PICATINNY ARSENAL

DOVER, NEW JERSEY

Code 1

TESTING MANUAL

SUBJECT: FRICTION PENDULUM

P. A. MANUAL NO. 7-1 **DATE** 8 May 1950

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Purpose of Test:

The purpose of a Friction Pendulum Test is to determine the sensitivity of explosives when subjected to a glancing blow with its attendant friction.

Description of Test:

A test consists of ten trials with the steel shoe, except when complete explosion or burning occurs in any trial. If explosion or burning occurs, the trials with the steel shoe are discontinued. Ten trials are made with fiber faced shoe only when complete explosion or burning occurs with steel shoe, or as prescribed in test directive. If the explosive passes the test with the use of the steel shoe, no further trials are conducted. From a viewpoint of economy and efficiency, therefore, all samples are tested first with the steel shoe. Each trial consists of 7 $\pm$ 0.1 grams of explosive.

Anvils and shoes are manufactured from steel as specified in Appendix "A". The hard fiber for fiber faced shoe is procured in accordance with ASTM Specification D-710-43T. It is supplied in three colors, black, red, and gray. It has been indicated that there may be slight differences in material for different colors. To make the test as uniform as possible, only the red hard fiber is used for this shoe. The hard fiber of which the shoe is made is not very resistant, and it is therefore difficult to keep this shoe in first-class operating condition under the hard usage to which it is subjected in the pendulum friction test and has to be inspected very often.

Criteria for Passing Test:

An explosive is regarded as passing the Friction Pendulum Test (which is a measure of its sensitivity to a glancing blow) if in ten trials with the hard-fiber-faced shoe, there is no more than an almost inaudible local crackling, regardless of its behavior when subjected to the action of the steel shoe.

Equipment:

The pendulum Friction Device (See Drawing D270 and Photograph M-35286), which was developed by the Bureau of Mines for determining the relative sensitivity of high explosives to initiation by a glancing blow consists essentially of a steel swinging shoe which is the bob of a pendulum. The frame supporting the pendulum is known as the "A-Frame". The two free bases of the A-frames at the lower ends of the device can be raised or lowered simultaneously, thus controlling the friction between the shoe and anvil, and hence, the number of swings of the pendulum.

The anvil consists of a plate of steel. The upper face of the anvil is a smooth, polished surface, across the central portion of which three parallel grooves are cut to prevent the sample of the explosive under test, which is spread upon the anvil, from being brushed off the anvil by movement of the shoe across it.

In testing explosives for permissibility, a steel shoe or one faced with red-hard fiber (called the "hard-fiber-faced shoe,") may be used. This facing is fixed permanently to the face of the particular shoe to which it is attached.

An automatic tripper is used by which the shoe can be dropped upon the anvil from any desired vertical height ranging from 1/2 meter to 2 meters. Height of drop normally used at Picatinny Arsenal is 1 meter.

What weight of pendulum?

Test Procedure:

Before trials are begun with the explosive to be tested, the shoe is tested out over the empty anvil to make sure that it is adjusted squarely with the anvil and that when loaded with weights shown on drawing, it is so adjusted in relation to the anvil that it shall swing across the face of the anvil 18 $\pm$ 1 times before coming to rest. The adjustment is made by operating the turnbuckle that raises or lowers the A-Frame.

The temperature of the anvil and shoe will be controlled to be about 70 $\pm$ 5°F. Because the building is not equipped with a constant temperature conditioning unit, this is not possible at all times.

With the device satisfactorily adjusted, 7 $\pm$ 0.1 grams of the explosive to be tested are spread in an even layer in and about the three grooves in the anvil and the shoe is dropped upon it. After the pendulum has ceased swinging, any explosive remaining is brushed off, and the faces of the shoe and anvil are cleaned thoroughly with a suitable solvent. To protect himself during cleaning, the operator will wear a face mask and asbestos gloves. The shoe and anvil are rubbed with carborundum cloth to remove any roughness caused by the impact of the shoe on the soft, steel anvil, also any adherent gritty matter. When the face of the shoe and anvil are clean and dry, another charge of 7 $\pm$ 0.1 grams of the explosive is placed on the anvil as before, and a second trial is made, and so on for 10 trials.

The observations to be made and recorded are "explosion" (whether complete or partial), "burning" (whether complete or partial), "local crackling" (whether distinctly audible or almost inaudible), and "no local crackling". (See sample report of test results.)

The number of swings on which these occurrences take place and the total number of swings for each trial are recorded. The number of swings on an empty anvil is checked and adjusted after every trial.

Safety Precautions:

When conducting Friction Pendulum tests, the following Safety rules must be followed:

1. Personnel conducting test must raise and release the shoe from behind the barricade.

2. The operator must wear protection for face and hands when cleaning the shoe and anvil.

3. The anvil and shoe must be thoroughly cleaned with a soft hair brush and washed with acetone after each trial is complete and before the next sample is placed on the anvil. Anvil and shoe must be dry before the next sample is tested.

4. The recovered unburned powder shall be removed from the building after each trial and a clean receptacle used for each subsequent removal.

5. After the pendulum has come to a stop on the anvil on which unburned powder still remains, the pendulum shall be withdrawn by carefully attaching the catch on the hoisting rope WITHOUT DISTURBING THE PENDULUM, and then FROM BEHIND THE BARRICADE, pulled to and locked in the safety position.

6. All personnel must remain outside the building until all gases resulting from burning or detonation of explosive have dispersed.

General Information:

It has long been recognized that the ease with which an explosive can be detonated when subjected to a glancing blow, with its attendant friction, is different from its sensitivity to a direct impact and that many accidents, such as those occurring in loading, pressing, tamping, and in other acts attending their manufacture, handling, and use have been due to this cause. Efforts were made originally to evaluate this sensitivity, or at least to classify explosives with respect to this characteristic by placing a small quantity of the explosive on a steel anvil and striking it with a glancing blow with a steel hammer or a hammer of other material. Officials of the Explosives Division of the Bureau of Mines believed that the personal equations of different persons attempting to make the various tests and of the same person carrying them out at different times were likely to be so large

that little reliance could be placed on the results, especially when they were negative. They thought that a mechanical device could be made to operate in so nearly a constant manner to reduce these errors. Such a mechanism was invented and developed in 1911 by Charles E. Munroe, Clarence Hall, and Spencer P. Howell, and has been in use ever since. This mechanism is known as the Bureau of Mines Pendulum Friction Device.

In no instance has it been found in any of the very large number of tests that have been made with this Pendulum Friction Device that an explosive which passed the test with the steel shoe subsequently failed to pass the test with the hard-fiber-faced shoe.

Reference

Additional information may be found in U. S. Dept of Commerce Bureau of Mines Bulletin 346, "Physical Testing of Explosives".

Prepared by: _____

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Chief
Safety and Security Division

Approved by _____

C. R. DUTTON
Col, Ord Dept
Chief, Technical Division

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

Explosives Testing Station

Bruceton, Pa.
July 18, 1946

Colonel Miles W. Kresge
Ordnance Department
Picatinny Arsenal
Dover, New Jersey

Dear Colonel Kresge:

Referring to SPOBB Tech. Div. 413.6/1259 and your letter of June 25, 1946:

The steel used for making our anvils and shoes was purchased under the following specification: Forged Bar

Carbon	0.20 - 0.25%
Manganese	0.40 - 0.50%
Phosphorous and Sulfur	0.03 -
Silicon	0.20 -
Hardness, Rockwell	B71
Tensile strength	55,000 - 65,000
Elastic limit	28,000 - 32,000
Elongation	25 - 35%
Reduction in area	50 - 60%

We also, on occasion, have had trouble with deep scratching and burring of the anvil and shoe when adjusting for the 18 ± 1 swing without explosive. In our case this trouble was traced to improper procedure, i.e., the operator started with the pendulum tight and then gradually loosened it to get the 18 swings. Start with loose pendulum, say around 20 to 24 swings, then tighten up to 18. Our procedure is to push the shoe across the plate by hand and by so doing the experienced operator knows by the "feel" about how many swings to expect. We have had no abnormal abrasion when this method was followed.

Another important consideration, not mentioned in Bulletin 346, is that the temperature of the anvil or plate should be kept higher than the surrounding air to prevent surface condensation. This is especially important in our work because most of the explosives tested contain ammonium nitrate and other hygroscopic salts.

It may be of interest to know the specification of the material used on the fiber shoe. We use the red fiber ASTM Spec. D-710-43T, Commercial grade, density 1.34, made by National Vulcanized Fiber Co, of Wilmington, Delaware.

Very truly yours,

A. B. Coates
Mechanical Engineer
Physical Testing Section
Explosives Division

PICATINNY ARSENAL
TESTING STATION DATA SHEET
AMMUNITION COMPONENT
STATIC TEST

Subject: Comp TNT (Purified)

Problem: 256
Ex. O. No: 2/17
Data Book No: 1162
Date: 30 September 1948

Object of Test: Sensitivity Test of Subject Material

Test Requested by: D. R. Jones

Rec'd for Test: 140 grams of Comp TNT

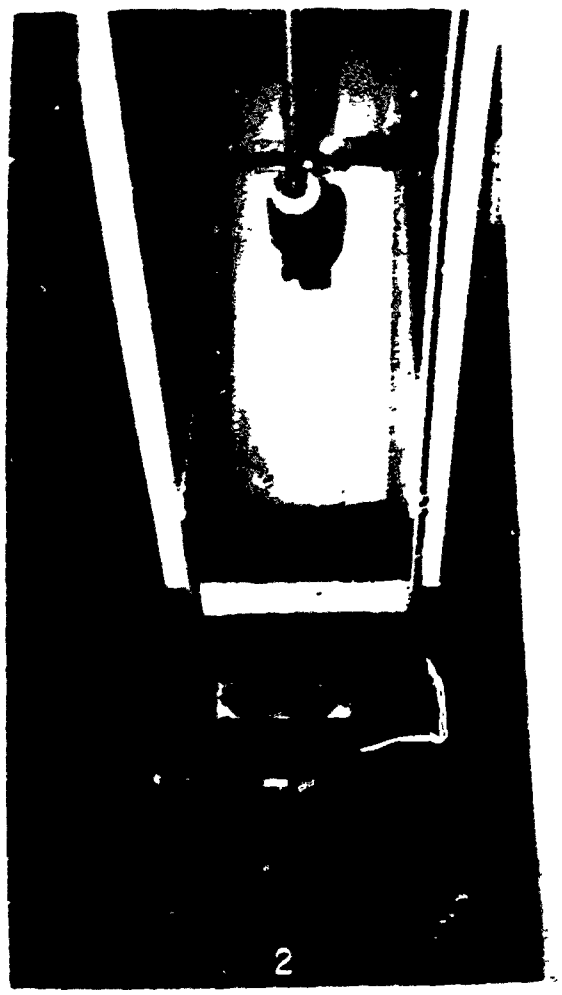
Auxiliary Components Used: None

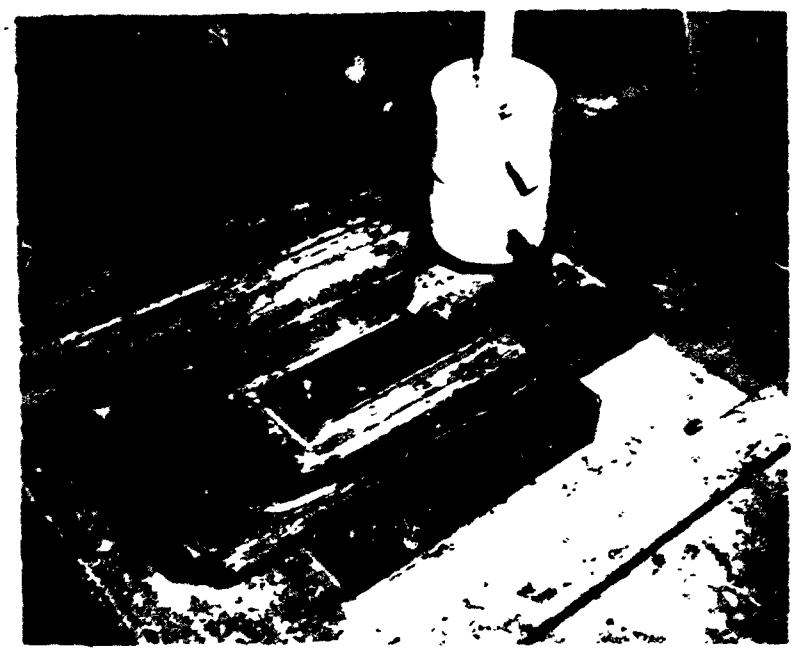
Test Procedure: Standard Friction Pendulum Procedure.

Results

Test No.	Swings	Crackles	Sparks	Burning	Detonation	Shoe
1	48	None	None	None	None	Steel
2	44	"	"	"	"	"
3	47	"	"	"	"	"
4	38	"	"	"	"	"
5	56	"	"	"	"	"
6	40	"	"	"	"	"
7	48	"	"	"	"	"
8	47	"	"	"	"	"
9	50	"	"	"	"	"
10	50	"	"	"	"	"

J. H. McIvor
Proof Director





M-35286 May 1949 Picatinny Arsenal Ordnance Department

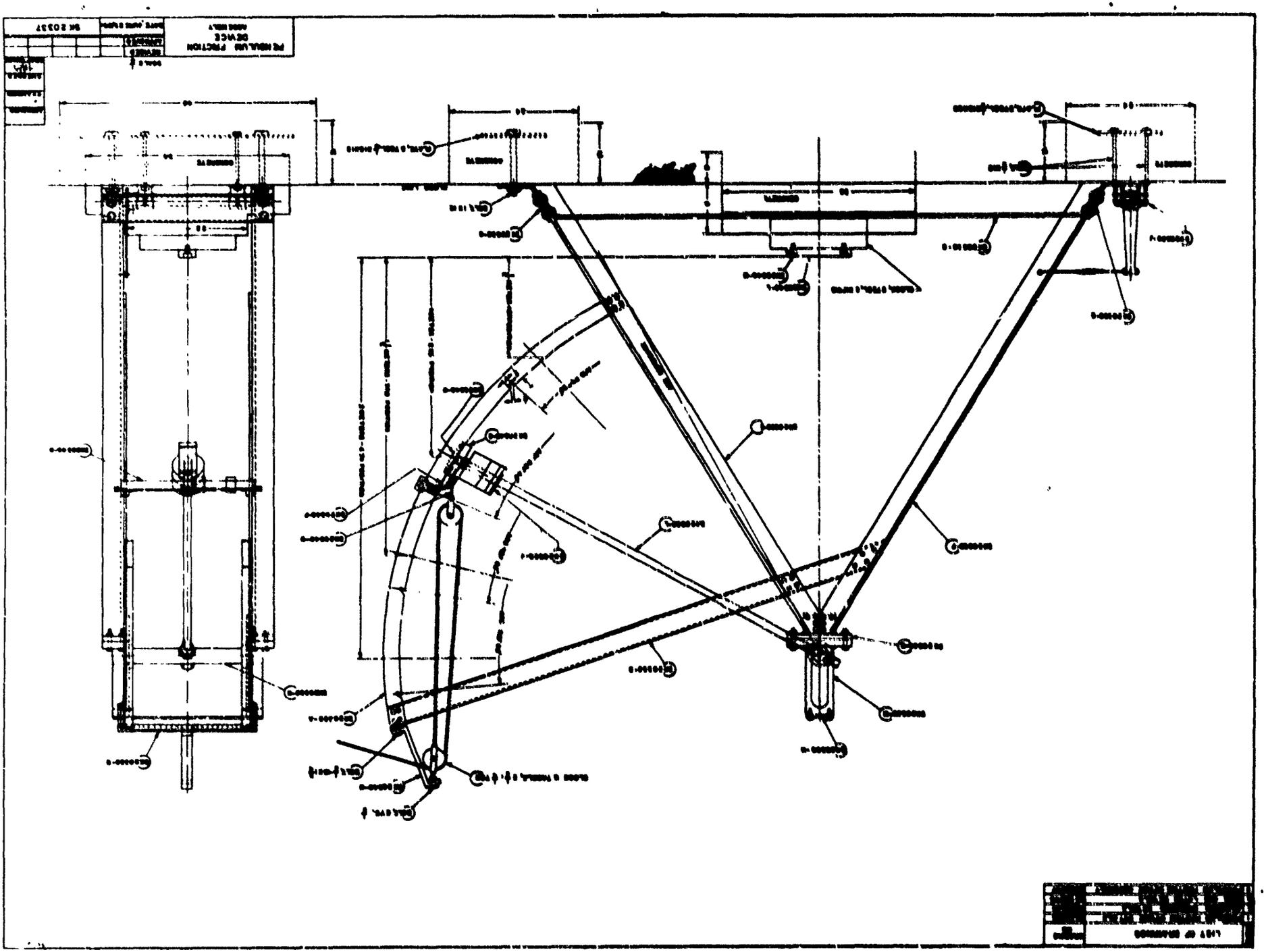
Bureau of Mines Pendulum Friction Device, Type A

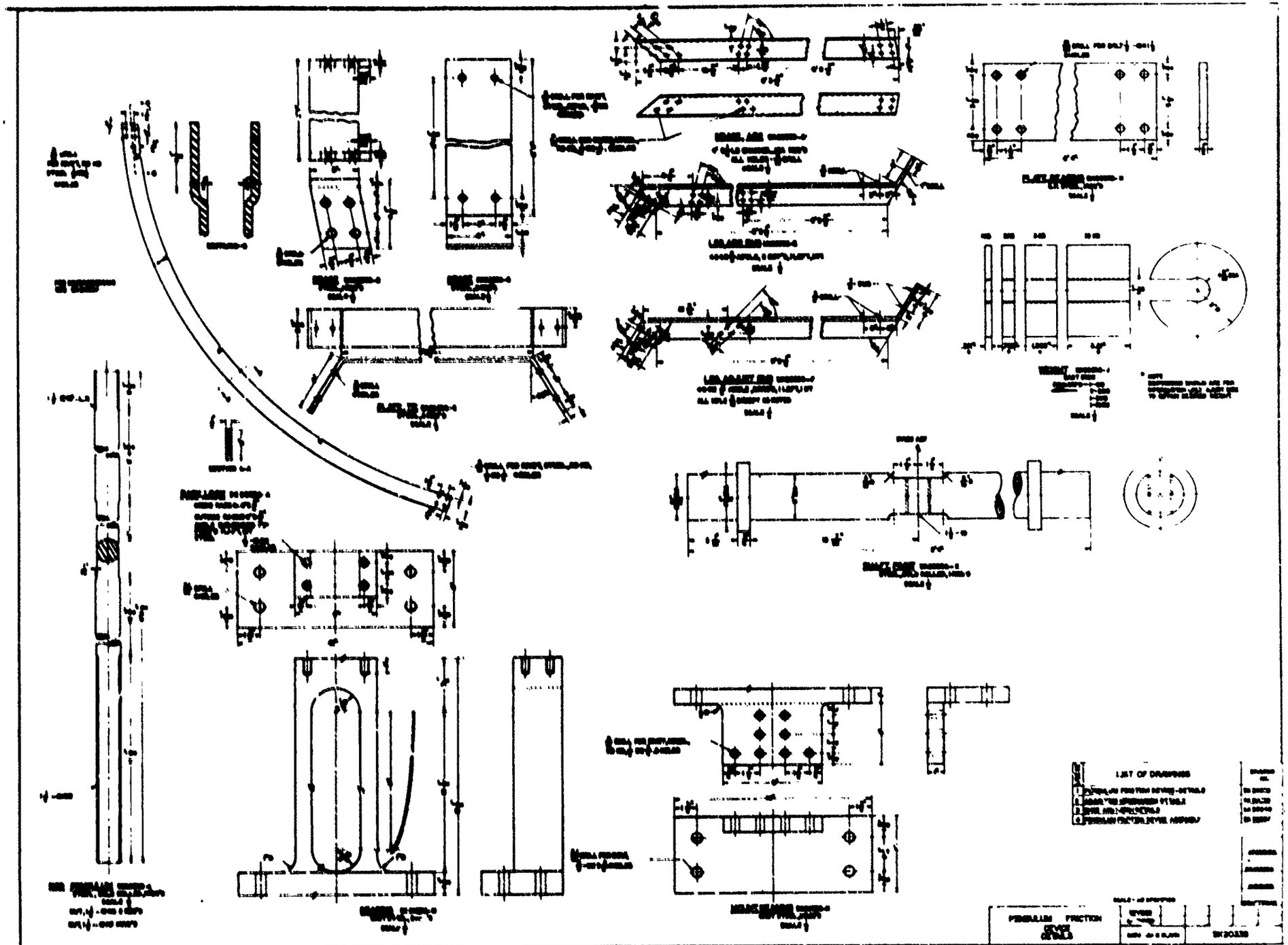
Figure 1 - Pendulum being raised to the tripping device

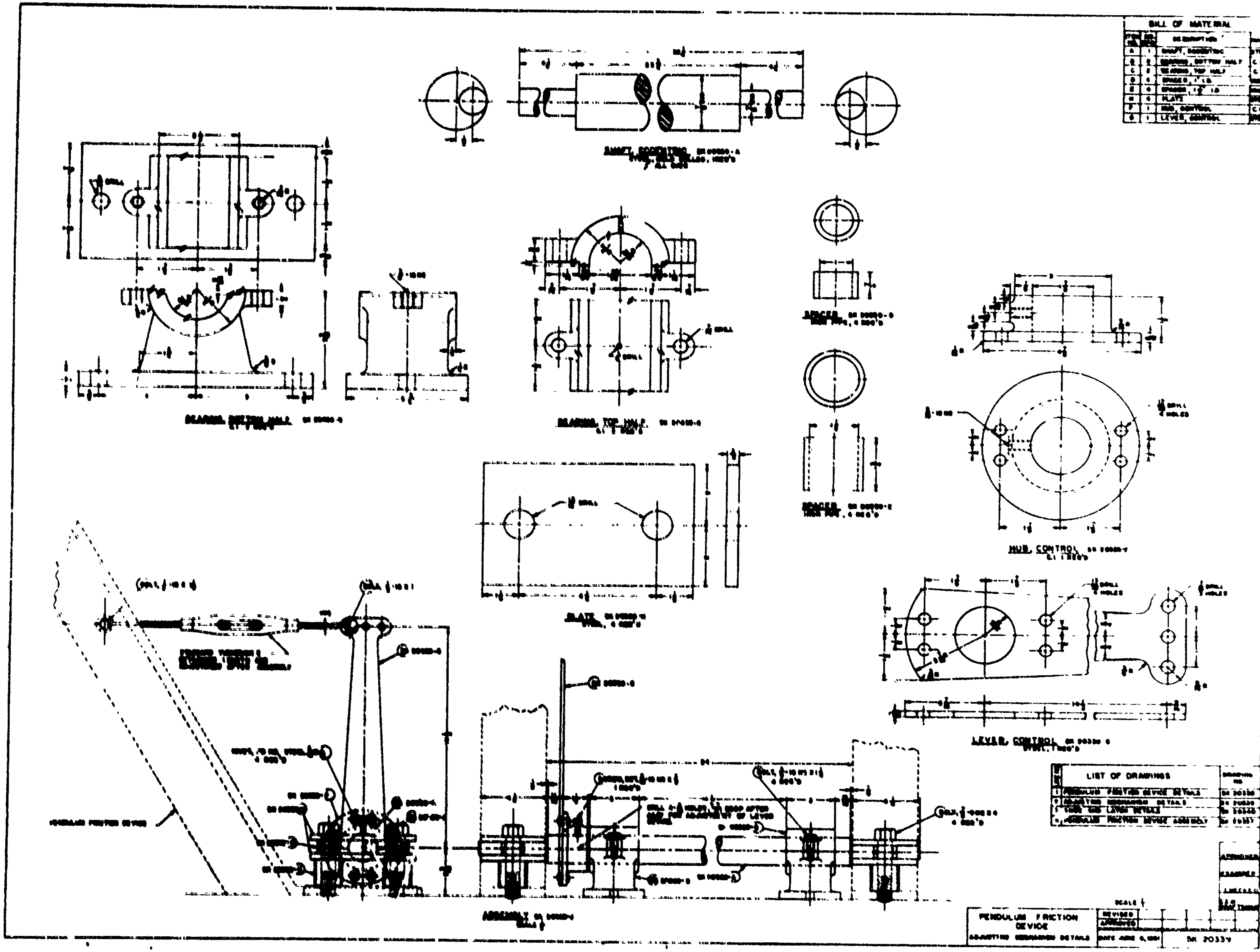
Figure 2 - View of pendulum and base from side opposite pendulum tripping device

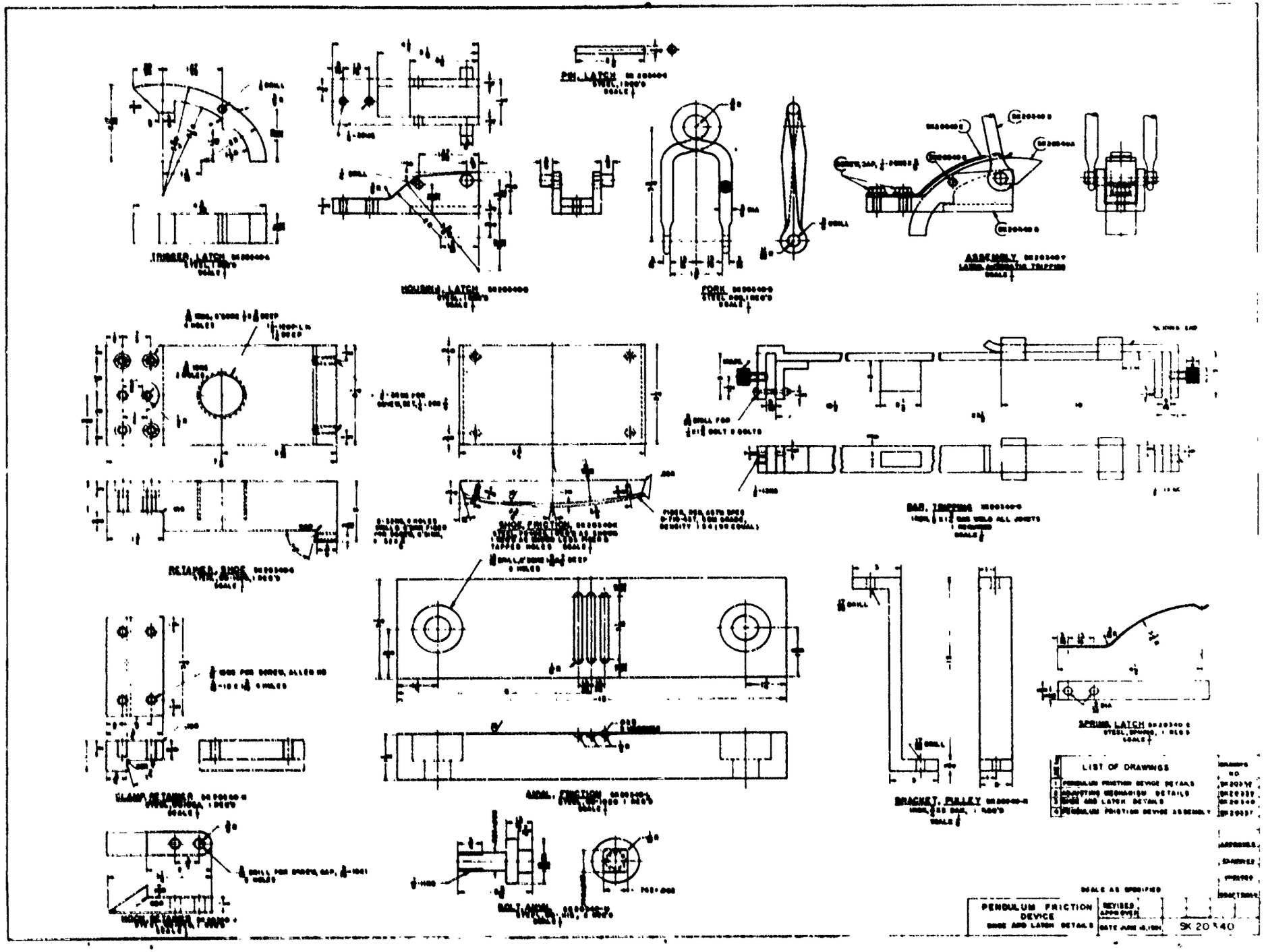
Figure 3 - Pendulum shoe passing over base

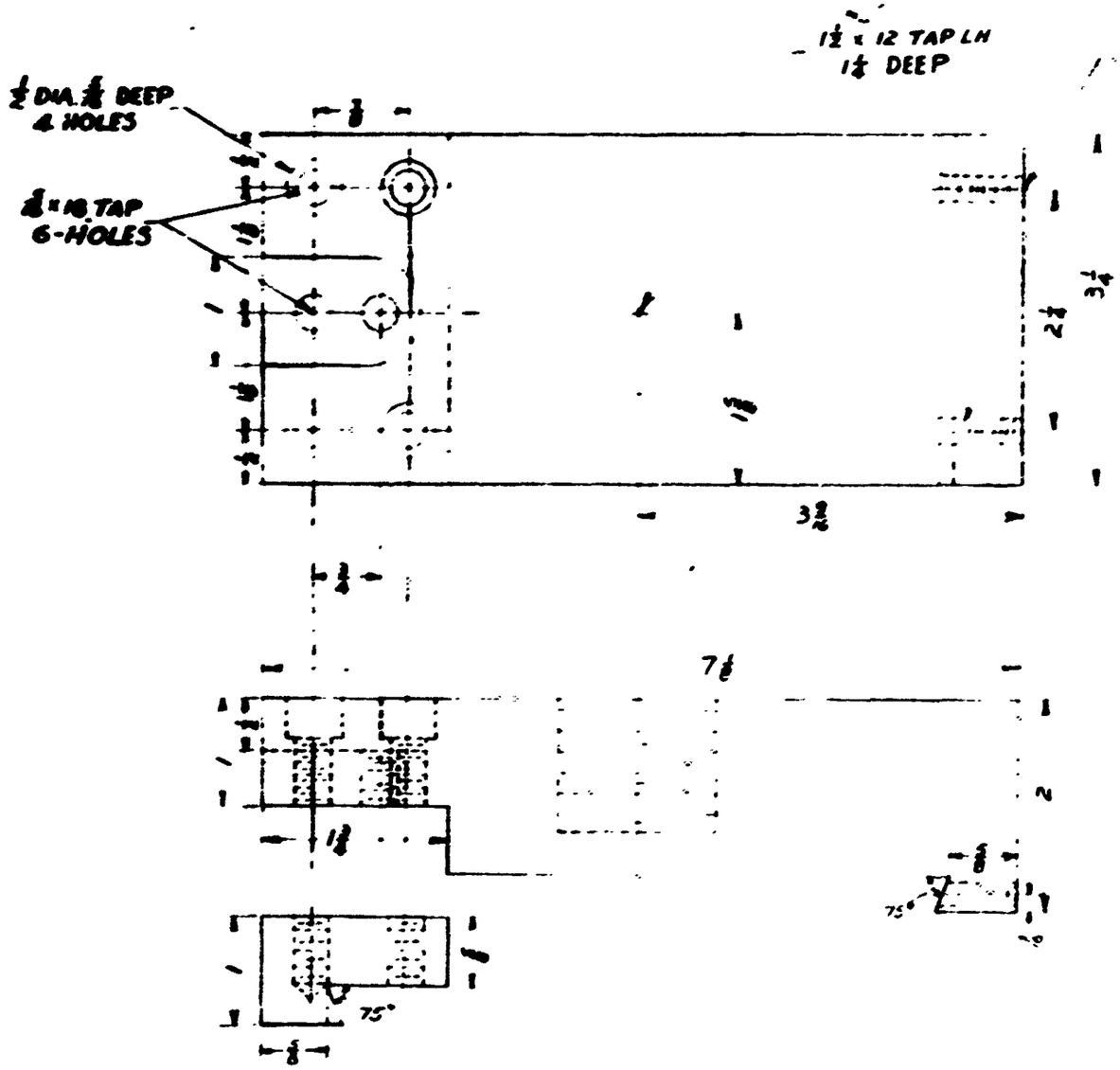
Figure 4 - View of base where sample is placed

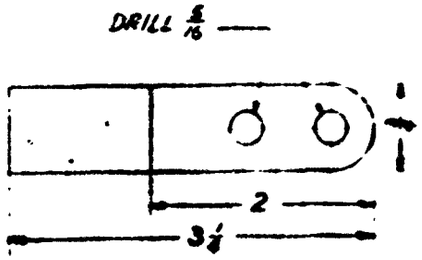




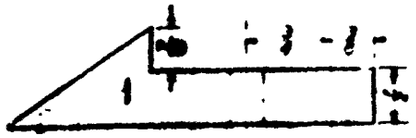

BILL OF MATERIAL
SHAFT, ECCENTRIC
BEARING, BOTTOM HALF
BEARING, TOP HALF
SPACER
PLATE
HUB, CONTROL
LEVER, CONTROL
LIST OF DRAWINGS
PENDULUM FRICTION DEVICE
ASSEMBLY
PENDULUM FRICTION DEVICE
SK 20339


LIST OF DRAWINGS
PENDULUM FRICTION DEVICE DETAILS
ADJUSTING MECHANISM DETAILS
SHOE AND LATCH DETAILS
PENDULUM FRICTION DEVICE ASSEMBLY
SCALE AS SPECIFIED
PENDULUM FRICTION DEVICE
SHOE AND LATCH DETAILS
REVISED
APPROVED
DATE JUNE 10, 1954
SK 20140





SHAFT, RETAINER
STEEL, AISI 1020

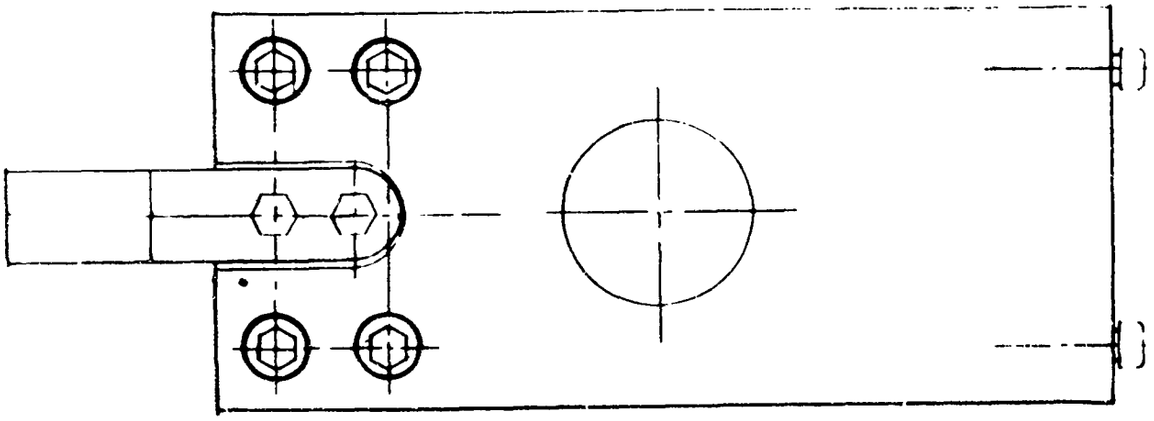


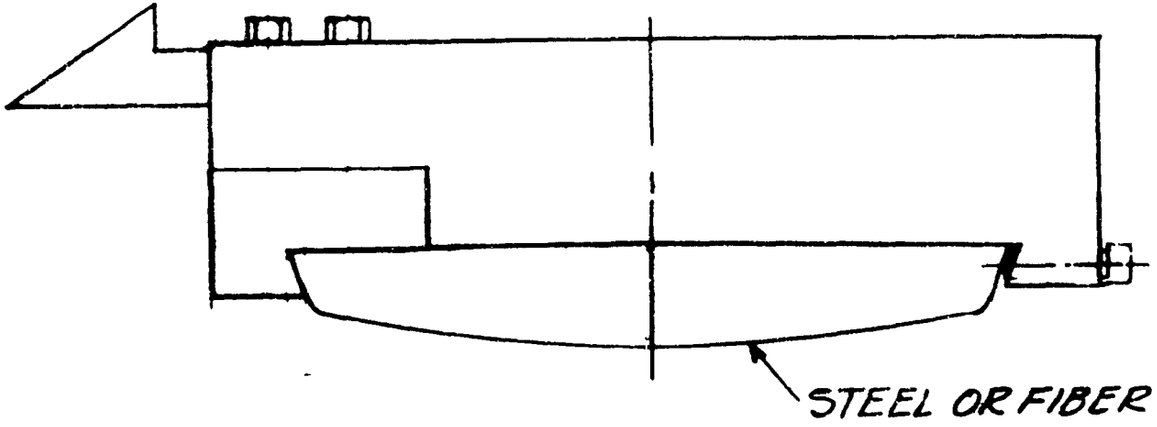
HOOK, TRIPPING
STEEL

PENDULUM, FRICTION
DEVICE

SKETCH NO. 1

40-1503





SHOE, RETAINER ASSEMBLY

PENDULUM FRICTION DEVICE SKETCH NO2