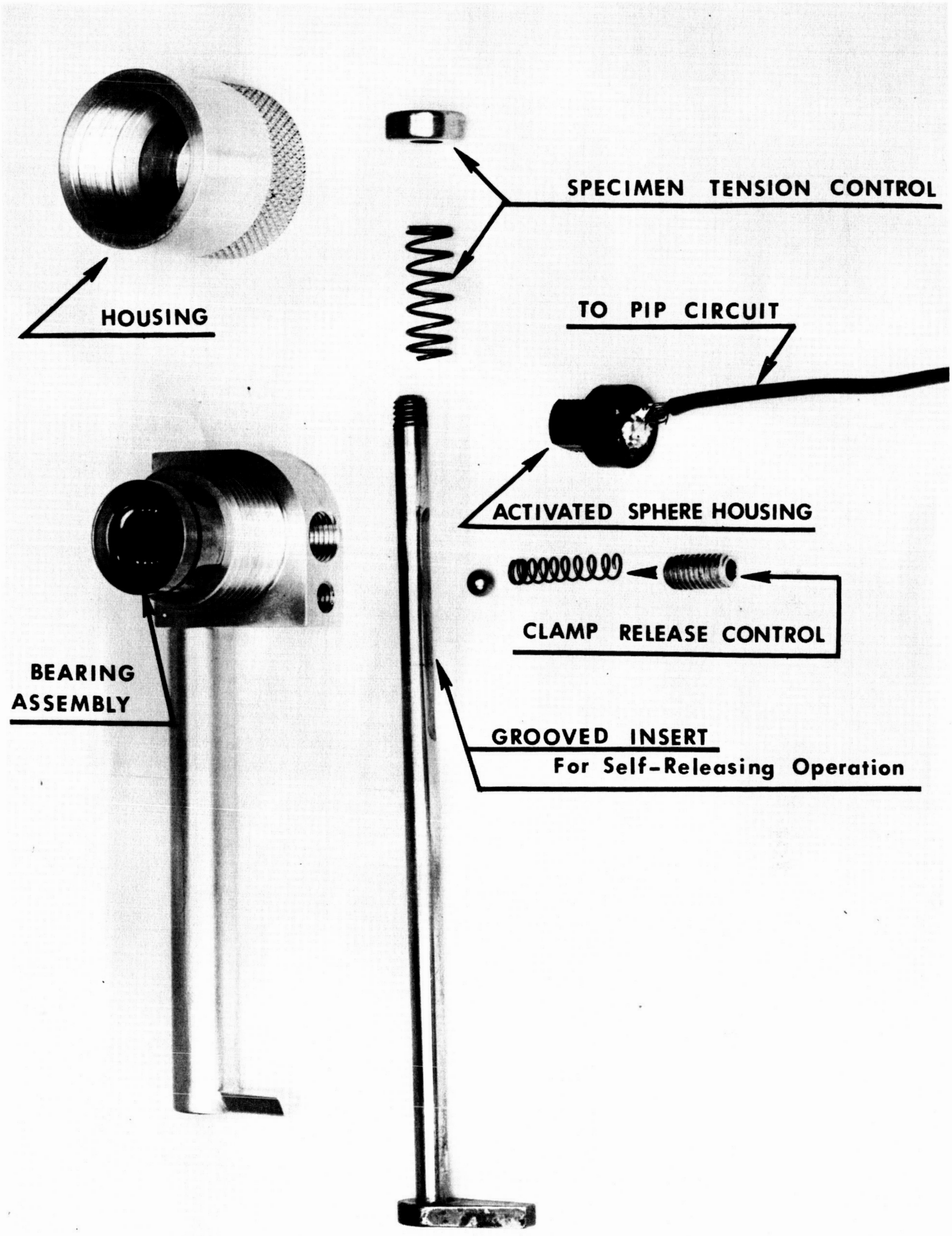

FIGURE 6.- LOWER CLAMP DISASSEMBLED

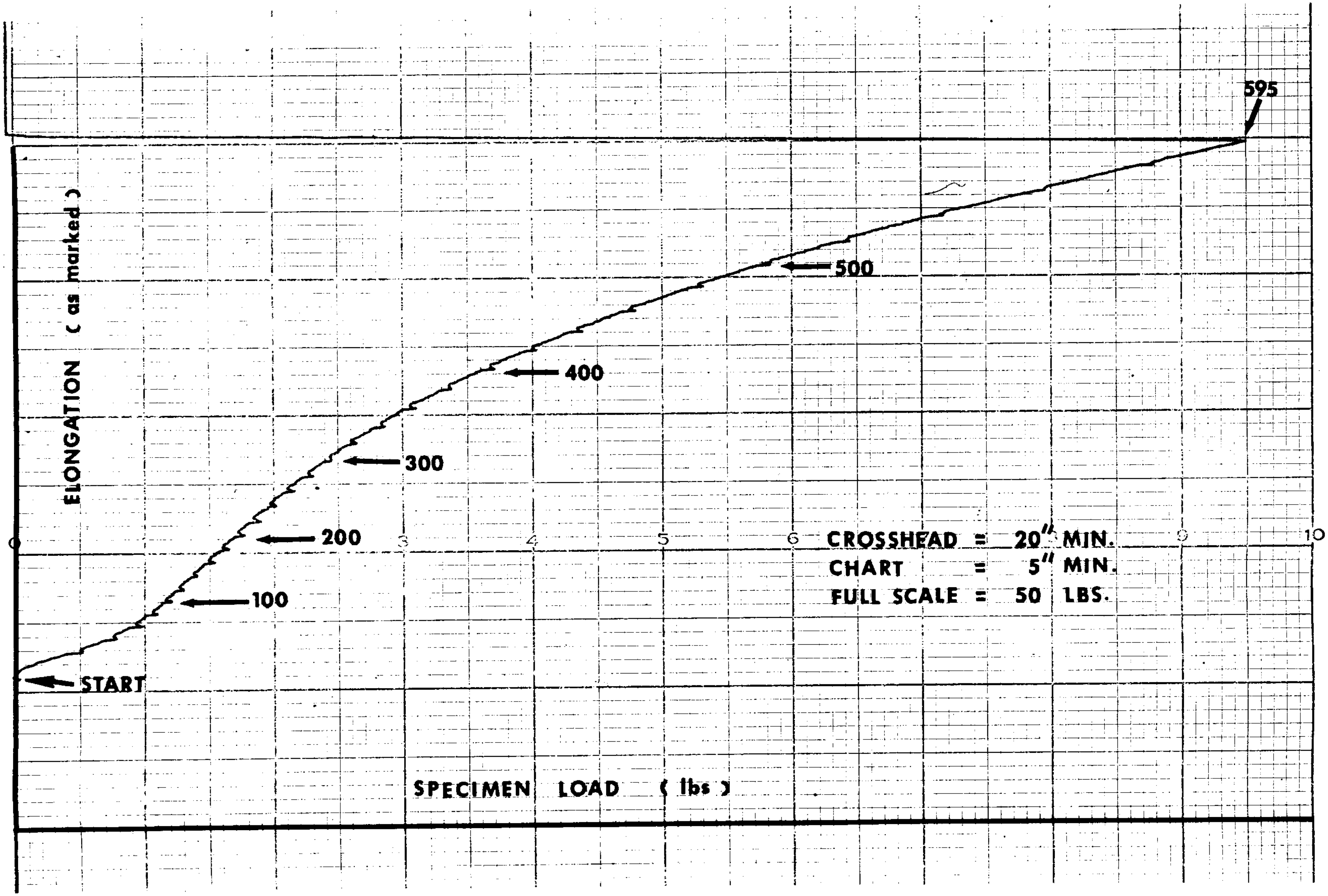

FIGURE 7.- TYPICAL CHART "PIPS" PRODUCED BY EXTENSOMETER

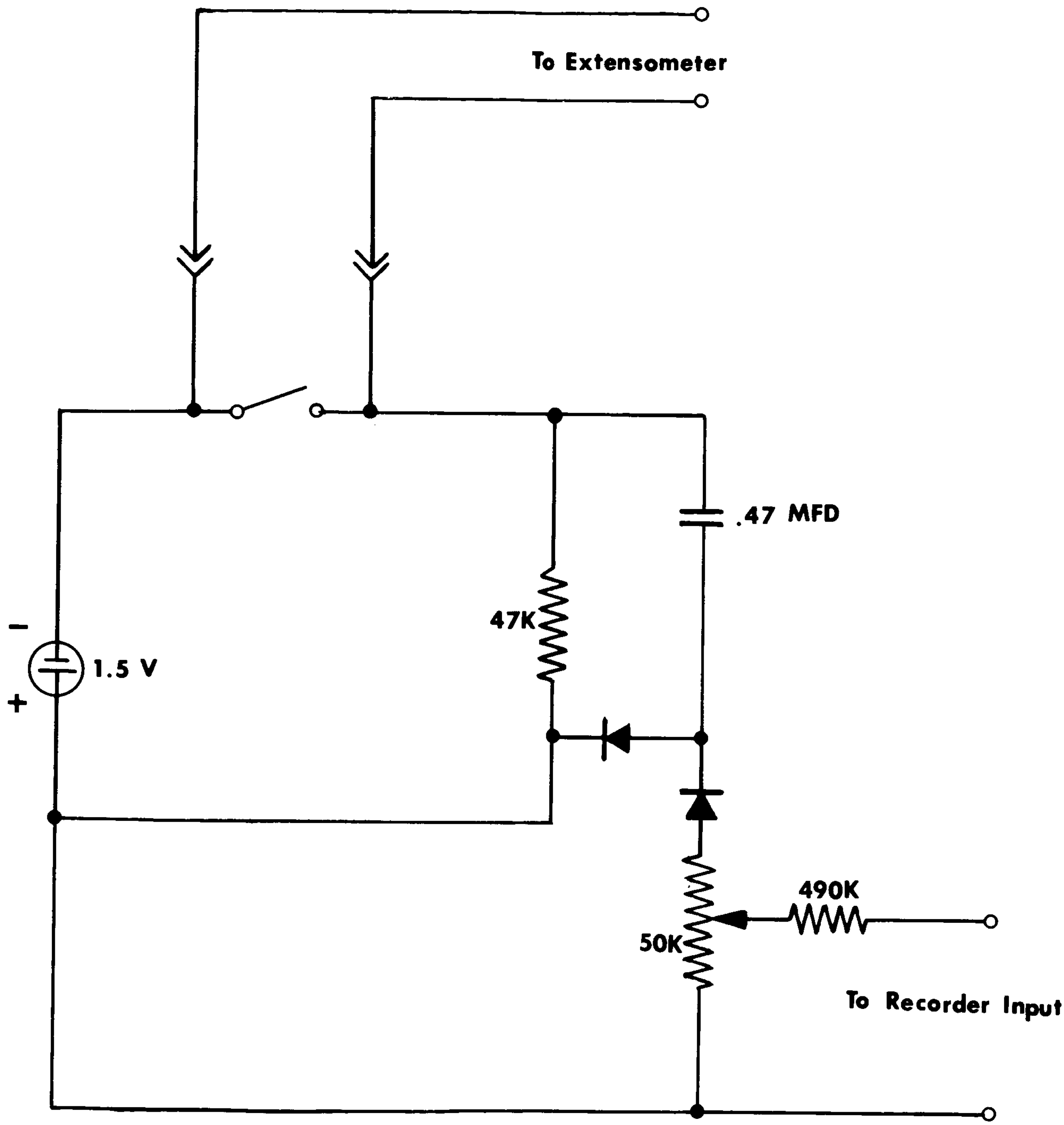

FIGURE 8.- SCHEMATIC OF "PIP" ELECTRONIC CIRCUIT

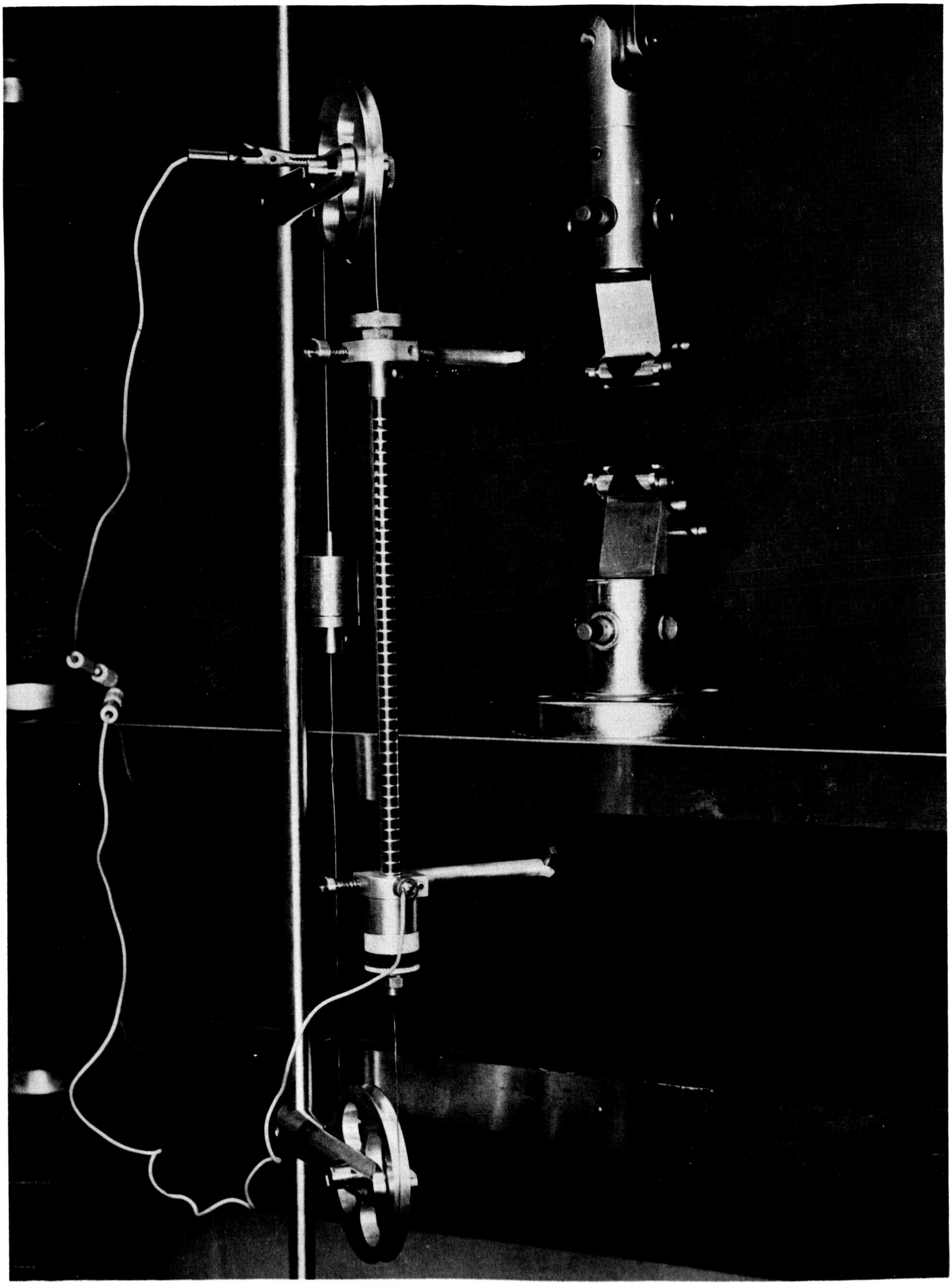

FIGURE 9.- EXTENSOMETER LOCATED ON TESTING INSTRUMENT

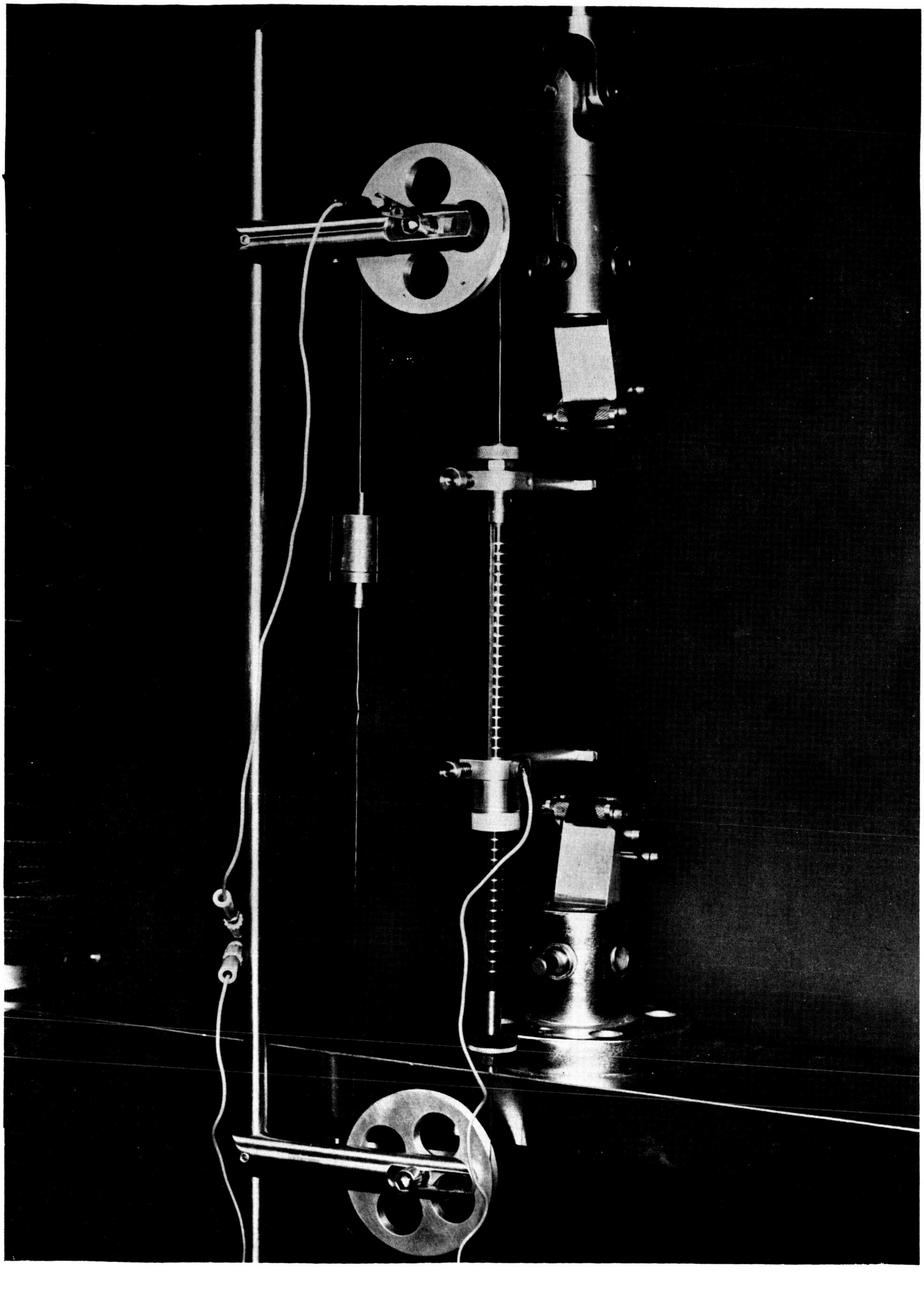

FIGURE 11.- EXTENSOMETER IN OPERATION

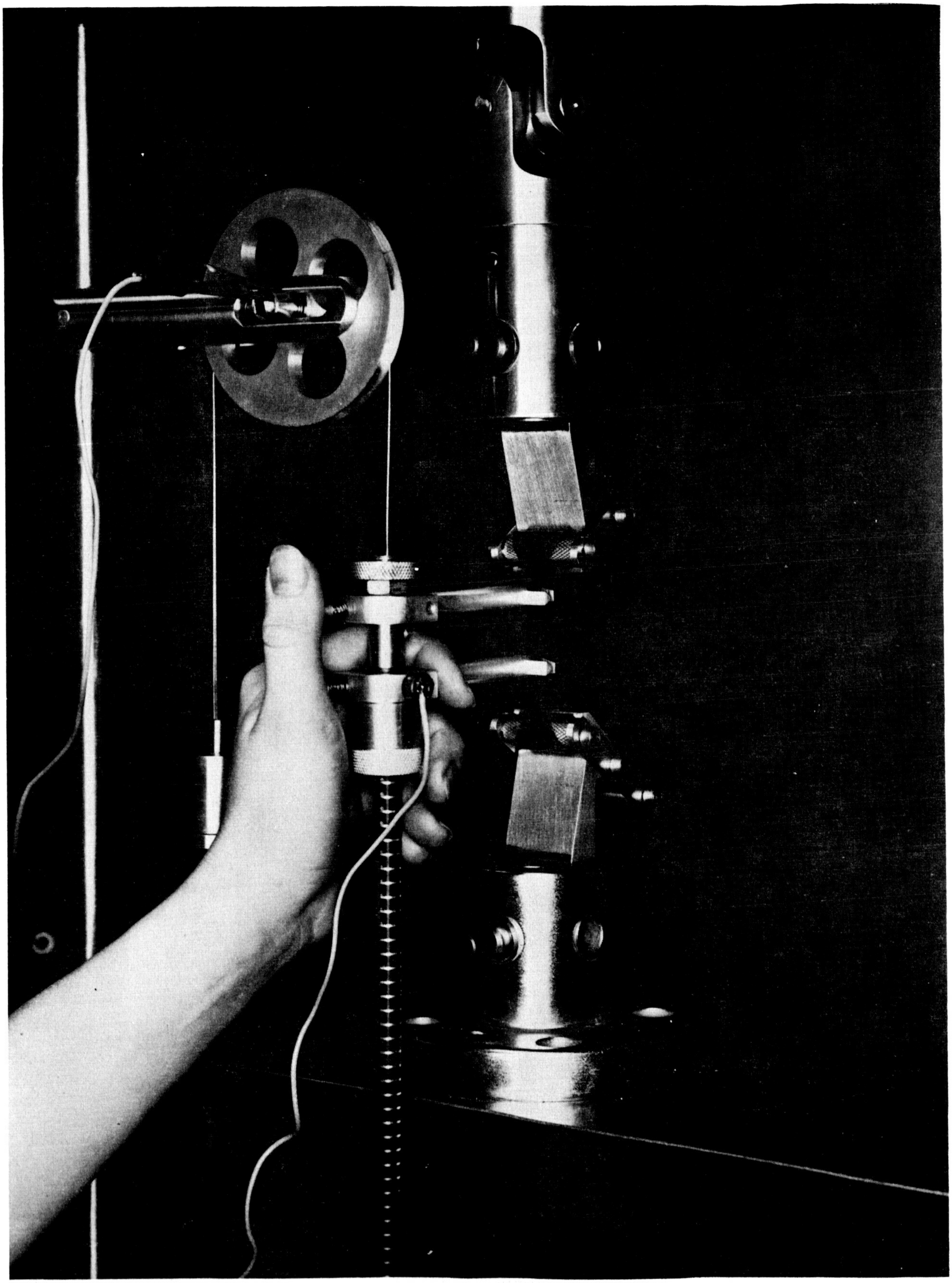

FIGURE 10. - EXTENSOMETER BEING ATTACHED TO TEST SPECIMEN

REFERENCES

1. Tension Testing of Vulcanized Rubber (Tentative), ASTM Standards on Rubber Products, 1960, American Society for Testing and Materials. Philadelphia, Pennsylvania (Method D412, p. 214).

2. Federal Test Method 601, Method 4111.

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By C. D. Hooper

The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy Commission programs has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document also has been reviewed and approved for technical accuracy.

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