









**NBSIR 75-913**

# **Structural Test Procedures for Bicycles**

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## TABLE OF CONTENTS

|                                                   | page |
|---------------------------------------------------|------|
| 1. SCOPE                                          | 1    |
| 1.1 Test Purpose                                  | 1    |
| 2. TEST EQUIPMENT                                 | 2    |
| 2.1 Load-Deflection Recorder                      | 2    |
| 2.2 Loading Frame                                 | 2    |
| 3. TEST PROCEDURE                                 | 3    |
| 3.1 Test Flow                                     | 3    |
| 3.2 Drive Chain Test (1512.8)                     | 3    |
| 3.2.1 Test Equipment                              | 3    |
| 3.2.2 Procedure                                   | 3    |
| 3.3 Handlebar Stem to Fork Clamp (1512.18 (h)(1)) | 3    |
| 3.3.1 Test Equipment                              | 3    |
| 3.3.2 Test Procedure                              | 3    |
| 3.4 Handlebar Strength (1512.18 (h)(2))           | 4    |
| 3.4.1 Test Equipment                              | 4    |
| 3.4.2 Test Procedure                              | 4    |
| 3.5 Handlebar Stem Test (1512.18 (g))             | 4    |
| 3.5.1 Test Equipment                              | 4    |
| 3.5.2 Test Procedure                              | 4    |
| 3.6 Seat Clamp Tests (1512.18 (1))                | 5    |
| 3.6.1 Test Equipment                              | 5    |
| 3.6.2 Test Procedure                              | 5    |
| 3.7 Rear Hub Retention Test (1512.12 (a)(1))      | 5    |
| 3.7.1 Test Equipment                              | 5    |
| 3.7.2 Test Procedure                              | 5    |
| 3.8 Rim Test (1512.18 (j))                        | 5    |
| 3.8.1 Test Equipment                              | 5    |
| 3.8.2 Test Procedure                              | 5    |
| 3.9 Frame Test (1512.18 (k)(2))                   | 6    |
| 3.9.1 Test Equipment                              | 6    |
| 3.9.2 Test Procedure                              | 6    |
| 3.10 Fork Test (1512.18 (k)(1))                   | 6    |
| 3.10.1 Test Equipment                             | 6    |
| 3.11.2 Test Procedure                             | 7    |
| 4. RESULTS                                        | 7    |
| 5. DISCUSSION                                     | 7    |
| 6. CONCLUSIONS                                    | 8    |

Table of Contents (Con't.)

page

7. REFERENCES

8

APPENDIX A

A-1

APPENDIX B

B-1

# STRUCTURAL TEST PROCEDURES FOR BICYCLES

Donald E. Marlowe

Tests for several structural performance criteria have been included in a mandatory regulation on bicycle safety which has been proposed by the Consumer Product Safety Commission. The apparatus and procedures developed to conduct these tests and results from 15 representative bicycles are described. Several of the bicycles tested failed to meet the requirements for the seat and handlebar stem friction clamp strength.

Key Words: Bicycle, consumer safety, regulations, safety, structural testing.

## 1. SCOPE

Accident reports received by the Consumer Product Safety Commission (CPSC) list many injuries to children as a result of accidents involving bicycles. Many of these injuries result from failure of the structural components of the bicycle during normal use. As a result, the CPSC has included a set of structural performance criteria in the proposed mandatory regulations [1] on bicycle safety. This report describes the apparatus and procedures developed at the National Bureau of Standards for the performance of tests to measure the structural properties of bicycles in accordance with the mandatory regulation and its proposed amendments.

### 1.1 Test Purpose

The purpose of the tests described here is to verify the technical feasibility of the tests as proposed in the regulation and to exercise the test apparatus which was designed at NBS for CPSC.

The tests included in the program and the paragraphs of the regulation to which they refer are as follows:

- |                                     |                  |
|-------------------------------------|------------------|
| 1) Drive chain strength             | (1512.8)         |
| 2) Handlebar strength               | (1512.18 (h))    |
| 3) Seat clamp strength              | (1512.18 (l))    |
| 4) Handlebar stem strength          | (1512.18 (g))    |
| 5) Frame strength                   | (1512.18 (k)(2)) |
| 6) Fork strength                    | (1512.18 (k)(1)) |
| 7) Rear hub retention strength, and | (1512.12 (a)(1)) |
| 8) Wheel rim strength               | (1512.18 (j))    |

## 2. TEST EQUIPMENT

The equipment used for these tests included a universal testing machine with a 11100 N (2500 lbf) range which complied with the calibration requirements of ASTM E-4 [2], spring force gages with capacities of 450 N (100 lbf) and 900 N (200 lbf), a loading frame equipped with a load cell, deflectometer and an X-Y plotter, and several specialized test jigs which will be described in conjunction with particular tests in later sections of this report.

### 2.1 Load-Deflection Recorder

This instrumentation was used for all tests which were conducted in the loading frame. The complete package includes an X-Y plotter, control box, load cell, and deflection transducer.

Operation: For operation and maintenance of the recorder, see the instruction manual [3] provided with the recorder.

Load Channel: An electrical signal proportional to load is provided for recording on the Y-axis of the recorder. Load is sensed with 2200 N (500-lbf) capacity load cell. The load scale is adjusted to 220 N/cm of record (50 lbf/in of record) when the recorder multiplier switch is set at 1 mV/in and the push to calibrate button results in a deflection of 22.4 cm (8.80 in).

Deflection Channel: An electrical signal proportional to deflection is provided for recording on the X-axis of the recorder. Deflection is sensed with a displacement transducer having a maximum range of 10 cm (4 in). The deflection scale is adjusted to 0.25 cm per cm (0.25 in per in) of record when the recorder multiplier switch is set at 100 mV/in and the push-to-calibrate button results in a pen deflection of 19.2 cm (7.55 in).

Schematic: A schematic of the control box circuit, which includes the load and displacement transducers, is shown in Figure 1.

### 2.2 Loading Frame

A loading frame, designed to supplement the use of a testing machine, was used in several of these tests. Its use will be illustrated for several tests in later sections of this report. The loading frame provides attachment points for the bicycle parts and the loading actuator employed. The actuator used was a double acting hydraulic cylinder and power supply. Drawings of this load frame are provided in Appendix A.

### 3. TEST PROCEDURE

#### 3.1 Test Flow

Special attention must be given to the order in which tests are performed if a single bicycle is to be used for all the tests. If care is not taken, the loading and subsequent destruction of bicycle parts not under test may occur which will invalidate tests to be performed later in the program. One possible order for these tests is shown in Figure 2. It should be noted that no component tests can be conducted until all braking tests, probe tests, reflector tests and road tests have been completed.

#### 3.2 Drive Chain Test (1512.8)

##### 3.2.1 Test Equipment

The apparatus used for these tests is shown in Figure 3. The fixtures are mounted as shown in a universal testing machine having a loading range of 11100 N (2500 lbf) capacity. The detailed drawings of the test fixtures are given in Appendix A.

##### 3.2.2 Procedure

The chain grips (Figure 4) were suspended in the testing machine using the testing machine pull rods. The drive chain was removed from the bicycle and installed in the grips. This was done by inserting the chain onto the sprocket wheel such that the test section of the chain was on the axis of the testing machine and the chain was wrapped around the sprocket until the last link rested in the tooth adjacent to the hole through the sprocket. A light gage wire was then inserted through the hole and wrapped around the chain or inserted through the hole in the last chain link (Figure 4). After placing the fly mesh screen around the specimen to contain all broken chain pieces, load was applied until chain failure (1512.8).

#### 3.3 Handlebar Stem to Fork Clamp (1512.18 (h)(1))

##### 3.3.1 Test Equipment

The apparatus used to conduct this test is shown in Figure 5. It includes a load bar clamped to the handlebar and a spring force gage attached to the load bar a measured distance from the stem clamp axis.

##### 3.3.2 Test Procedure

The front fork was restrained from rotating by clamping it against a stationary object. The load bar was clamped to the handlebar. The

distance from the stem axis to the loading point on the loading bar was measured. A gradually increasing load was applied through the force gage until a torque on the clamp of 47.2 N-m (35 ft-lb) was reached or the stem began to turn in the fork (1512.18(h)(1)).

### 3.4 Handlebar Strength (1512.18 (h)(2))

#### 3.4.1 Test Equipment

The apparatus used to conduct this test is shown in Figure 6. It includes a fixture to hold the handlebar stem in the testing machine, and a loading jig to apply loads to the ends of the handlebar. The test was conducted in a testing machine for convenience only and could have been done with the stem inserted in the bicycle. The detailed drawings of these test fixtures are given in Appendix A.

#### 3.4.2 Test Procedure

The stem was removed from the bicycle, inserted in the holding fixture and the stem clamp tightened. Adjustments were made to the fixture to level the portions of the handlebar near the ends where load would be applied. The fixture was placed in a testing machine. The loading yoke was placed on the handlebar ends and load slowly applied by the machine until a load of 445 N (100 lbf) was reached, or an energy of 22.6 J (200 in-lb) was absorbed in handlebar bending, or the handlebar slipped in the clamp (1512.18(h)(2)).

### 3.5 Handlebar Stem Test (1512.18 (g))

#### 3.5.1 Test Equipment

This test was performed in a testing machine which complies with the requirements of ASTM designation E4-72. The apparatus used for this test is shown in Figure 7. This test fixture fulfills the requirements of paragraph 1512.18 (g)(1) and Figure 2 of the proposed regulation. A detailed drawing of this fixture is given in Appendix A.

#### 3.5.2 Test Procedure

The handlebar was removed from the stem and a solid bar inserted in the stem in its place. The handlebar clamp was retightened. The stem was placed in the stem loading fixture at its minimum insertion mark and the stem bolt tightened. For stems which did not have a minimum insertion mark, the diameter of the stem was measured and the stem was inserted into the fixture to a depth of 2.5 diameters. Gradually increasing loads were applied in the testing machine through the loading yoke in a direction as shown in Figure 2 of the regulation until a load of 2000 N (450 lbf) was reached (1512.18(g)(1)). The load was removed. The stem was removed from the fixture and checked visually for cracks.

### 3.6 Seat Clamp Tests (1512.18 (1))

#### 3.6.1 Test Equipment

For this test a 900 N (200 lbf) spring force gage was used as shown in Figure 8.

#### 3.6.2 Test Procedure

With the bicycle frame restrained from movement by clamping its frame to the frame of a testing machine, 668 N (150 lbf) was applied downward, 25 mm (1 in) from the seat front and then 25 mm (1 in) from the seat back so as to test the seat clamps in pitch. A load of 222 N (50 lbf) was then applied horizontally at these same distances from the seat front and back so as to test the seat clamps in yaw (1512.18(1)(1)).

### 3.7 Rear Hub Retention Test (1512.12 (a)(1))

#### 3.7.1 Test Equipment

The equipment needed for this test is shown in Figure 9. This equipment included a hydraulic ram and load cell for applying and measuring the load, the connectors needed to grip the bicycle frame and rear axle, and a reaction frame.

#### 3.7.2 Test Procedure

For this test, the front wheel was removed from the bicycle. The test fixtures for holding the frame and axle were attached to the bicycle (Figure 10). The fixtures were attached to the reaction frame and hydraulic ram such that the applied load was in the direction of the axle adjustment slot in the frame. Force was gradually applied to the axle-frame coupling until 1780 N (400 lbf) had been reached or until the axle moved in the frame.

### 3.8 Rim Test (1512.18 (j))

#### 3.8.1 Test Equipment

The test apparatus used in this test is shown in Figure 11. This equipment included the masks for each tire size, a hydraulic ram to apply the load, a load cell and indicator to measure the load, a coupling for each bicycle axle, and a reaction frame. The mask rested on the frame and supported the rim through the tire around its entire circumference. A coupling which fitted the threads of the axle and a chain (Figure 12) was used to connect the loading ram to the wheel.

### 3.8.2 Test Procedure

Wheel rims were tested in accordance with paragraph 1512.18 (j) of the regulation. If both wheels of the bicycle were symmetric about the plane of the tire, only one was to be tested. If, however, the wheel hub was offset, as occurred when a multiple drive sprocket was used on the rear axle both wheels were tested. For the wheel with the offset, load was applied in the direction of the offset.

After the wheel to be tested was removed from the bicycle, the tire was inflated to the pressure recommended by its manufacturer. The axle coupling was installed, and the wheel was placed on the mask in the reaction frame with the mask supporting only the tire. The chain was attached to the loading ram and the axle coupling. A gradually increasing load was applied to 2000 N (450 lbf). This load was held for 30 seconds and removed. The wheel was then reinstalled on the bicycle according to the manufacturers instructions and tested for alinement in accordance with paragraph 1512.11 of the regulation.

## 3.9 Frame Test (1512.18 (k)(2))

### 3.9.1 Test Equipment

The equipment needed for this test is shown in Figure 13. It includes a reaction frame, load cell and deflectometer for measuring load and deflection, the X-Y plotter, and a hydraulic ram for applying the load.

### 3.9.2 Test Procedure

After the wheels were removed from the bicycle, the rear fender brackets were removed. The frame was inserted in the reaction frame as shown in Figures 13 and 14. Shown in Figure 14a is the positioning of the deflectometer to measure frame deformations. As the load was applied using the hydraulic ram, a plot of load versus deflection was made. Load was gradually applied until a force of 890 N (200 lbf) was reached or 39.5 J (350 in-lb) of energy was absorbed in frame deflection, whichever resulted in the greater force (1512.18(k)(2)). After the load had been released, the frame was removed from the test fixture and the front wheel reinstalled on the bicycle and checks were made to determine if the steering of the bicycle had been affected.

## 3.10 Fork Test (1512.18 (k)(1))

### 3.10.1 Test Equipment

The equipment needed for this test is shown in Figure 15. This fixture complies with the requirements of paragraph 1512.18 (k)(1)(i) and Figure 1 of the proposed regulation. Also required for this test

is a testing machine, a deflectometer and the X-Y plotter. A drawing of the apparatus used in the test is given in Appendix A.

### 3.10.2 Test Procedure

After the results of the frame test had been evaluated, the fork was removed from the bicycle and all bearings, hardened shoulders and any cable fittings were removed. A hardened steel roller wheel was installed at the axle attachment point (Figure 15). The fork was placed in the fixture with the fork yoke hard against the V block. The deflectometer was adjusted to measure fork deflection. The X-Y plotter was connected to the load readout of the testing machine and to the deflectometer and the spans adjusted to a convenient value. Gradually increasing loads were applied through the roller wheel until a deflection of 64 mm (2.5 in) was reached. The area under the force deflection curve was computed to find the energy absorbed. The Regulation required that a minimum of 39.5 J (350 in-lbf) of energy shall be absorbed in bending of the fork (1512.18(k)(1)).

## 4. RESULTS

All tests were conducted in a normal laboratory environment at room temperature. It is estimated that the errors did not exceed 1 percent for load measurement and 0.05 inches for deflection. Fifteen bicycles were tested to evaluate the regulation and the test equipment. These bicycles are described in Table 1. The results of the structural tests performed during this evaluation are given in Table 2. Typical load-deflection autographic recordings, from which the energy of deformation for the forks and frames are calculated, are shown in Figure 16 and 17.

Because no spare forks were submitted with these bicycles, the frame test (1512.18 (k)(2)) was performed before the fork test. The regulation provides that a second fork, identical to that tested in the fork test be installed in the bicycle for this test but that provision was not possible for these tests. Accordingly the fork, which was supplied on the bicycle at the time of purchase and which may have been deformed by the frame test, was tested.

## 5. DISCUSSION

As can be seen from Table 2, 11 of the 15 bicycles tested failed to pass one or more of the clamp tests. These clamps were tested in the "as received" condition, or as "assembled" in our laboratory before the bicycle was ridden during the braking system tests. No attempt was made to retighten and retest a clamp which had failed.

The apparatus and the procedures used for these tests are not unique. Several alternate ways of applying the necessary forces to the bicycle components could have been devised. One of the purposes of these tests was to exercise the test apparatus which was assembled at NBS for CPSC. This was done with only a few minor modifications to the test apparatus. The procedures used and the order in which the tests were performed were developed during this program.

## 6. CONCLUSIONS

The structural tests proposed in the mandatory regulation have been performed on 15 bicycles which represent many of the types and sizes which are currently available in the marketplace.

The greatest number of "failures" occurred during the testing of friction clamps such as are used in seats and handlebar stems. However the bicycles had been tested for brake performance before these tests and the clamps were adequately tight.

The testing of the bicycle forks in accordance with the regulation requires that a new fork, nominally identical to that provided with the bicycle, be the test object. Many of the sources of bicycles, such as department stores, large drug stores, hardware retail stores, etc., may be unable to supply the part at the time the bicycle is procured for testing. Some consideration should be given to the meaning of a test performed on an already damaged fork.

## 7. REFERENCES

1. Requirements for Bicycles, Part 1512, Federal Register, Vol. 39, No. 137, July 16, 1974, as amended; Federal Register, Vol. 40, No. 4, January 7, 1975, as amended; Federal Register, Vol. 40, No. 116, June 16, 1975.
2. Standard Methods of Verification of Testing Machines, ASTM E4-72, American Society for Testing and Materials, Philadelphia, Pennsylvania.
3. Instruction Manual, Series 2000 Omnigraphia X-Y Recorder, Houston Instrument Co., Bellaire, Texas.

Table 1 - Test Specimen Parameters

| Bicycle No. | Brake Type                           | Number of Speeds | Maximum Gear Ratio | Wheel Size |    | Bicycle Mass |      | Wheel Base |       | Frame Size(d) |                      |
|-------------|--------------------------------------|------------------|--------------------|------------|----|--------------|------|------------|-------|---------------|----------------------|
|             |                                      |                  |                    | mm         | in | kg           | lb   | mm         | in    | mm            | in                   |
| 1           | Coaster and Single Caliper           | 1                | 40/16              | 508        | 20 | 14.1         | 31.1 | 887.7      | 34.95 | 349.2         | 13.75 <sup>(a)</sup> |
| 2           | Double Caliper <sup>(e)</sup>        | 10               | 52/14              | 686        | 27 | 11.8         | 26.0 | 1027.7     | 40.46 | 527.0         | 20.25                |
| 3           | Double Caliper                       | 3                | 48/20              | 660        | 26 | 18.2         | 40.1 | 1051.6     | 41.40 | 527.0         | 20.75                |
| 4           | Double Caliper                       | 10               | 52/14              | 686        | 27 | 13.9         | 30.5 | 1088.6     | 42.86 | 635.0         | 25.00                |
| 5           | Double Caliper with Extension Levers | 10               | 50/14              | 686        | 27 | 13.4         | 29.5 | 1025.6     | 40.38 | 485.6         | 19.12 <sup>(a)</sup> |
| 6           | Double Caliper with Extension Levers | 10               | 52/14              | 660        | 26 | 15.0         | 33.1 | 1041.4     | 41.00 | 552.5         | 21.75                |
| 7           | Double Caliper                       | 10               | 50/14              | 686        | 27 | 18.4         | 40.4 | 1071.1     | 42.17 | 508           | 20.00                |
| 8           | Double Caliper                       | 10               | 52/14              | 686        | 27 | 16.8         | 37.0 | 1055.4     | 41.55 | 552.5         | 21.75                |
| 9           | Double Caliper                       | 10               | 52/14              | 660        | 26 | 15.2         | 33.5 | 1044.4     | 41.12 | 552.5         | 21.75                |
| 10          | Double Caliper                       | 5                | 50/14              | 686        | 27 | 16.6         | 36.6 | 1058.2     | 41.66 | 590.5         | 23.25                |
| 11          | Coaster                              | 1                | 36/16              | 508        | 20 | 13.9         | 30.5 | 894.6      | 35.22 | 352.3         | 13.87                |

(continued)

Table 2 - Structural Test Results for Bicycles

| Bicycle No.       | Drive Chain Failure Load | Handlebar |      |          |      | Seat Clamp Pitch(b) | Rear Hub Locking Device |      | Wheel Rim |      | Frame Test |         | Fork Test |      |         |        |
|-------------------|--------------------------|-----------|------|----------|------|---------------------|-------------------------|------|-----------|------|------------|---------|-----------|------|---------|--------|
|                   |                          | Stem      |      | Strength |      |                     |                         |      |           |      |            |         |           |      |         |        |
|                   |                          | N         | Load | N        | Defl | N                   | N                       | N    | Front     | Rear | Load       | Defl(e) | Energy    | Load | Defl(e) | Energy |
|                   |                          |           |      |          | mm   |                     | Yaw(b)                  |      | N         | N    | N          | mm      | J         | N    | mm      | J      |
| 1                 | 7740                     | 32        | 2000 | 445      | 3.17 | 668                 | 222                     | (c)  | 2000      | (c)  | 1560       | 47      | 55.4      | 1310 | 64      | 67.3   |
| 2                 | 9520                     | 38        | 2000 | 445      | 3.17 | 668                 | 164                     | 1780 | 2000      | 2000 | 1330       | 60      | 68.6      | 1180 | 64      | 55.4   |
| 3                 | 7760                     | 65        | 2000 | 445      | 3.17 | 668                 | 196                     | 1780 | 2000      | (c)  | 1560       | 57      | 60.7      | 1530 | 64      | 73.6   |
| 4                 | 9760                     | 61        | 2000 | 445      | 2.54 | 668                 | 151                     | 1780 | 2000      | 2000 | 1250       | 57      | 53.1      | 1070 | 64      | 54.4   |
| 5                 | 7760                     | 47        | 2000 | 445      | (c)  | 668                 | 222                     | 1780 | 2000      | 2000 | 1290       | 57      | 50.4      | 1220 | 64      | 25.2   |
| 6                 | 9350                     | 47        | 2000 | 445      | 3.17 | 668                 | 160                     | 1780 | 2000      | 2000 | 1380       | 60      | 58.8      | 1360 | 64      | 74.2   |
| 7                 | 9440                     | 27        | 2000 | 445      | 4.32 | 668                 | 222                     | 1780 | 2000      | 2000 | 1780       | 47      | 46.4      | 1620 | 64      | 73.4   |
| 8                 | 10090                    | 49        | 2000 | 445      | 3.17 | 668                 | 222                     | 1780 | 2000      | 2000 | 1470       | 57      | 65.8      | 1200 | 64      | 24.5   |
| 9                 | 9950                     | 49        | 2000 | 445      | 2.54 | 668                 | 156                     | 1780 | 2000      | 2000 | 1380       | 44      | 47.1      | 1220 | 64      | 67.7   |
| 10                | 9270                     | 41        | 2000 | 445      | 3.17 | 668                 | 222                     | (c)  | 2000      | 2000 | 1670       | 51      | 51.6      | 1690 | 64      | 55.4   |
| 11                | 8230                     | 26        | 2000 | 445      | 4.75 | 668                 | 222                     | (c)  | 2000      | (c)  | 2220(f)    | 25      | 28.2      | 1670 | 22      | 55.8   |
| 12                | 9040                     | 49        | 2000 | 445      | 2.54 | 668                 | 222                     | 1780 | 2000      | 2000 | 1850       | 51      | 60.7      | 2560 | 64      | 50.0   |
| 13(a)             | 8330                     | (c)       | (c)  | (c)      | (c)  | (c)                 | 222                     | 1110 | 2000(d)   | (c)  | 1600       | 64      | 56.8      | (c)  | (c)     | (c)    |
| 14(a)             | 8740                     | 38        | 1200 | 445      | 3.17 | 668                 | 222                     | 1780 | 2000      | (c)  | 1730       | 44      | 47.7      | 1850 | 64      | 89.3   |
| 15                | 4870                     | 34        | 2000 | 445      | 3.17 | 668                 | 147                     | 1780 | 2000      | 2000 | 1580       | 54      | 60.0      | 1090 | 64      | 54.8   |
| REQUIREMENTS      |                          |           |      |          |      |                     |                         |      |           |      |            |         |           |      |         |        |
| Bicycles          | 8010                     | 47        | 2000 | 445      | 76   | 668                 | 222                     | 1780 | 2000      | 2000 | 890        |         | 39.5      |      | 64      | 39.5   |
| Sidewalk Bicycles | 6230                     | 20        | 1000 | 445      | 76   | 334                 | 111                     | 1780 | 2000      | 2000 | 890        |         | 39.5      |      | 64      | 39.5   |

(a) Sidewalk Bicycle

(b) Tested in as received condition

(c) Data not recorded

(d) Non-inflated tire rolls off the rim while under test

(e) Total deflection while under load. A large portion of this is recovered upon unloading.

(f) This frame exceeded the capacity of the testing apparatus. Therefore the absorbed energy is not indicative of the actual capacity of this frame.

Table 2a - Structural Test Results for Bicycles

| Bicycle No.       | Drive Chain Failure Load lbf | Handlebar |       |          |       | Seat Clamp Pitch(b) lbf | Yaw(b) lbf | Rear Hub Locking Device lbf | Wheel Rim |          | Frame Test |            | Fork Test     |          |            |               |  |
|-------------------|------------------------------|-----------|-------|----------|-------|-------------------------|------------|-----------------------------|-----------|----------|------------|------------|---------------|----------|------------|---------------|--|
|                   |                              | Stem      |       | Strength |       |                         |            |                             | Front lbf | Rear lbf | Load lbf   | Defl(e) in | Energy in-lbf | Load lbf | Defl(e) in | Energy in-lbf |  |
|                   |                              | lb-ft     | lb-ft | lb-ft    | lb-ft | Pitch(b)                | Yaw(b)     |                             |           |          |            |            |               |          |            |               |  |
| 1                 | 1740                         | 24        | 450   | 100      | 0.125 | 150                     | 50         | (c)                         | 450       | (c)      | 350        | 1.87       | 490           | 295      | 2.5        | 596           |  |
| 2                 | 2140                         | 28        | 450   | 100      | .125  | 150                     | 37         | 400                         | 450       | 450      | 300        | 2.37       | 607           | 265      | 2.5        | 490           |  |
| 3                 | 1744                         | 48        | 450   | 100      | .125  | 150                     | 44         | 400                         | 450       | (c)      | 350        | 2.25       | 537           | 345      | 2.5        | 651           |  |
| 4                 | 2195                         | 45        | 450   | 100      | .100  | 150                     | 34         | 400                         | 450       | 450      | 280        | 2.25       | 470           | 240      | 2.5        | 481           |  |
| 5                 | 1745                         | 35        | 450   | 100      | (c)   | 150                     | 50         | 400                         | 450       | 450      | 290        | 2.25       | 446           | 275      | 2.5        | 223           |  |
| 6                 | 2101                         | 35        | 450   | 100      | .125  | 150                     | 36         | 400                         | 450       | 450      | 310        | 2.37       | 520           | 305      | 2.5        | 657           |  |
| 7                 | 2122                         | 20        | 450   | 100      | .170  | 150                     | 50         | 400                         | 450       | 450      | 400        | 1.87       | 411           | 365      | 2.5        | 650           |  |
| 8                 | 2269                         | 36        | 450   | 100      | .125  | 150                     | 50         | 400                         | 450       | 450      | 330        | 2.25       | 582           | 270      | 2.5        | 217           |  |
| 9                 | 2238                         | 36        | 450   | 100      | .100  | 150                     | 35         | 400                         | 450       | 450      | 310        | 1.75       | 417           | 275      | 2.5        | 599           |  |
| 10                | 2084                         | 30        | 450   | 100      | .125  | 150                     | 50         | (c)                         | 450       | 450      | 375        | 2.00       | 457           | 380      | 2.5        | 490           |  |
| 11                | 1850                         | 19        | 450   | 100      | .187  | 150                     | 50         | (c)                         | 450       | (c)      | 500(f)     | 1.00       | 250           | 375      | 0.87       | 494           |  |
| 12                | 2033                         | 36        | 450   | 100      | .100  | 150                     | 50         | 400                         | 450       | 450      | 415        | 2.00       | 537           | 575      | 2.5        | 442           |  |
| 13(a)             | 1873                         | (c)       | (c)   | (c)      | (c)   | (c)                     | 50         | 250                         | 450(d)    | (c)      | 360        | 2.50       | 503           | (c)      | (c)        | (c)           |  |
| 14(a)             | 1964                         | 28        | 270   | 100      | .125  | 150                     | 50         | 400                         | 450       | (c)      | 390        | 1.75       | 422           | 415      | 2.5        | 790           |  |
| 15                | 1095                         | 25        | 450   | 100      | .125  | 150                     | 33         | 400                         | 450       | 450      | 355        | 2.12       | 530           | 245      | 2.5        | 485           |  |
| REQUIREMENTS      |                              |           |       |          |       |                         |            |                             |           |          |            |            |               |          |            |               |  |
| Bicycles          | 1800                         | 35        | 450   | 100      | <3.0  | 150                     | 50         | 400                         | 450       | 450      | 200        |            | 350           |          | 2.5        | 350           |  |
| Sidewalk Bicycles | 1400                         | 15        | 225   | 100      | <3.0  | 75                      | 25         | 400                         | 450       | 450      | 200        |            | 350           |          | 2.5        | 350           |  |

(a) Sidewalk Bicycle

(b) Tested in as received condition

(c) Data not recorded

(d) Non-inflated tire rolls off the rim while under test

(e) Total deflection while under load. A large portion of this is recovered upon unloading.

(f) This frame exceeded the capacity of the testing apparatus. Therefore the absorbed energy is not indicative of the actual capacity of this frame.



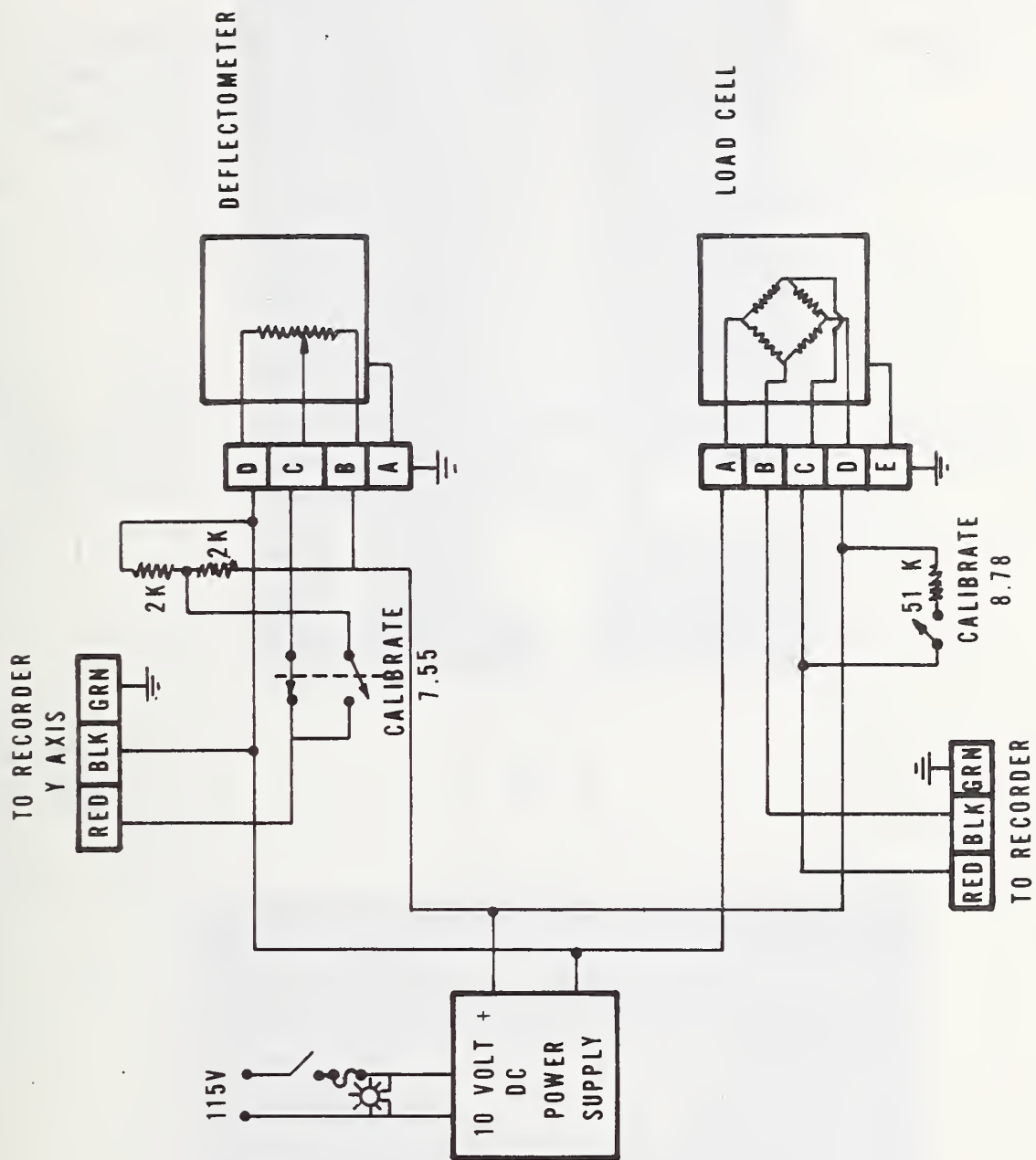


Figure 1 - Schematic of the load-deflection instrumentation

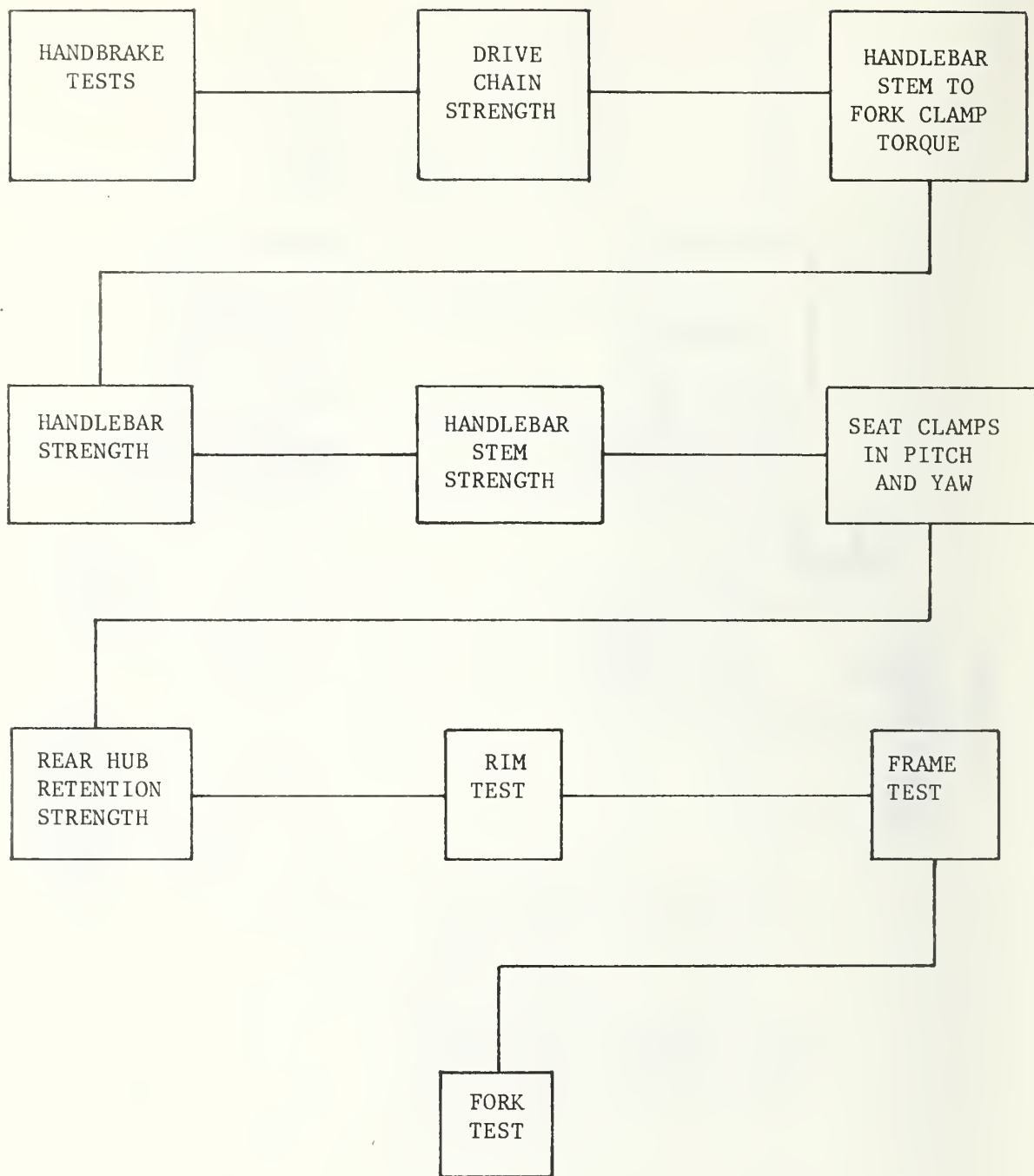


Figure 2 - Flow Diagram for Bicycle Performance Tests



Figure 3 - Drive Chain Test Apparatus

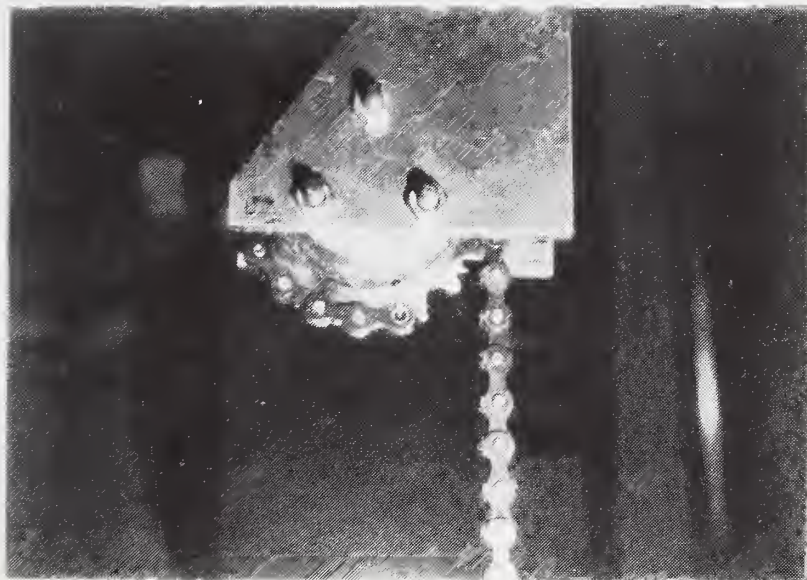


Figure 4 - Drive Chain Test Loading Fixture

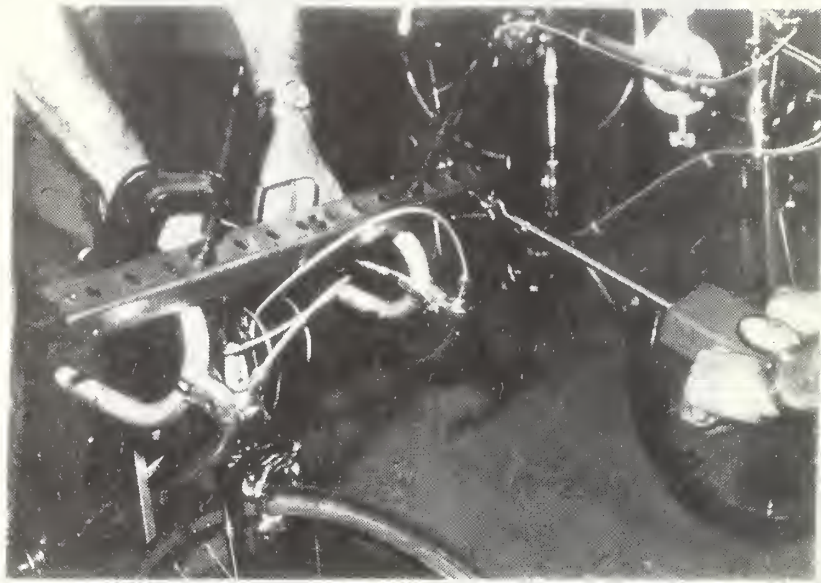


Figure 5 - Handlebar Stem-to-Fork Clamp Test

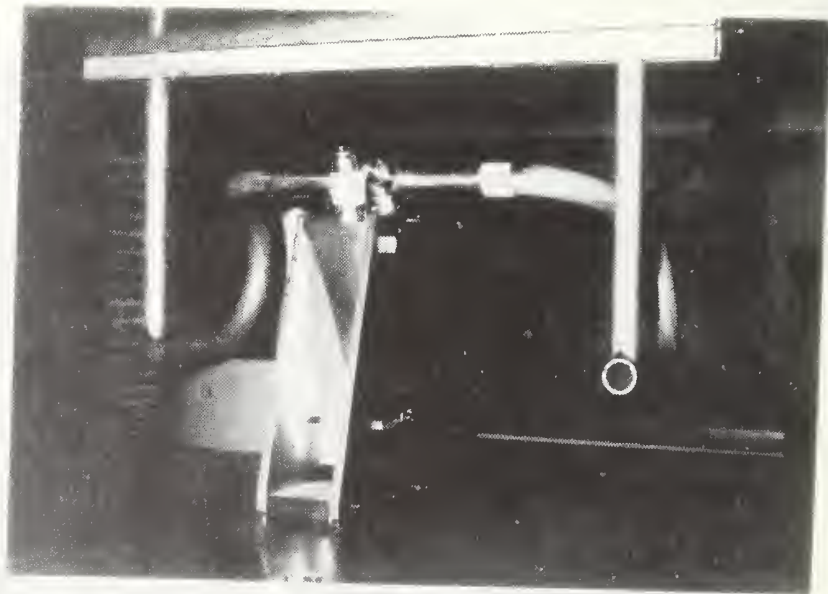


Figure 6 - Handlebar Strength Test Fixture

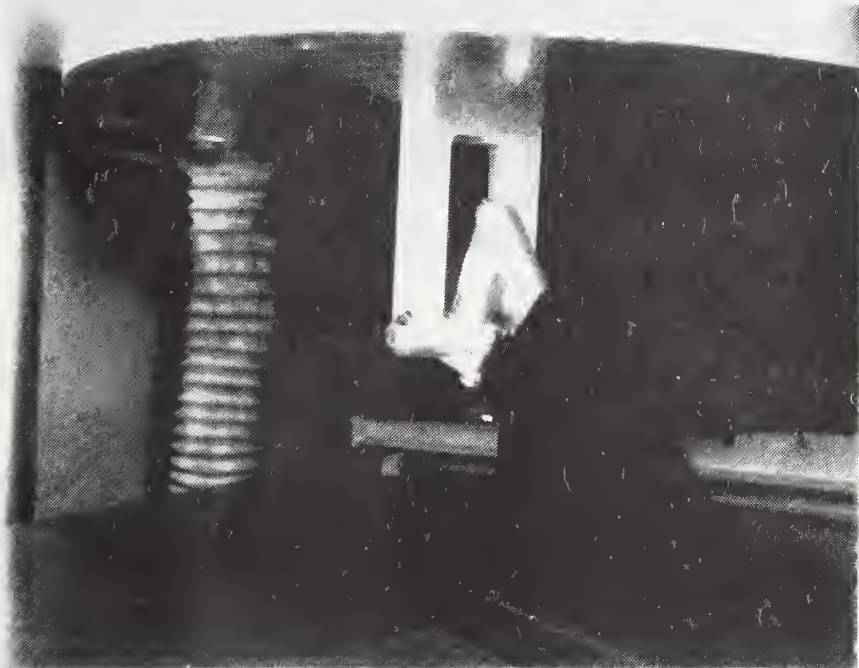


Figure 7 - Stem Test Fixture

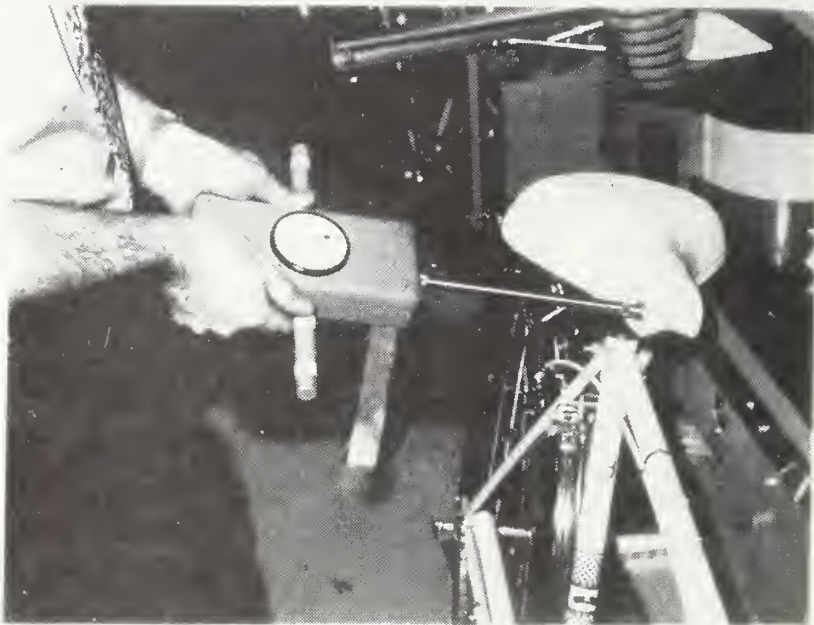


Figure 8 - Seat Clamp Test

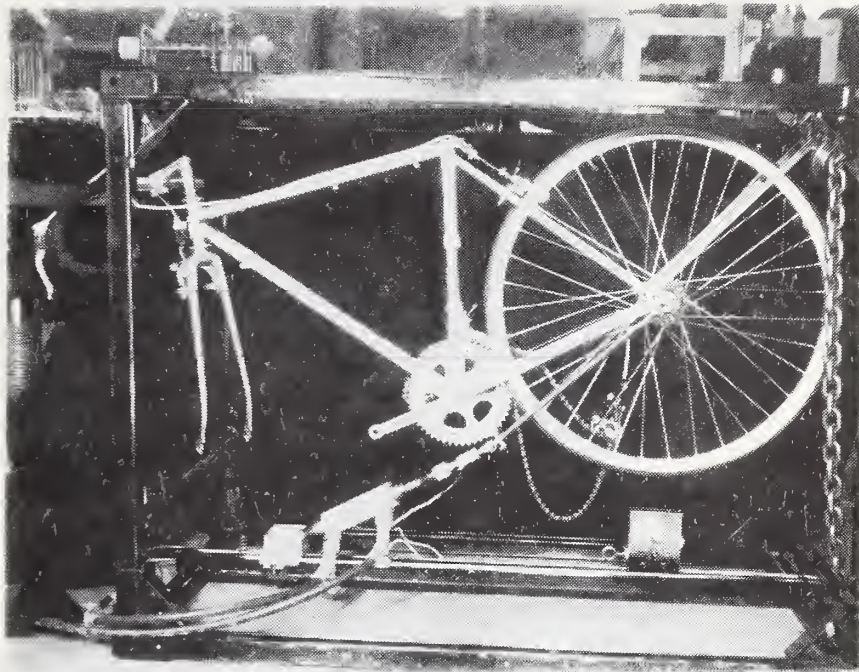


Figure 9 - Rear Hub Retention Test

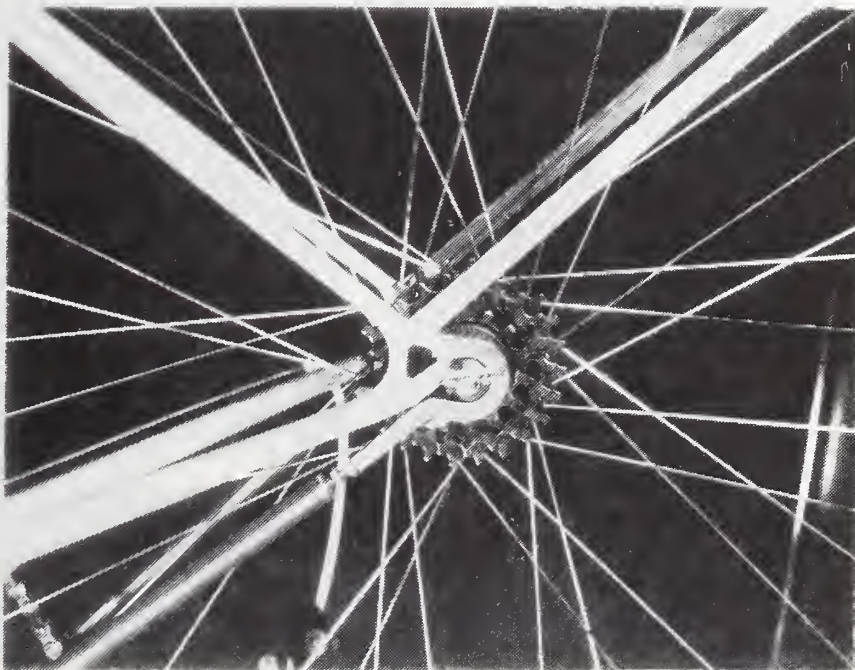


Figure 10 - Rear Hub Retention Test - Close-up of Axle Attachment

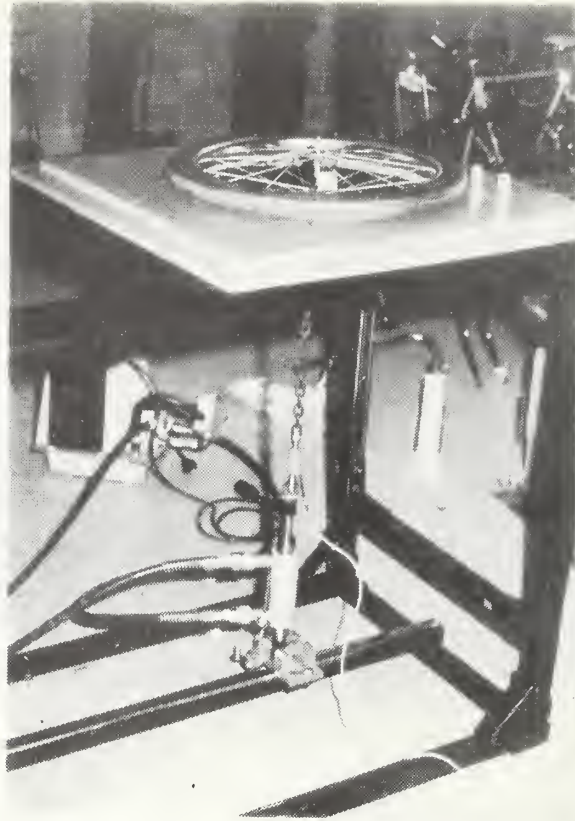


Figure 11 - Rim Test Fixture

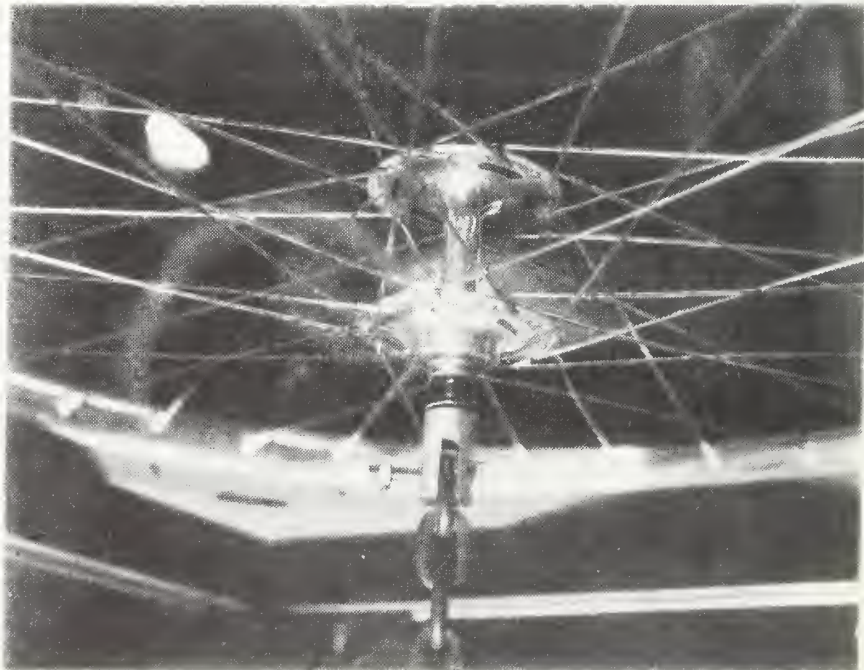


Figure 12 - Rim Test Fixture - Close-up of Axle Coupling

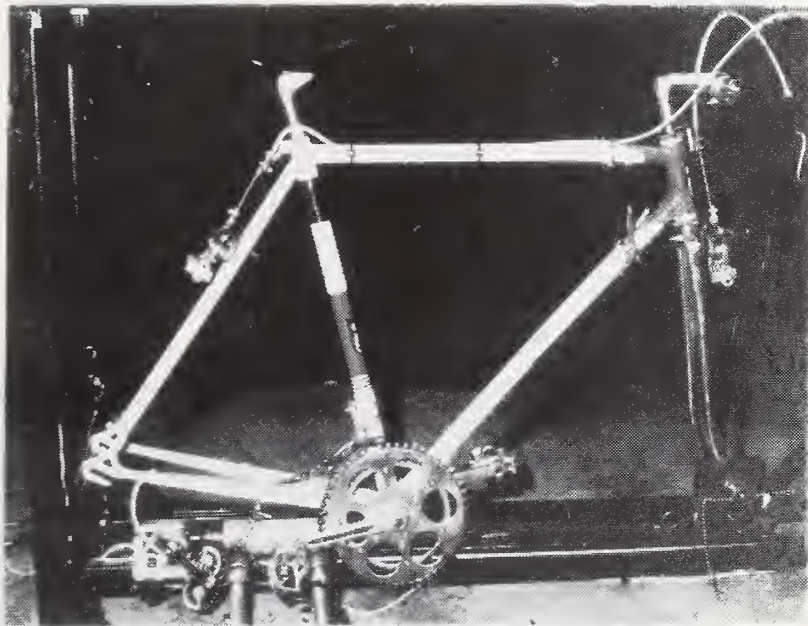


Figure 13 - Frame Test Fixture

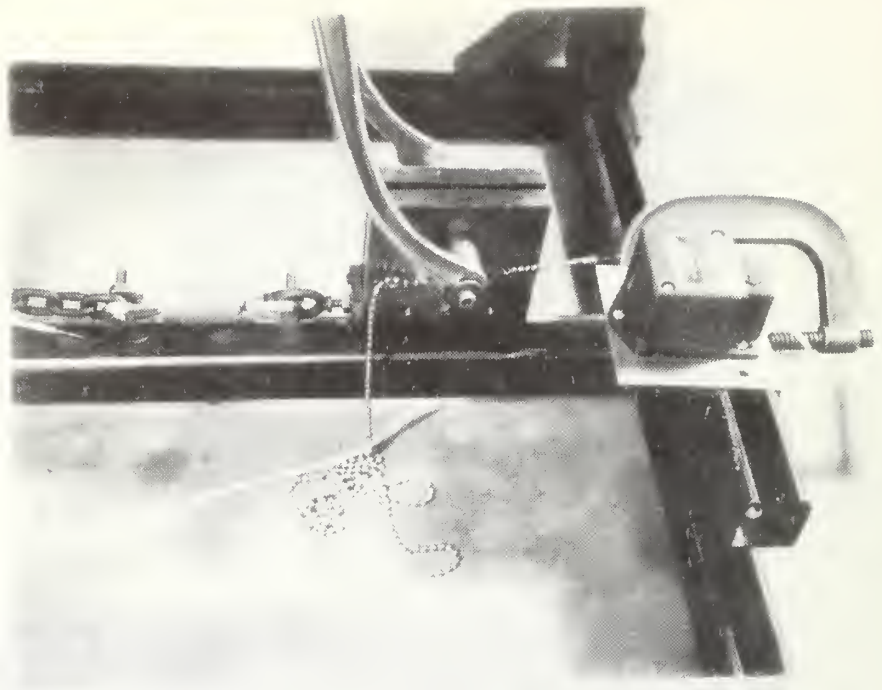


Figure 14a - Frame Test Fixture - Close-up of Front Attachment

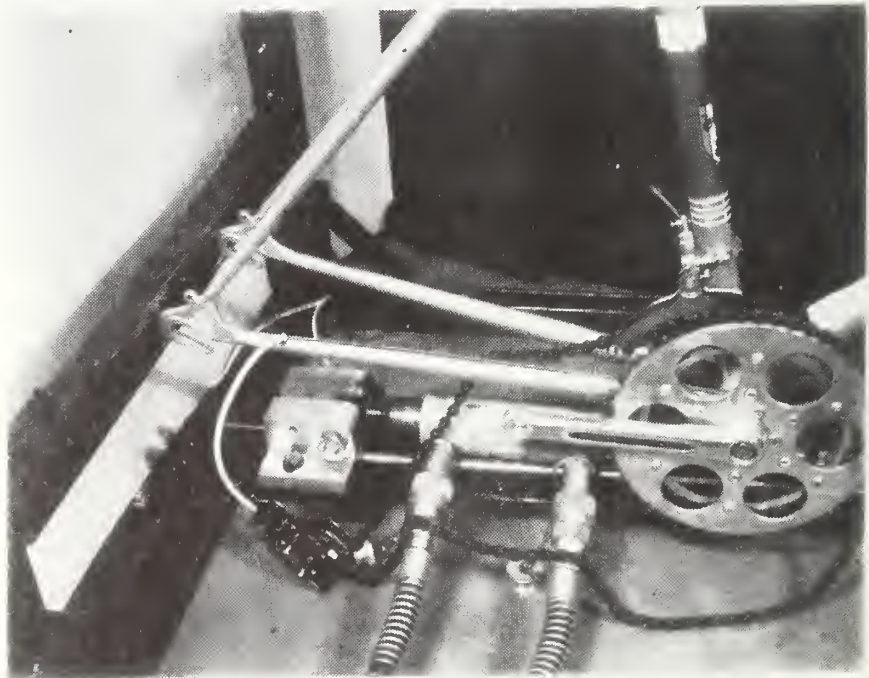


Figure 14b - Frame Test Fixture - Closeup of Rear Attachment

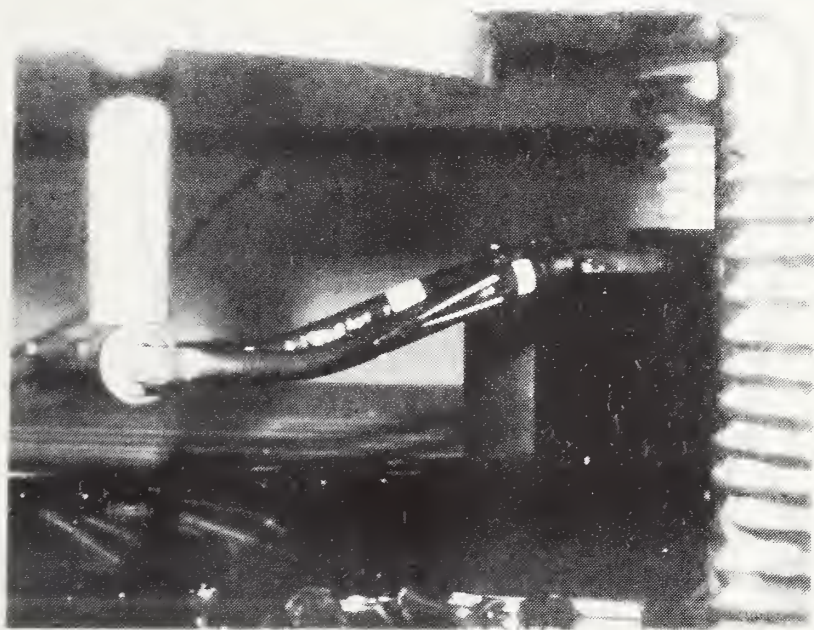


Figure 15 Fork Test Fixture

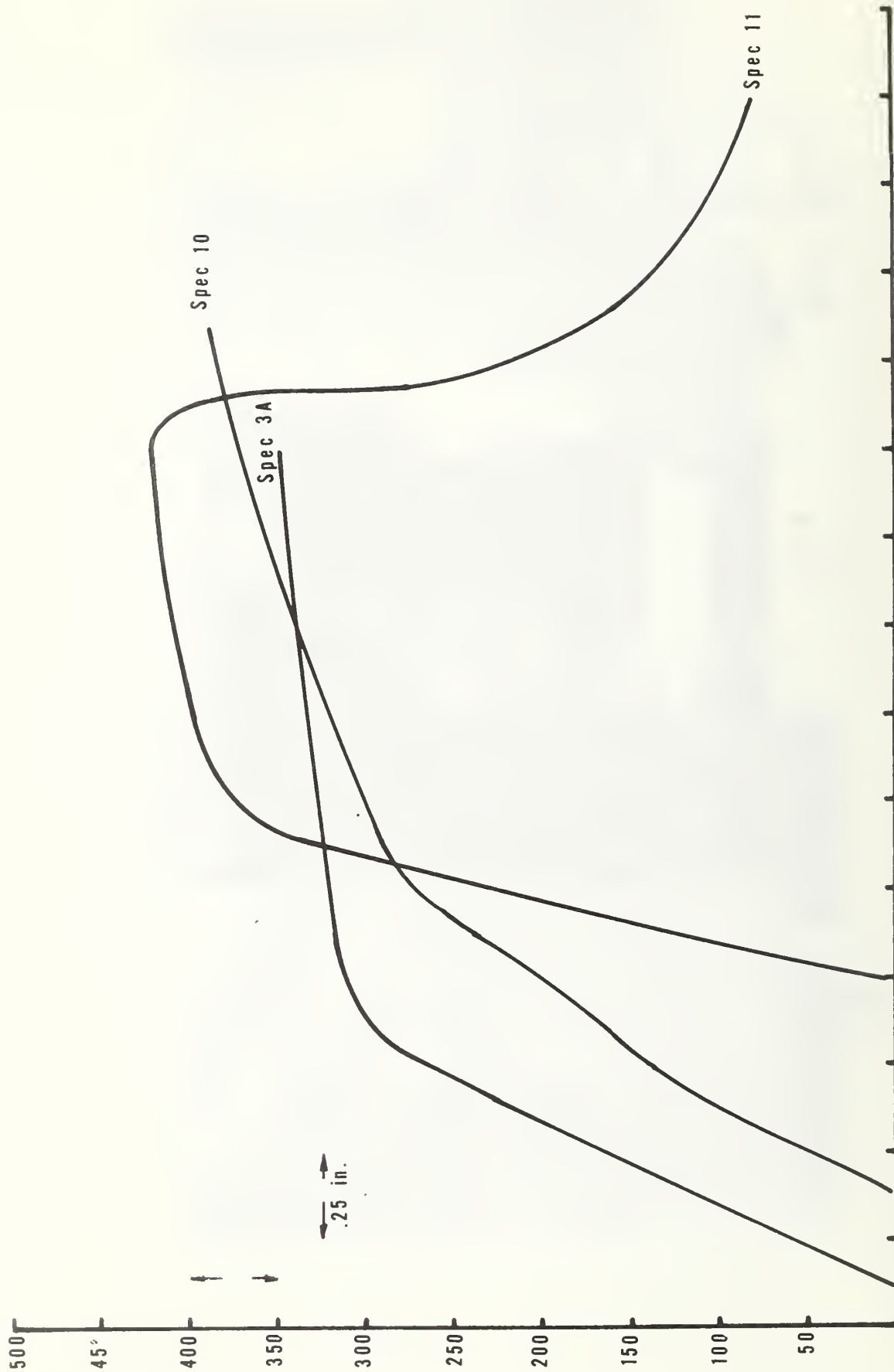


Figure 16 Typical Fork Test Load-Deflection Recordings

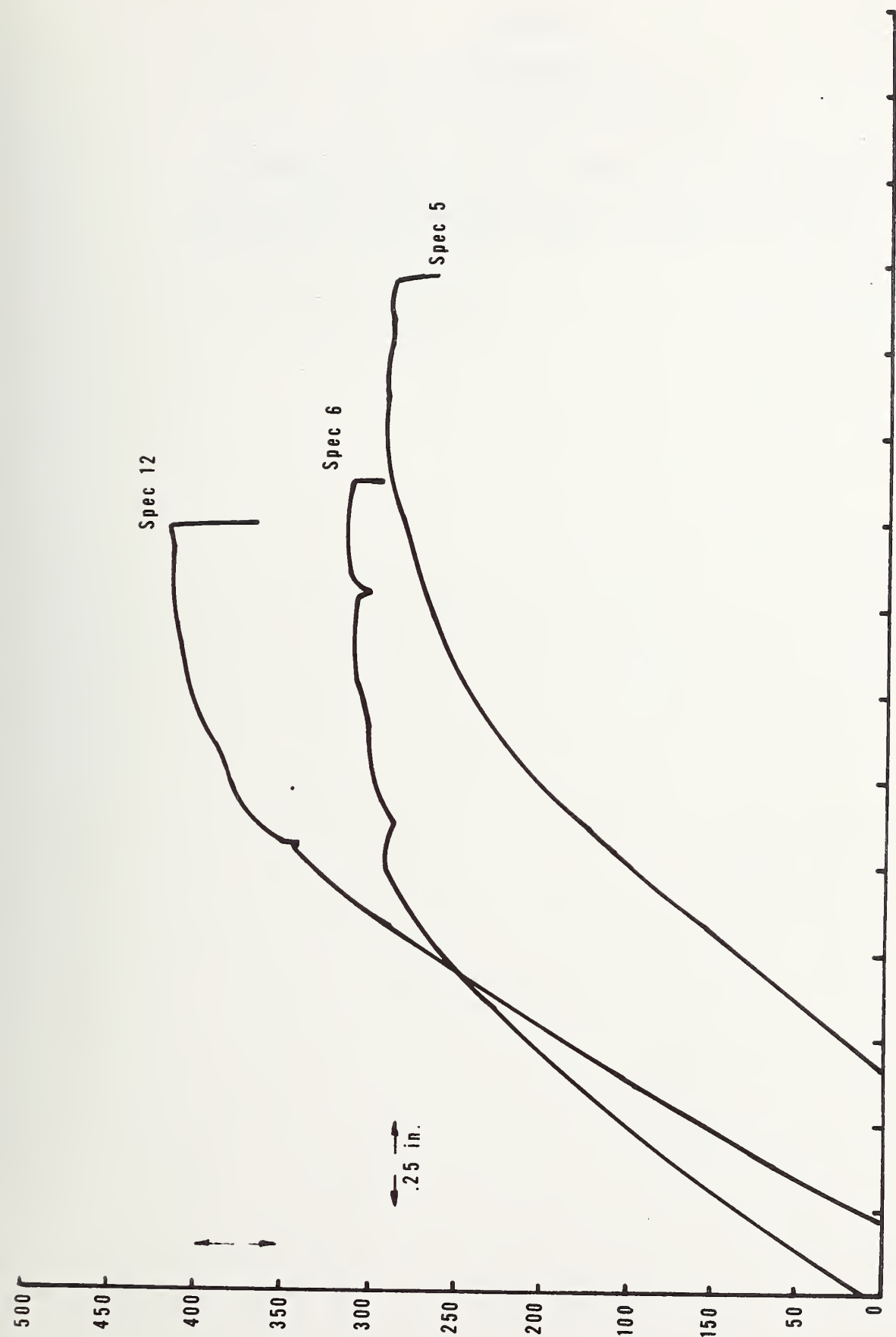


Figure 17 - Typical Frame Test Load-Deflection Recordings



## Appendix A

### Test Fixtures for Structural Tests on Bicycles

Detailed drawings for the fixtures used for the tests described in this report are given in Figures A-1 to A-18.



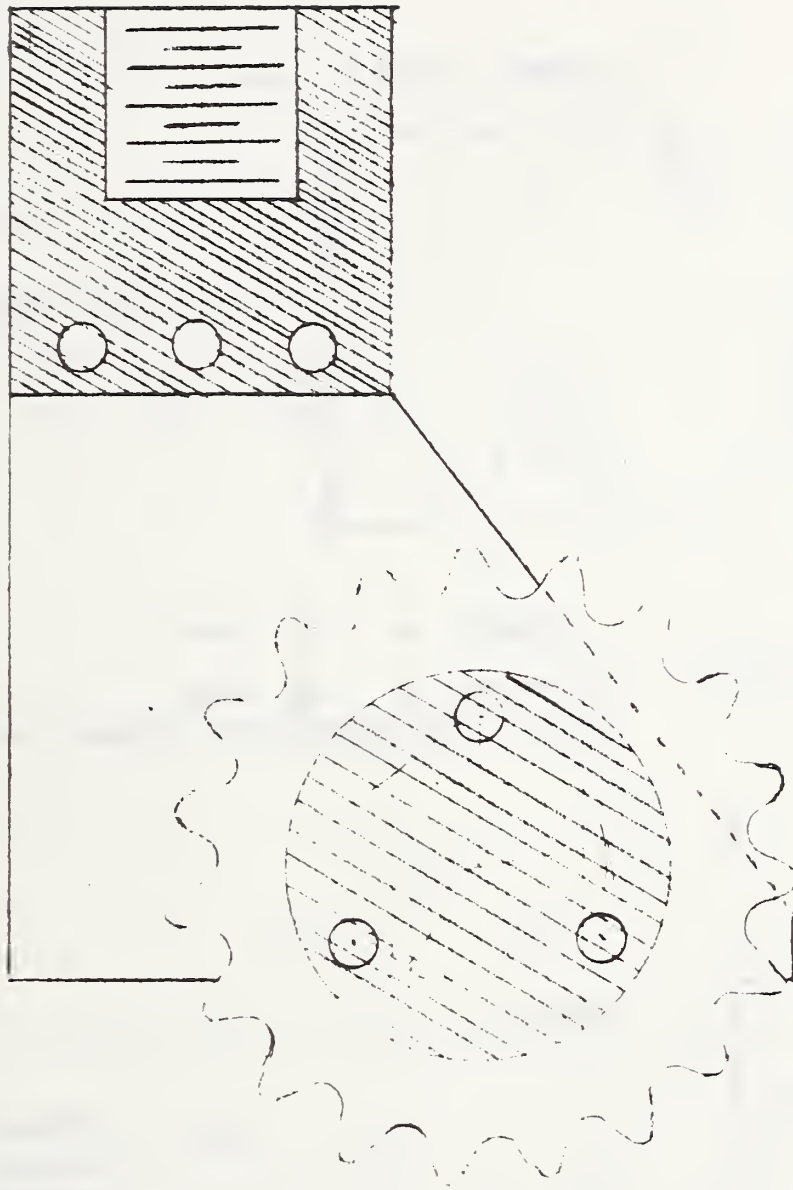
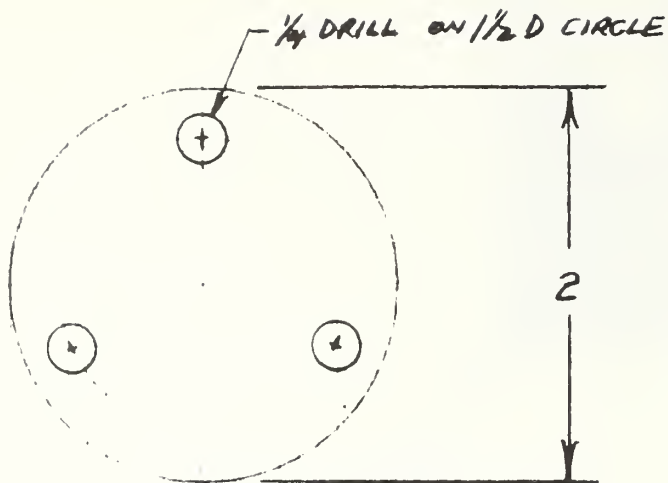


FIGURE A-1  
CHAIN TEST JIG  
2130442  
ASSEMBLY  
2 REQUIRED



SPACER A 1/2 LONG  
 SPACER B 7/8 LONG  
 WELD TO SPROCKET BEFORE DRILLING

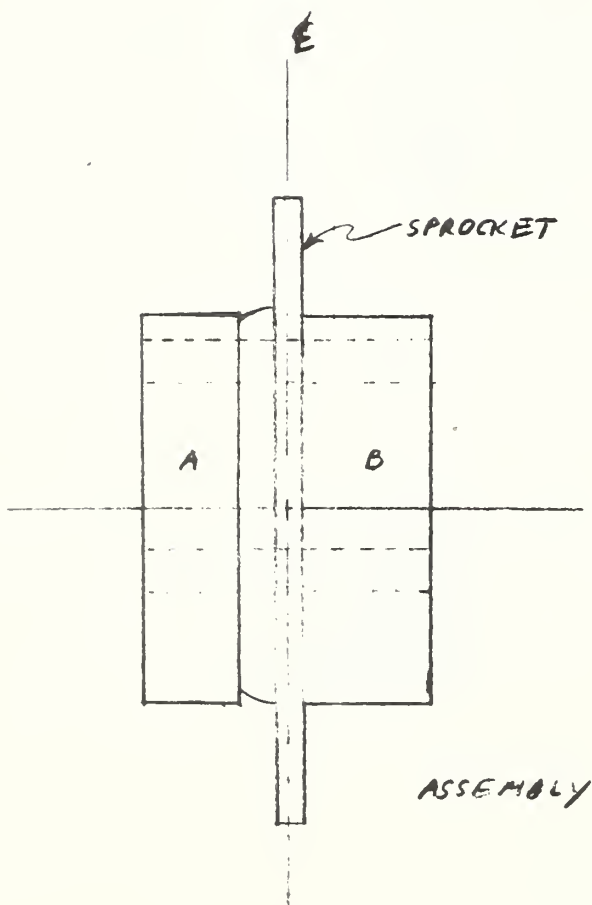


FIGURE A-2  
 CHAIN TEST  
 SPROCKET SPACER  
 2 REQ'D  
 MAT'L STEEL

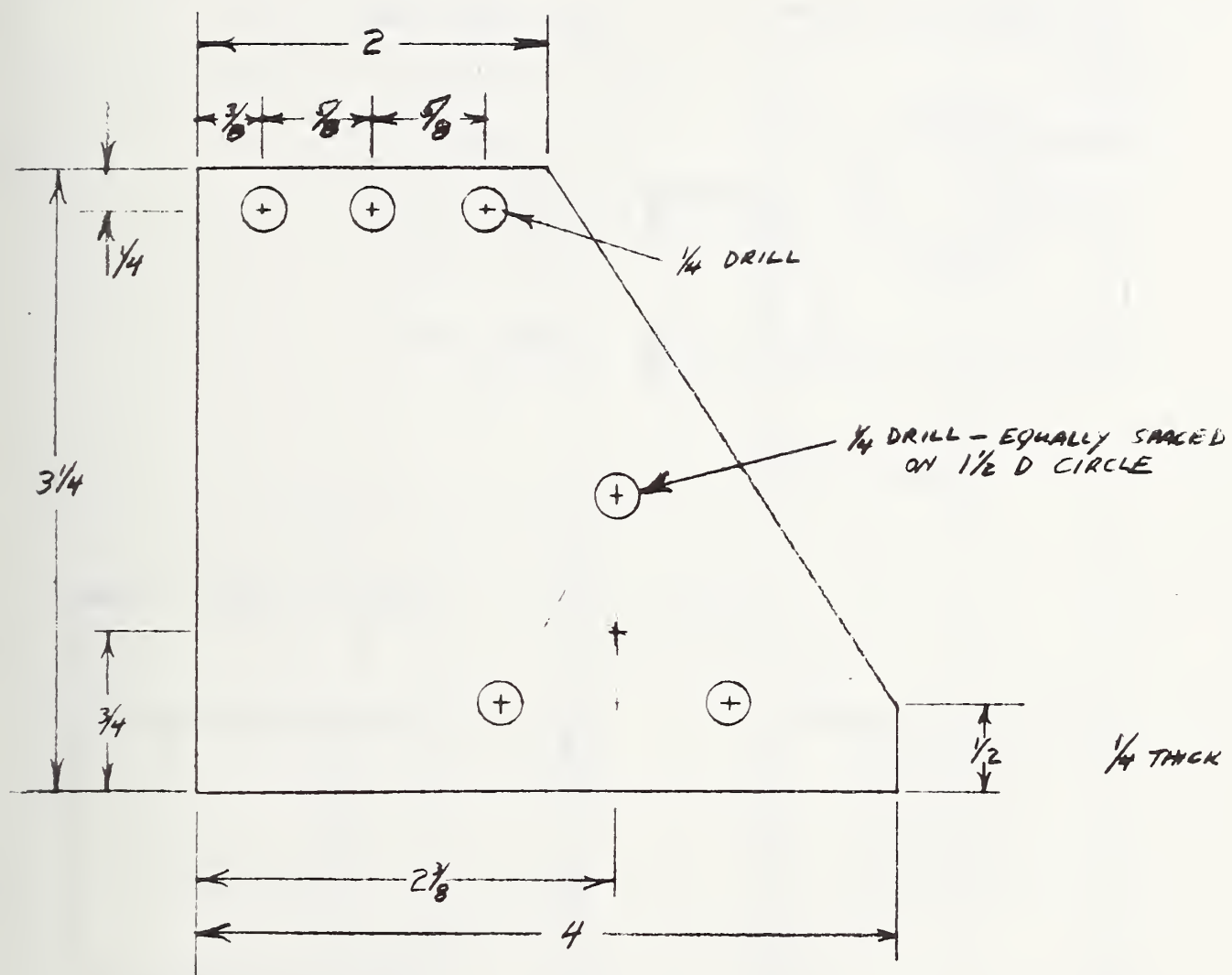


FIGURE A-3  
CHAIN TEST  
PIECE 2  
MAT'L ALUM

FIGURE A-4  
CHAIN TEST  
PIECE 1  
MAT'L ALUM

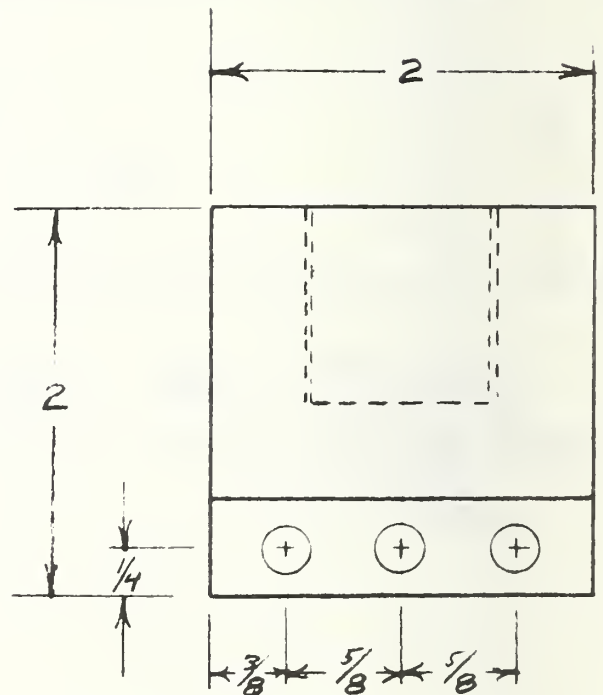
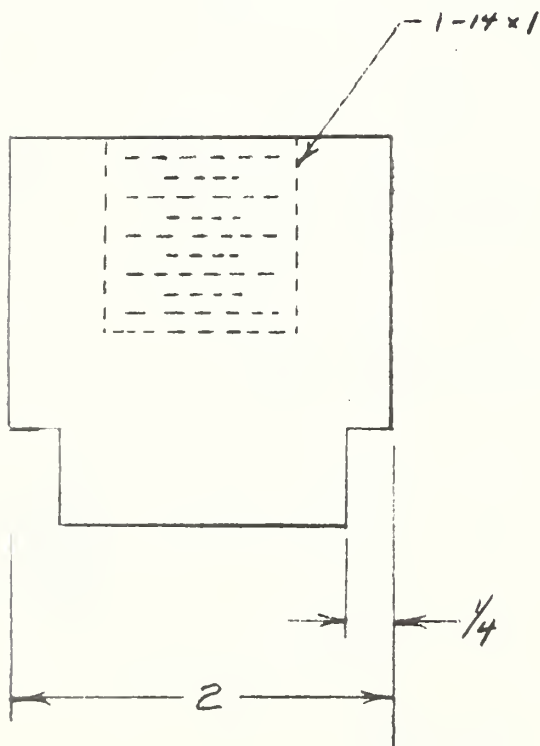
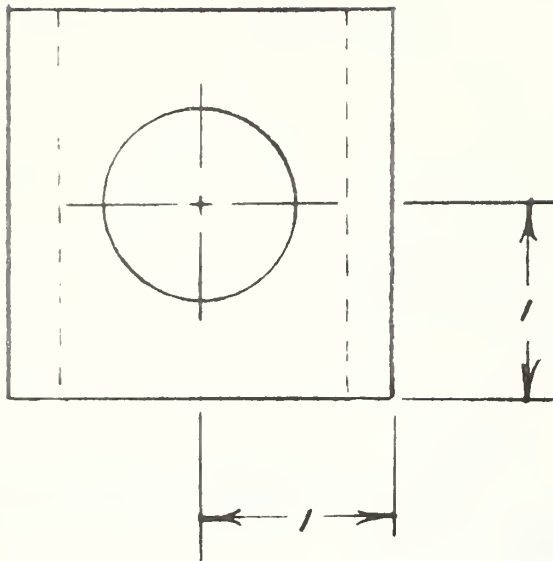


FIGURE A-5  
 HANDREAR TEST  
 PIECE 1  
 MAT'L: ALUMINUM

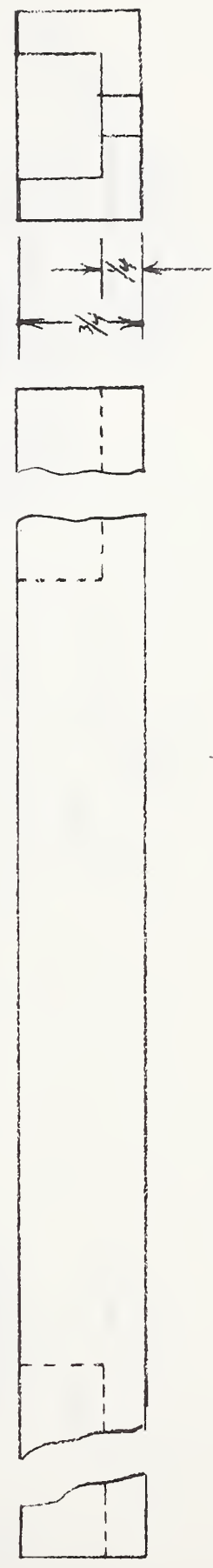
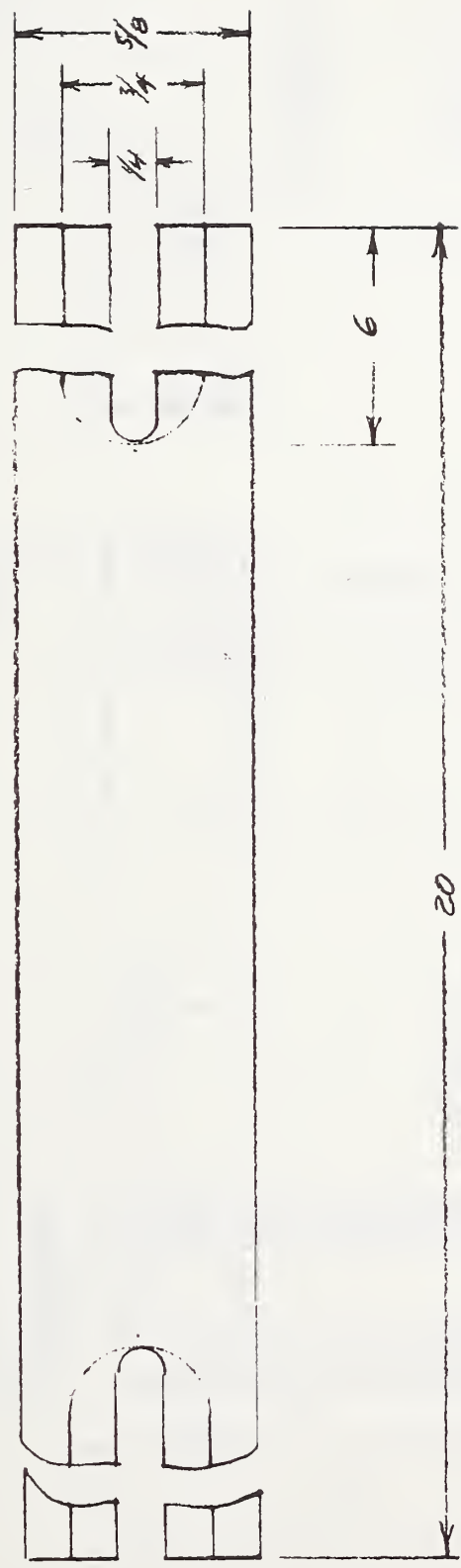
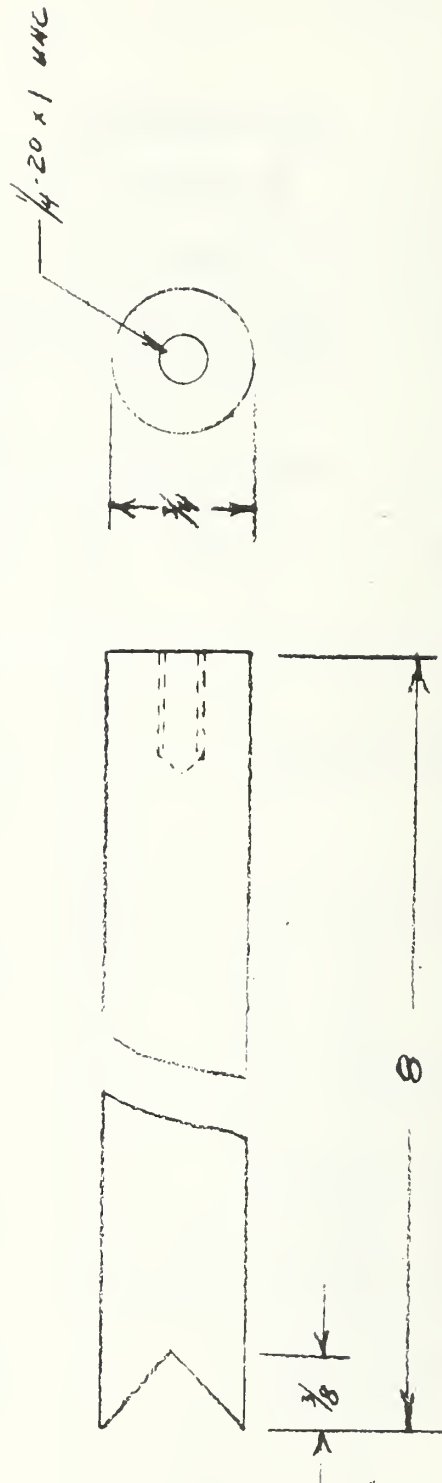
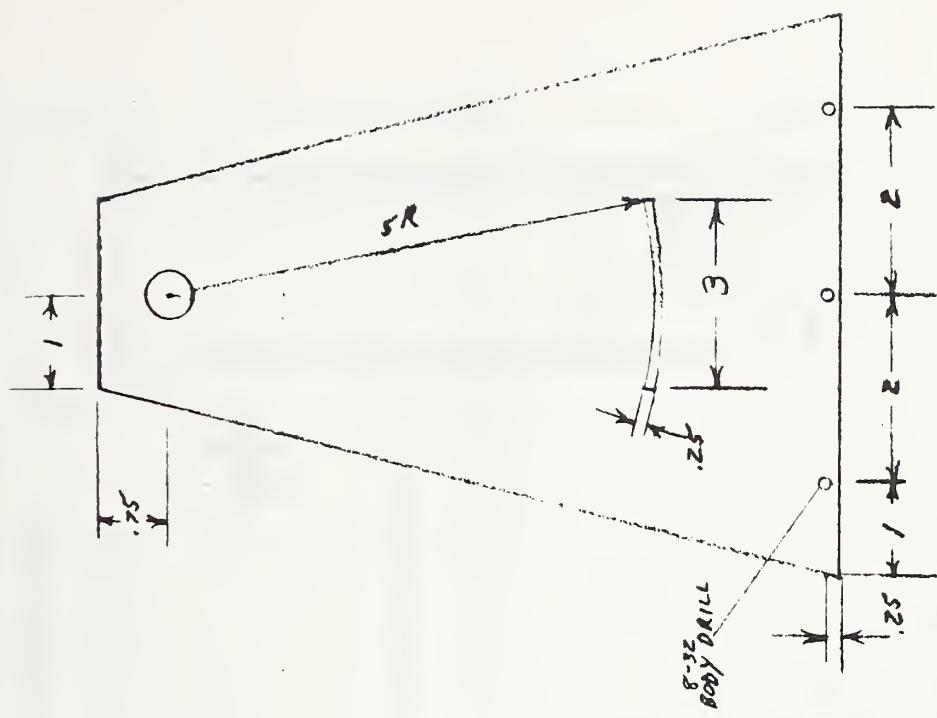
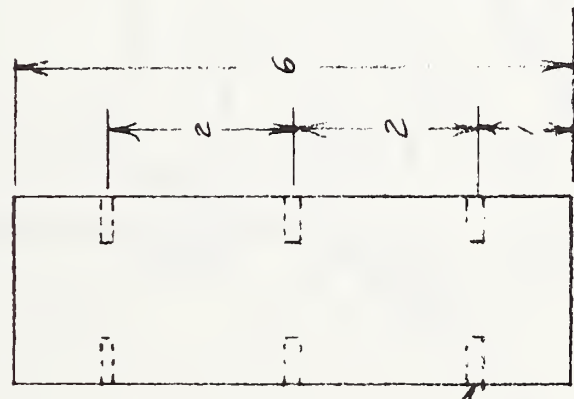
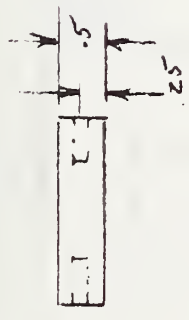


FIGURE A-6  
 HANDLE BAR TEST  
 MAT'L AL OR FIBRE  
 2 REG'D  
 PIECE 2

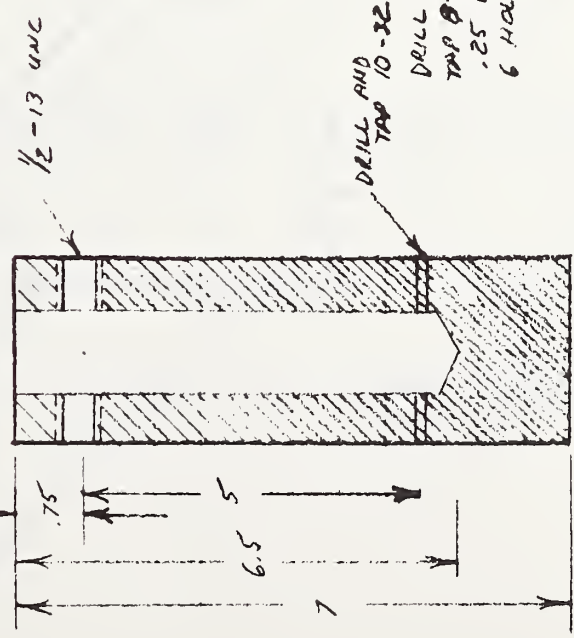
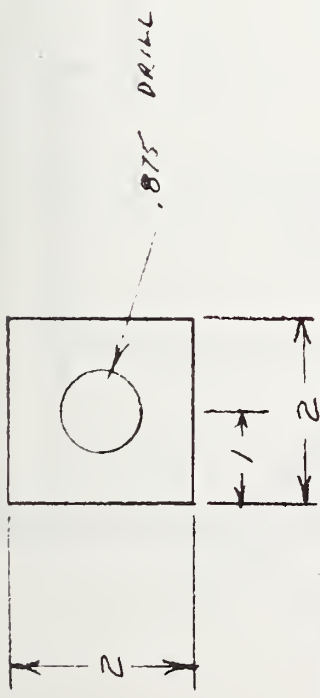




MAT'L ALUMINUM  
2 REQ'D  
PIECE 5



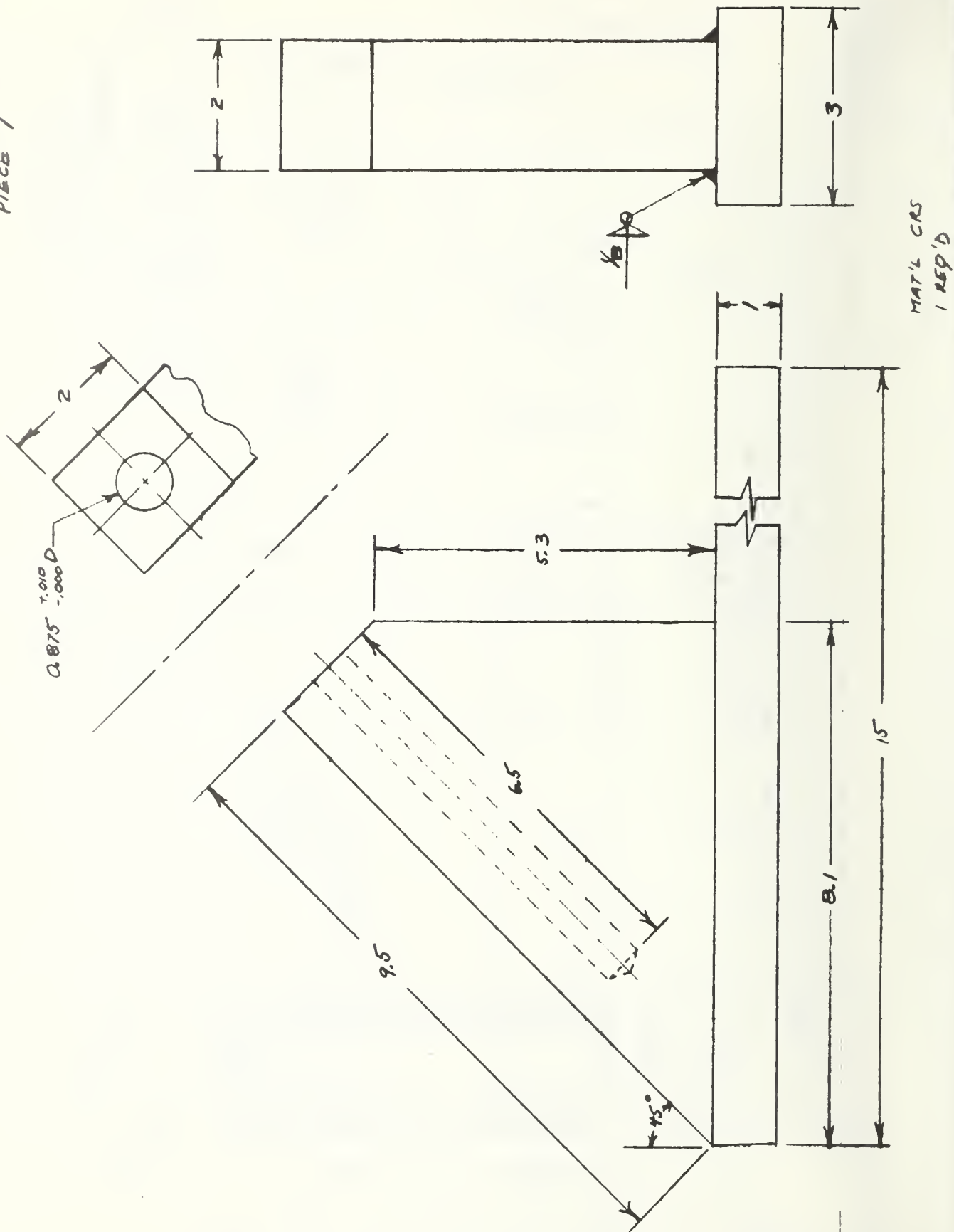
PIECE 4  
MAT'L ALUMINUM  
1 REQ'D



PIECE 3  
MAT'L ALUMY  
1 REQ'D

FIGURE A-7  
HANDLE BAR TEST

FIGURE A-8  
STEM TEST JIG  
PIECE 1



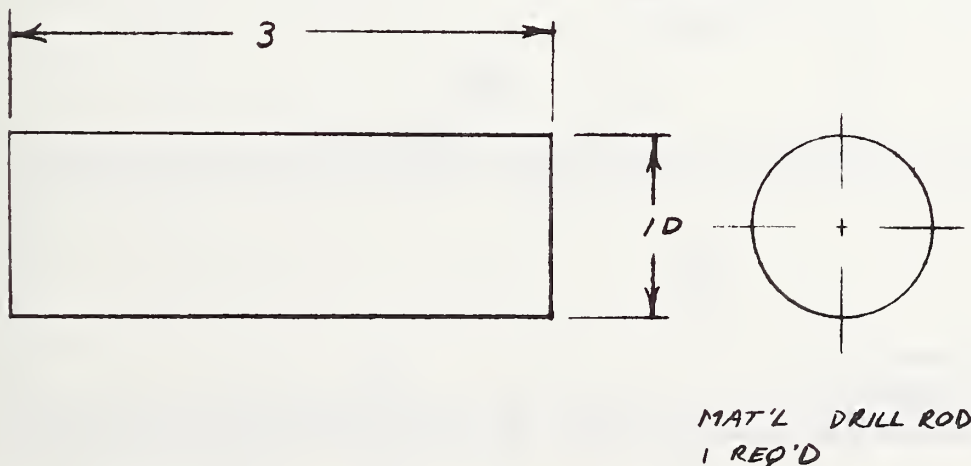
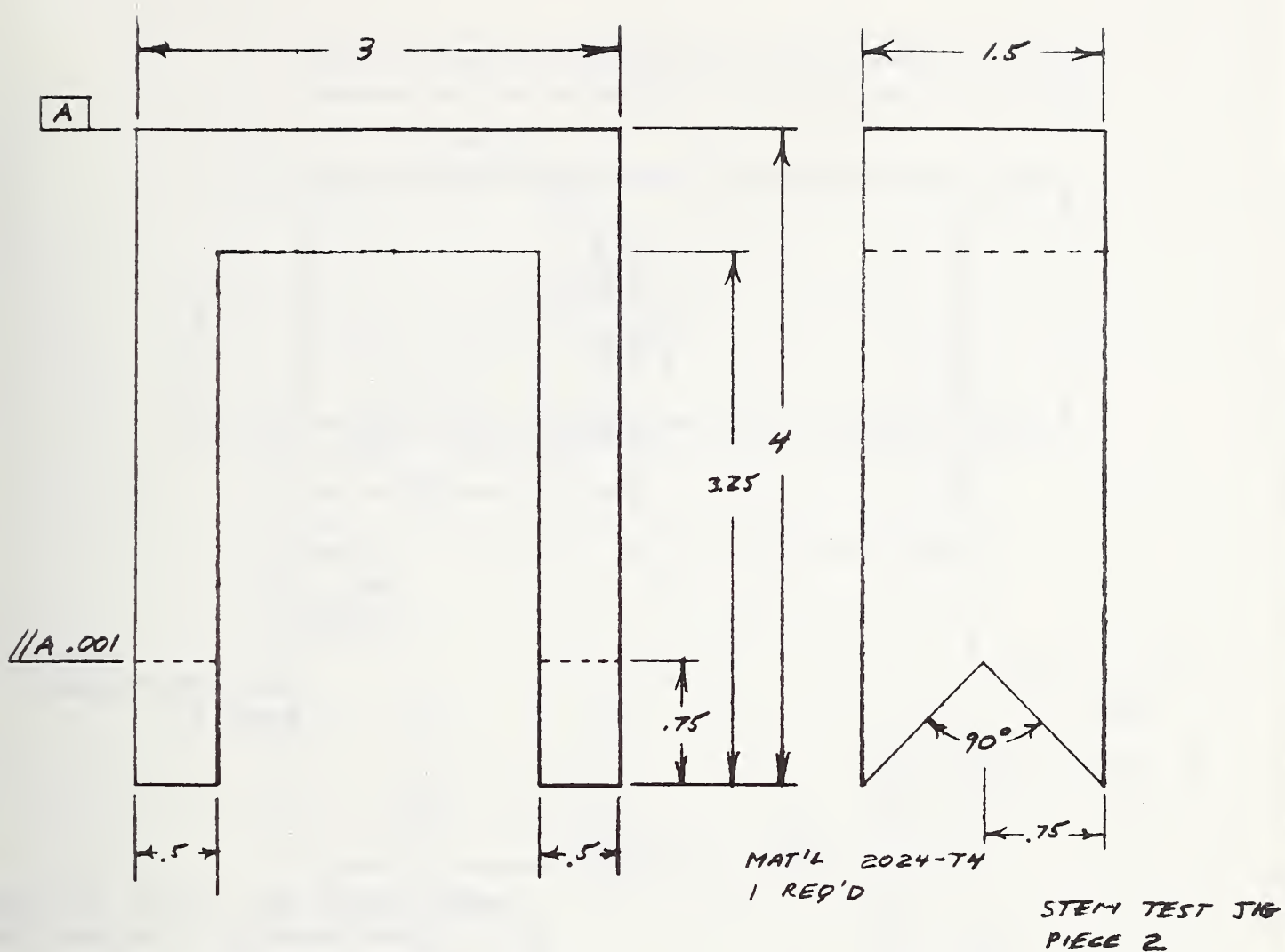
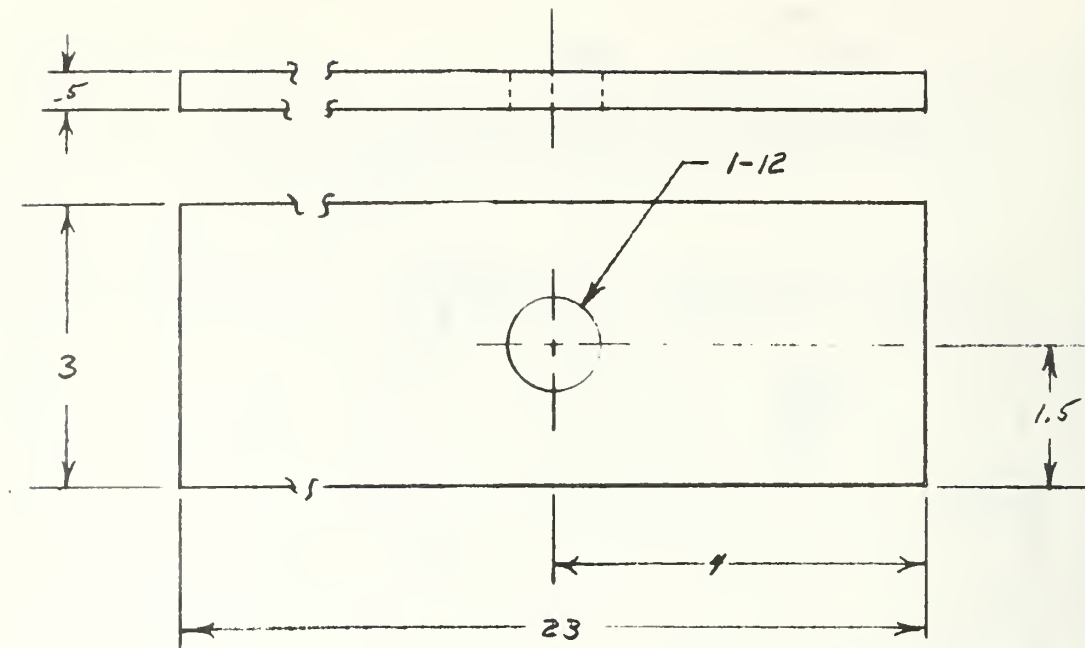


FIGURE A-9  
STEM TEST JIG  
PIECE 3



FORK TEST JIG  
PIECE 5

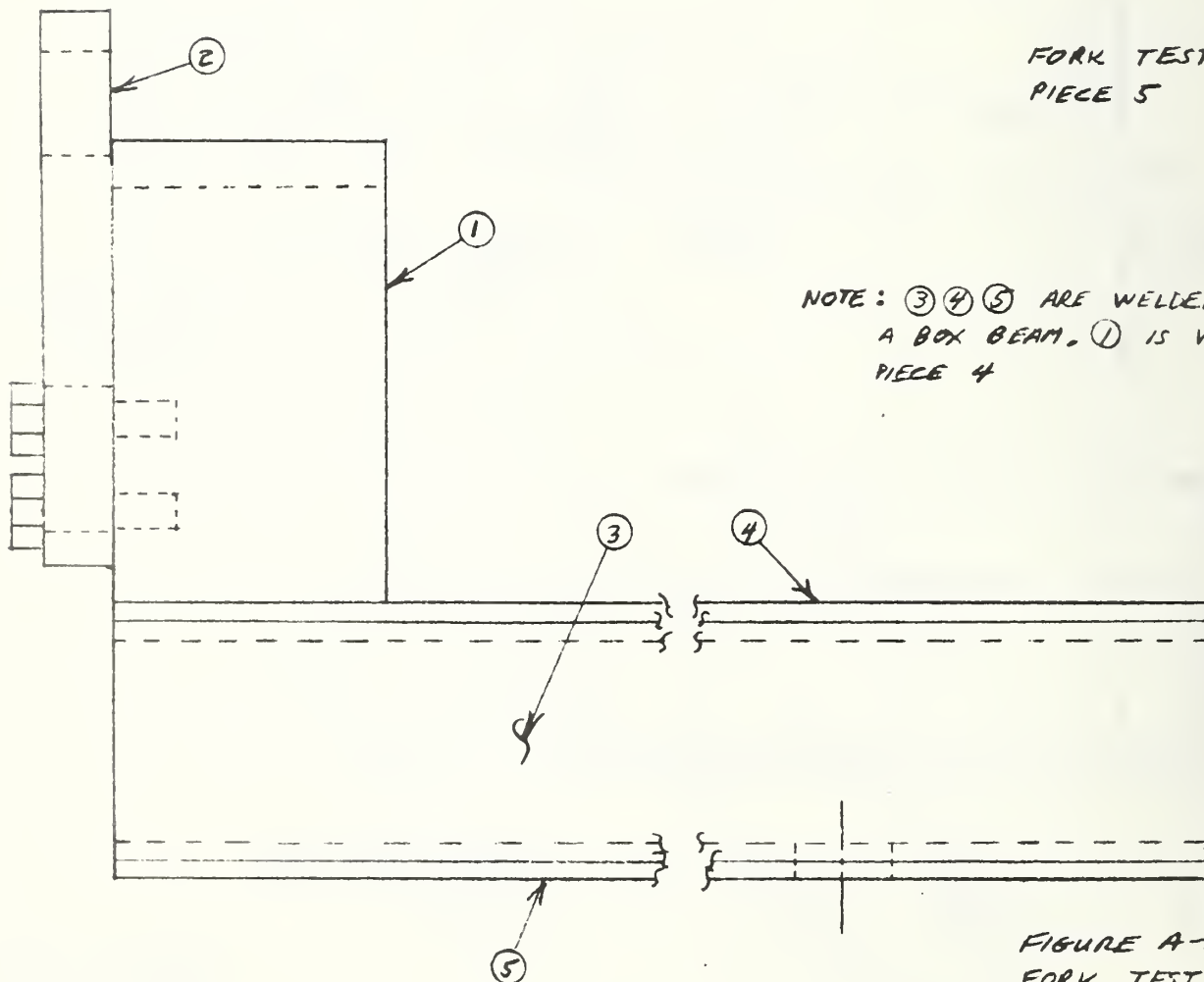
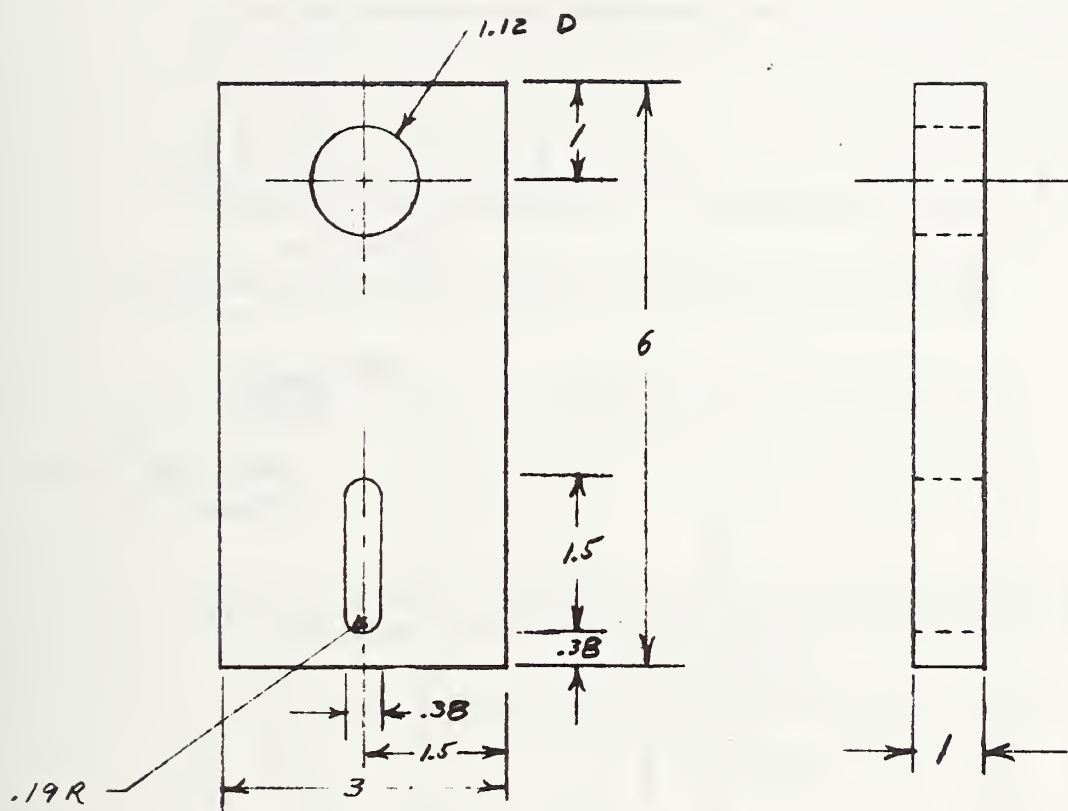
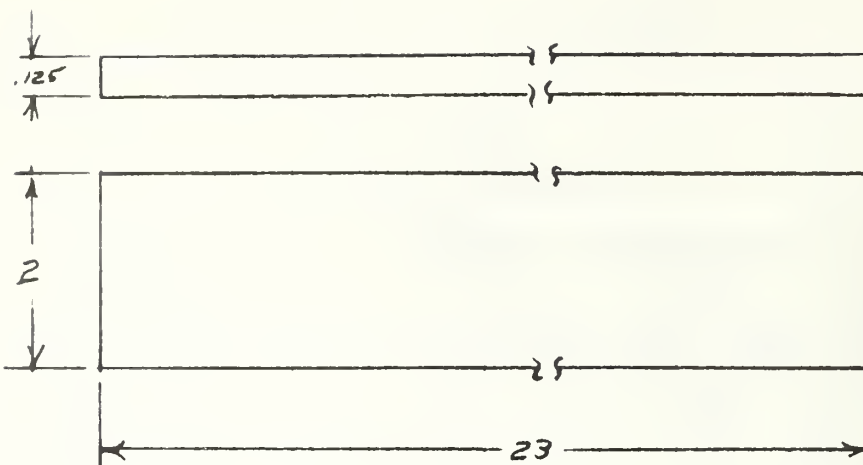


FIGURE A-10  
FORK TEST JIG  
ASSEMBLY



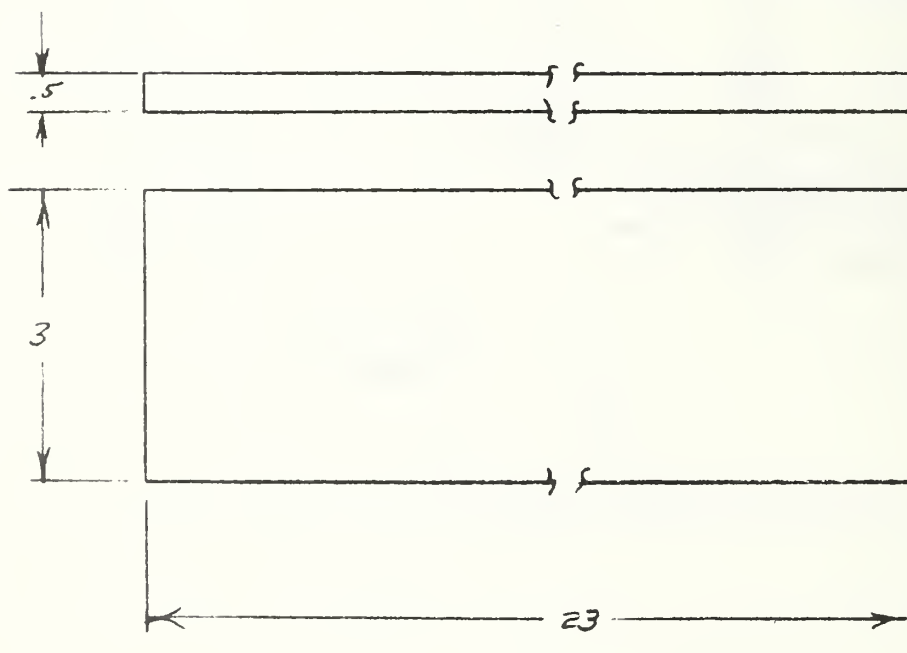
MAT'L CRS  
1 REQ'D

FIGURE A-11  
FORK TEST JIG  
PIECE 2



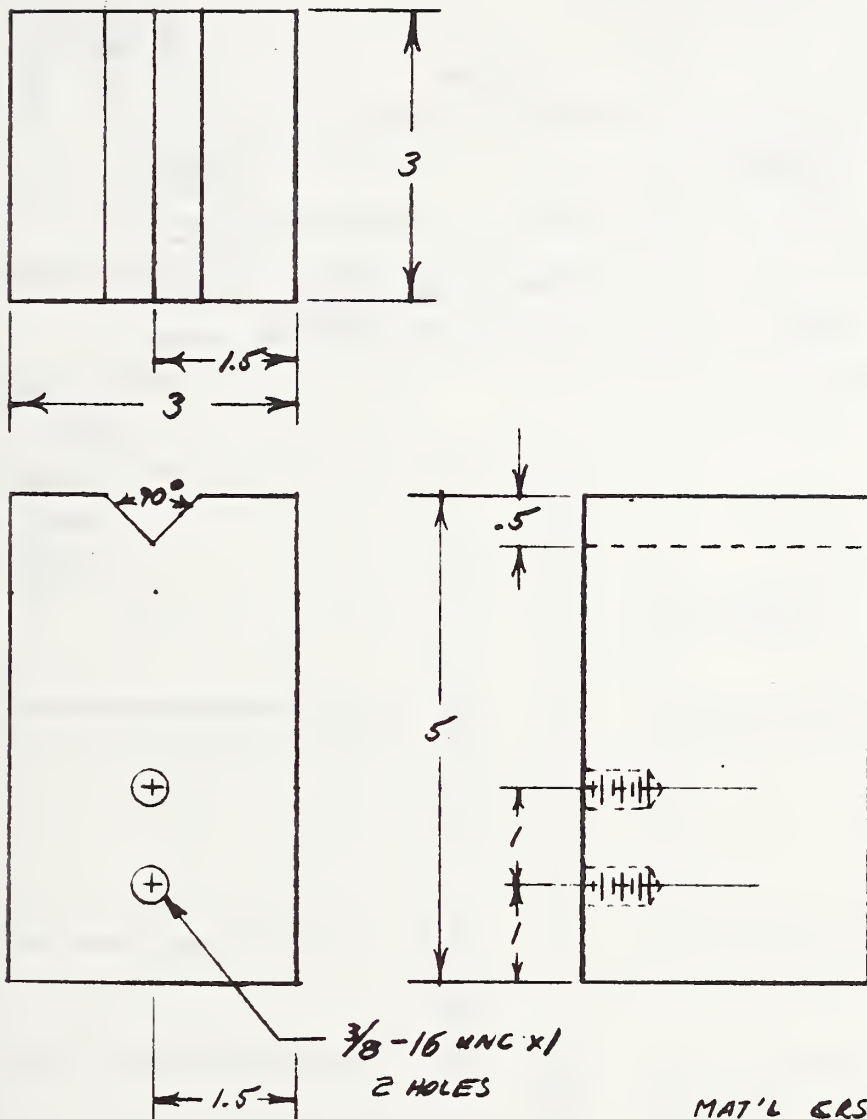
MAT'L CRS  
2 REQ'D

FORK TEST JIG  
PIECE 3



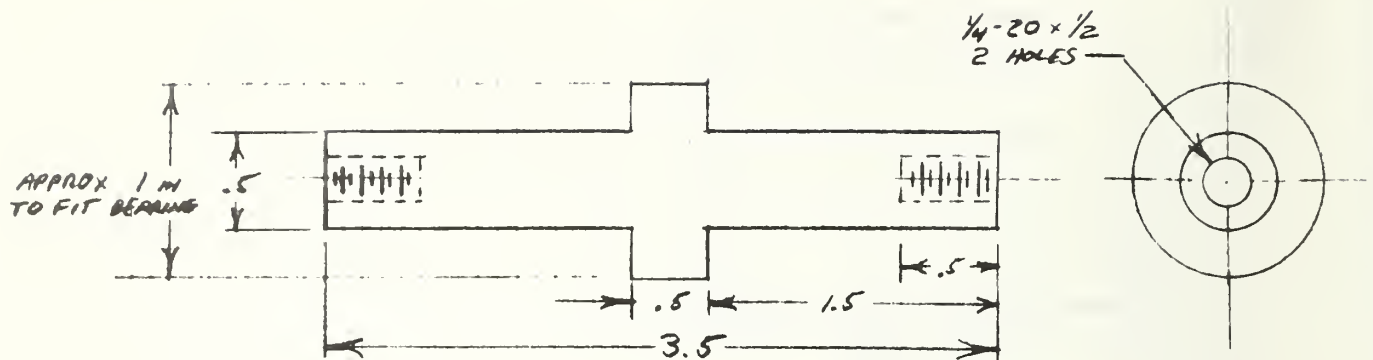
MAT'L CRS  
1 REQ'D

FIGURE A-12  
FORK TEST JIG  
PIECE 4



MAT'L CRS  
1 REQ'D

FIGURE A-13  
FORK TEST JIG  
PIECE 1



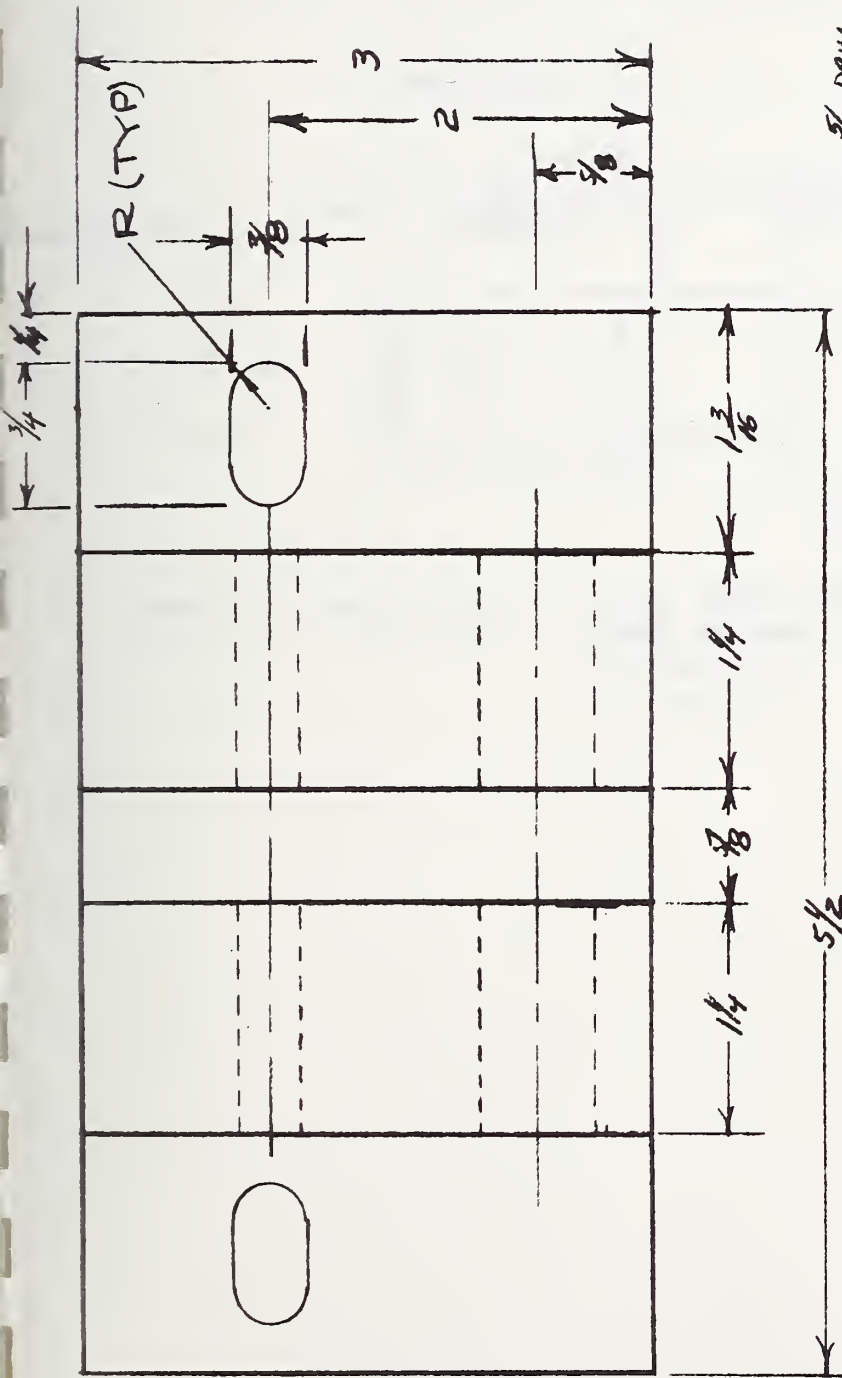
MAT'L DRILL ROD  
1 REQ'D

FIGURE A-14  
FORK TEST JIG  
PIECE 6

FIGURE A-15

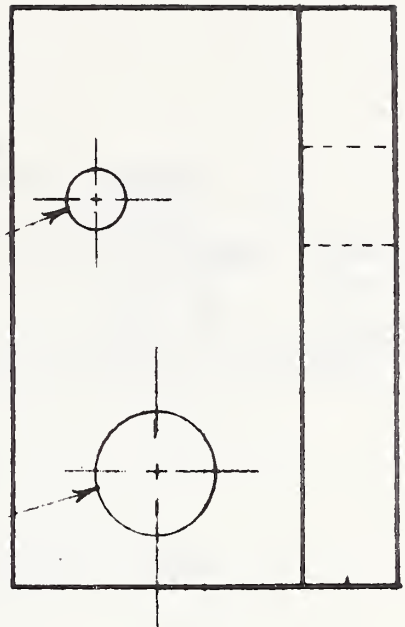
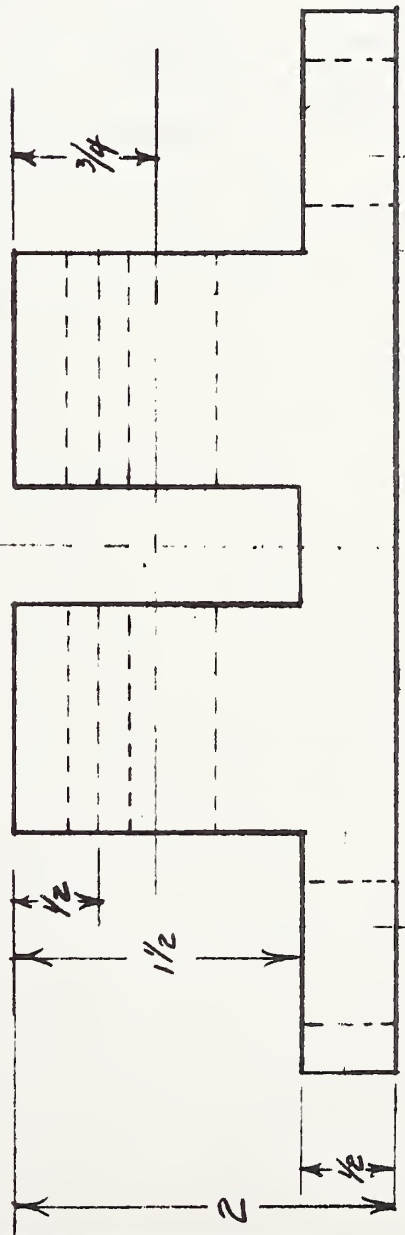
FORM FRAME - TEST  
PIECE 2

MATL ALUM.

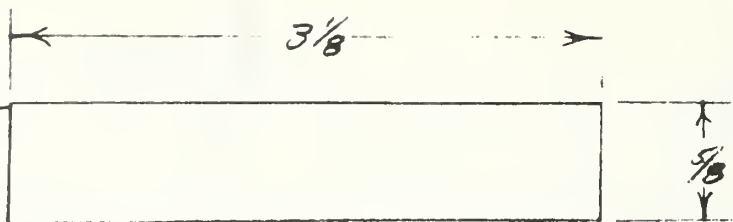


$\frac{5}{8}$  DRILL

$\frac{7}{16}$  DRILL



FORK FRAME TEST  
 PIECE 10  
 LOADING PIN  
 MAT'L & STEEL



PIECE 11  
 LOADING PIN  
 MAT'L STEEL

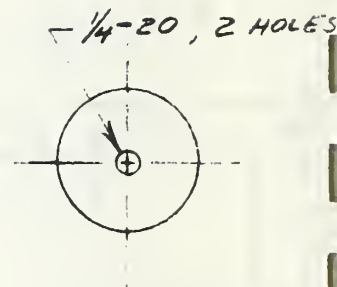
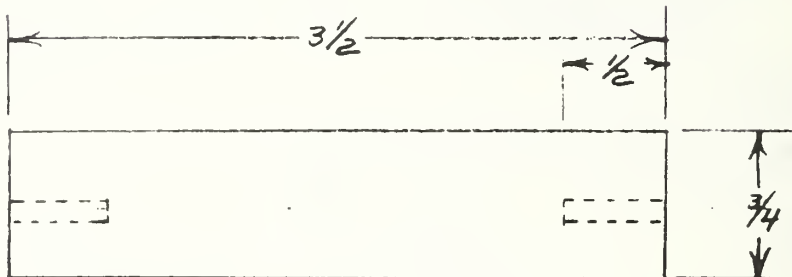


FIGURE A-16  
 FORK - FRAME TEST

FIGURE A-17

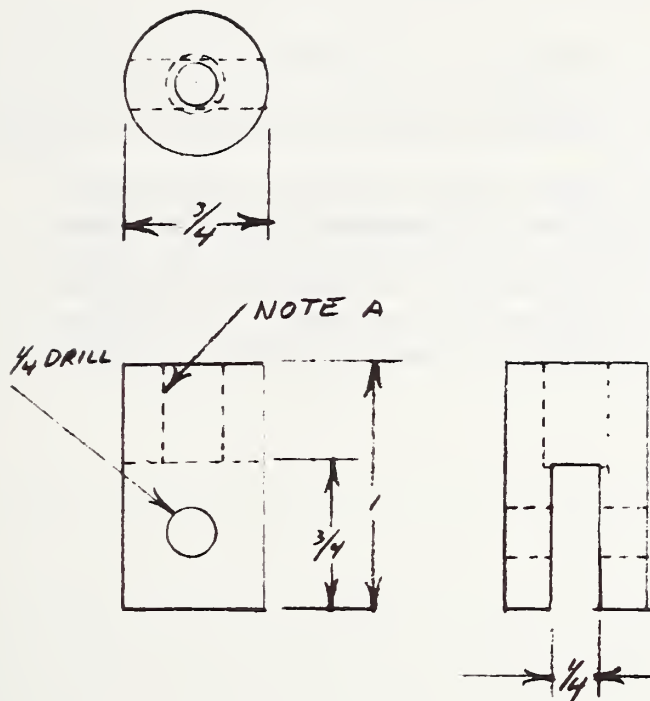
CLEVIS

RIM TEST

2130442

MAT'L ALUMINIUM

3 REQ'D



NOTE A: THREAD SIZES

1)  $\frac{5}{16}$ -24

2) M8x1.25

3) M10x1.5



## Appendix B

### Test Fixtures for Structural Tests on Bicycles

The operation manuals for equipment purchased to  
conduct the structural tests on bicycles include:

Dynamod Power Products Corp. (Power Supply)  
American Design Components (Load Cell)  
NBS Load Cell Calibrations - Ormond Cell No. 1196  
Houston Instrument Co., Series 2000 XY Recorder  
Research Inc. Displacement Transducer, Model 7101-4  
Enerpac, Hydraulic Pump, Model PER 1541

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  |                                                                                                                      |                                                            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|
| U.S. DEPT. OF COMM.<br>BIBLIOGRAPHIC DATA<br>SHEET                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 1. PUBLICATION OR REPORT NO.<br><br>NBSIR 75-913 | 2. Gov't Accession<br>No.                                                                                            | 3. Recipient's Accession No.                               |
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  | 6. Performing Organization Code                                                                                      |                                                            |
| 7. AUTHOR(S)<br>D. E. Marlowe                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                  | 8. Performing Organ. Report No.<br>NBSIR 75-913                                                                      |                                                            |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br><br>NATIONAL BUREAU OF STANDARDS<br>DEPARTMENT OF COMMERCE<br>WASHINGTON, D.C. 20234                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                  | 10. Project/Task/Work Unit No.                                                                                       |                                                            |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                  | 11. Contract/Grant No.                                                                                               |                                                            |
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| 15. SUPPLEMENTARY NOTES                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                  |                                                                                                                      |                                                            |
| 16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)<br><br><p>Tests for several structural performance criteria have been included in a mandatory regulation on bicycle safety which has been proposed by Consumer Product Safety Commission. The apparatus and procedures developed to conduct these tests and results from 15 representative bicycles are described. Several of the bicycles tested failed to meet the requirements for the seat and handlebar stem friction clamp strength.</p> |                                                  |                                                                                                                      |                                                            |
| 17. KEY WORDS (six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)<br><br><p>Bicycle; consumer safety; regulations; safety; structural testing.</p>                                                                                                                                                                                                                                                                                                                                                                         |                                                  |                                                                                                                      |                                                            |
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