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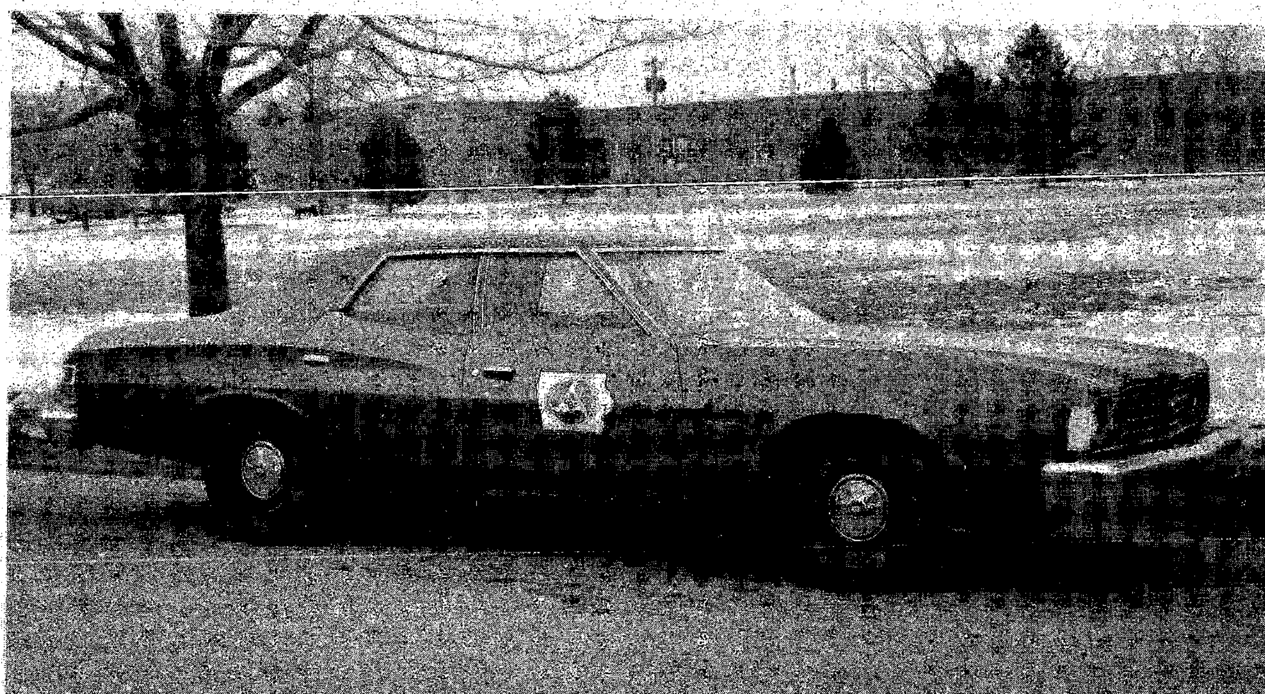
IOWA
DEPARTMENT OF TRANSPORTATION

DIVISION OF HIGHWAYS

OFFICE OF MATERIALS

Special Investigations Section



THE IJK RIDE INDICATOR

MARCH 1, 1976

IOWA DEPARTMENT OF TRANSPORTATION

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March 1, 1976

by

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Materials Engineer

Author

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ACKNOWLEDGEMENT

We wish to express our appreciation to Donald Johannsen, mechanical engineer, for his contribution to the concept and design of the IJK Ride Indicator. We also wish to express our appreciation to Stan Kirk for his contribution to the design and construction of the unit.

THE IJK RIDE INDICATOR

I. INTRODUCTION

A. Present Serviceability Index

State highway engineers realized a need for a numerical quality index and began planning for a research project of this type in 1951. The Present Serviceability Index was developed through the AASHO (now AASHTO) Road Test near Ottawa, Illinois, from 1956 to 1962.[1] Longitudinal profile and physical deterioration such as cracking, patching, and rut depth (for flexible pavements) were considered in deriving these Present Serviceability Index (PSI) equations:

For flexible pavement:

$$PSI = 5.03 - 1.91 \log (1+\overline{SV}) - 0.01 \sqrt{C+P} - 1.38 \overline{RD}^2$$

For rigid pavement:

$$PSI = 5.41 - 1.80 \log (1+\overline{SV}) - 0.09 \sqrt{C+P}$$

Where:

$\overline{SV}$ = The mean of the slope variance in the two wheel paths (by AASHO Road Test Profilometer).

C = Lineal feet (for rigid pavement) or area in square feet (for flexible pavement) of cracks per 1000 sq. ft. of pavement surface.

P = Square feet of patching per 1000 sq. ft. of pavement surface.

$\overline{RD}$ = Mean rut depth of both wheelpaths under a 4' straightedge.

At the start of the AASHO Road Test, a "Road Test Profilometer" measured the variation in the longitudinal profile. This unit was too expensive for general state highway department use, so a much less expensive, simpler electronic-mechanical device was developed.[2] This unit was called the CHLOE profilometer (named after the engineers who designed it: Carey, Huckins, Leathers and Other Engineers). The CHLOE principle was based on slope variance of the surface profile as measured by slope detecting wheels nine inches apart. The data obtained by this unit was very reliable but the unit had a maximum operating speed of 5 mph, which was very unacceptable in the highway testing field.

B. PCA Road Meter Development

In an effort to provide a testing unit that would give reliable results at normal highway speeds, Max Brokaw, an engineer with the Portland Cement Association (PCA), developed the "PCA Road Meter".[3] Phillip Brua, also an engineer with the PCA, visited various state (including Iowa) agencies to demonstrate the advantages of the PCA road meter. He also advised them in the construction of a road meter.

The principle of the PCA road meter was to measure the movement of the car body with respect to the chassis. This unit traveled at 50 mph and correlated well with the CHLOE profilometer.

The road meter could be used to obtain a statewide inventory of the Present Serviceability Index on all primary roadways.

C. PCA Road Meter Use in Iowa

The Iowa State Highway Commission (now the Highway Division of the Iowa Department of Transportation) constructed a PCA type road meter in 1967.[4] It was mounted in a 1967 Chevelle station wagon and a 1967 Ford Custom (weak suspension). Both units were too affected by wind to provide satisfactory results. The next vehicles used were well equipped 1968 Ford Custom with stronger coil springs. Their suspension seemed to be just right and didn't exhibit much detrimental wind effect unless the wind was above 10 mph.

Using three of these 1968 Ford Customs, a statewide primary road inventory (about 20,000 lane miles of testing) was almost completed during the summer of 1968. Most of the primary system was retested in the summer of 1969.

Early in 1970, we obtained new Ford Custom 500's with cruise control to maintain a constant speed. The springing was too weak, so the rear springs were interchanged with the desirable 1968 springs.

Since 1970, a program of testing one third of the primary system each year (so all roads are retested on a three year cycle) has been used.

The 1974 Ford Torinos we are now using also needed suspension system modification (stronger shock absorbers), to be satisfactory for PCA road meter use.

D. Road Meter Modifications and Improvements[5]

Various improvements had been made to improve testing accuracy and increase productivity. A flexible 240-lb.-test, nylon-covered aircraft cable replaced the fish leader connector that broke too often. The roller contactor slide plate was made from a Delrin plastic, which reduced wear and friction. A bank of ten electrical counters was used to yield greater numerical difference between smooth and rough roads, thereby gaining greater accuracy. Two banks of counters with a rotary switch were incorporated to make possible testing of back-to-back sections without stopping and going back. An electric-eye distance counter was incorporated so the section length was recorded simultaneously with the riding quality values. A transistorized circuit was used so that the "coil breakdown" in the counters would not cause arcing on the segmented contact board.

An automatic electromechanical null-seeking device was incorporated into the road meter to improve testing accuracy.[6] The null-seeking device was intended to eliminate error in manual zeroing, compensate for change in car load, and adjust for aerodynamic variation due to wind velocity. Though it met the first two objectives, it did not satisfy our desire in regard to wind.

E. Advantages of the PCA Road Meter

The major advantage of the PCA type road meter was that it could operate at highway speed and yield a numerical value for the riding quality. Furthermore, it was a very simple, inexpensive unit that had very few maintenance problems. When correlated against the CHLOE profilometer, the resulting data would generally give correlation coefficients of 0.96 or better (usually between 0.96 and 0.97). Therefore, it was a very good, economical unit for conducting a road riding quality inventory.

F. Disadvantages of the PCA Road Meter

The major disadvantage of the PCA road meter was the adverse effect of wind. Any winds except those in the direction of travel would affect the indicated riding quality. In Iowa, objectionable winds are present much of the time. Vehicles with stiffer suspension systems seem to be influenced less by wind than those with softer suspensions. To decrease wind effect, road meter operation was scheduled for early morning or evening hours when the wind is normally slower. Even after incorporating the null-seeking device, wind effect was still apparent. This was supported by the fact that the null-seeking device did not improve the correlation coefficients with respect to the CHLOE.

Also, the road meter was very dependent on the vehicle suspension. New vehicle suspension usually had to be modified by changing either the shocks or springs or both, followed by continual monitoring of the shocks during the life of the car. Replacement shocks were also a problem because dealers could not assure the same strength as the original shocks.

II. IJK RIDE INDICATOR DEVELOPMENT

A. The Sprung Mass Concept

In the winter of 1970, after three years of road metering experience, the program was reviewed for possible improvements. Don Johannsen, a graduate mechanical engineer, was aware of our road meter problems and began studying ways to alleviate them. Most problems seemed to relate to the wind effect on the car body. The new idea was to depart from the basic concept of measuring car body movement with respect to the chassis and go to a new sensing device mounted on the differential housing. Approval to work on the new sensing device was given, but funding for the venture was limited. Stan Kirk, a special equipment technician, was assigned to help build the apparatus. He later contributed to the experimental design changes which led to the success of the IJK Ride Indicator.

Mr. Johannsen's first design was a cylindrical weight with a hole in the center. The weight rested on a coil spring housed in a larger tube and slid up and down on a vertical center shaft. The movement was still detected by electrical contact of segments. This unit showed promise for the sprung mass idea, but there was too much friction between the weight and the shaft to allow the free movement necessary on smoother roads.

B. IJK Ride Indicator Design

Using the same sprung mass concept, the second design, now referred to as the IJK (Iowa-Johannsen-Kirk) Ride Indicator, was built in mid 1971. A drawing of the various parts and their names is shown on page 31 in Appendix A. To minimize the friction problem, the weight was put on a bearing-mounted oscillator arm (Figures 1 and 2).

This unit was covered (Figure 3) and mounted on the differential housing of the vehicle (Figure 4).

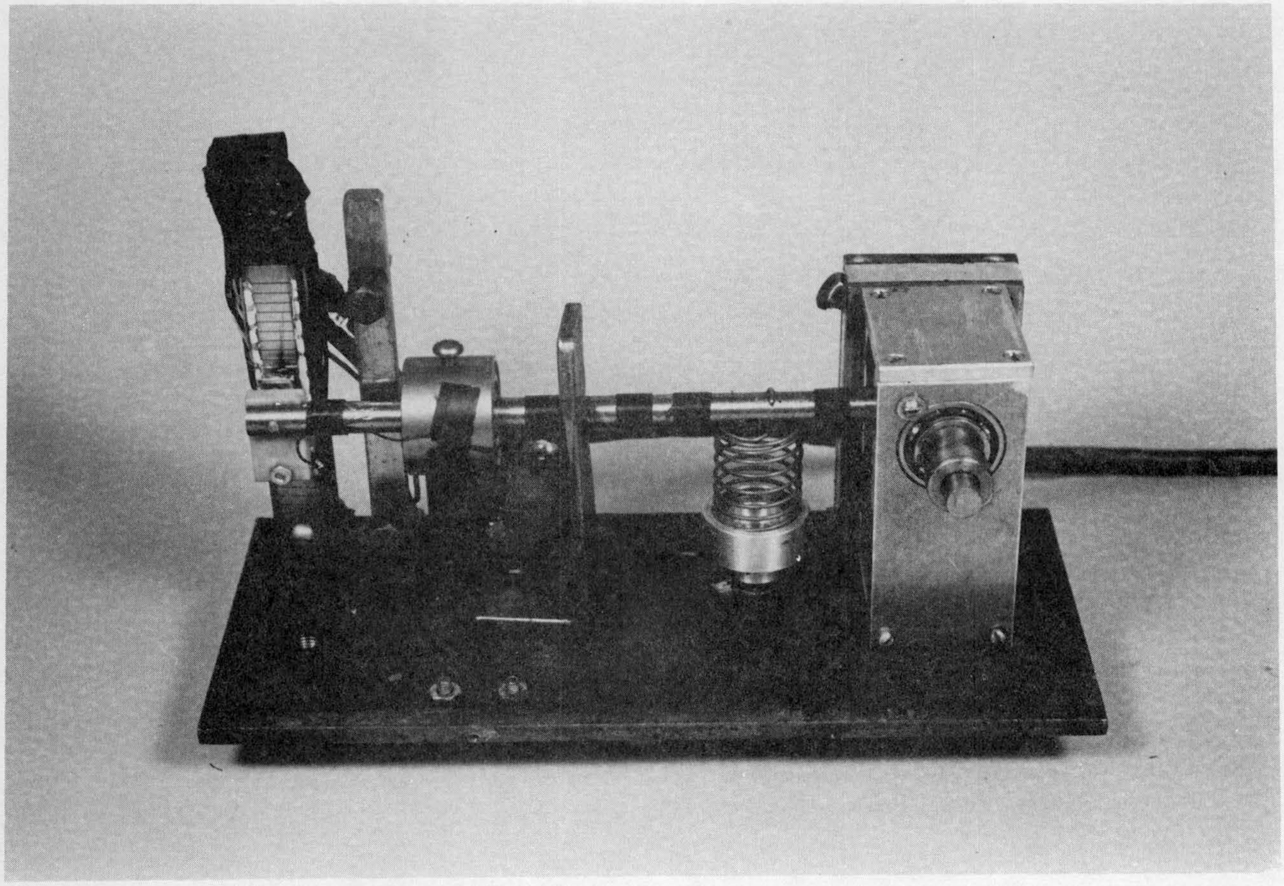


Figure 1 -- Overall View from Segment Board Side of IJK Ride Indicator Unit with Arm Lock Engaged.

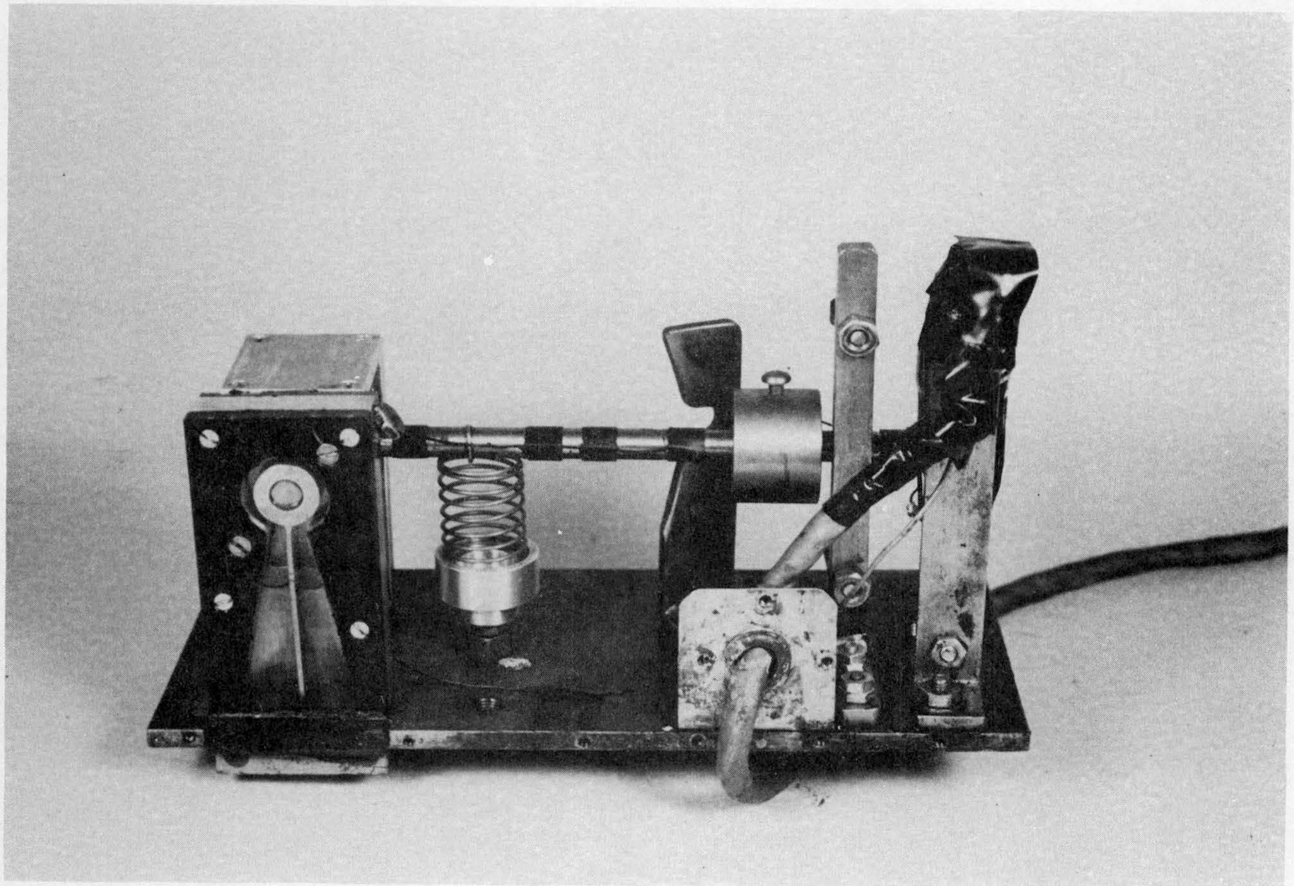


Figure 2 -- Overall View from Dampening Chamber Side of IJK Ride Indicator Unit with Arm Lock Disengaged.

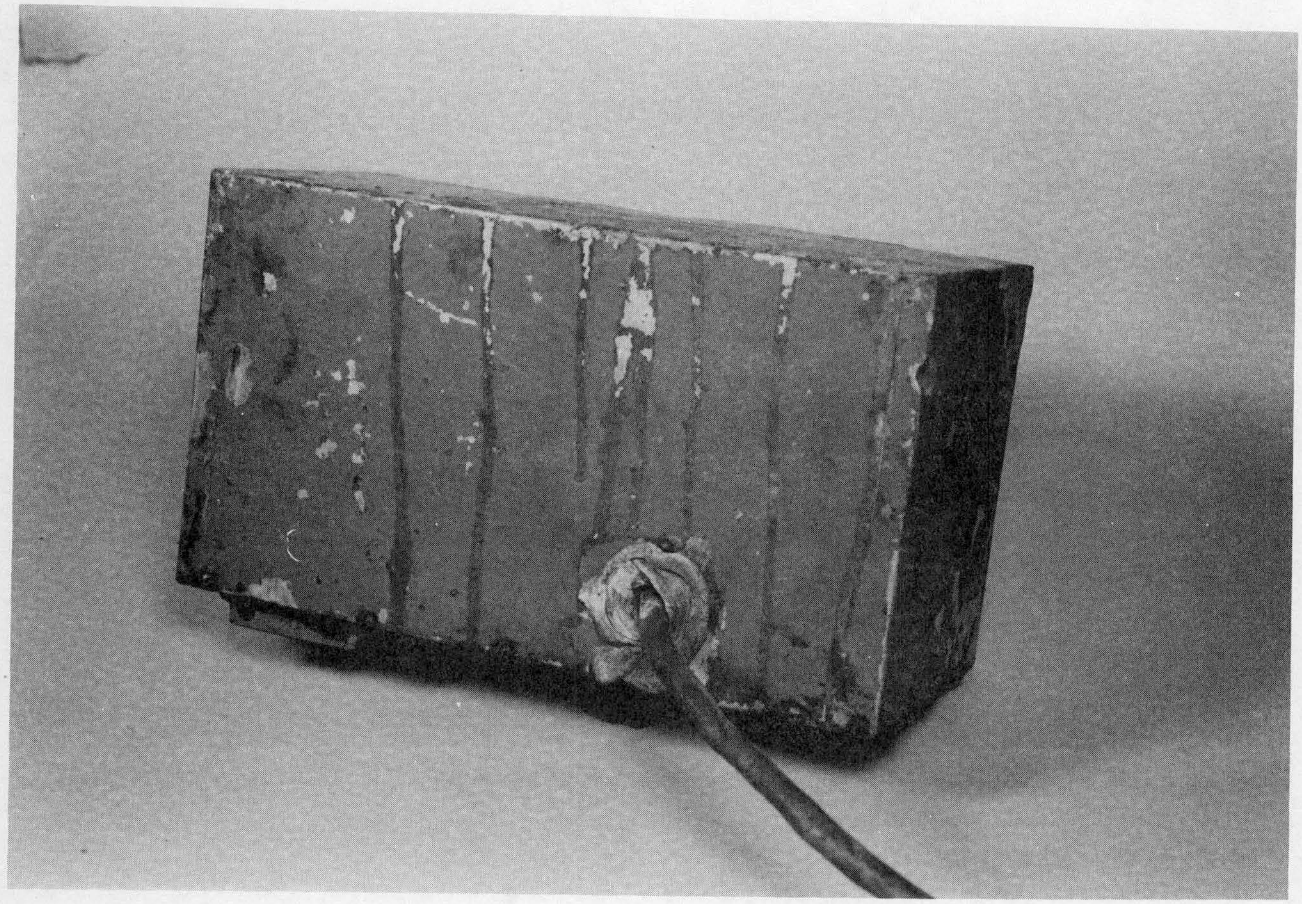


Figure 3 -- IJK Ride Indicator Unit
With Protective Cover

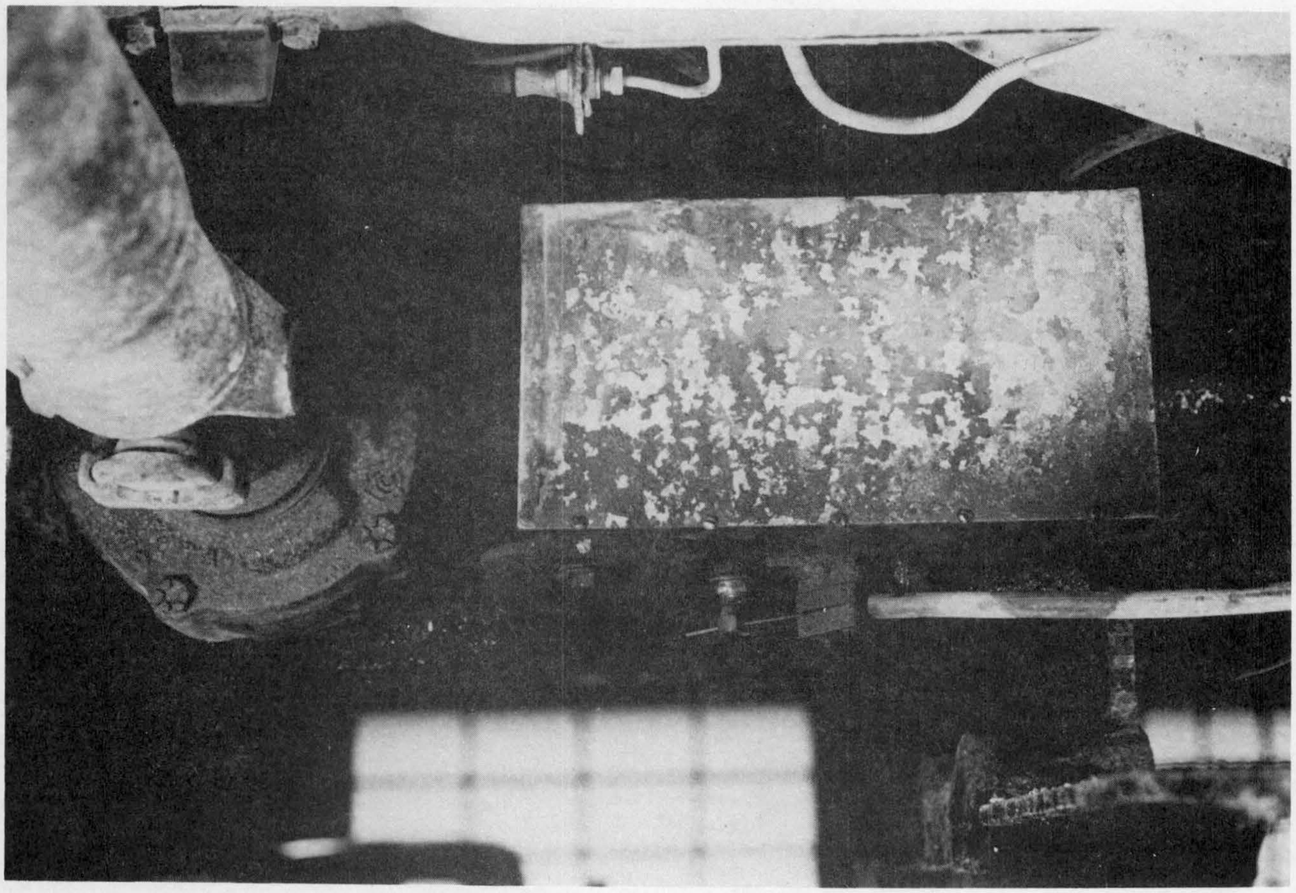
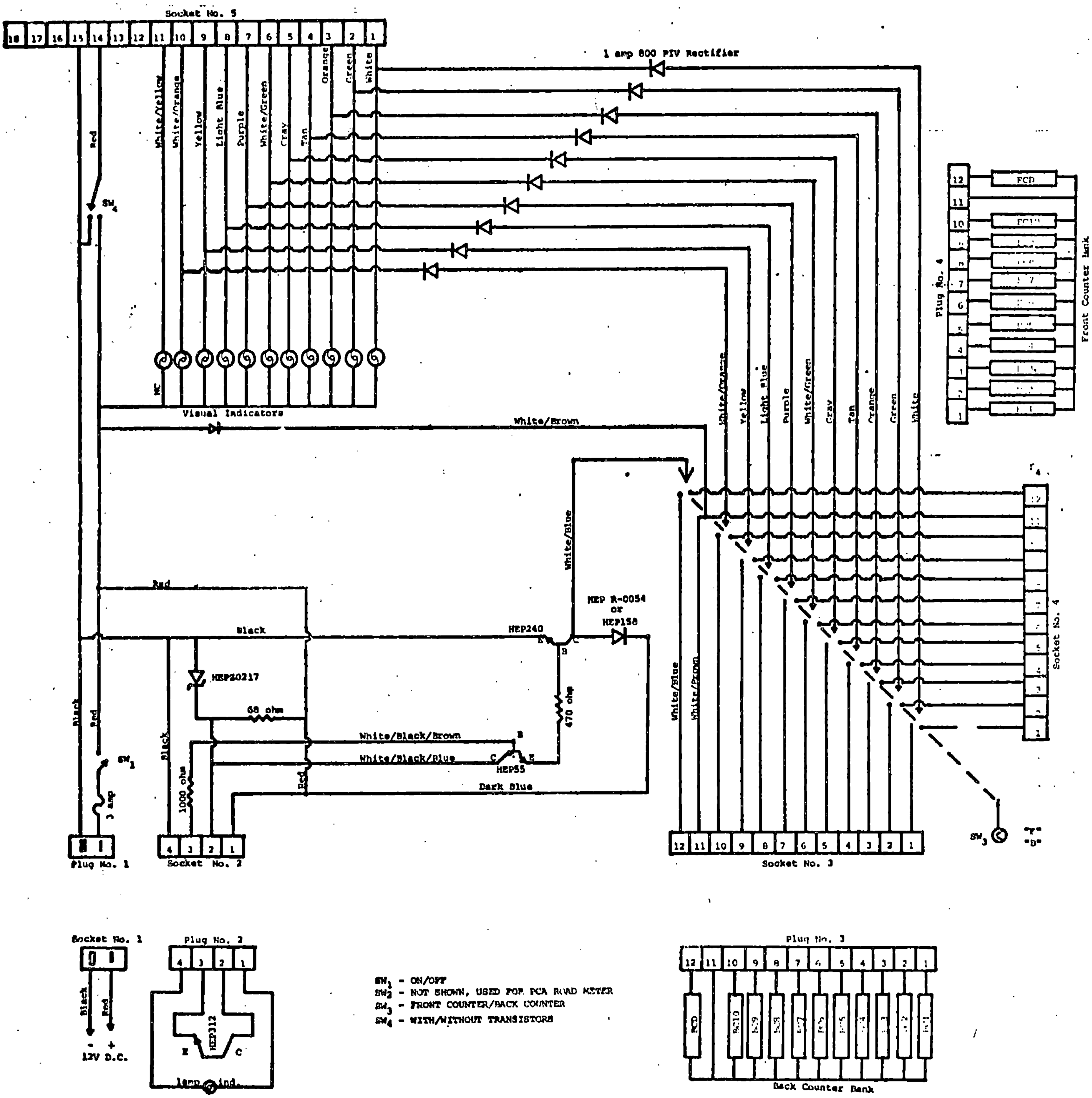


Figure 4 -- IJK Ride Indicator Unit
Mounted Under Vehicle

The measurement of relative movement was still an electrical roller contact on a segmented board. A paddle in a tightly restricted fluid chamber was used to dampen the unit, thus keeping it from oscillating too much. This paddle dampening system served the same purpose as the shock absorbers on an automobile, and operated off one end of the horizontal shaft of the oscillator arm. Determining where and how to mount the spring required much experimentation. After many trials the optimum spring mounting position was established under the oscillator arm. During 1971, trying to eliminate friction, determining proper pressure on the roller contact, and finding the best dampening were the areas of experimentation. On October 13, 1971, the IJK obtained a correlation coefficient of 0.981 when compared to CHLOE Slope Variance, which showed that it was a reliable means of determining riding quality.

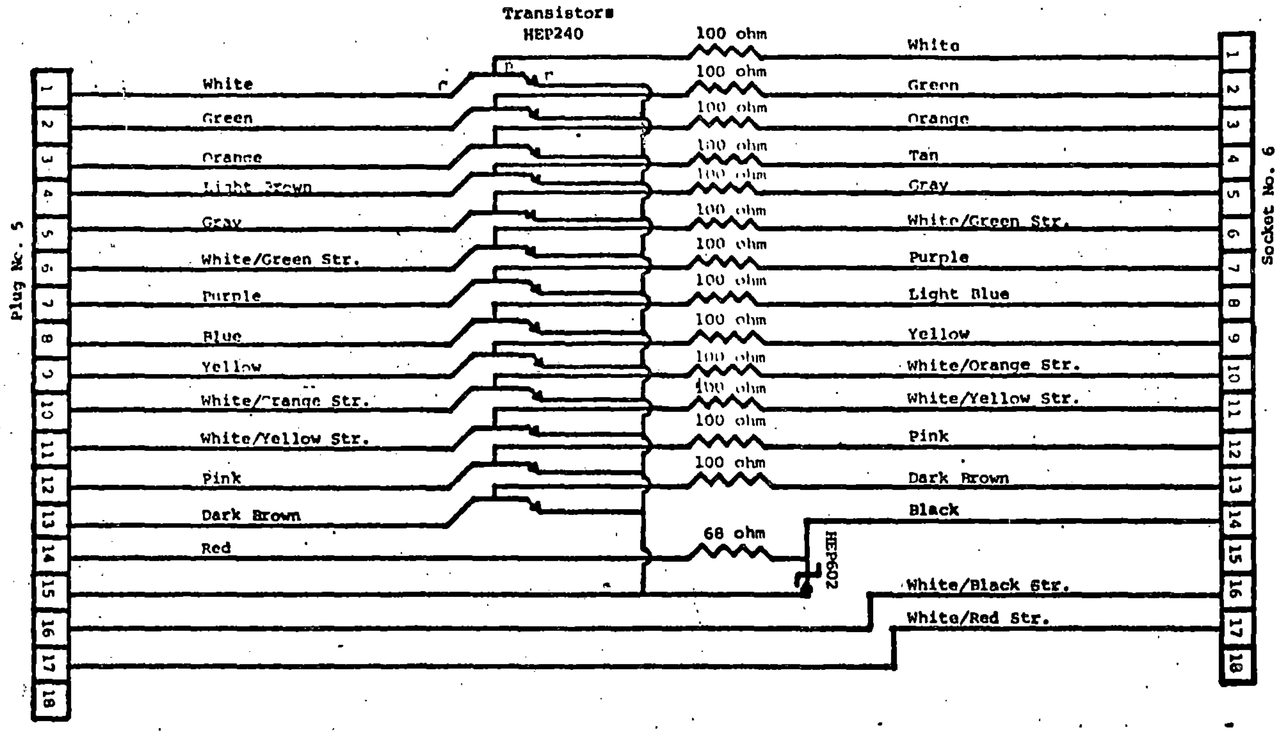
The electrical recording system was essentially the same as that used in the PCA Road Meter system for recording the counts from the electrical segment board (Figures 5 and 6).

Detailed drawings of the IJK Ride Indicator are shown in Appendix A.



SCHEMATIC ELECTRICAL DIAGRAM OF IJK INDICATOR MARCH 10, 1976

Fig. 5 ELECTRICAL SCHEMATIC (Part 1)



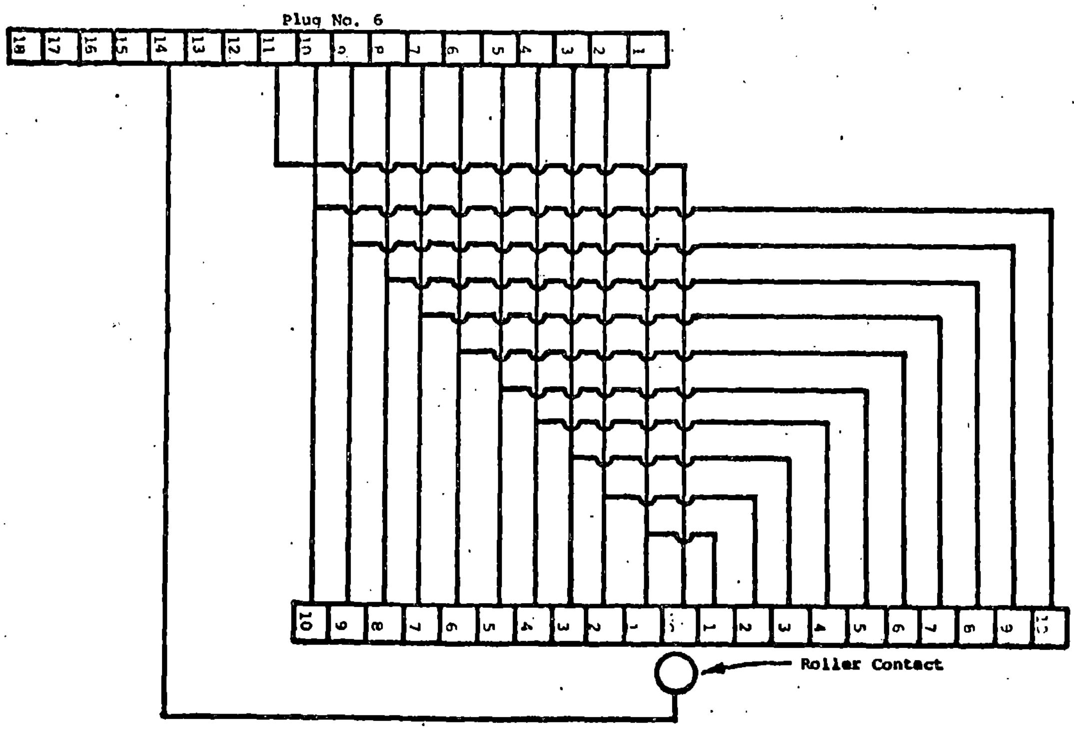
Output

Socket from extension cord of console

Transistors are HEP240
100 ohm Resistors 10% 1/2 watt
68 ohm Resistor 10% 2 watt

Input

Plug from LJK unit



SCHEMATIC ELECTRICAL DIAGRAM OF LJK INDICATOR MARCH 10, 1976

ADDITIONAL PLUG AND SOCKET CONTACTS ARE USED FOR THE NULL SEEKING PORTION OF THE PCA ROAD METER

Fig. 6
ELECTRICAL SCHEMATIC
(Part 2)

C. Early Improvements in the IJK Ride Indicator

Even though the IJK had exhibited a high degree of accuracy, it would operate only for a short time without mechanical malfunction. Initially the greatest source of malfunction was the electrical roller contact. After varying the mounting, size of roller and roller material failed to solve the problem, a carbon brush contact of an electric motor was used. The contact problems were eliminated by a common 1/4" diameter round carbon brush (Figure 7) sawed to a 1/4" length. When it showed wear, it was simply rotated to a spot that did not show wear. This brush has worked so well that it has been used for two years.

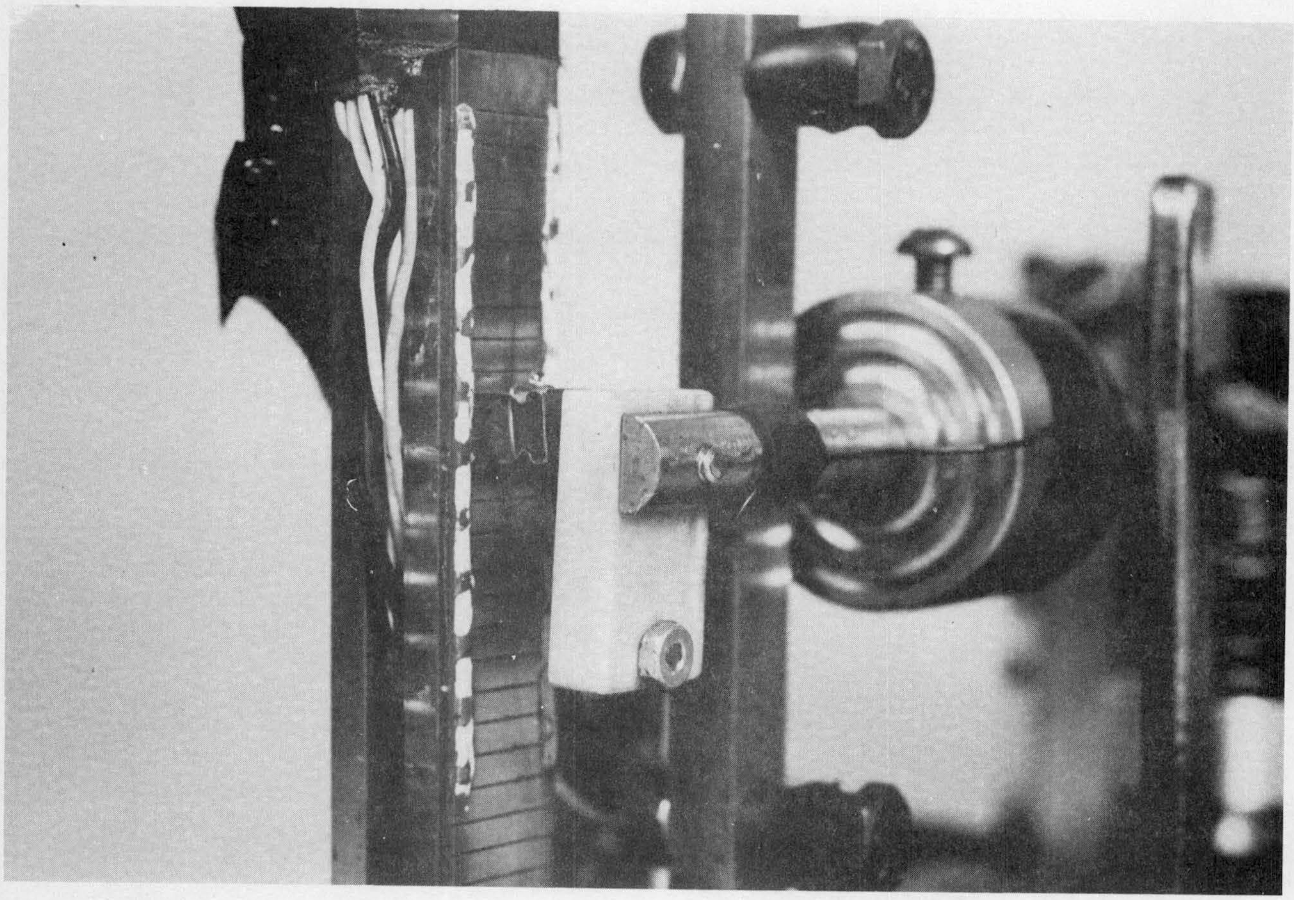


Figure 7 -- Brush Contact of
IJK Ride Indicator

The transistorized system was used to eliminate arcing on the contact board. This prevents the much higher voltage caused by counter coil breakdown from flowing in this part of the circuit.

In the early development of the IJK, there was a friction problem in the bearings of the oscillator arm. Higher quality bearings with less friction were obtained and have provided the desired movement.

Two dampening chamber designs were studied, with the conclusion that to yield proper dampening, the paddle must operate in a tightly restricted chamber (Figure 8). A larger dampening chamber did not provide adequate restriction to limit movement with the energy that was developed.

A locking mechanism was installed to prevent the oscillator arm from moving when not testing. This lock and a better arm stop system reduced damage to the unit.

D. Determination of Proper Dampening Fluid

In conjunction with the study of the two dampening chambers, a study was conducted to determine the right dampening fluid to use. The fluid needed to have a consistent viscosity in cold or hot weather. Two fluids with this characteristic are kerosene and Dow Chemical's DC-200. These were blended in different proportions while experimenting with the dampening of the

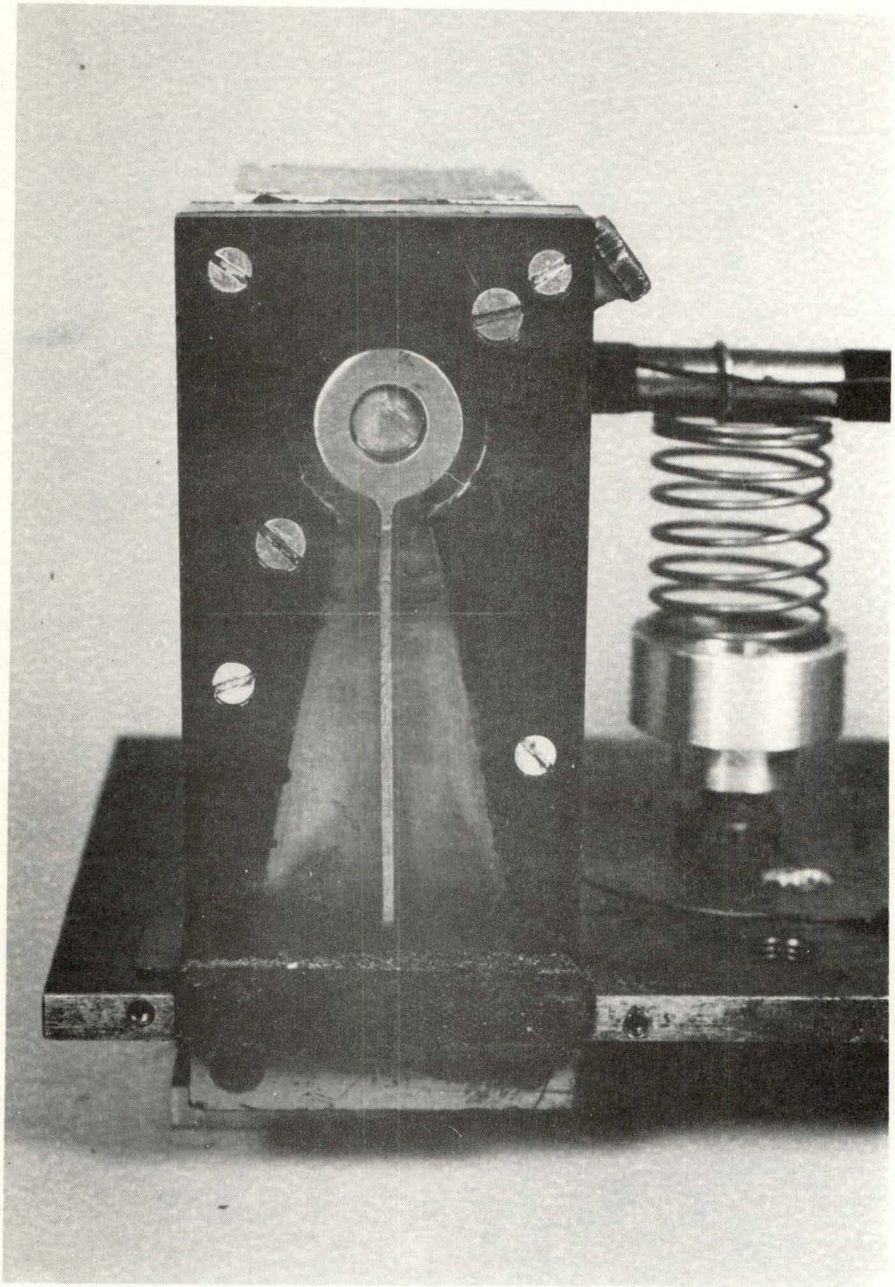


Figure 8 -- IJK Ride Indicator
Dampening Chamber

IJK unit. The 1973 testing season was devoted to this dampening study and experimental operation to verify that various equipment malfunctions had been remedied.

E. Advantages of Testing with the IJK Ride Indicator

The biggest advantage of the IJK unit is its freedom from adverse wind effects. Because the sensing unit is covered and mounted beneath the car body, wind causes no movement of the sprung mass. Wind would influence the unit only if it were strong enough to cause the car body to pick up the chassis. There has been no apparent influence in winds up to 30 MPH so no wind restriction has been imposed. Even in strong winds, the IJK has consistently obtained correlation coefficients better than 0.98 when compared to the CHLOE.

The IJK Ride Indicator is nearly independent of vehicle suspension so with any standard suspension system, there should be no need for modification. Changes in shock absorber strength are not critical and the problem of variation in replacement shocks has been eliminated. No recorrelation is necessitated by these changes. It would have been required with the PCA Road Meter.

The internal zero is another advantage of the IJK Unit. If the zero is set accurately, no adjustments are necessary. There is little possibility of a change in correlation due to variation in the vehicle loading.

Testing quality and quantity have been improved by these advantages. Prior to the IJK, testing was suspended during periods of strong wind, which decreased the productivity. Such winds sometimes caused data to be suspect. Retesting was required and not only decreased production but also lowered confidence in the values obtained. The IJK is a continuous testing system with no operational reason other than safety to suspend testing.

F. IJK Ride Indicator Performance

The IJK has been used exclusively for our primary road inventory surveys in 1974 and 1975. The data appear to be the most reliable we have ever obtained, with fewer problems than in previous years.

The only problem noted with the IJK is that the tight dampening chamber causes oil to be pumped out through the bearing. To maintain constant dampening, the oil level must remain constant. Under present operation, the unit must be removed weekly for oil level adjustment.

G. IJK Ride Indicator Modification

Loss of oil from the dampening chamber is the only problem that causes inconvenience, so this has been the only reason for considering unit modification.

During the winter of 1974-5, a study of magnetic dampening was conducted. Both rotary and regular "horseshoe" magnets were used, but neither attained sufficient dampening to control the energy developed in the system. No further efforts in magnetic dampening have been considered.

Present efforts to solve the oil loss problem are in designing a special oil seal. This new oil seal is still in the experimental stage and further testing is necessary to determine its success.

Another way to eliminate wearing parts would be to replace the electrical contacts with an electric eye system, which would be relatively easy. However, there have been no problems with the transistorized circuit; hence there is no reason to change.

III. IJK RIDE INDICATOR USE FOR PAVEMENT INVENTORY

A. IJK Ride Indicator Testing Procedure

Before mounting on the car, the IJK sensing unit is accurately zeroed while in a level position. The dampening fluid is also adjusted to the proper level. Eight selected correlation sections near the central laboratory are tested weekly during Ride Indicator operation, to verify proper performance. The testing procedure is described in Test Method No. Iowa 1002-B (Appendix B).

The unit is warmed up for 10 miles before testing to eliminate flat spots on the tires. The lock on the sensing unit is disengaged and the vehicle is brought to 50 mph, which is maintained by the cruise control. As the rear wheels cross the beginning of the test section, the electrical counters are turned on. The electric eye distance counter operates on the same circuit, thereby giving an accurate testing length even when bridges or railroad tracks are omitted. Upon completion of one test section, the rotary switch is turned to the other bank of counters. The data are recorded and the counters are reset for testing the next section.

B. IJK Ride Indicator Correlation

The CHLOE Profilometer is still our standard for measuring the riding quality in determining the Present Serviceability

Index. Because it is based on slope variance and is not dependent on the relative motion of a system, it is a stable method for obtaining qualitative values. If the electrical system calibrates properly and other mechanical parts are maintained, it yields very reproducible values from year to year. For this reason, the IJK Ride Indicator is correlated annually with the CHLOE.[7]

The Iowa correlation layout consists of 46 carefully selected 1/2-mile-long sections of P.C. concrete roadway. The 1/2-mile lengths are short enough for the CHLOE (at 3 mph) and long enough for the IJK Ride Indicator (at 50 mph). For correlation, only the profile portion of the Present Serviceability Index is considered, with an effort to select roadways with as little physical deterioration as possible. These Iowa correlation sections have a Present Serviceability Index range of 2.6 to 4.8. Experience has shown that the P.C. roadways are more stable and do not affect the CHLOE slope variance as do some A.C. roadways with open surface texture. Lower PSI values are available, but these are found on badly broken P.C. roadways which have more variability. The values for these roadways are not stable from year to year. Because the car with the IJK Ride Indicator tests both the inside and outside wheeltracks, the CHLOE values for both are obtained and averaged. Correlation testing is usually conducted in April or May.

After the IJK and CHLOE values have been obtained, they are submitted to a data processing program (Appendix C) through a terminal entry. This program uses a method of least squares parabolic fit, thereby letting the curve obtain a better correlation coefficient than a straight-line equation. This yields a table for determining the Longitudinal Profile Value, which is the riding quality portion of the Present Serviceability Index (Appendix B Page 54).

C. Primary Road Sections for Determining Present Serviceability Index

The State of Iowa has established a milepost system on all primary roadways. The milepost markers have been the best way to identify test section limits so that there is no misunderstanding in communications. The test section limits correspond with the limits of the last surface restoration project (Appendix D). These have been assembled for each of Iowa's 99 counties in a booklet entitled "Test Sections by Mileposts". Because there are many surface restoration projects each year, the booklet must be continually updated.

D. Data Collection and Distribution

In Iowa, one third of the counties are tested each year. Therefore, all primary roads are tested with the IJK Ride Indicator on a 3-year cycle. A cracking, patching, and rut depth survey is made every third year for the entire state rural primary road system. These data are reported in summary form (Page 56, Appendix B) and are used in a state road sufficiency rating.

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1. National Academy of Sciences -- National Research Council, The AASHO Road Test: Report 5 - Pavement Research. HRB Special Report 61E, 1962.

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4. Bunnag, Anuphan, Iowa State Highway Commission's PCA Type Road Meter, 1967.

5. Pradubjew, Derek, and Marks, Vernon J., Road Meter Modifications and Improvements, 1970.

6. Brokaw, M.P., "Development of an Automatic Electromechanical Null-Seeking Device for the PCA Road Meter", Highway Research Board Special Report 133, Pavement Evaluations Using Road Meters, 1973, pp. 93-96.

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APPENDICES

APPENDIX A

DETAILED DRAWINGS

IOWA DEPARTMENT OF TRANSPORTATION

HIGHWAY DIVISION

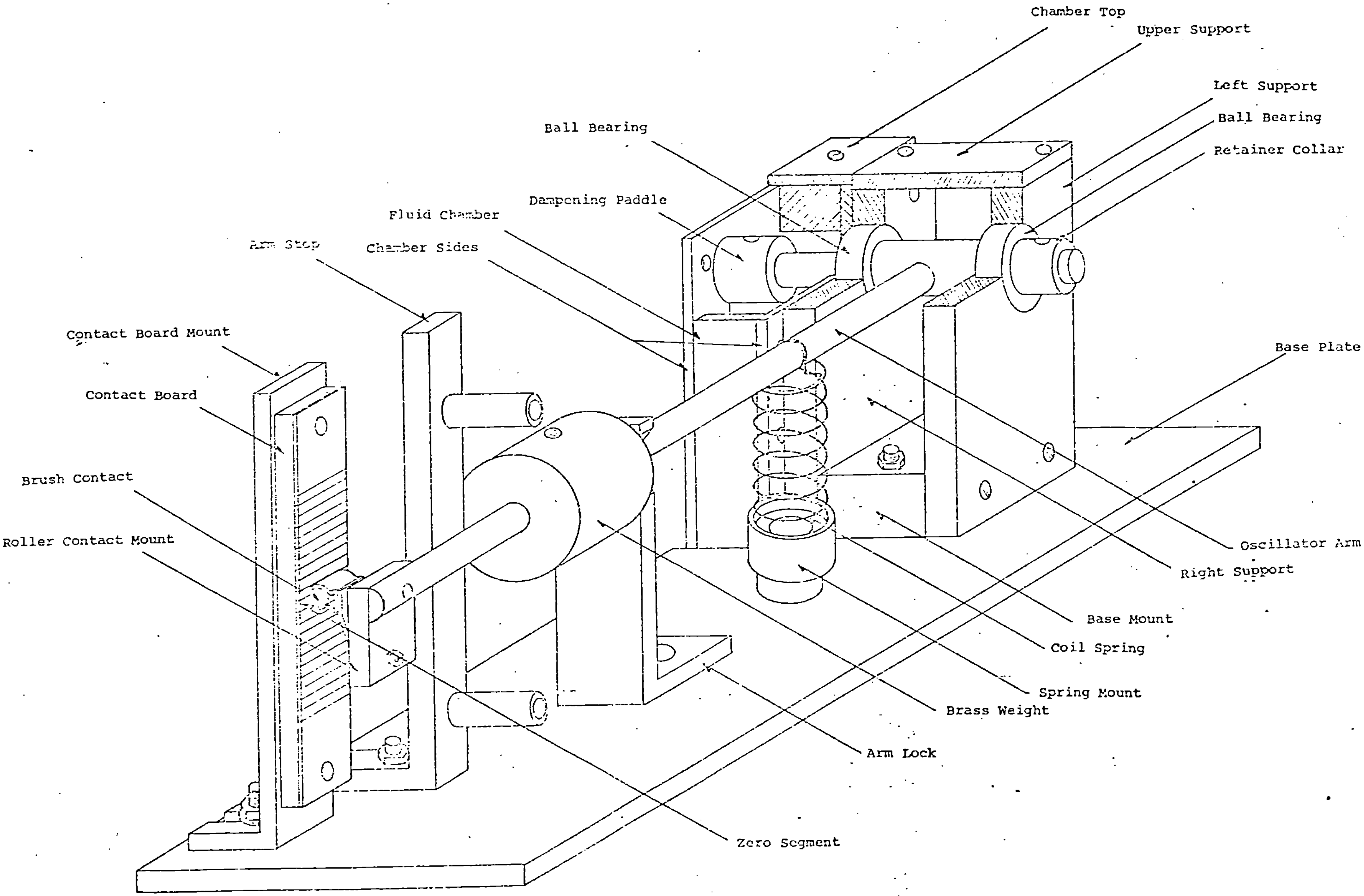
Office of Materials

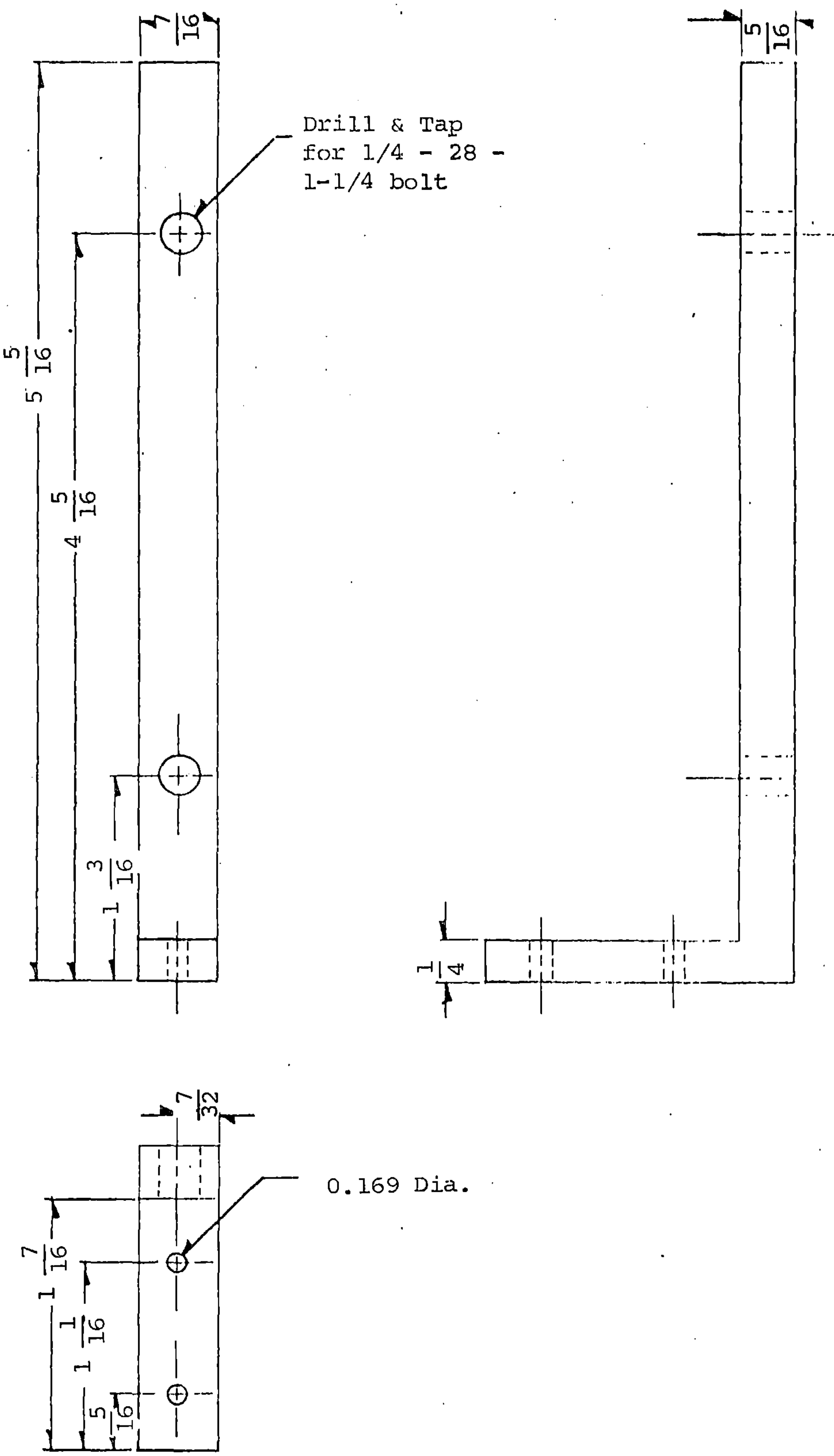
SPECIAL INVESTIGATIONS SECTION

DETAIL DRAWINGS OF THE

IJK RIDE INDICATOR

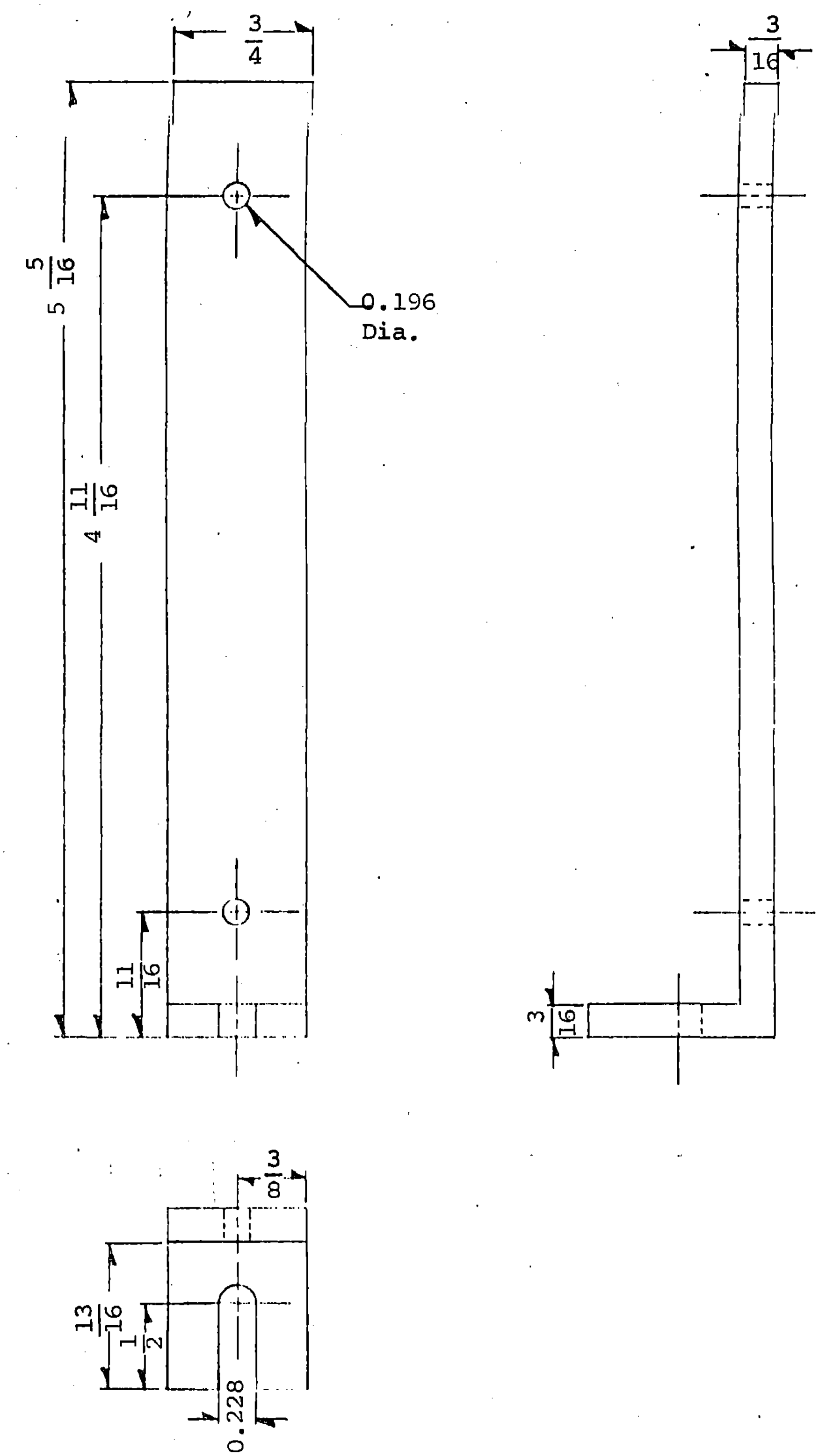
IJK Ride Indicator



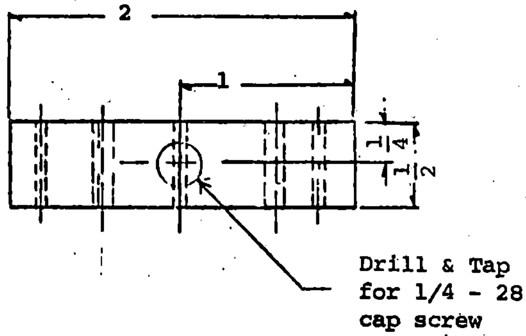


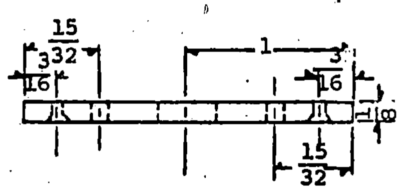
ARM STOP

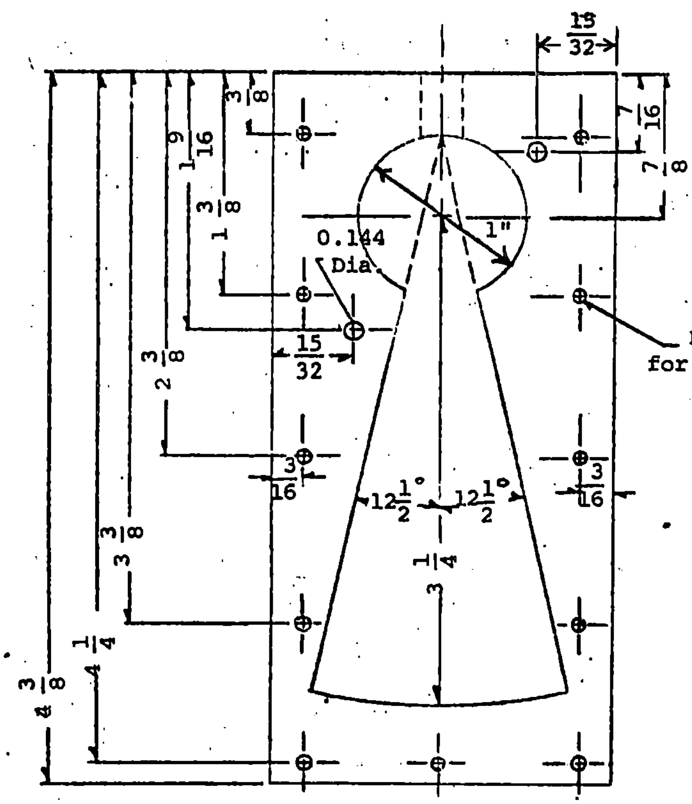
NOTE: Cover 1/4 x 1-1/4 - 28 tread bolt with rubber tubing to absorb shock.



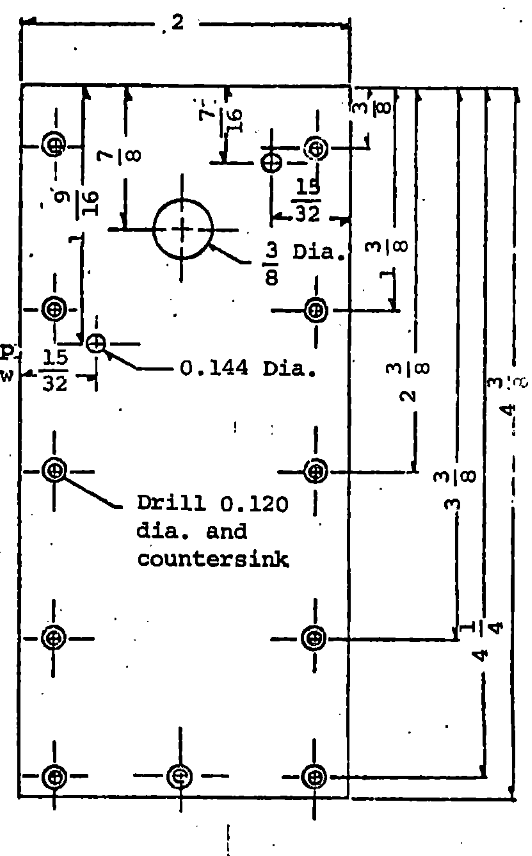
CONTACT BOARD MOUNT



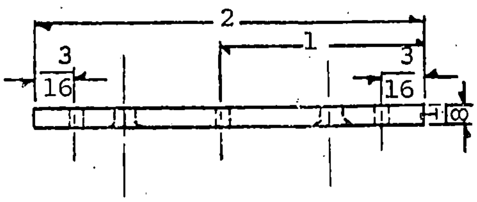


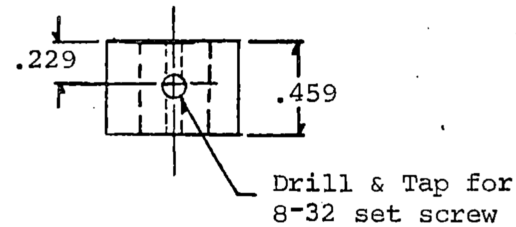


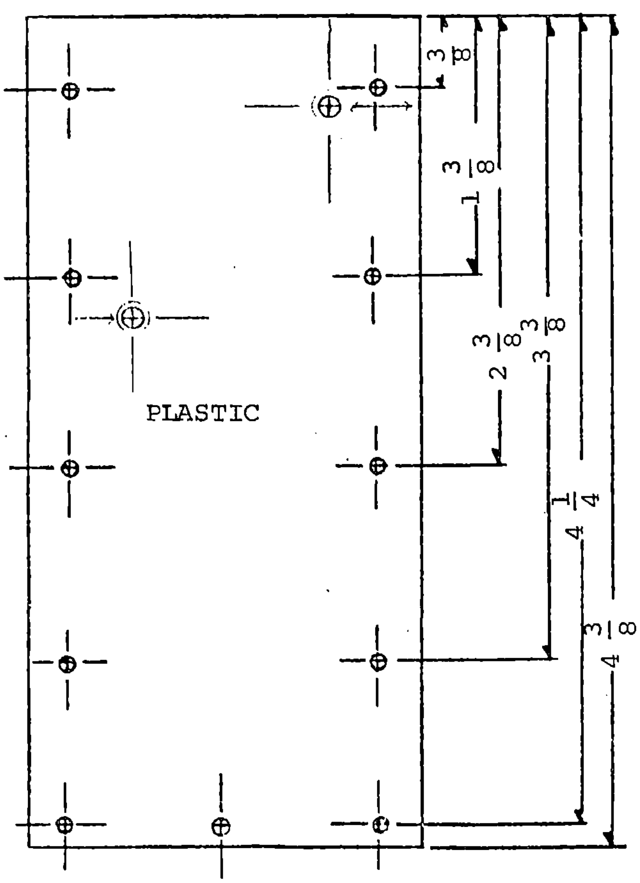
FLUID CHAMBER

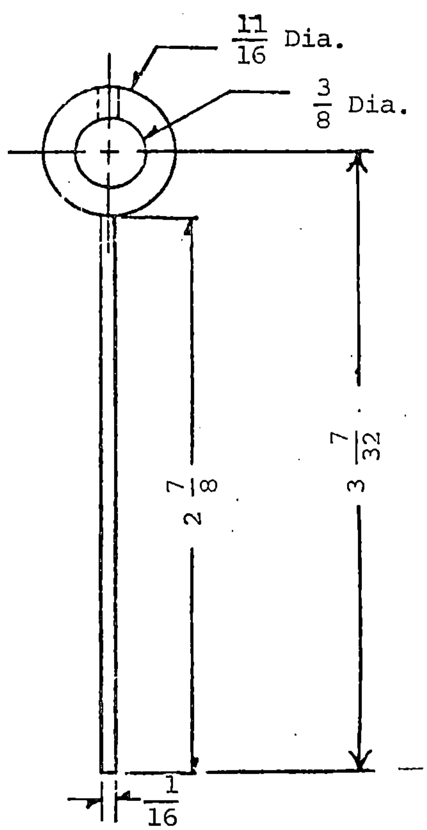


CHAMBER SIDE (INSIDE)

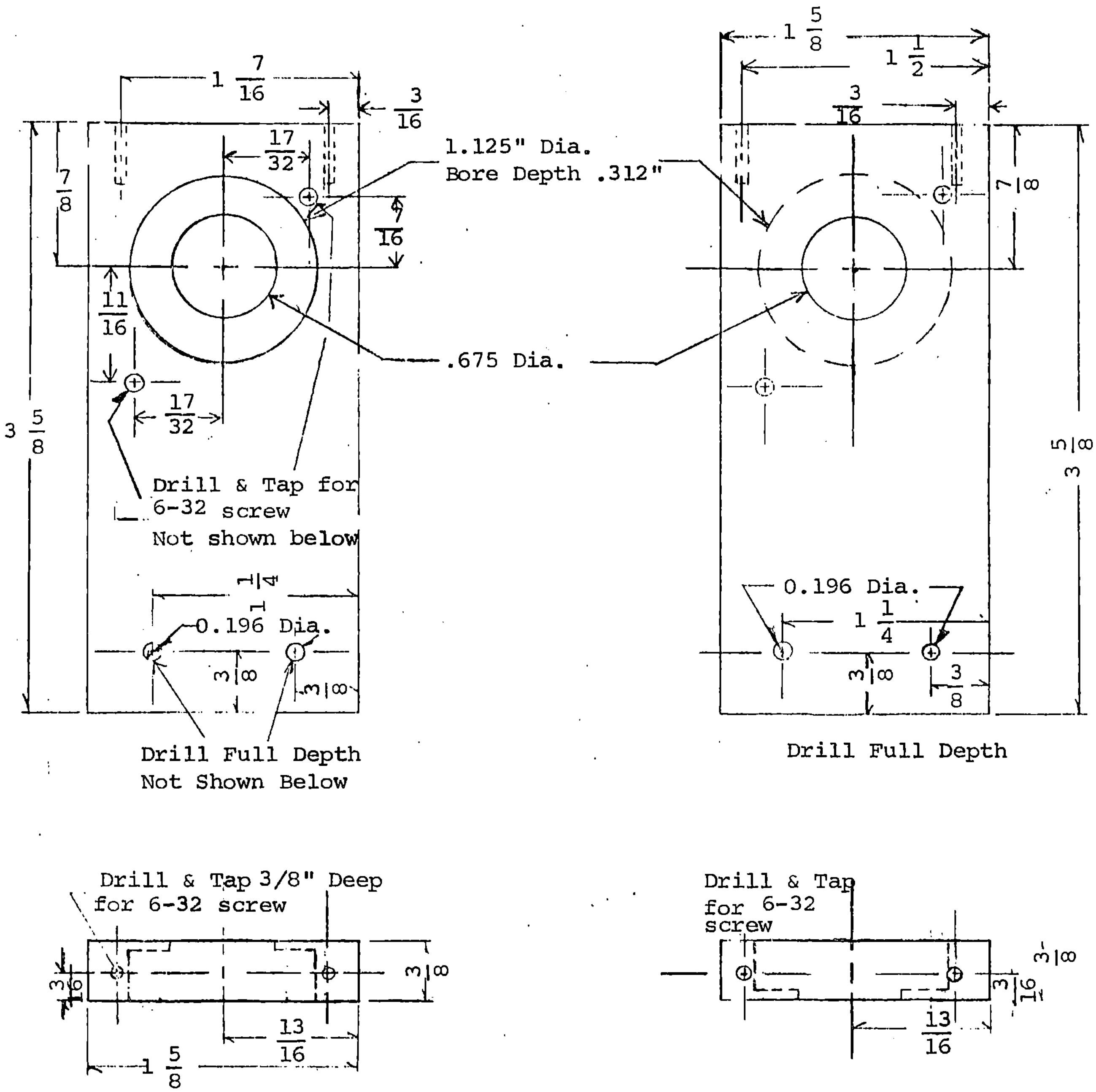








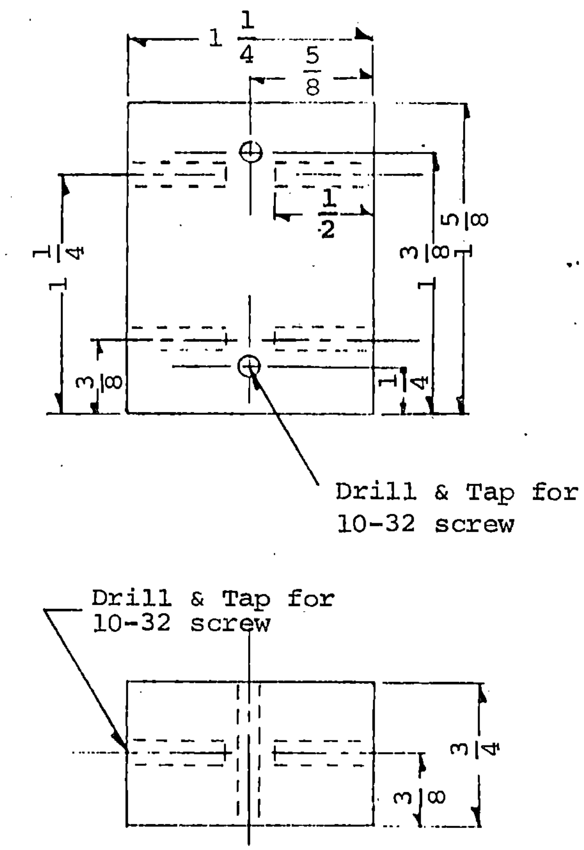
CHAMBER SIDE (OUTSIDE)



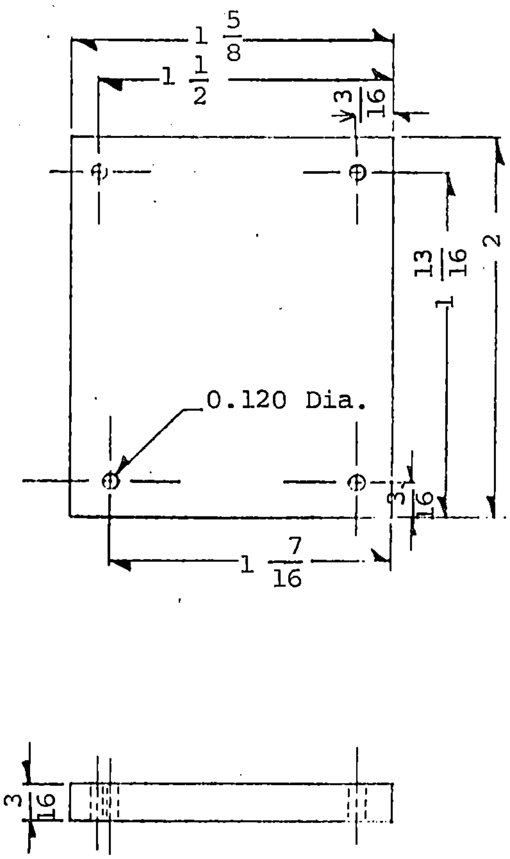
LEFT SUPPORT

RIGHT SUPPORT

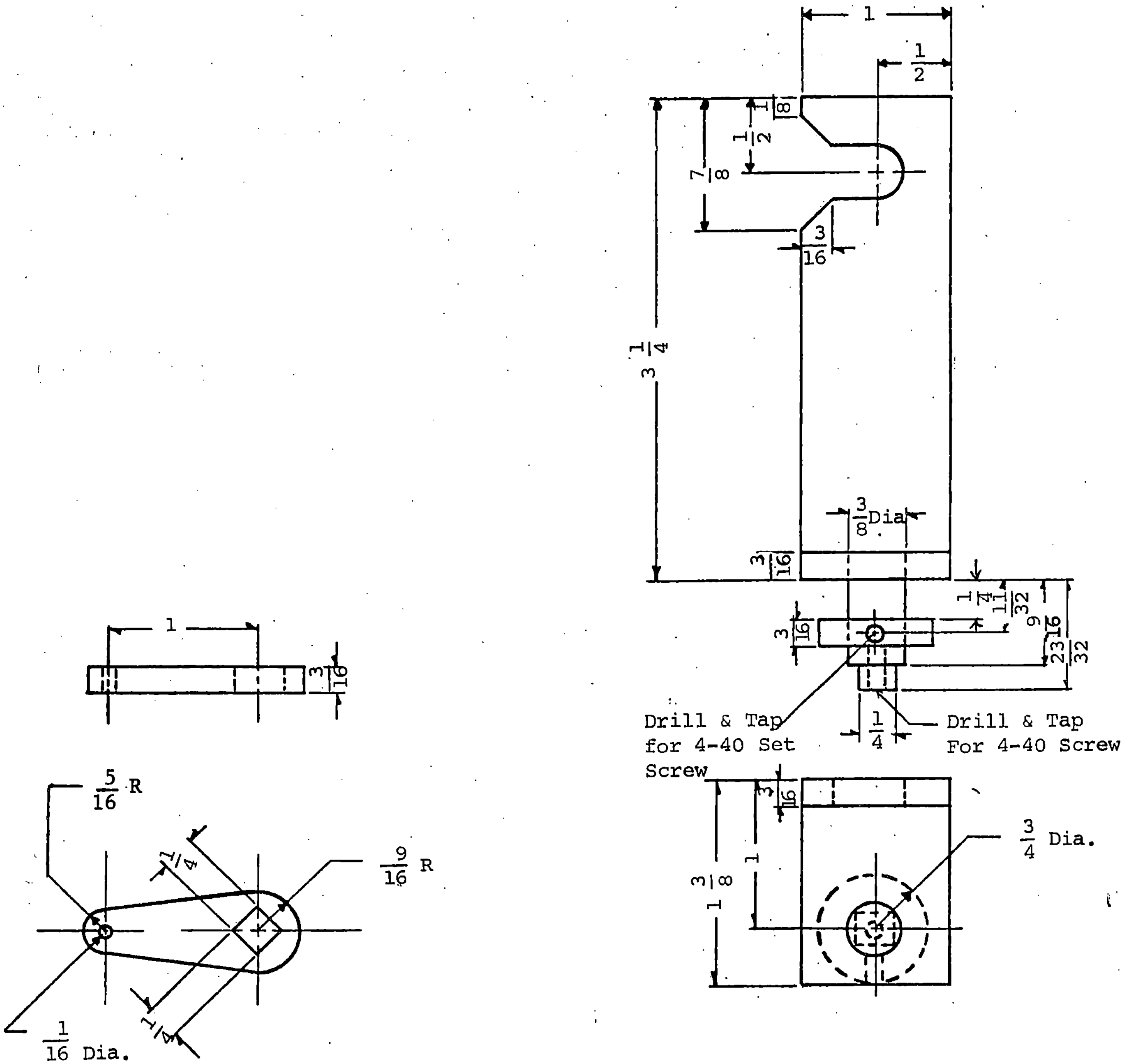
Ball Bearing Number Fafnir SK 5 DD.
Width .312", Bore .500", O.D. 1.125"



BASE MOUNT

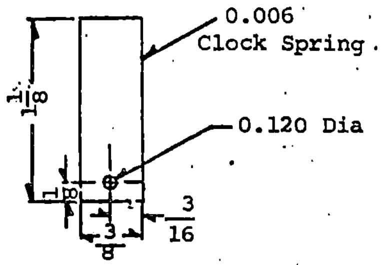


UPPER SUPPORT



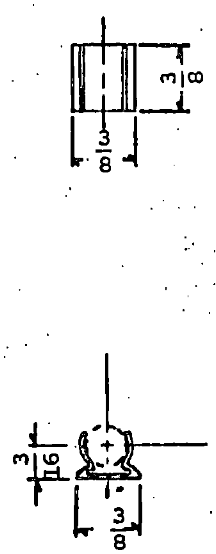
Drill & Tap for 4-40 Set Screw
Drill & Tap For 4-40 Screw
3/8 Dia.
3/4 Dia.
5/16 R
9/16 R
1/16 Dia.

ARM LOCK

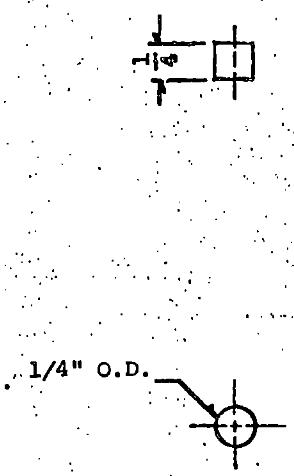


CARBON BRUSH SPRING

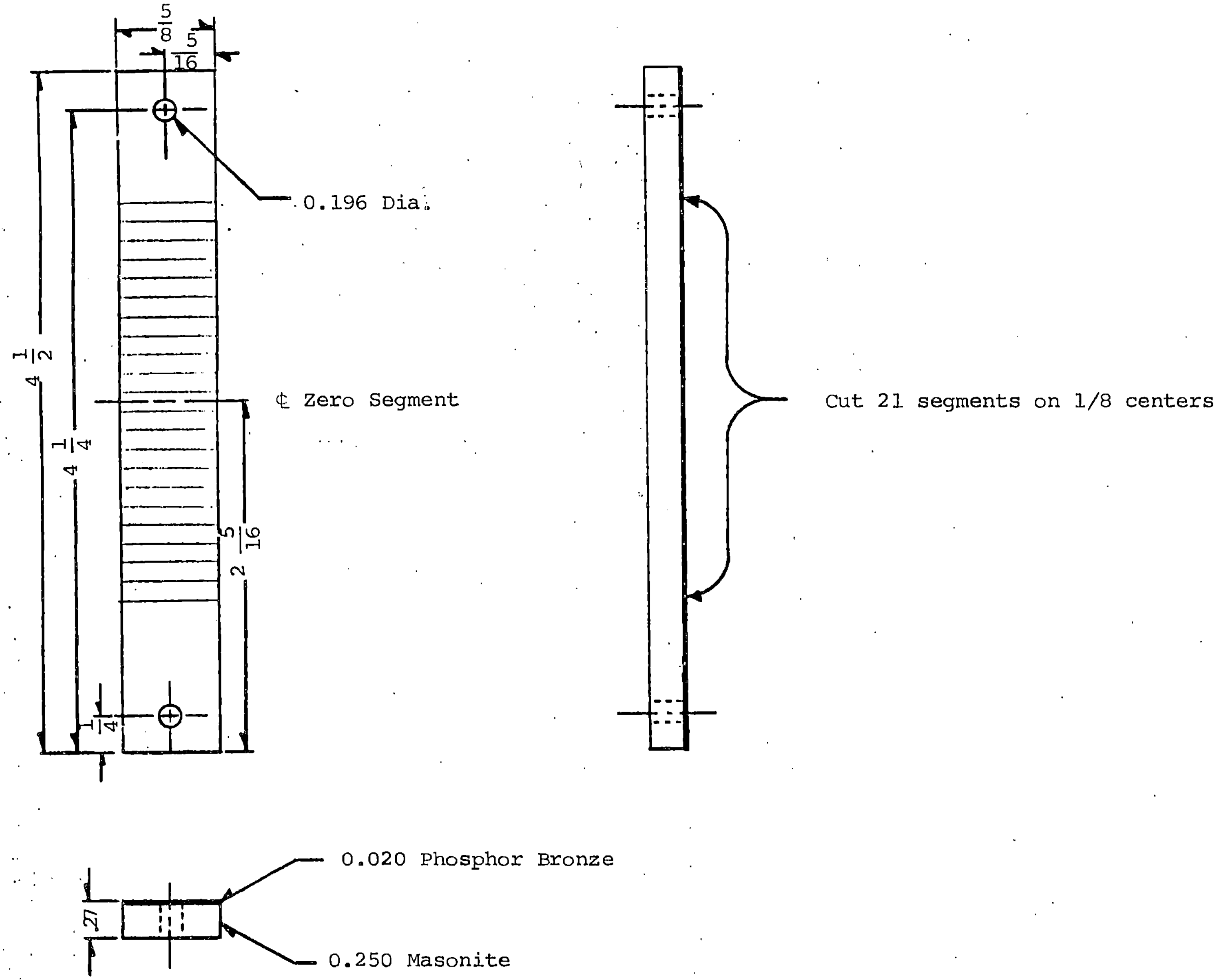
NOTE: Attach 7x32 AWG wire to Oscillator Arm from the Axis to the Brush Contact Mount and solder to the Roller Spring.



CARBON BRUSH BRACKET
0.020" Phosphor Bronze or Miniature Fuse Clip
Solder and rivet to .006" Clock Spring.

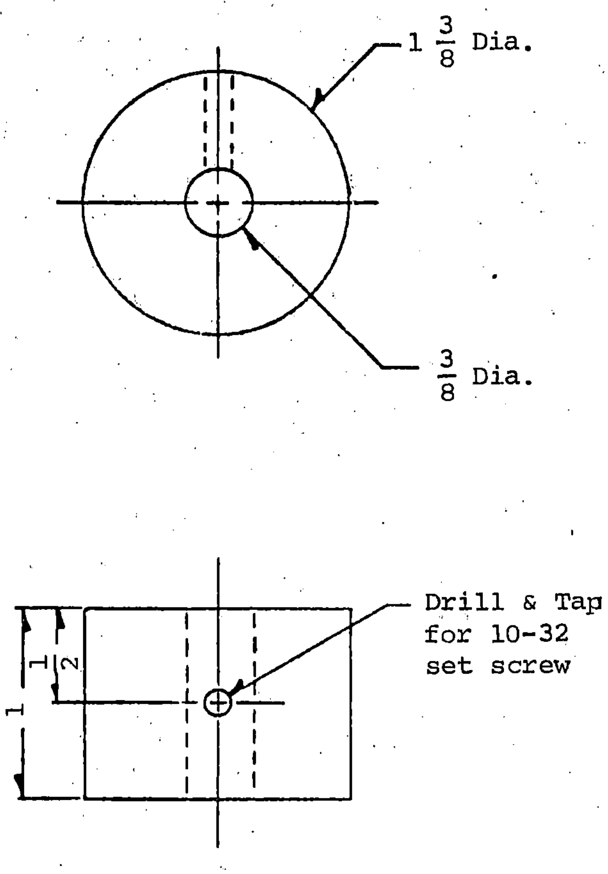


CARBON BRUSH
1/4" O.D. Vacuum Cleaner Carbon Brush

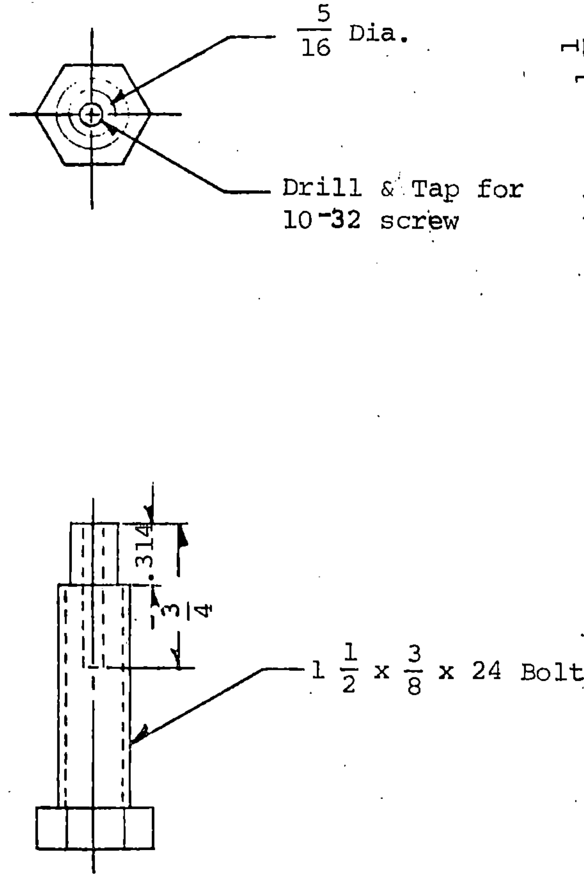


CONTACT BOARD

NOTE: Glue Phosphor Bronze Strip to Masonite. Saw slits on 1/8" centers using 0.010 saw. Drill 0.040" Dia. holes at edge of bronze strip for attaching wires. Solder wire leads in holes. Fill slits and secure wires using epoxy cement. Sand off excess epoxy.

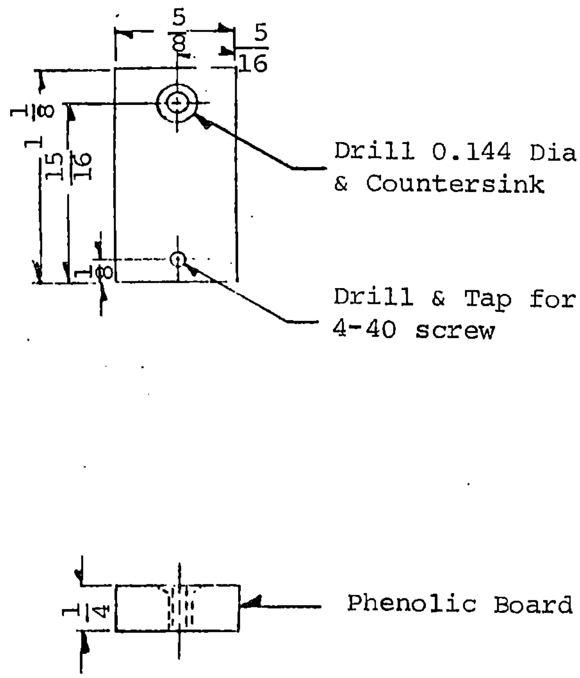


BRASS WEIGHT

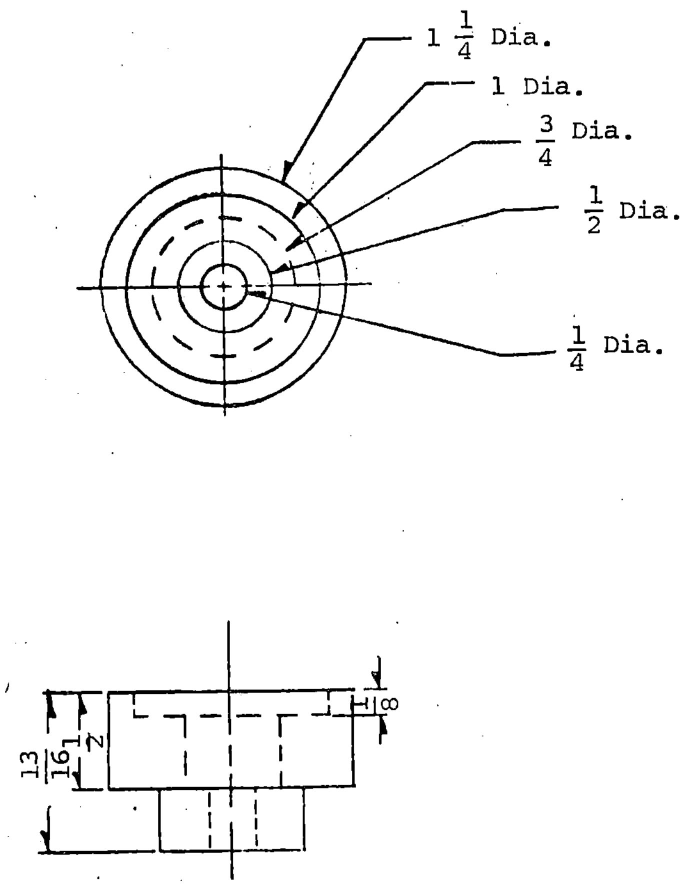


ZERO ADJUSTMENT

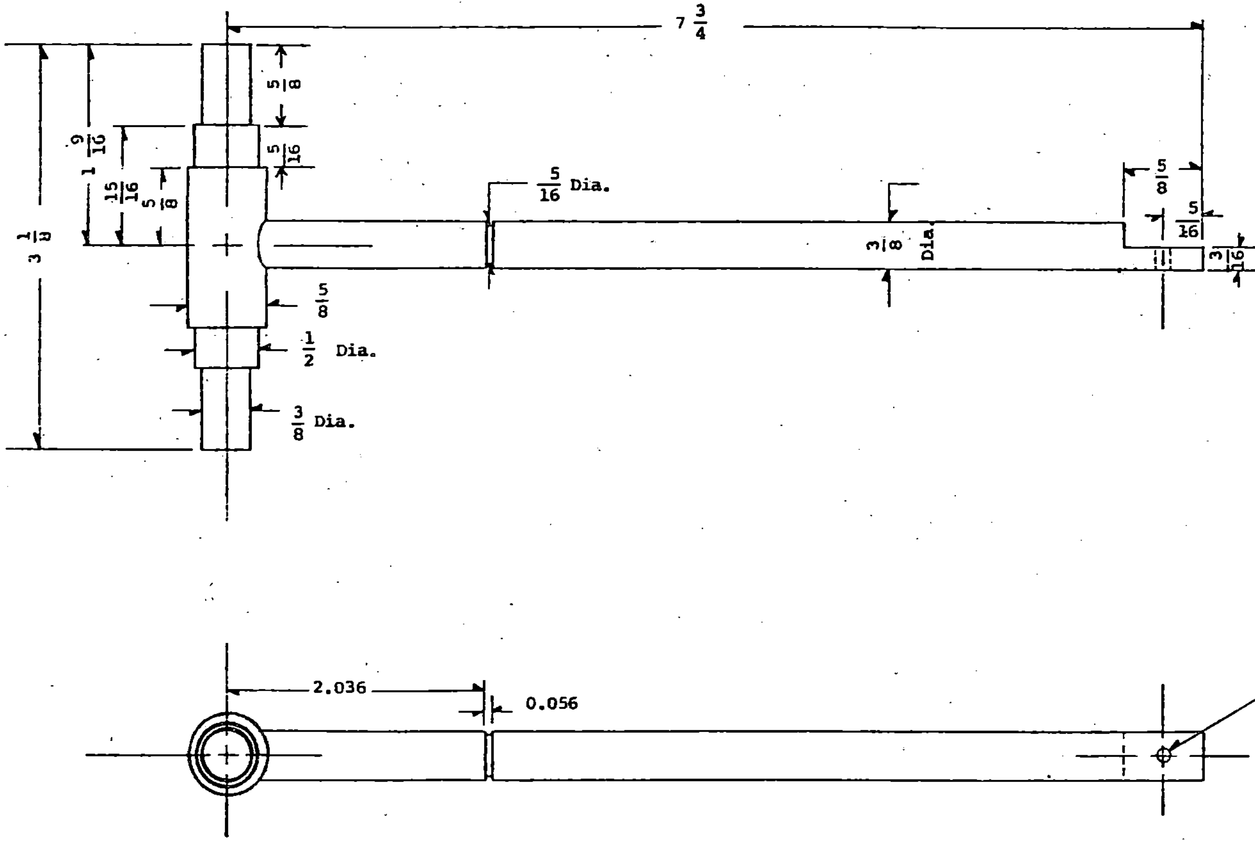
NOTE: Adjust so that when the oscillator arm is in the neutral position the roller contact rests on the zero segment. Use a jam nut to lock in this position.



BRUSH CONTACT MOUNT

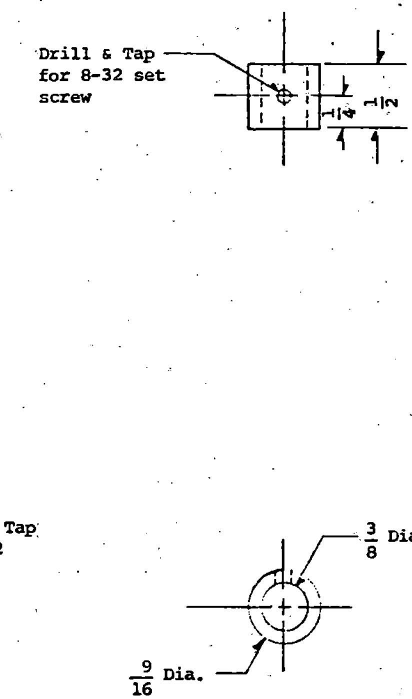


SPRING MOUNT

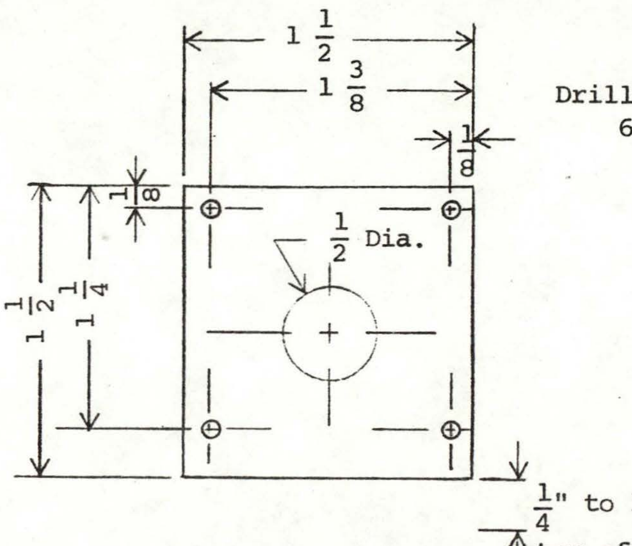


OSCILLATOR ARM

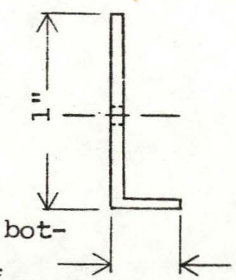
Brass weight set on arm 5-15/16" from ℄ cross shaft to farthest edge of weight.



RETAINER COLLAR

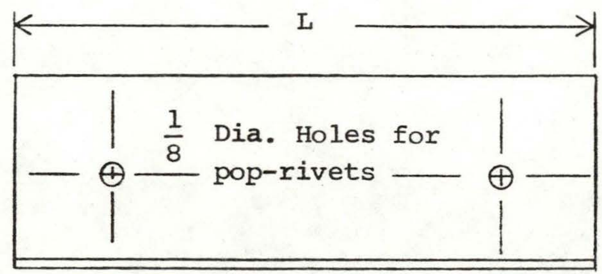


16 Gauge
Drill 1/8 Dia. Holes
in Cover to Match.



16 Gauge

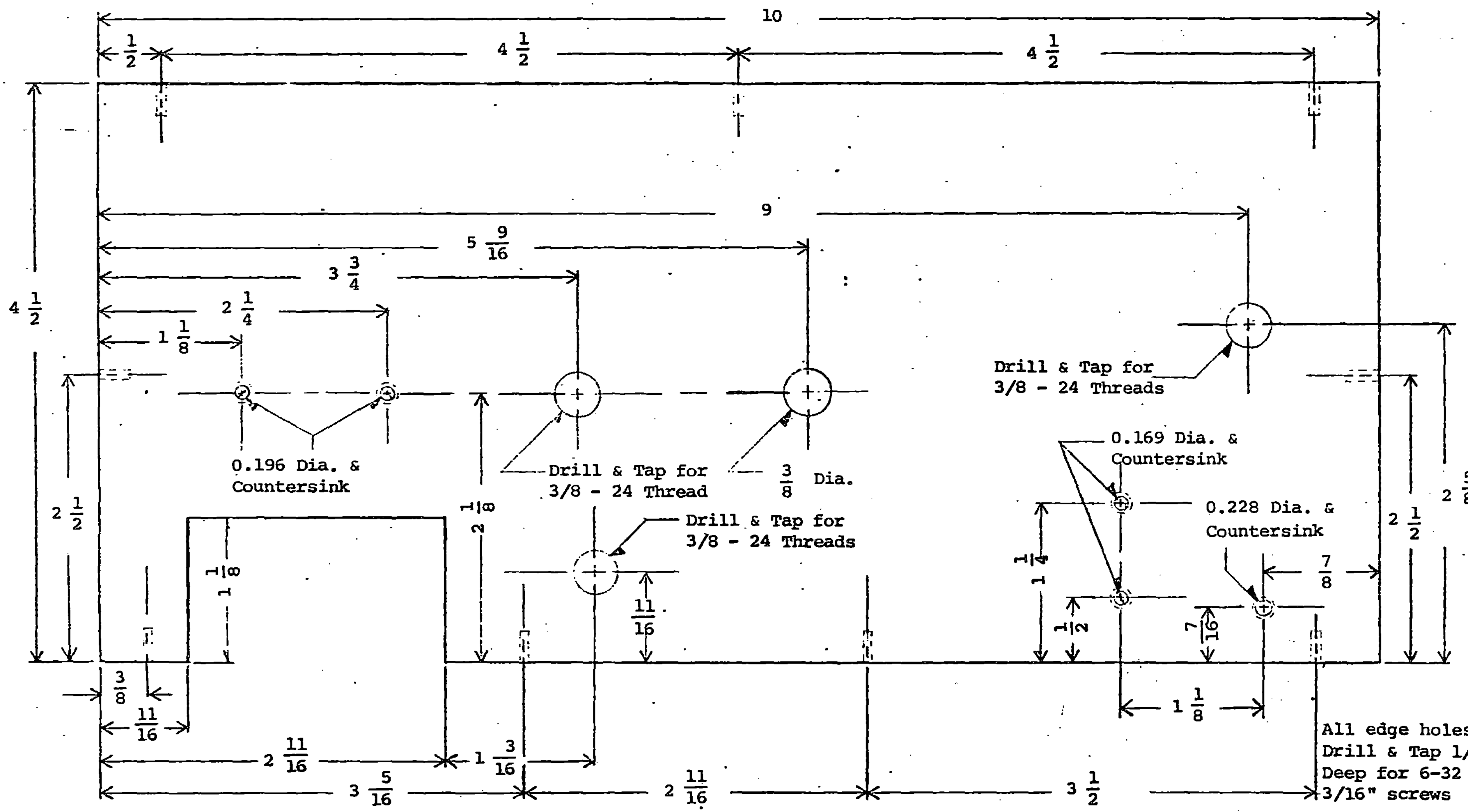
OUTLET CORD PORT



NOTE: Make 4 pieces, L = 9-3/4, 3-1/2, 3-1/2, & 3
Drill 1/8 dia. holes at appropriate spaces.
Position angle so 3/8 leg is 3/8" from
bottom edge of cover and drill matching
holes in cover. Rivet angle in place.
Glue 1/4 & 3/8 weather stripping on 3/8
leg.

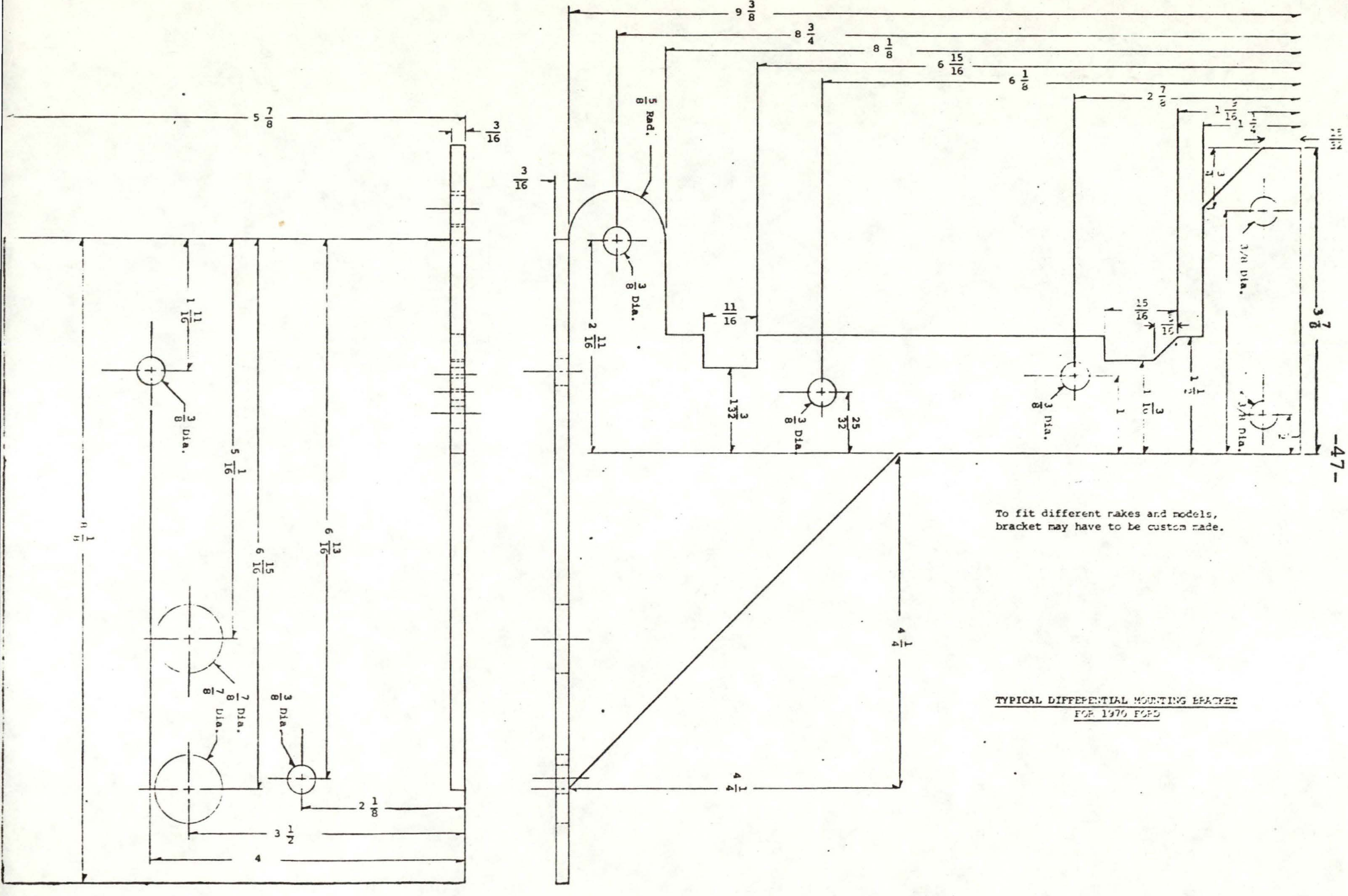
Attach 3" piece to cover box so when box is
in place, the piece is between outlet cord
port and base of arm stop.

WEATHER STRIPPING SUPPORTS



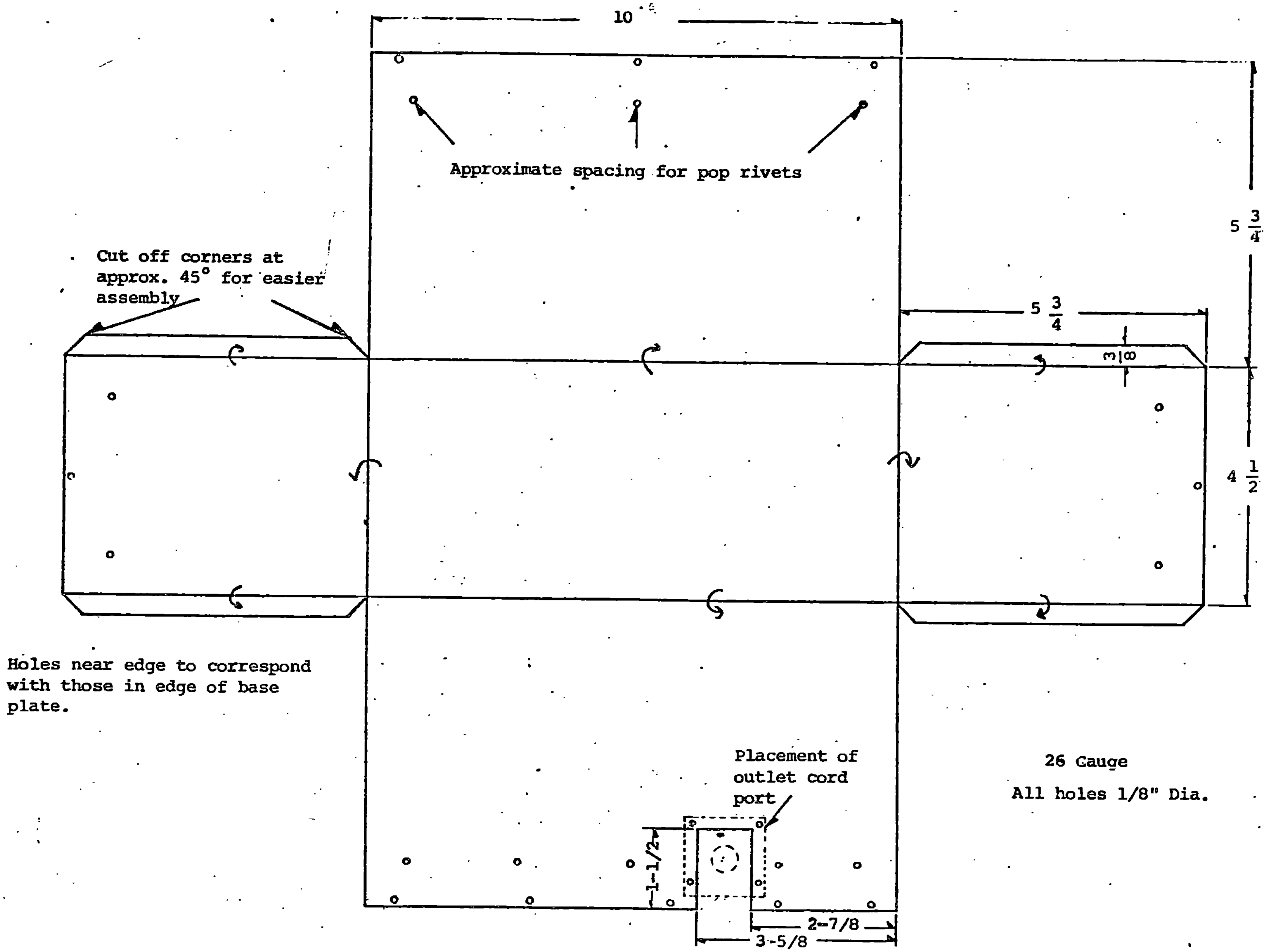
10
1/2
4 1/2
4 1/2
4 1/2
9
5 9/16
3 3/4
2 1/4
1 1/8
0.196 Dia. &
Countersink
Drill & Tap for
3/8 - 24 Thread
3/8 Dia.
Drill & Tap for
3/8 - 24 Threads
Drill & Tap for
3/8 - 24 Threads
0.169 Dia. &
Countersink
0.228 Dia. &
Countersink
2 1/2
2 1/8
1 1/8
11/16
1 1/4
1/2
7/16
7/8
1 1/8
2 1/2
2 5/8
3/8
11/16
2 11/16
1 3/16
3 5/16
2 11/16
3 1/2
All edge holes
Drill & Tap 1/4"
Deep for 6-32
3/16" screws

BASE PLATE



To fit different makes and models, bracket may have to be custom made.

TYPICAL DIFFERENTIAL MOUNTING BRACKET
FOR 1970 FORD


10
Approximate spacing for pop rivets
Cut off corners at approx. 45° for easier assembly
5 3/4
5 3/4
3/8
4 1/2
Holes near edge to correspond with those in edge of base plate.
Placement of outlet cord port
1-1/2
2-7/8
3-5/8
26 Gauge
All holes 1/8" Dia.

COVER BOX

APPENDIX B

TEST METHOD NO. IOWA 1002-B

MARCH 1976

Test Method No. Iowa 1002-B
March 1976

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION

Office of Materials

METHOD OF DETERMINATION OF LONGITUDINAL PROFILE VALUE USING THE IJK RIDE INDICATOR

Scope

This testing method is used to determine the Longitudinal Profile Value (LPV) using the IJK Ride Indicator. The Longitudinal Profile Value is used to determine the Present Serviceability Index (P.S.I.), a concept developed by the American Association of State Highway Officials (AASHO) Road Test. It (P.S.I.) is used as an indicator of the ability of a pavement to serve the traveling public and as an objective method of highway evaluation.

The IJK (Iowa-Johannsen-Kirk) Ride Indicator was developed by the Iowa Department of Transportation Materials Laboratory.

Procedure

A. Apparatus

1. IJK Ride Indicator (An electromechanical device mounted on the differential of a standard automobile)(Fig. 1 to 4).
2. Tire pressure gauge.
3. Portable calculator.

B. Test Record Forms and Section Identification

1. Longitudinal Profile Value Worksheet (Form 921).
2. Final Report (Forms 915 or 922).
3. "Test Sections by Milepost" booklet.
4. Correlation Table (Longitudinal Profile Value vs. Sum/Length for testing unit).

C. Personnel

1. Two personnel are required. One is assigned to drive while the other operates the counters and makes calculations.

D. Correlation

1. The Longitudinal Profile Value is derived from equations of the AASHO Road Test using a correlation between the CHLOE Profilometer and the IJK Ride Indicator. The CHLOE is used as a correlation standard because it is not affected by possible changes in suspension but primarily is dependent only on proper electrical operation. The relationship between the CHLOE and the IJK Ride Indicator is determined through a computer program by the least square parabolic method ($Y=CX^2+MX+B$).

E. Test Procedure

1. Drive the test vehicle at least 10 miles before beginning testing.
2. Operate the vehicle in a careful, legal, conscientious manner.
3. Be sure the IJK unit is accurately zeroed before mounting on the vehicle.
4. Be sure the dampening fluid level is correct. This should be checked weekly during continuous operation.
5. During continuous testing, the unit should be tested on eight conveniently close correlation sections weekly to verify proper operation.
6. When ready to begin testing, disengage the IJK arm lock.
7. Start the test vehicle far enough from the beginning of the test section to insure adequate distance for acceleration to the standard test speed of 50 MPH. Turn the main switch to the "ON" position as the rear wheels pass the start of the test section. It is turned off in the same position at the end of the section.

8. Turn the main switch off while crossing railroad tracks and bridges (including approaches). This length and roughness counts are electrically omitted.

9. There is a rotary switch to change from one bank of recording counters to the other so testing can be continuous.

10. Record the counter values and calculate the Sum/L.

11. If there is some reason to indicate possible erroneous data a repeat run should be made. Valid runs are expected to check within 10% of each other.

12. Using the Sum/L, obtain the proper Longitudinal Profile Value from the table to the closest 0.05 (3.95, 4.15 etc.).

F. Precautions

1. Maintain the tire pressure at 25 psi cold, 28 psi, warm. If any tire alignment or balancing problems are noted, have them corrected.

2. Be sure to engage the IJK arm lock when not testing.

3. Keep the vehicle in a neat orderly condition.

4. Have the automobile serviced at the proper interval.

G. Calculations for Longitudinal Profile Value

1. Enter the necessary descriptive data in the heading portion of the LPV worksheet. The method of calculation is as follows: the summation of counts from counter no. 1 x 1, counter no. 2 x 2, counter no. 3 x 3, etc. These products are totaled and divided by the tested length (in miles) to obtain the Sum/L. This sum/length is then used to find the Longitudinal Profile Value from the correlation table.

H. Reporting Results

1. The final report for all testing uses the same data that was necessary for the worksheet. Form 915 is used for county inventory testing and Form 922 is used for testing individual projects. A deduction for cracking, patching and rut depth is used (from the most recent survey) to yield a Present Serviceability Index.

Fig. 1

The IJK Ride Indicator Vehicle

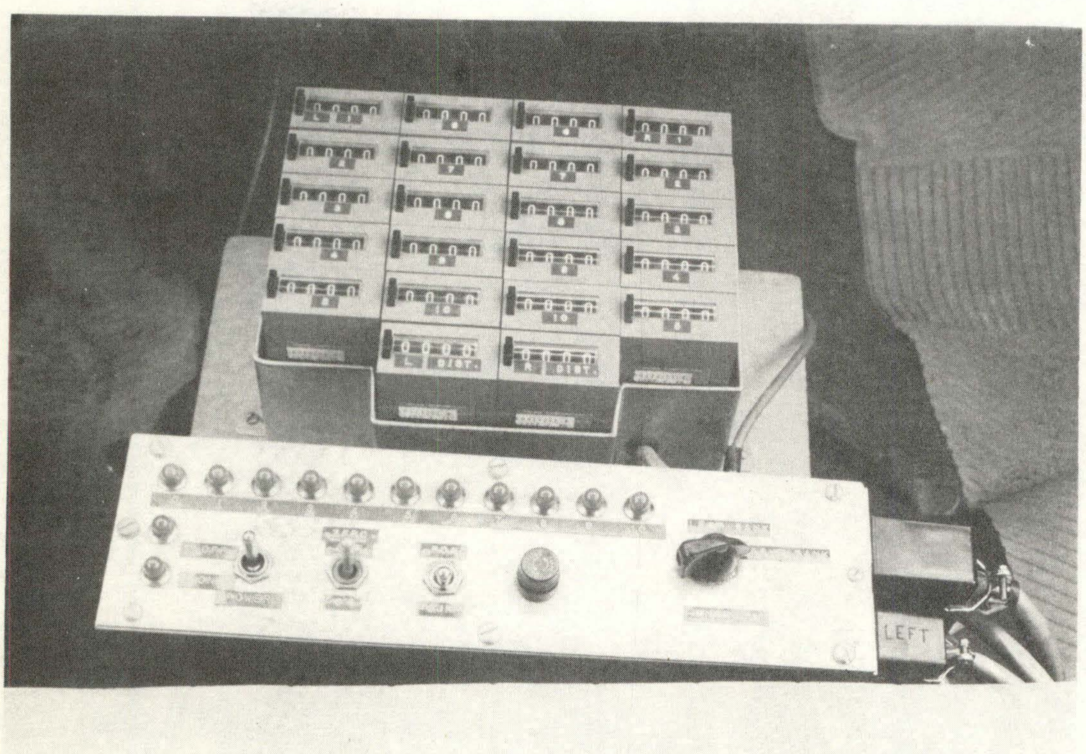


Fig. 2

The IJK Ride Indicator Control Console, showing Visual Indicators, Switches and Electrical Counters on the floor of the automobile.

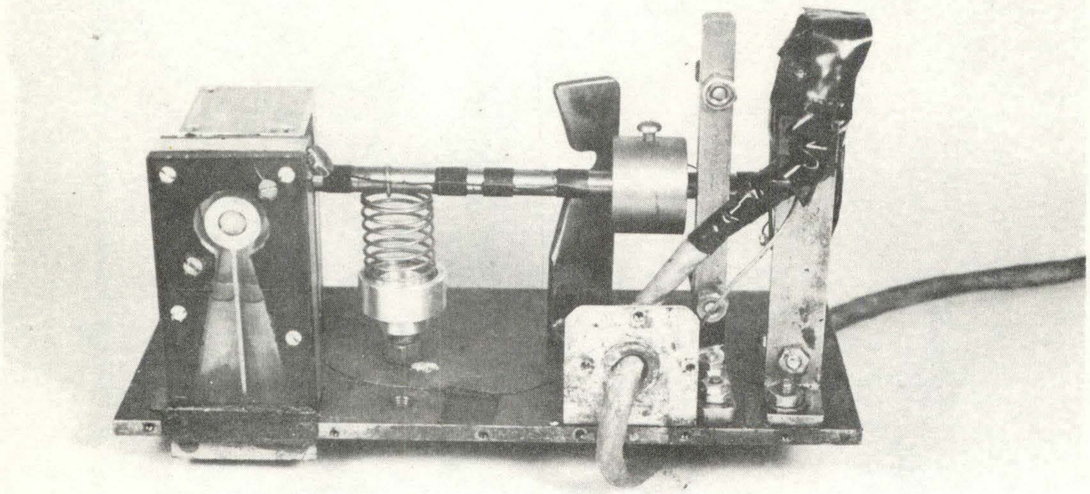


Fig. 3

The IJK Ride Indicator Sensing Unit

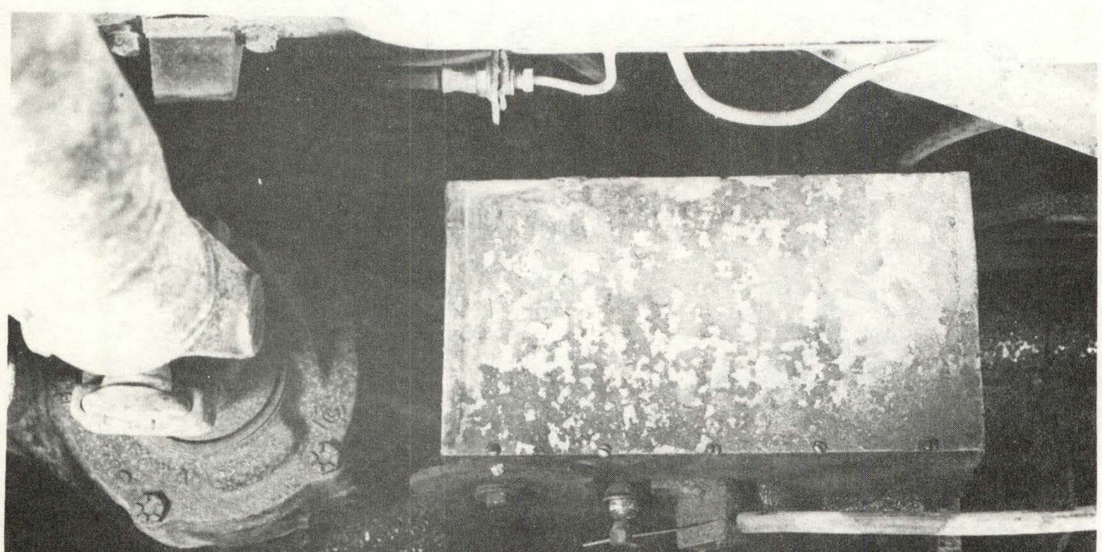


Fig. 4

The IJK Ride Indicator Sensing Unit with Cover as Mounted on the Rear Differential Housing of the Vehicle

CORRELATION TABLE
IJK RIDE INDICATOR UNIT E
JULY 1975

LPV	SUM/LENGTH AC	PC	LPV	SUM/LENGTH AC	PC	LPV	SUM/LENGTH AC	PC
0.000	18770	29785	2.000	4449	7023	4.000	502	985
0.025	18462	29283	2.025	4360	6886	4.025	481	952
0.050	18159	28790	2.050	4272	6750	4.050	460	920
0.075	17860	28304	2.075	4185	6617	4.075	440	889
0.100	17566	27825	2.100	4100	6486	4.100	420	858
0.125	17276	27355	2.125	4016	6357	4.125	401	828
0.150	16991	26891	2.150	3933	6231	4.150	382	799
0.175	16710	26435	2.175	3852	6106	4.175	364	770
0.200	16433	25987	2.200	3772	5984	4.200	346	742
0.225	16160	25545	2.225	3693	5863	4.225	328	715
0.250	15892	25111	2.250	3615	5744	4.250	311	688
0.275	15628	24684	2.275	3539	5628	4.275	294	661
0.300	15367	24263	2.300	3464	5513	4.300	277	635
0.325	15110	23849	2.325	3391	5400	4.325	261	610
0.350	14858	23441	2.350	3318	5290	4.350	245	585
0.375	14609	23041	2.375	3247	5181	4.375	230	561
0.400	14364	22646	2.400	3176	5073	4.400	215	538
0.425	14122	22258	2.425	3107	4968	4.425	200	515
0.450	13885	21876	2.450	3039	4864	4.450	186	492
0.475	13650	21500	2.475	2973	4762	4.475	172	470
0.500	13420	21130	2.500	2907	4662	4.500	158	448
0.525	13193	20766	2.525	2842	4563	4.525	145	427
0.550	12969	20407	2.550	2779	4467	4.550	132	407
0.575	12749	20055	2.575	2716	4371	4.575	119	387
0.600	12532	19708	2.600	2655	4278	4.600	107	367
0.625	12318	19366	2.625	2594	4186	4.625	94	348
0.650	12107	19030	2.650	2535	4095	4.650	83	329
0.675	11900	18700	2.675	2477	4006	4.675	71	311
0.700	11696	18374	2.700	2419	3919	4.700	60	293
0.725	11495	18054	2.725	2363	3833	4.725	49	275
0.750	11297	17739	2.750	2307	3748	4.750	38	258
0.775	11102	17429	2.775	2253	3665	4.775	27	242
0.800	10910	17124	2.800	2199	3583	4.800	17	225
0.825	10721	16824	2.825	2146	3503	4.825	7	210
0.850	10534	16529	2.850	2095	3424	4.850	1	194
0.875	10351	16238	2.875	2044	3347	4.875		179
0.900	10170	15952	2.900	1994	3270	4.900		164
0.925	9992	15670	2.925	1944	3196	4.925		150
0.950	9817	15393	2.950	1896	3122	4.950		136
0.975	9645	15121	2.975	1849	3050	4.975		122
1.000	9475	14853	3.000	1802	2979	5.000		109
1.025	9308	14589	3.025	1756	2909	5.025		96
1.050	9143	14329	3.050	1711	2840	5.050		84
1.075	8981	14074	3.075	1667	2773	5.075		71
1.100	8821	13822	3.100	1624	2707	5.100		59
1.125	8663	13575	3.125	1581	2642	5.125		48
1.150	8509	13332	3.150	1539	2578	5.150		36
1.175	8356	13092	3.175	1498	2515	5.175		25
1.200	8206	12856	3.200	1458	2454	5.200		14
1.225	8058	12625	3.225	1418	2393	5.225		4
1.250	7912	12396	3.250	1379	2334			
1.275	7769	12172	3.275	1341	2275			
1.300	7628	11951	3.300	1303	2218			
1.325	7489	11734	3.325	1267	2162			
1.350	7352	11520	3.350	1231	2107			
1.375	7217	11309	3.375	1195	2052			
1.400	7084	11102	3.400	1160	1999			
1.425	6953	10899	3.425	1126	1947			
1.450	6825	10698	3.450	1093	1896			
1.475	6698	10501	3.475	1060	1845			
1.500	6573	10307	3.500	1028	1796			
1.525	6451	10116	3.525	996	1748			
1.550	6330	9928	3.550	965	1700			
1.575	6211	9744	3.575	935	1653			
1.600	6094	9562	3.600	905	1608			
1.625	5978	9383	3.625	876	1563			
1.650	5865	9207	3.650	847	1519			
1.675	5753	9034	3.675	819	1475			
1.700	5643	8863	3.700	791	1433			
1.725	5534	8696	3.725	764	1391			
1.750	5428	8531	3.750	738	1351			
1.775	5323	8369	3.775	712	1311			
1.800	5220	8209	3.800	687	1272			
1.825	5118	8052	3.825	662	1233			
1.850	5018	7898	3.850	637	1196			
1.875	4919	7746	3.875	614	1159			
1.900	4822	7597	3.900	590	1123			
1.925	4727	7450	3.925	567	1087			
1.950	4633	7305	3.950	545	1052			
1.975	4540	7163	3.975	523	1018			

IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS

Unit E Worksheet

Road No. I-35 County Story Lab. No. LV
Year Built Date Tested 7-29-69 Date Reported
Contractor Hallett Construction Company Project No. I-IG-35-4/12/10
Location From Polk Co. line to Jct. New US 30

Weather Clear Wind NE 5-8 mph Temp. 71° F.
Speed 50 mph Test Personnel Dalbey & Robinson Surface P.C.

S.T. P.C.	D. 0-NB		S.T.	D. 0-SB	
EMP	13.87		EMP	24.17	
BMP	3.95		BMP	14.20	
Length	9.92		Length	9.97	
1	4031	4031	1	4075	4075
2	1794	3588	2	1740	3480
3	412	1236	3	403	1209
4	91	364	4	132	528
5	25	125	5	60	300
6	6	36	6	27	162
7	1	7	7	12	84
8	—	—	8	4	32
9	—	—	9	1	9
10	—	—	10	—	—
Sum		9387	Sum		9879
Sum/L		946	Sum/L		990
LPV		4.65	LPV		4.66

C.S.	S.T.	D.	C.S.	S.T.	D.
End			End		
Start			Start		
Length			Length		
Deduct			Deduct		
Length			Length		
1			1		
2			2		
3			3		
4			4		
5			5		
6			6		
7			7		
8			8		
9			9		
10			10		
Sum			Sum		
Sum/L			Sum/L		
RMRV			RMRV		

Notes

S.T. = Surface Type D. = Direction

Test Method No. Iowa 1002-B
March 1976

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IOWA DEPARTMENT OF TRANSPORTATION
HIGHWAY DIVISION
OFFICE OF MATERIALS

Road Meter
County
J. McCaskey
V.R. Snyder (2)

1976 Present Serviceability Index Summary for Jones County (53)

Date Reported 3-16-76 Lab. No. LV 6-44 to 57

Lab. No. LV-	Beginning Milepost	Ending Milepost	Road No.	Length (Miles)	Surface Type	Dir. & Lane	Longitudinal Profile Value of March 1976	Winter 75-76 Ded. for Cracking Patching	Present Serviceability Index
44	20.77	22.24	US 151	1.47	AC	EB	3.70	.05	3.65
						WB	3.70	.05	3.65
45	22.24	27.34	US 151	5.10	AC	EB	3.65	.10	3.55
						WB	3.65	.10	3.55
46	27.34	37.61	US 151	(5.58)	AC	EB	3.55	.05	3.50
						WB	3.60	.05	3.55
				(4.26)	PC	EB	3.30	.15	3.15
						WB	3.50	.15	3.35
47	38.69	48.07	US 151	(6.68)	AC	EB	3.55	.05	3.50
						WB	3.55	.05	3.50
				(2.52)	PC	EB	3.35	.10	3.25
						WB	3.25	.10	3.15
48	0.00	21.22	IA 64	(14.47)	AC	EB	3.15	.00	3.15
						WB	3.20	.00	3.20
				(5.16)	PC	EB	3.25	.70	2.55
						WB	3.25	.70	2.55
49	115.78	119.25	IA 1	3.47	AC	NB	3.05	.35	2.70
						SB	3.10	.35	2.75
50	39.10	42.44	IA 38	3.34	AC	NB	4.00	.00	4.00
						SB	3.95	.00	3.95
51	43.45	47.81	IA 38	4.36	AC	NB	3.55	.10	3.45
						SB	3.50	.10	3.40
52	50.01	53.39	IA 38	3.38	AC	NB	3.55	.00	3.55
						SB	3.55	.00	3.55
53	53.39	63.50	IA 38	10.11	AC	NB	4.00	.00	4.00
						SB	4.00	.00	4.00
54	65.11	68.41	IA 38	3.30	PC	NB	4.05	.00	4.05
						SB	4.05	.00	4.05
55	43.16	53.42	IA 136	10.26	AC	NB	3.85	.00	3.85
						SB	3.85	.00	3.85
56	54.79	58.39	IA 136	3.60	AC	NB	3.75	.05	3.70
						SB	3.80	.05	3.75
57	58.39	72.04	IA 136	13.65	AC	NB	3.90	.00	3.90
						SB	3.95	.00	3.95

Deductions for cracking and patching were calculated on a 2 lane roadway basis.

(Length) indicates tested length on an AC/PC section.

IOWA DEPARTMENT OF TRANSPORTATION

HIGHWAY DIVISION

OFFICE OF MATERIALS

LPV REPORT

Road No. I-35 County Story Lab No. LV-9-522

Year Built 1965 Date Tested 7-29-69 Date Reported 8-15-69

Contractor Hallett Construction Company Project No. I-IG-35-4/12/103

Project Length (Miles) 10.03 Surface Type PC

Location From Polk County line north to Junction New US 30

Weather Clear Wind NE 5-8 mph Temperature 71°

Test Personnel Dalbey and Robinson

	N Outside Bound Lane	S Outside Bound Lane
Length Tested	9.97	10.02
Longitudinal Profile Value	4.05	4.00
Average Longitudinal Profile Value		4.05
Deducation for Cracking, Patching and Rut Depth		0.05
Present Serviceability Index		4.00

APPENDIX C

DATA PROCESSING PROGRAM

DATA PROCESSING PROGRAM

```
RDM: PROCEDURE OPTIONS(MAIN);
     /* THIS PROGRAM CORRELATES THE ROAD METER WITH CHLOE SV    */
     /* AND OBTAINS VALUES TO PLOT CURVES.                      */
     /* IT WILL ALSO HANDLE ROAD ROUGHNESS CORRELATIONS.        */;
DEFAULT RANGE (*) DECIMAL FLOAT VALUE (DECIMAL FLOAT(16));
   DCL MTAB(10) FLOAT DEC INIT
        (100,300,500,700,900,1100,2000,4000,6000,10000);
   DCL RTAB(10) FLOAT DEC INIT
         (40,60,80,100,120,140,160,180,200,220);
    DCL INTER1 DEC(16) FLOAT, INTER2 DEC(16) FLOAT;
    DCL RNO CHAR(10), DTE CHAR(20);
   DCL X(100) DEC(16), Y(100) DEC(16);
    DCL M(10) DEC(16), AC(10) DEC(16), PC(10) DEC(16);
   DCL SX DEC(16), SY DEC(16), SX2 DEC(16), SX3 DEC(16);
   DCL SX4 DEC(16), SXY DEC(16), X2Y DEC(16), SY2 DEC(16);
   DCL V1 DEC(16), V2 DEC(16), V3 DEC(16), V4 DEC(16);
   DCL V5 DEC(16), V6 DEC(16), XA DEC(16), YA DEC(16);
   DCL CX DEC(16), CY DEC(16), X2 DEC(16), Y2 DEC(16);
   DCL CC DEC(16), ANS CHAR(1);
   DCL V7 DEC(16), V8 DEC(16), V9 DEC(16),V10 DEC(16);
   DCL K DEC(16);
   DCL EXP DEC(16), TV DEC(16);
   DCL SYX DEC(16), MN DEC(16);
  DCL CHARCON CHAR(6);
  DCL SWITCH CHAR(1);
   DCL TABANS CHAR(1) STATIC INITIAL('Z');
GETSW: PUT SKIP(2) LIST
('IF ROAD METER RUN ENTER M, ROUGHNESS RUN OP PIPE TABLE ENTER R :');
  GET EDIT(SWITCH)(SKIP,A(1));
  IF SWITCH = 'M' THEN DO;
    CHARCON = ' SUM/L';
  INIT=0;
  LMT = 4000;
  INCR = 400;
  GO TO RD0;
  END;
 IF SWITCH ¬= 'R' THEN GO TO GETSW;
 CHARCON='  RR  ';
  INIT=40;
 LMT = 160;
 INCR = 20;
RD0:  PUT LIST(' ENTER RUNO, 10 CHAR. MAXIMUM  :');
  GET EDIT(RNO)(A(10));
  PUT LIST('ENTER DATE, 20 CHAR. MAXIMUM  :');
  GET EDIT(DTE)(A(10));
   X=0;
   Y=0;
   SX=0;
   SY=0;
   SX2=0;
   SX3=0;
   SX4=0;
   SXY=0;
   X2Y=0;
   SY2=0;
   PUT LIST('ENTER NUMBER OF OBSERVATIONS  :');
   GET SKIP LIST(N);

  IF SWITCH = 'M' THEN
   PUT LIST('ENTER ROAD METER SUM/L VALUES (X VALUES)');
  ELSE
  PUT LIST('ENTER ROAD ROUGHNESS RR VALUES');
   PUT SKIP LIST('ENTER 99999 TO END X VALUES');
```

```

   J=0;
RD1: J=J+1;
   GET LIST(X(J));
   IF X(J)=99999 THEN DO;
   IF N=(J-1) THEN GO TO T1;
   PUT EDIT(N,' OBSERVATIONS SPECIFIED',J-1,' X VALUES ENTERED')
     (SKIP(1),F(4),A,F(4),A);
   PUT SKIP LIST
    ('USE FOLLOWING ERROR ROUTINE TO ADJUST DATA ARRAY IF DESIRED');
   GO TO T1;
   END;
   GO TO RD1;
T1: PUT SKIP LIST('ANY X VALUES IN ERROR (Y OR N)  :');

   GET EDIT (ANS) (A(1));
   IF ANS = 'N' THEN GO TO RD2;
   PUT LIST('WHICH ONE?  :');
   GET LIST(CNO);
   PUT EDIT('REENTER X(',CNO,')')(A,F(3),A);
   GET LIST(X(CNO));
   GO TO T1;
RD2: PUT LIST('ENTER CHLOE SLOPE VARIANCE VALUES (Y VALUES)');
   PUT SKIP LIST('ENTER 99999 TO END Y VALUES');

   J=0;
RD3: J=J+1;
   GET LIST(Y(J));
   IF Y(J)=99999 THEN DO;
   IF N=(J-1) THEN GO TO T2;
   PUT EDIT(N,' OBSERVATIONS SPECIFIED',J-1,' Y VALUES ENTERED')
     (SKIP(1),F(4),A,F(4),A);
   PUT SKIP LIST
    ('USE THE FOLLOWING ERROR ROUTINE TO ADJUST DATA IF DESIRED');
   GO TO T2;
   END;
   GO TO RD3;
T2: PUT SKIP LIST('ANY Y VALUE IN ERROR? (Y OR N)  :');

   GET EDIT (ANS)(A(1));
   IF ANS = 'N' THEN GO TO COM;
   PUT LIST('WHICH ONE?  :');
   GET LIST(CNO);
   PUT EDIT('REENTER Y(',CNO,')')(A,F(3),A);
   GET LIST (Y(CNO));
   GO TO T2;
COM: DO I= 1 TO N;
   CX=X(I);
   CY=Y(I);
   X2=CX*CX;
   Y2=CY*CY;
   SX=SX+CX;
   SY=SY+CY;
   SX2=SX2+X2;
   SX3=SX3+(X2*CX);
   SX4=SX4+(X2*CX*CX);
   SXY=SXY+(CX*CY);
   X2Y=X2Y+(X2*CY);
   SY2=SY2+Y2;
   END;
   PUT SKIP(3);
   PUT LIST('ROAD METER: ',RNO,'  DATE ',DTE);
   PUT EDIT('     SUM OF X=',SX,'  SUM OF Y=',SY,'  SUM OF X SQUARED=',
     SX2,'  SUM OF X CUBED =',SX3)(R(F1));
F1: FORMAT(SKIP(1),A,F(10),A,F(13,2),A,F(14),A,F(17));
```

```

    PUT EDIT('SUM OF X TO THE 4TH POWERS=',SX4,'   SUM OF XY PRODUCTS=',
      SXY,'  SUM OF X2Y=',X2Y)(R(F2));
F2: FORMAT(SKIP(1),A,F(21),A,F(15,2),A,F(18,2));

    V1=((SX*SY-SXY*N)*(SX2*SX2-SX3*SX)-(SXY*SX2-SX*X2Y)*(SX*SX-SX2*N));
    V2=((SX*SX2-SX3*N)*(SX2*SX2-SX3*SX)-(SX3*SX2-SX4*SX)*(SX*SX-SX2*N));
    V3=V1/V2;
    V4=(SXY*SX2-SX*X2Y-V3*(SX3*SX2-SX4*SX))/(SX2*SX2-SX3*SX);
    V5=(SY-V4*SX-V3*SX2)/N;
    PUT LIST(' ');
    PUT EDIT('A=',V5,'  B=',V4,'  C=',V3)(SKIP(1),3(A,F(22,15)));
    IF SWITCH = 'R' THEN DO;
GETTANS:
    PUT SKIP LIST('DO YOU WANT A TABLE PRINTED? (Y OR N) :');
    GET EDIT(TABANS)(SKIP,A(1));
    IF (TABANS¬='Y')&(TABANS¬='N') THEN GO TO GETTANS;
    END;
    MN=SY/N;
    EXP=0;
    TV=0;
    SYX=0;
    DO I=1 TO N;
    V6=(V5+V4*X(I)+V3*X(I)*X(I)-MN);
    V7=V6*V6;
    EXP=EXP+V7;
    TV = TV+((Y(I)-MN)*(Y(I)-MN));
    CC=SQRT(EXP/TV);
    V8=(SY2-V5*SY-V4*SXY-V3*X2Y)/N;
    V9=ABS(V8);
    SYX=SQRT(V9);
    END;
    PUT LIST(' ');
    PUT EDIT('CORRELATION COEFF.=',CC,
      '      STD ERROR OF ESTIMATE OF Y ON X =',SYX)(R(F4));
F4: FORMAT(SKIP(1),A,F(9,4),A,F(10,4));
     IF TABANS = 'Y' THEN GO TO PRTABL;

    PUT EDIT(CHARCON,'SV')(SKIP(1),A,X(11),A);

    DO K=INIT TO LMT BY INCR;
    YA=V5+V4*K+V3*(K*K);
    PUT EDIT(K,YA)(SKIP(1),F(6,0),F(16,2));

    END;
    IF SWITCH = 'M' THEN DO;
      DO J=1 TO 10;
        M(J)=MTAB(J);
       END;
       END;
    ELSE DO;
      DO J= 1 TO 10;
        M(J) = RTAB(J);
        END;
    END;
    DO I = 1 TO 10;
     INTER1=V5-2+V4*M(I)+V3*M(I)*M(I);
     INTER2=V5-2+V4*M(I)+V3*M(I)*M(I);
     AC(I)=5.03-1.91*LOG10(INTER1);
     PC(I)=5.41-1.8*LOG10(INTER2);
    END;
    PUT EDIT(CHARCON,'AC','PC')(SKIP(2),X(2),A,X(6),A,X(6),A);
    DO I = 1 TO 10;
    PUT EDIT(M(I),AC(I),PC(I))(SKIP(1),F(8,0),F(9,3),F(8,3));
```

```
   END;
FUNCI: PROC(IVAL) RETURNS(FLOAT DEC(16));
   DEFAULT RANGE (*) DECIMAL FLOAT VALUE(DECIMAL FLOAT(16));
    IF V3 = 0 THEN DO;
      MVAL = 0;
      GO TO RETMV;
      END;
    TMVAL = 1/V3*(IVAL-V5+2+((V4*V4)/(4*V3)));
    IF TMVAL <= 0 THEN DO;
      MVAL = 0;
      GO TO RETMV;
      END;
    MVAL = SQRT(TMVAL) - (V4/(2*V3)) + .5;
 RETMV: RETURN(MVAL);
    END;
   PUT SKIP(3) LIST('POSITION PAPER AT TOP OF NEW SHEET');
   PUT SKIP LIST('DEPRESS SPACE THEN RETURN WHEN READY :');
   GET EDIT(ANS)(SKIP,A(1));
   PUT EDIT('PSIR','AC','PC ','PSIR','AC','PC ')
     (SKIP(1),X(9),2(X(5),A,X(4),A,X(5),A));
   PUT SKIP(1);
    AP = 0.0;
    AP2 = 3.00;
   OLDINT = 0;
    DO I = 1 TO 120;
       I1 = 10.**((5.03-AP)/1.91);
      I3 = 10.**((5.03-AP2)/1.91);
      M1 = FUNCI(I1);
     M3 = FUNCI(I3);
      I2 = 10.**((5.41-AP)/1.80);
      I4 = 10.**((5.41-AP2)/1.80);
      M2 = FUNCI(I2);
      M4 = FUNCI(I4);
     APINT = TRUNC(AP+.000000000000005);
      IF APINT ¬= OLDINT THEN DO;
       OLDINT = APINT;
       PUT SKIP(1);
     END;
     PUT EDIT(AP,M1,M2,AP2,M3,M4)
      (SKIP(1),X(9),2(X(3),F(6,3),X(1),P'ZZZZZZ',X(1),P'ZZZZZZ'));
     AP = AP + 0.025;
     AP2 = AP2 + 0.025;
    END;
   GO TO JOBEND;
PRTABL:
    IF TABANS = 'Y' THEN DO;
    PUT SKIP(2);
    DO K=0 TO 6600 BY 100;
      YA=V5+V4*K+V3*(K*K);
      K2 = K+6700;
      YB=V5+V4*(K+6700)+V3*(K+6700)*(K+6700);
      K3=K+13400;
      YC=V5+V4*(K+13400)+V3*(K+13400)*(K+13400);
      K4=K+20100;
      YD=V5+V4*(K+20100)+V3*(K+20100)*(K+20100);
      K5=K+26800;
      YE=V5+V4*(K+26800)+V3*(K+26800)*(K+26800);
      K6=K+33500;
      YF=V5+V4*(K+33500)+V3*(K+33500)*(K+33500);
      PUT EDIT(K,YA,K2,YB,K3,YC,K4,YD,K5,YE,K6,YF)
        (SKIP(1),12(F(8,0)));
      END;
    END;
JOBEND:
    PUT SKIP(3) LIST('END OF JOB');
    END RDM;
```

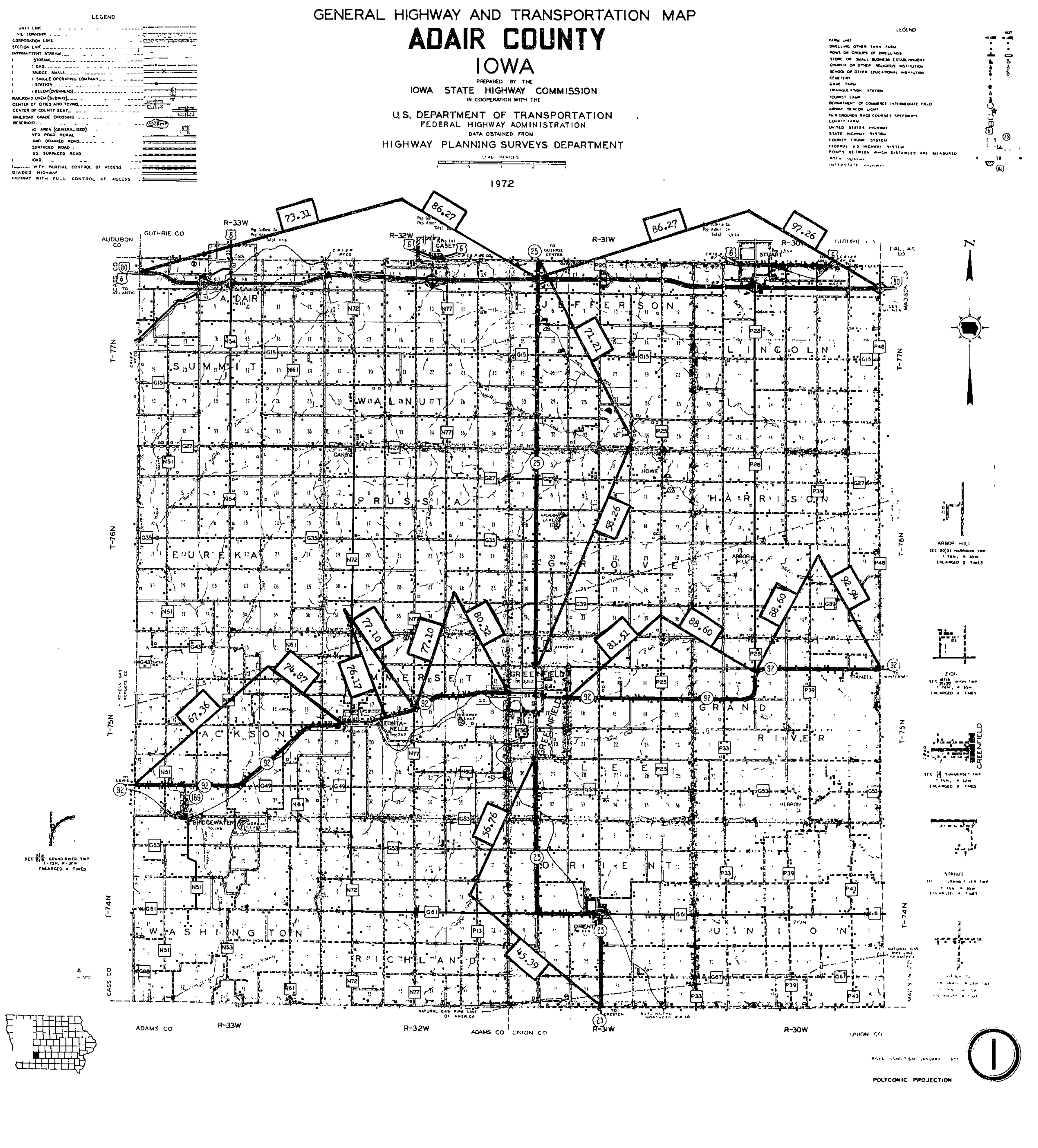
APPENDIX D

PRIMARY ROAD SECTIONS

ADAIR COUNTY CONTROL SECTION

County No. 1

Highway No.	Beginning Milepost	Ending Milepost	Length	Surface Type	Year Built	Project No.	Control Section
Ia. 92	67.36	74.87	7.51	PC			0100
Ia. 92	76.17	77.10	0.93	AC	1967	FN-92-3(5)	0100
Ia. 92	77.10	80.32	3.22	AC	1967	F-92-3(1)	0100
Ia. 92	81.51	88.60	7.09	AC	1967	F-92-3(2)	0200
Ia. 92	88.60	92.94	4.34	AC	1967	F-92-3(3)	0200
I-80	73.31	86.27	12.96	AC	1966	F-I-80-2(21)76	0400
I-80	86.27	97.26	9.995	AC	1970	INP-80-2(30)89	0500
Ia. 25	45.39	56.76	11.37	SC	1961	MD-45	0700
Ia. 25	58.26	71.21	12.95	AC	1968	FN-25-3(2)	0800


GENERAL HIGHWAY AND TRANSPORTATION MAP
ADAIR COUNTY
IOWA
PREPARED BY THE
IOWA STATE HIGHWAY COMMISSION
IN COOPERATION WITH THE
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
DATA OBTAINED FROM
HIGHWAY PLANNING SURVEYS DEPARTMENT
1972
LEGEND
73.31
86.27
86.27
97.26
71.21
58.26
81.51
88.60
88.60
92.94
80.32
77.10
77.10
76.17
74.87
67.36
56.76
45.39
ADAIR
JEFFERSON
LINCOLN
SUMMIT
WALNUT
PRUSSIA
HARRISON
EUREKA
GROVE
SUMMERSET
GRAND
RIVER
JACKSON
LEE
ORIENT
WASHINGTON
UNION
RICHLAND
GREENFIELD
FONTANELLE
BRIDGEWATER
CASEY
STUART
ORIENT
HOWE
ARBOR HILL
HEBRON
STANZEL
AUDUBON CO
GUTHRIE CO
DALLAS CO
MADISON CO
CASS CO
ADAMS CO
UNION CO
R-33W
R-32W
R-31W
R-30W
T-77N
T-76N
T-75N
T-74N
POLYCONIC PROJECTION