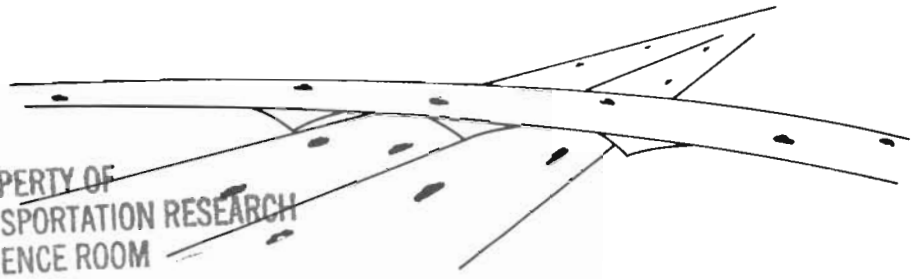

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DEVELOPMENT OF A TEXTURE PROFILE RECORDER

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Development of a Texture Profile Recorder

by

B. H. Ashkar

Research Report No. 133-2

for

A Pilot Study to Determine the Degree of Influence of Various Factors Pertaining to the Vehicle and the Pavement on Traffic Accidents Under Wet Conditions

Research Project 1-8-69-133

Conducted by

Texas Highway Department
Highway Design Division, Research Section

In Cooperation With The
U. S. Department of Transportation
Federal Highway Administration
Bureau of Public Roads

July 1970

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The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the Bureau of Public Roads.

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Mr. Paul R. Tutt, the study supervisor, contributed valuable guidance and suggestions throughout the development.

Acknowledgment is also given to Mr. Kenneth D. Hankins, Supervising Designing Research Engineer, who gave many hours of counsel and continuous advice.

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ABSTRACT

Development of a Texture Profile Recorder.

Project Number	:	HPR-1(9), 1-8-69-133
Investigator	:	B. H. Ashkar
Research Agency	:	Texas Highway Department
Sponsor	:	Texas Highway Department & Bureau of Public Roads
Date	:	December, 1969
Started	:	September, 1968
Status	:	Active
Estimated Completion:		August, 1971

Key Words	:	Skid Resistance, Pavement Texture, Texture Measurement, Texture Measuring Equipment, Wet Pavement Accidents.

Surface texture is one of the main factors that influences the skid resistance and the possibility of hydroplanning on wet weather pavements. Therefore, to determine a minimum level of skid resistance that should be possible on a particular pavement a knowledge of the drainage ability and characteristics of the roadway surface texture is required. Accordingly, a texture profile recorder which is a device designed to accurately record the local variations in surface geometry was fabricated.

SUMMARY

It was concluded that a texture profile recorder for field use should be a simple, portable, mechanical device that could be handled by one man and record enough length of the road to be representative of the area to be surveyed. The areas surveyed by the Texture Profile Recorder were the sites of the accidents occurring under wet conditions, a part of a research study aimed to investigate the elements involved in the roadway-tire-vehicle area with respect to wet weather accidents.

IMPLEMENTATION STATEMENT

The Texture Profile Recorder is a device which is portable enough to be handled by one person and relatively inexpensive enough to be mass produced. In the few tests performed with this instrument to date, the speed at which the pavement could be surveyed appeared to be reasonable. Therefore, it was decided that this machine be used in surveying wet weather accident sites as proposed in this project.

It should be remembered that future use of this instrument will call for more improved data recording techniques. In order to achieve a more accurate and refined description of the pavement surface, an electronic sensor instead of the mechanical feeler can be used with the results stored on a magnetic tape.

SECTION I

STATE OF THE ART:

While the fine scale texture of the roadway surface is believed to be the predominant factor determining the skid resistance between tire and road at low speeds, the rate of decrease in coefficient is thought to partially depend on the larger scale texture. At speeds of the order of 80 mph it would be helpful to have sufficiently large and angular projections on the road surface (easily visible asperities) to deform the surface of the tire tread, even in the presence of a film of water on the surface as well as permitting the rapid disposal of the main bulk of water (Ref. 1, 2, 3, & 4). Thus, for a wet roadway to have a good skidding resistance at high speed, it is essential that the asperities on its surface be sufficiently large and angular or that the surface should have sufficient drainage characteristics. The extent to which either requirement is met in practice would require a knowledge of the texture of the roadway surface. Accordingly, a texture profile recorder similar to the instrument developed by the Southwest Research Institute at San Antonio was fabricated (Ref. 5).

SECTION II

DESCRIPTION OF EQUIPMENT:

The Texture Profile Recorder is an instrument designed to scribe a magnified profile of the surface texture as a "feeler" is drawn across the surface. That is, the feeler is placed on the pavement surface and as it is drawn over the surface texture irregularities, the vertical movement of the feeler is magnified through a linkage system. The feeler-linkage system is mounted on a platform that moves horizontally on a base frame which is supported on the pavement by four leveling screws. The movement of the feeler-linkage system results in a duplicated, but magnified, texture profile which is scribed on a paper chart. Also, the "upward" vertical excursions are recorded on a counter of which the counter reading, at any time, is the cumulative vertical peak heights of the surface texture through the length transversed by the feeler.

The Texture Profile Recorder consists of the following:

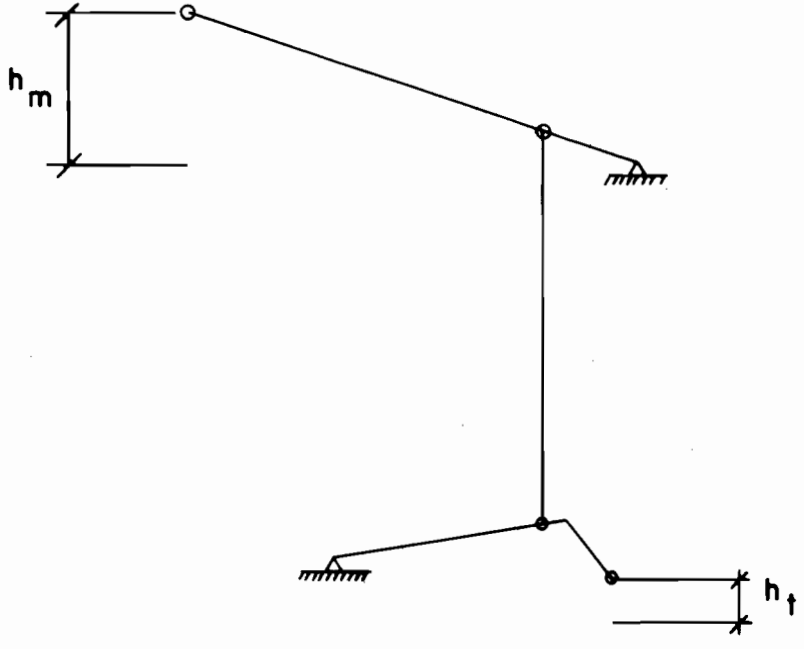
1. The main metal base frame which is supported by 2-1/2" leveling screws. The rectangular base frame is 36" long and 12" wide and consists of a metal angle member at each short end connected to each other by two steel shafts.

2. A stainless steel platform which is mounted on the two shafts in such a way that it moves through a rack mechanism from one end of the frame to the other. This movement is generated by a motor driven worm-gear with an adjustable rotational speed.

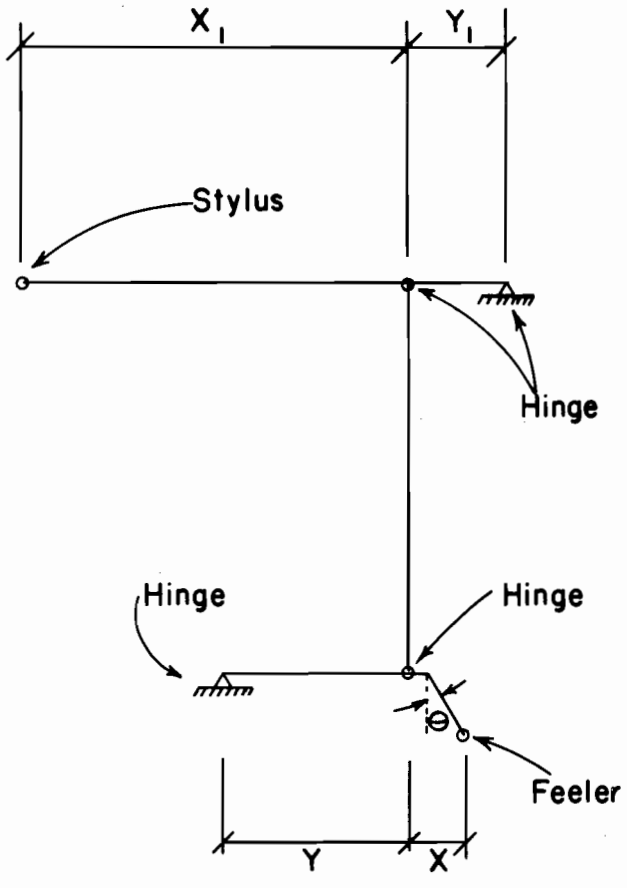
3. Mounted on the platform is the texture recording mechanism that consists of the following:

   a. The pavement feeler which is connected directly, through a linkage system, to a spring loaded stylus that rests on a pressure sensitive chart paper as shown in the schematic drawing in Fig. (1).

   b. An accumulative digital counter which is linked to the spring loaded stylus arm by a nylon cord and a one-



II



I

h_t — Height of the asperity

h_m — Magnified Height of the asperity is scribed on the paper strip chart.

Magnification Ratio = $\frac{h_m}{h_t} = \left(\frac{X_1 + Y_1}{X + Y}\right) \left(\frac{Y}{Y_1}\right)$

Θ - Optimum Angle of the feeler.

FIGURE 1 Schematic Drawing of the Magnification Mechanism

way clutch. A reading of 29 digits on this counter represents one inch of accumulative vertical movement of the feeler. This interpretation of the counter reading is explained in Sec. III. on Calibration.

SECTION III

CALIBRATION:

The Texture Profile Recorder has been calibrated for two different aspects of measurements as follows:

1) The local variations in the surface geometry are recorded on the paper strip chart with a magnification ratio. This magnification ratio was found by using several different artifically textured wooden boards such that the heights of the asperties were known. The texture profile recorder was then tested on these calibration specimens and the resulting profile was measured and correlated with the known specimen heights. The magnification ratio was found to be 3.2. The two calibration specimens used are shown in Figures A-1 and A-2 of the Appendix. A schematic drawing of the magnification mechanism is shown in Fig. (1).

   It should also be remembered that the optimum angle and sharpness of the feeler shown in Fig. (1) have been selected by trial and error to allow the feeler to transverse the pavement surface without lodging and to produce an accurate reproduction of the surface texture profile at the same time.

2) After the optimum angle of the pavement feeler was determined by trial and error as mentioned previously, the digital counter was mounted such that when the feeler is moved one inch vertically the counter yields a "constant". The digital counter was calibrated using the various artifically textured wooden boards, as mentioned previously, such that the heights of the asperities were known. The Texture Profile Recorder was then tested on these calibration specimens and the resulting counter reading was divided by the known heights of the asperities to obtain the counter reading constant. This constant was found to be equal to 29. Note that the accumulative height of peaks is reported in inches.

SECTION IV

PROCEDURE:

In the field, the texture profile recorder is placed on the pavement surface desired and the spring loaded stylus is released so that it encounters the paper strip chart. The counter is initialized to zero. The motor switch is turned on thus moving the feeler-stylus network horizontally along the frame thereby recording the magnified profile of the pavement surface texture. The counter reading is recorded (generally written on the chart paper) after which the paper strip chart is removed, identified, and returned to the office for interpretation.

It is noteworthy that the movement of the stylus-feeler network system is generated by a motor driven worm-gear with an adjustable speed. Accordingly, the minimum and maximum periods of time required to make one texture measurement are 15 seconds and 45 seconds respectively. The change in speed at which the stylus assembly is driven has proven to have a very negligible effect on measurements taken. Also, the accuracy has proven to be very slightly affected by repetitive measurements.

The motor driving the stylus-feeler network is a small 1/8 HP, 12 volt, fan type motor that derives its power from the battary of the accompaning vehicle. In case of a motor malfunction, battery failure, or lack of an electrical power source, the texture profile recorder can be manually operated. The time required for a manual texture measurement is about 42 seconds.

SECTION V

ANALYSIS AND INTERPRETATION OF DATA:

The data obtained is processed in the following manner:

1. The counter reading is divided by the number 29 to get the accumulative height of the asperities in inches as explained previously.

2. Figures 2 through 5 illustrates the type of the chart paper and actual grid size used. Also, shown are various texture profile traces with the peaks marked in small circles. Arbitrarily, a peak has been defined as any magnified asperity with a minimum height of 1/16" and a maximum base length of 1/4" or any multiple set of these diminsions.

3. The Average Peak Height is obtained by dividing the accumulative peak heights by the number of peaks.

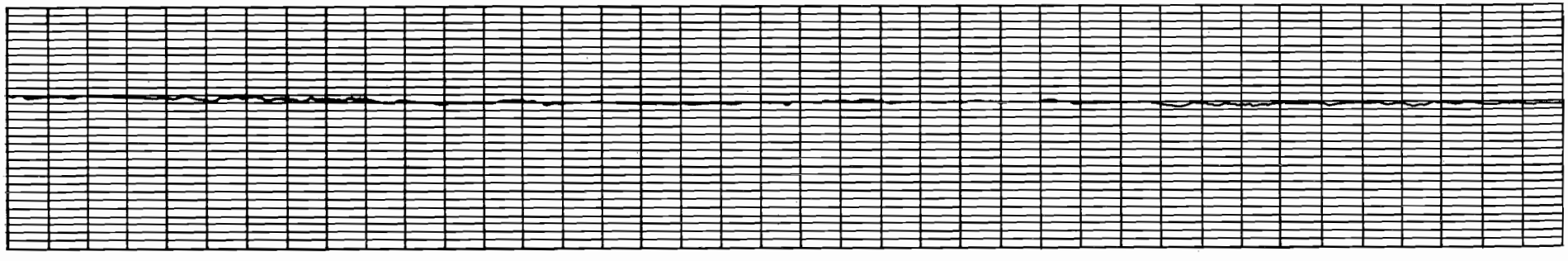
   As an example, the average peak height is obtained for each of the profiles in figures 2 through 5 as follows:

Scale:

Vertical 3.2" = 1" or 1" = 5/16"

Horizontal 1" = 1"

* Note: Counter Reading = 0
Number of Peaks = 0



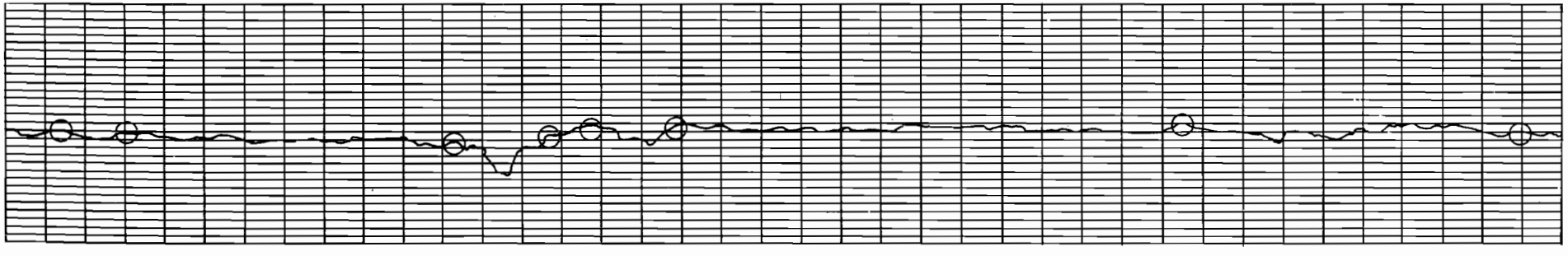
* Above profile is a partial full size section taken from the original 2'- 3" chart for which the number of peaks and the counter reading are as shown above.

FIGURE 2. Highly Smooth Texture Profile

Scale :

Vertical 3.2" = 1" or 1" = 5/16"
Horizontal 1" = 1"

* Note: Counter Reading = 13
Number of Peaks = 25



* Above profile is a partial full size section taken from the original 2'-3" chart from which the number of peaks and the counter reading are as shown above.

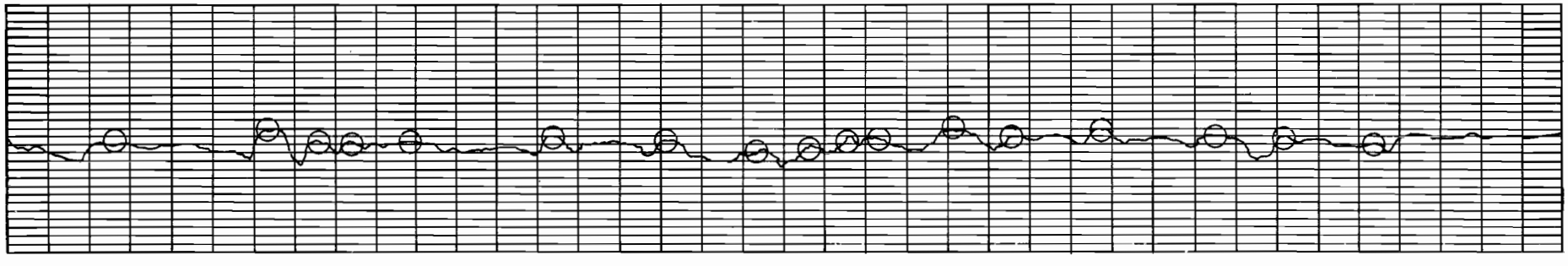
FIGURE 3. Smooth Texture Profile

Scale:

Vertical 3.2" = 1" or 1" = $^{5}/_{16}$"

Horizontal 1" = 1"

* Note: Counter Reoding = 30
Number of Peaks=40



* Above profile is a partial full size section taken from the original 2'-3" chart for which the number of peaks and the counter reading are as shown above.

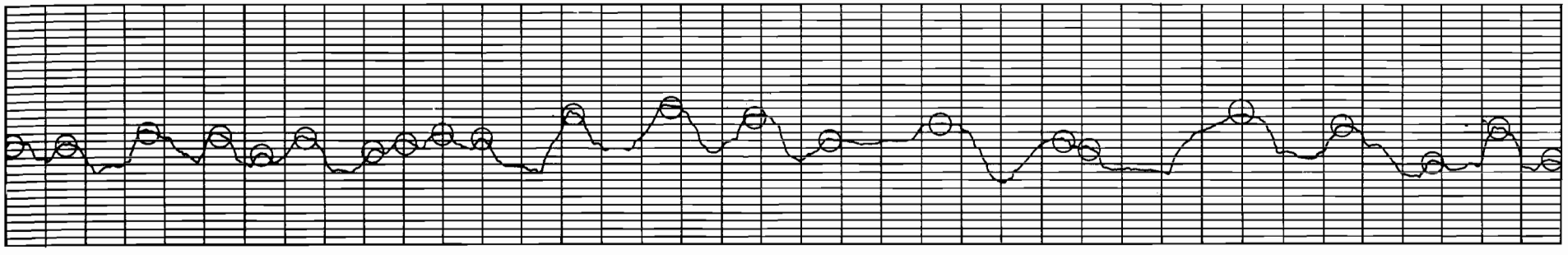
FIGURE 4. Medium Texture Profile

Scale:

Vertical 3.2" = 1" or 1" = 5/16"

Horizontal 1" = 1"

* Note: Counter Reading = 68
Number of Peaks = 59



* Above profile is a partial full size section taken from the original 2'-3" chart for which the number of peaks and the counter reading are as shown above.

FIGURE 5. Rough Texture Profile

C.R. : Counter Reading
A.P.H. : Accumulative Peak Heights (inches)
N.P. : Number of Peaks
A.V.P.H.: Average Peak Height (inches)

	C.R.	A.P.H.	N.P.	A.V.P.H.
Figure *2	0	0.000	0	0.000
Figure 3	10	0.450	25	0.018
Figure 4	30	1.030	40	0.026
Figure 5	68	2.340	59	0.039

In the above table the Accumulative Peak Heights is obtained by dividing the Counter Reading by 29, while the Average Peak Height is the ratio of the Accumulative Peak Heights to the Number of Peaks.

*Note that the average peak height is set to zero when the number of peaks is equal to zero. Mathematically, this is not correct because the average peak height is indeterminate when the accumulative peak heights are divided by the number "zero".

It should be remembered that the counter reading and the corresponding number of peaks are measured on a stretch of the pavement 2'-3" in length.

It is felt that this method of analysis is a simple measure used to assess the profile, which bears some relation to "texture depth" but also takes into account the number of the asperities in the given length.

SECTION VI

CONCLUSIONS:

To evaluate the effectiveness of surface texture as an important parameter influencing wet pavement skidding or hydroplanning, a texture profile recorder has been designed, developed, and fabricated.

The nature of this device provides for two types of measurements. The digital measurement is a measure of the coarseness of the roadway surface texture and hence of the texture depth which is a major element that influences the rate of change of the wet coefficient of friction width speed. The other type of measurement is the graphical representation of the actual surface texture profile which can be used with proper engineering judgement to determine and compare the drainage abilities and characteristics of roadway surfaces.

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APPENDIX

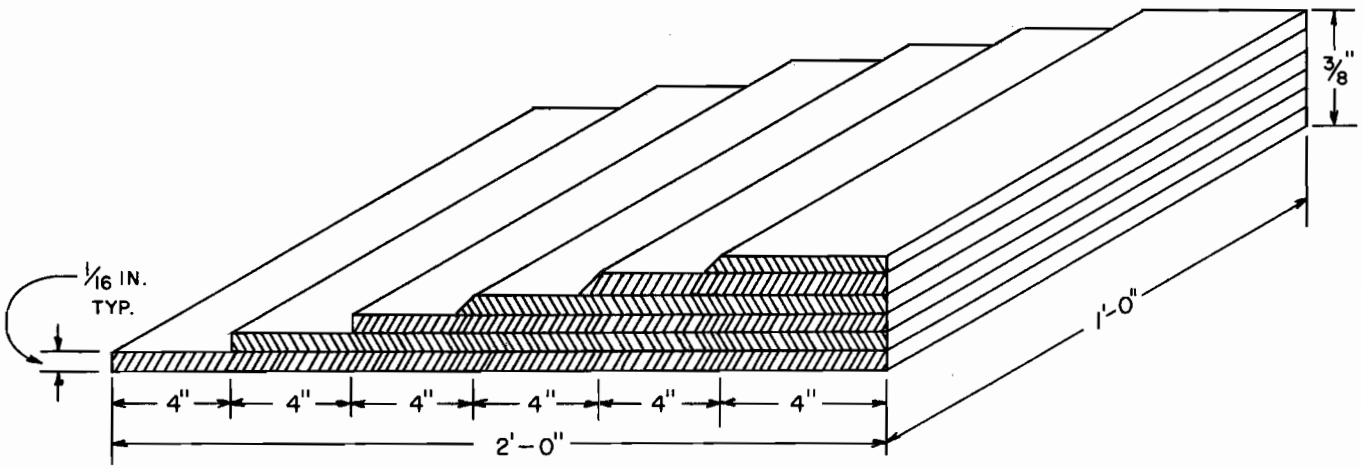


Figure A-1 CALIBRATION SPECIMEN I

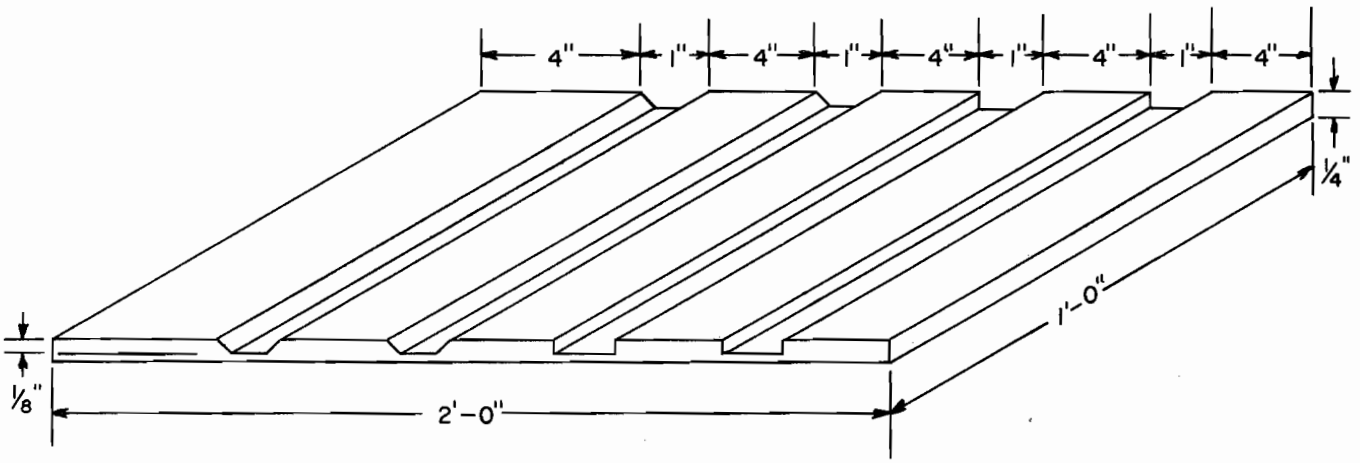
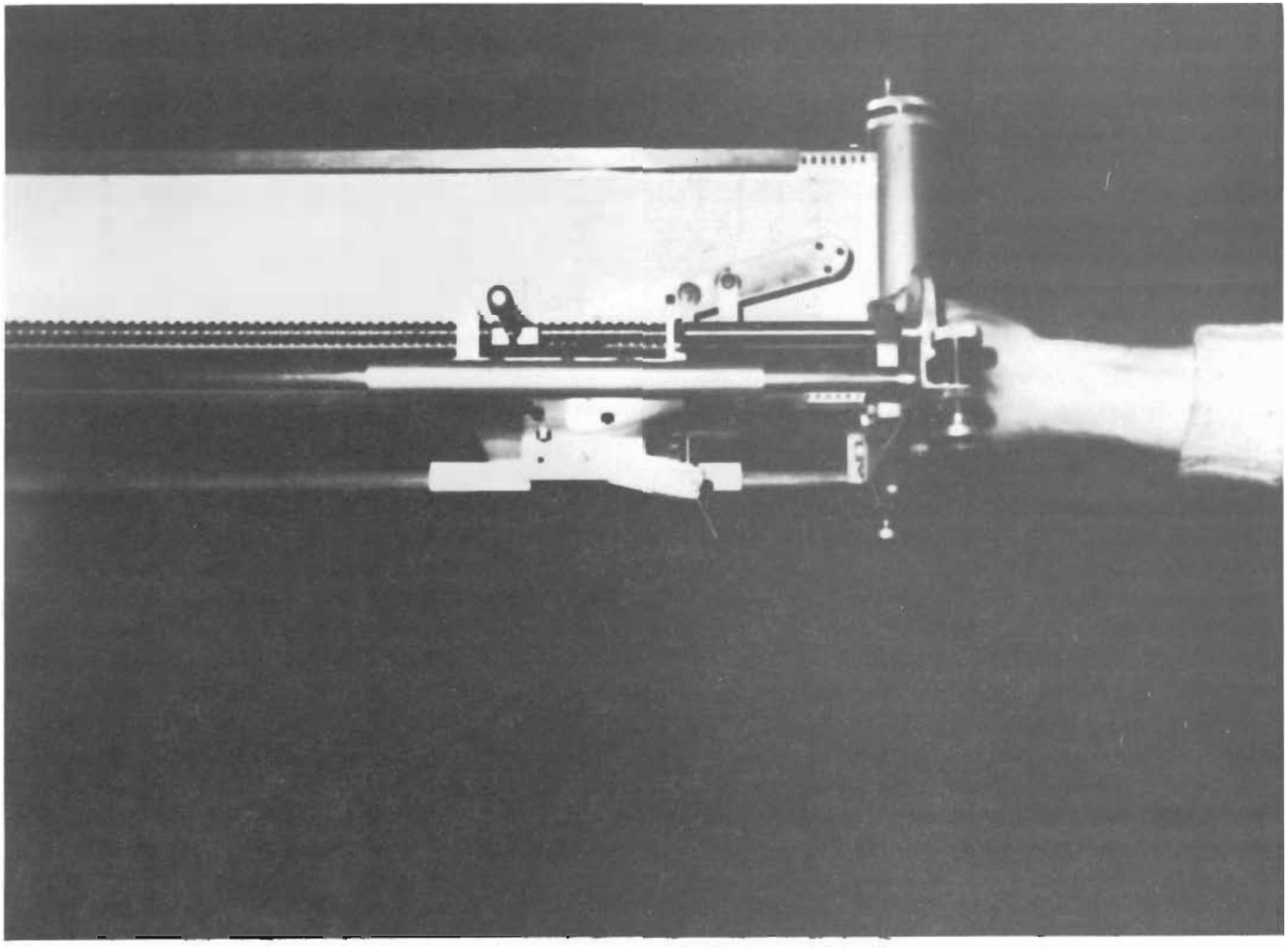
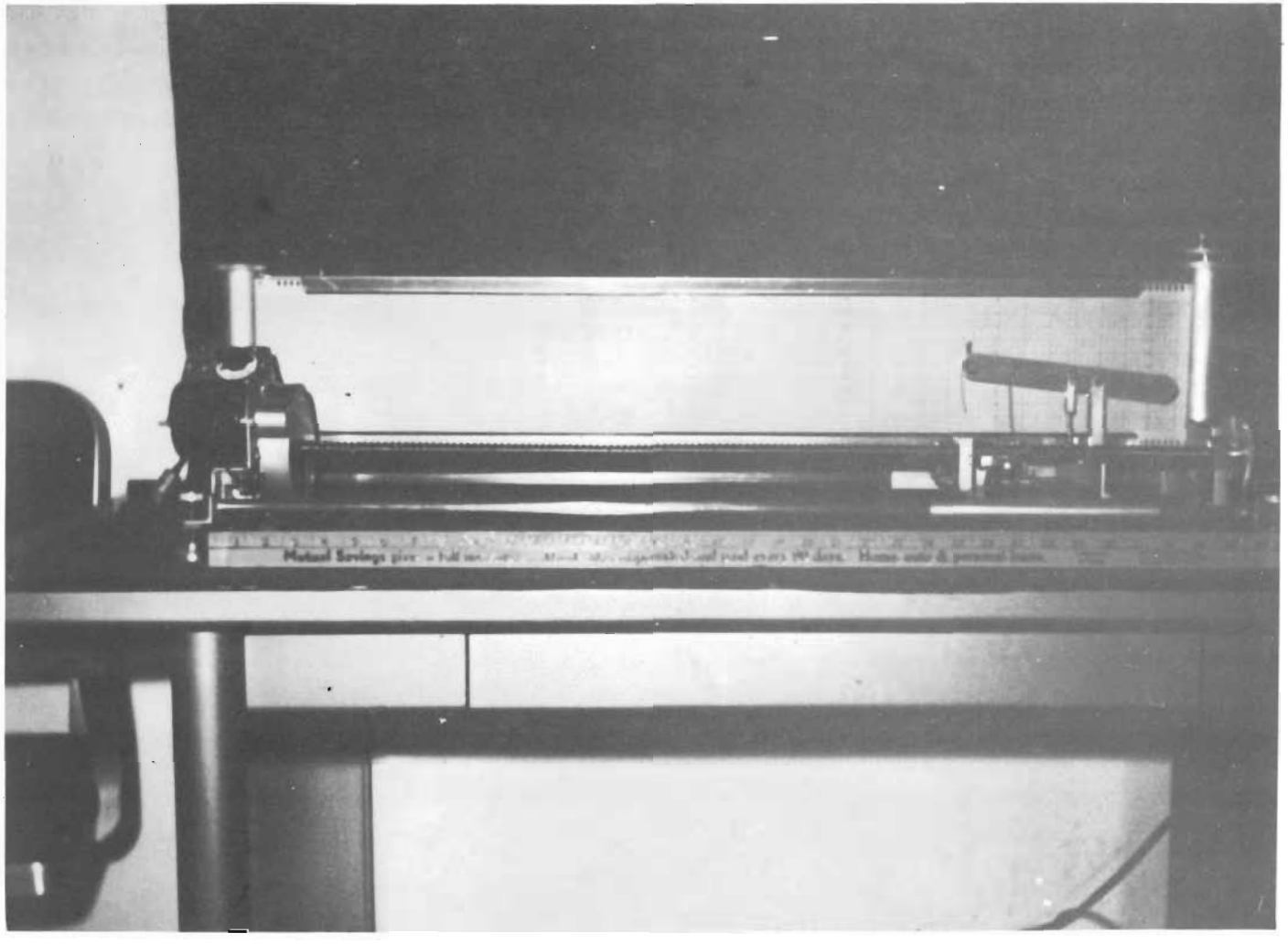
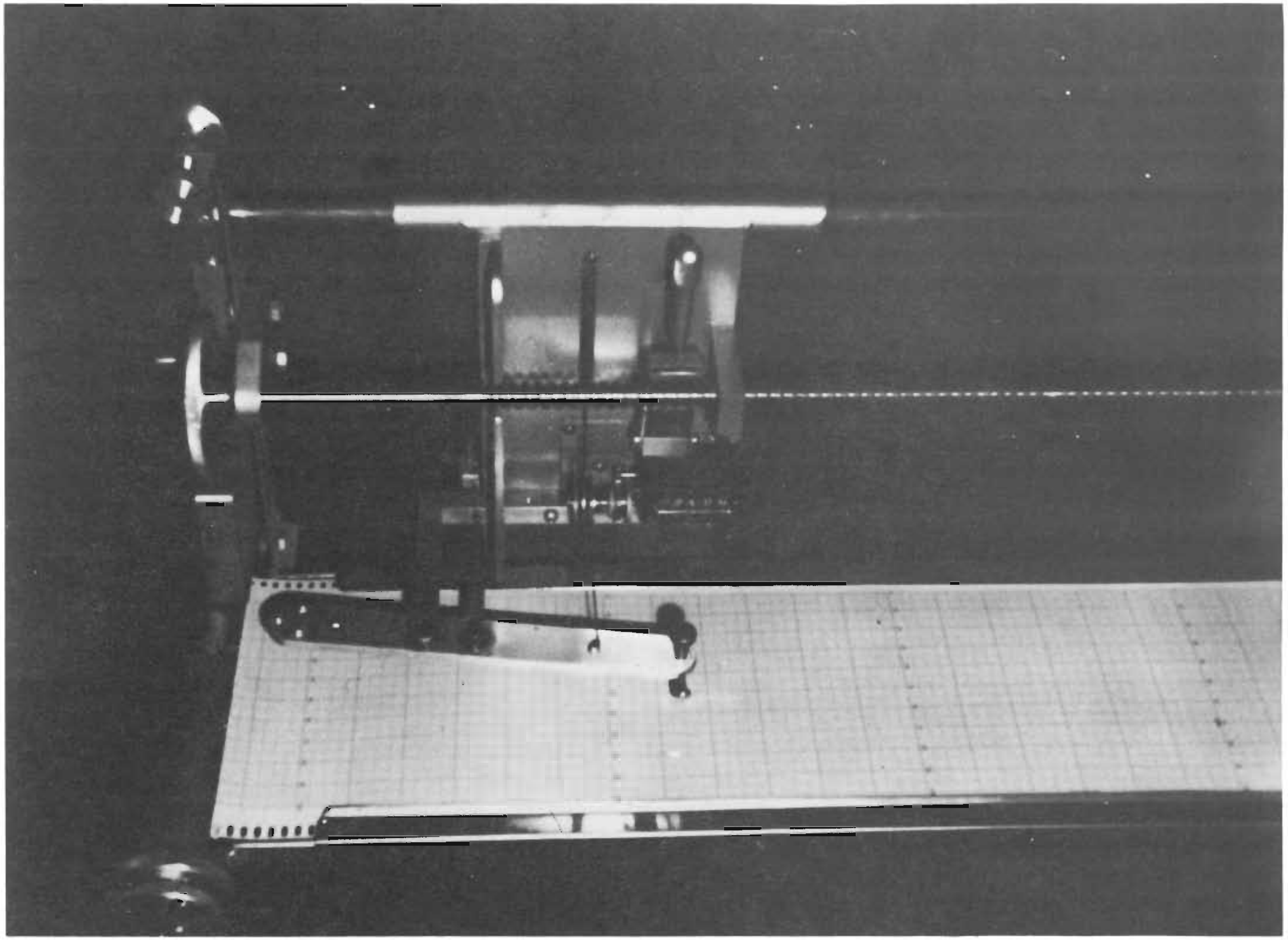
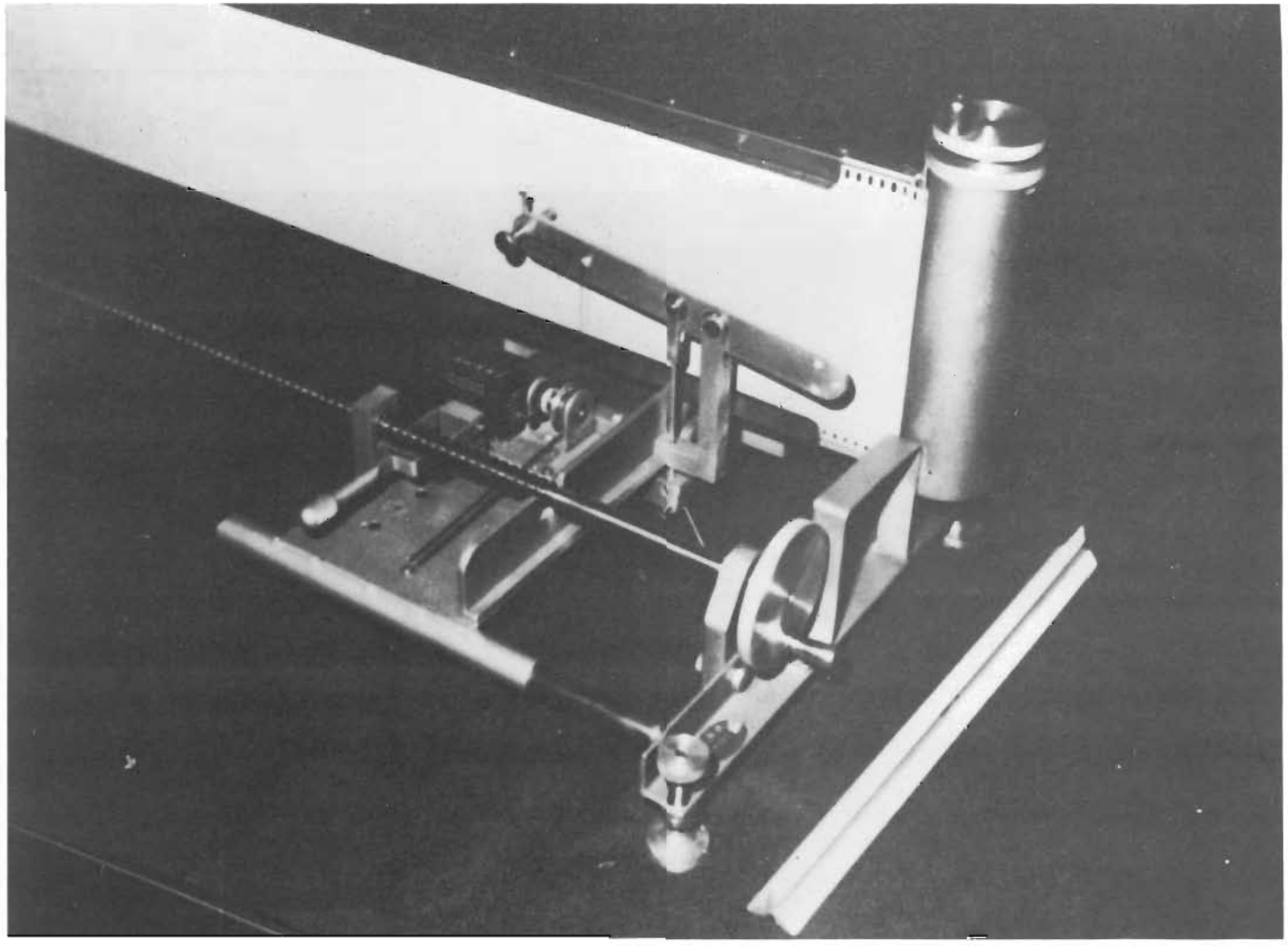


Figure A-2 CALIBRATION SPECIMEN II



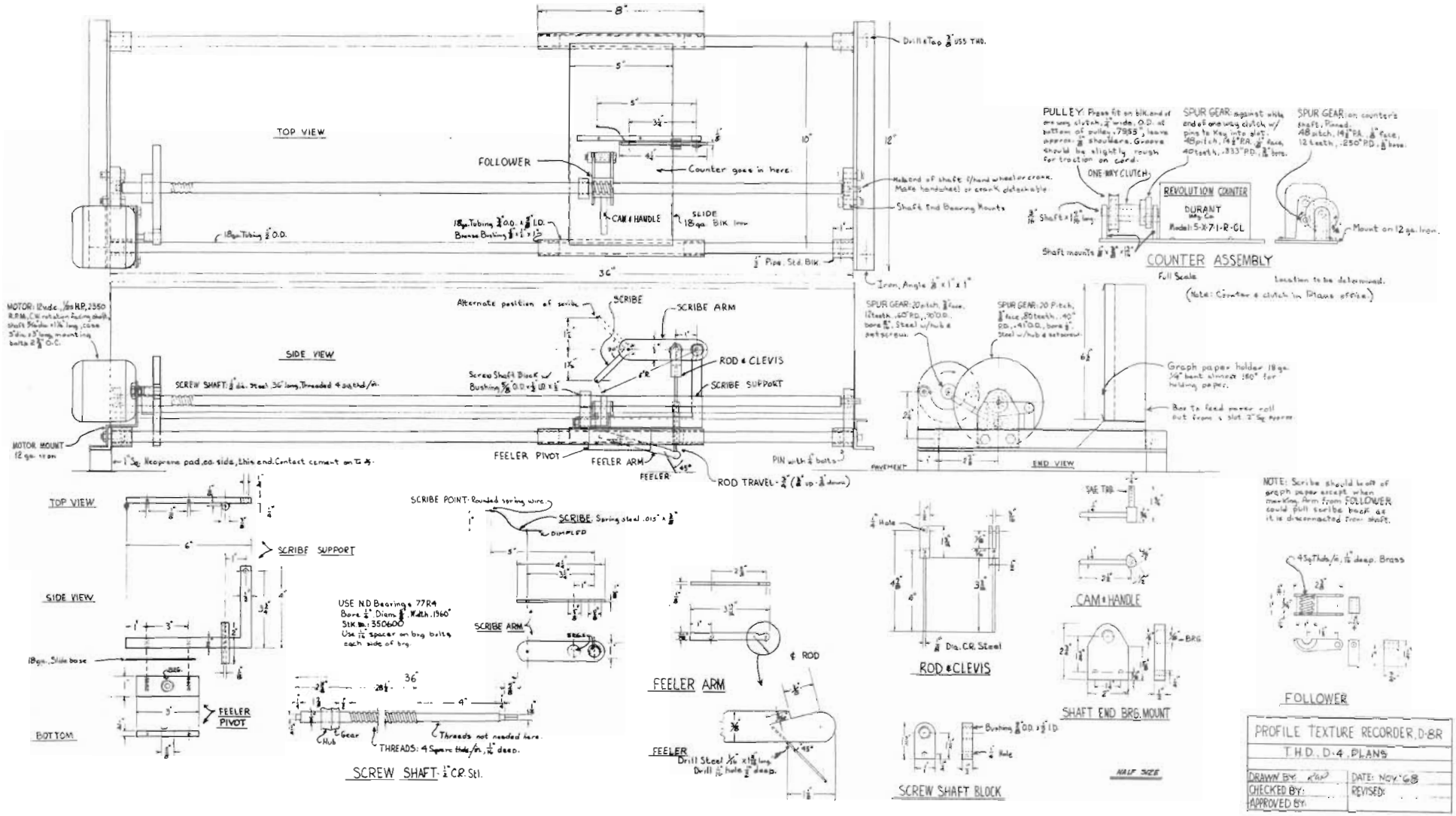






SHOP DRAWING

TEXTURE PROFILE RECORDER



NOTE: Scribe should be out of graph paper except when marking. Arm from FOLLOWER could pull scribe back as it is disconnected from shaft.

PROFILE TEXTURE RECORDER, D-8R	
T.H.D., D-4, PLANS	
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CHECKED BY:	REVISED:
APPROVED BY:	