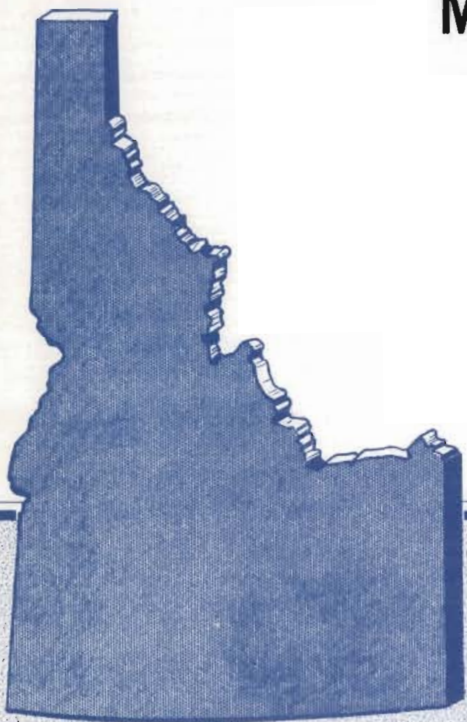
COMPARATIVE RETROREFLECTIVITY OF GLASS BEADS IN TRAFFIC MARKING PAINT



RESEARCH PROJECT NO. 57

STATE OF IDAHO DEPARTMENT OF HIGHWAYS

COMPARATIVE RETROREFLECTIVITY OF GLASS BEADS IN TRAFFIC MARKING PAINT

ROGER L. HOPT
Engineer-In-Training

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Idaho Department of Highways
Boise, Idaho

ACKNOWLEDGMENTS

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The opinions and recommendations expressed or implied herein are those of the author.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Idaho Department of Highways uses over one-half million pounds of glass beads at a cost of over fifty thousand dollars annually. The purpose of this study is to determine if the State could benefit by using a different type of bead at a smaller application rate with no decrease in effectiveness.

Glass beads are manufactured from scrap glass. In one method, ground glass is heated in a suspending gaseous stream sufficient to allow surface tension to pull each particle into spherical shape. In another method, a fine stream of molten glass is poured into a suspending gaseous stream where it is broken into small particles which are pulled into spherical shape. The beads are then cooled, sieved, and bagged for use. In recent years a so-called "floating" bead coated with a fluorocarbon has been developed. Paint has a reduced capillary attraction for the coated glass, which reduces the embedment of the bead in the paint film and exposes more of the glass. The presently used uncoated beads sink into the paint film to the surface below and capillarity of the paint causes further embedment. The smallest beads are thus buried in the 15 mil paint film and are largely ineffective.

CONCLUSIONS

The floating beads cost about 20 percent more per pound than the nonfloating beads, but have better reflective qualities when applied at only 80 percent of the present rate for nonfloating beads. The floating beads have significantly better reflectance than the nonfloating beads during the first few months of service. However, as the effective life of the paint and glass is reached they have almost identical reflective qualities. On concrete and plantmix pavements the nonfloating beads had slightly increased reflectivity throughout the first test period as the paint wore off the top of the glass. Decreased reflectivity from exposure to traffic was noted during the following periods.

RECOMMENDATIONS

On the basis of these results the following recommendations are made:

1. Should further studies be undertaken, a broader spectrum of application rates and a mixture of floating and nonfloating beads should be tested.
2. If further tests are not to be made, Idaho should adopt four pounds of floating glass beads per gallon of paint as their standard.

DISCUSSION

The study parameters selected for this test were: two bead gradations, 20-100 and 40-80; floating and nonfloating beads; application rates of 4 and 6 pounds of beads per gallon of paint for each type and gradation of bead. The beads were examined and rated for shape and floating ability, and graded by size as shown below:

Test Section	Per Cent Float	Per Cent Non-Spherical	Gradation	Application Rate lb/gal
1	83	30	40-80	4
2	83	30	40-80	6
3	47	35	40-80	4
4	47	35	40-80	6
5	0	25	40-80	4
6	0	25	40-80	6
7	0	15	20-100	4
8	0	15	20-100	5
9	0	15	20-100	6
10	0	20	20-100	4
11	0	20	20-100	6

TABLE 1 - Bead Characteristics

Test locations with three types of pavement surfaces, i.e., plantmix, concrete, and seal coat, were selected on I-80N near Boise to take advantage of the constant vehicular traffic and few roadside lights. Each test location was divided into 11 quarter-mile sections of about 30 stripes each. All test sections were on the white skip stripe dividing the westbound lanes.

The application rates were controlled by varying the truck speed while the flow of beads remained constant. The amount of beads applied to several stripes at a constant speed was measured and the speed adjusted to obtain the desired application rates. The material required for two 20-foot stripes was calculated as shown in Table 2.

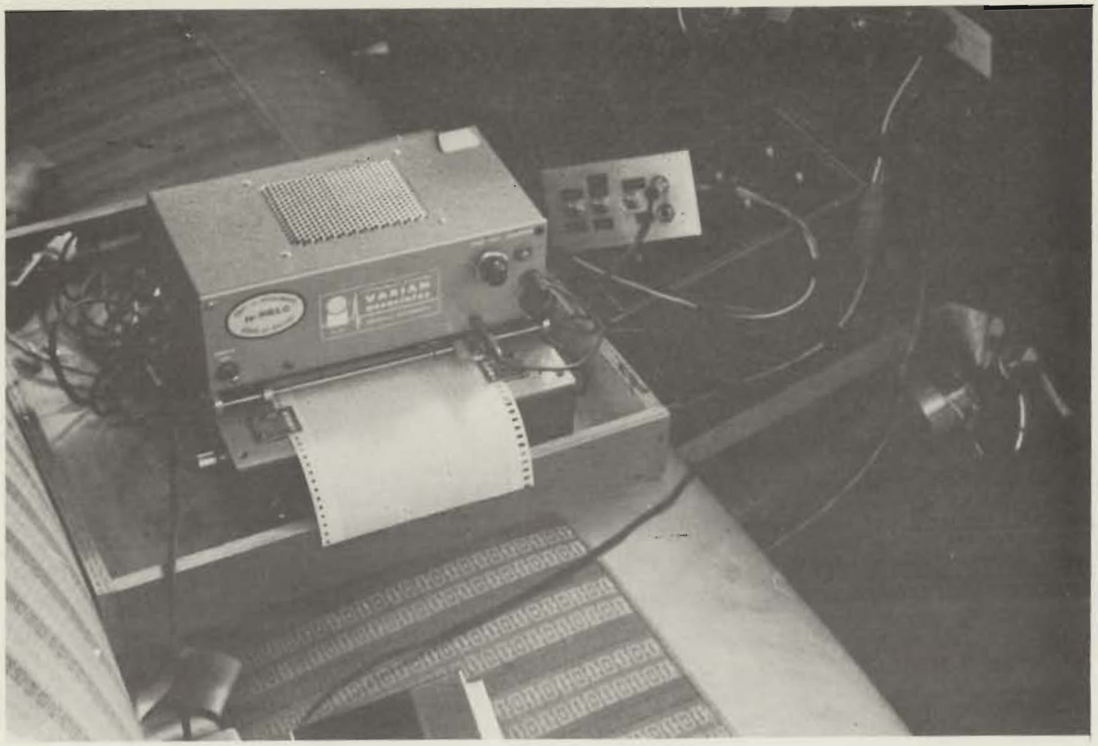
Paint $\frac{2 \times (20 \text{ feet}) \times (18 \text{ gallons})}{5{,}280 \text{ feet}} = .137$ gallons

Beads	lb/gal x gal	lb beads	grams beads	@RPM	MPH
	4 x .137 =	.548	250	3300	15
	5 x .137 =	.685	312	2750	12.5
	6 x .137 =	.821	375	2200	10

TABLE 2 - Bead Dispenser Calibration

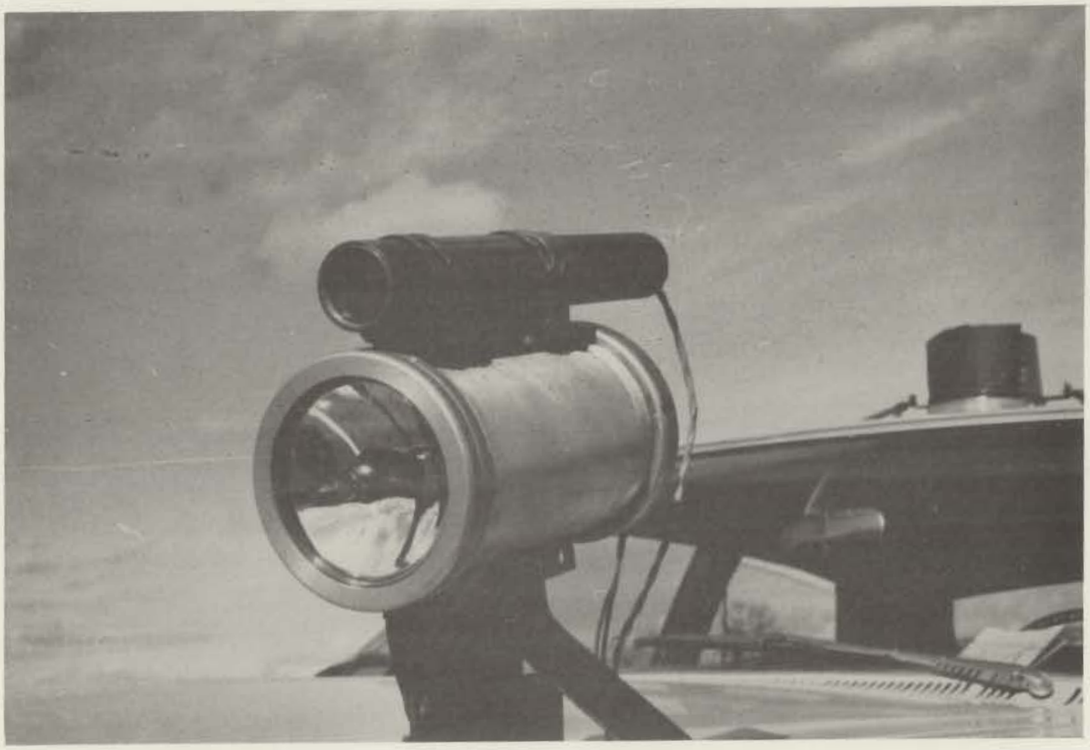
It was found that the human eye could not evaluate the reflectance of the beads critically enough so a photometer device similar to Colorado's was assembled and used. Appendix A shows a schematic of the photometer device, a sketch of the spotlight-photocell apparatus, and copies of good and poor photometer response records. Light striking the photocell reduces its electrical resistivity and changes the size of the electrical impulse delivered to the graphic recorder. The graphic recorder transcribes the responses on the moving chart paper for future analysis. (See Figure 1)

The spotlight-photocell apparatus shown in Figure 2 was mounted temporarily on the left front fender of a State sedan. It illuminates a spot on the pavement in front of the vehicle with 135 foot candles. Light is reflected back from the beads through a flat lens in the metal tube and focused upon the photocell by a double convex lens. (See sketch of apparatus in Appendix A)



Recorder and control box on front seat.

Figure 1



Spotlight - photocell apparatus mounted
on left front fender.

Figure 2

The photometer device was used during darkness in the early morning hours to minimize traffic interference. The car was driven at a constant speed down the travel lane with the spotlight shining on the stripes. At a speed of about 5 mph the recorder pen was allowed time to record the reflected light and return to zero between stripes. The amplitude of each wave represents the relative reflectance for that stripe. (See Appendix A) The average test results for each test section are shown in Appendix B. The average photometer amplitudes for each test section on all pavements were calculated and plotted into the graph shown in Figure 3.

Safety equipment in the form of blinkers and a "slow moving vehicle" sign were incorporated on the test car and advanced warning signs were used to warn traffic during the test.

The testing procedure lasted six months and was accomplished on three test dates at about 2-1/2 month intervals. The November test was conducted about one month after the beads were applied. The January test was made after a period of snow removal and sanding. The roadway was ready for restriping by the time of the April test, as about 20 to 70 percent of the test paint was chipped off.

The effectiveness of the floating beads deteriorated throughout the test period. The nonfloating beads, however, became more effective as paint wore away from the glass, and then deteriorated as the glass and paint neared the end of their effective life. Immediately following application, the floating beads were superior to the nonfloating beads; but after six months, the reflectance was nearly the same for all test sections.

On seal coated pavements both type beads deteriorated throughout the test period. The reflectance of the beads was nearly identical on the plantmix and concrete pavements because of their similar surface texture character-

AVERAGE PHOTOMETER AMPLITUDES

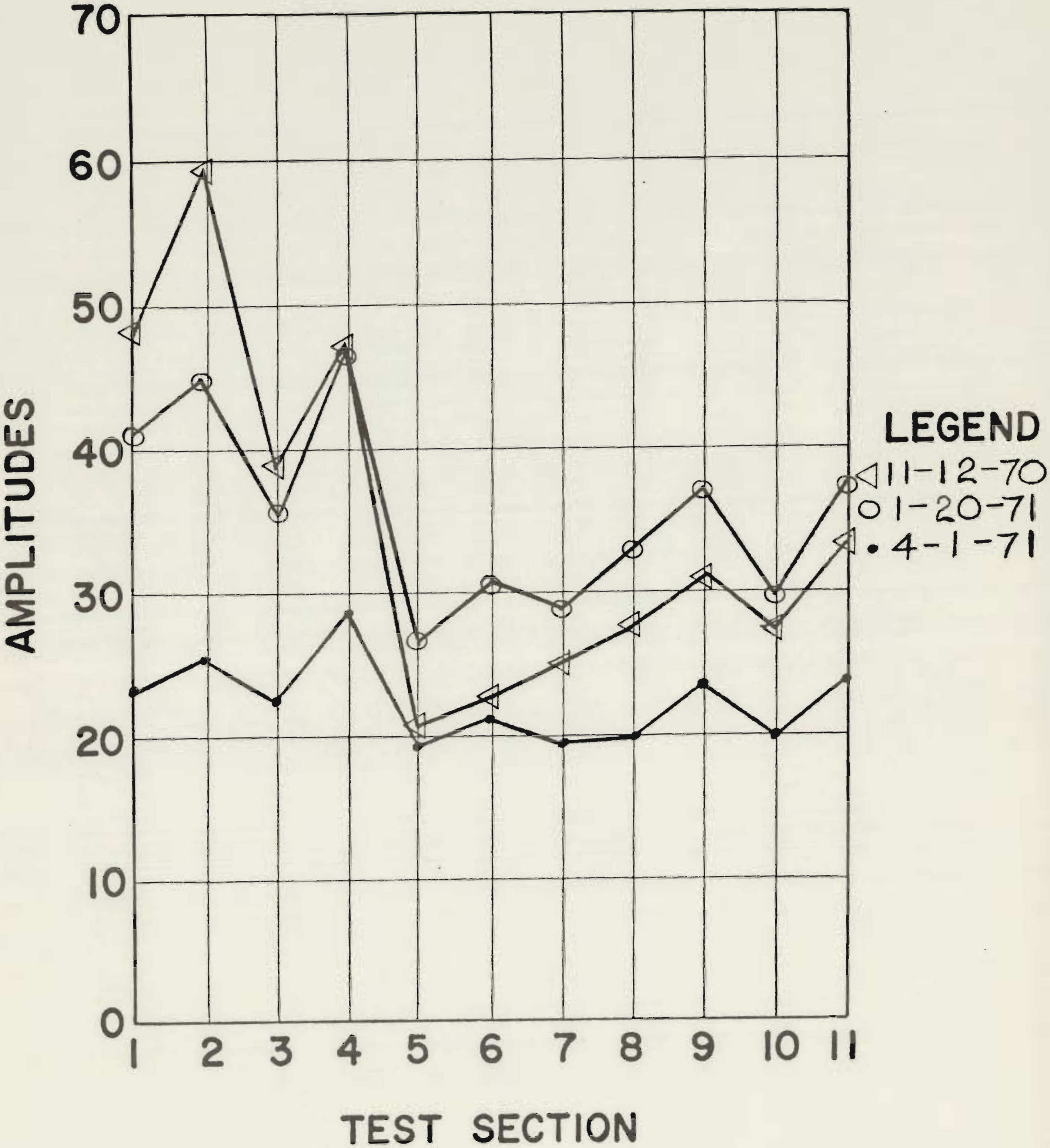


FIGURE 3

istics. Application rates of the beads appeared to have a greater effect on the reflectivity of the floating beads than on the nonfloating beads as shown by the greater difference in amplitudes between the two rates of floating beads and the same rates for nonfloating beads. This would indicate that the reflectivity of the floating beads could decrease sharply with a small decrease in application rate.

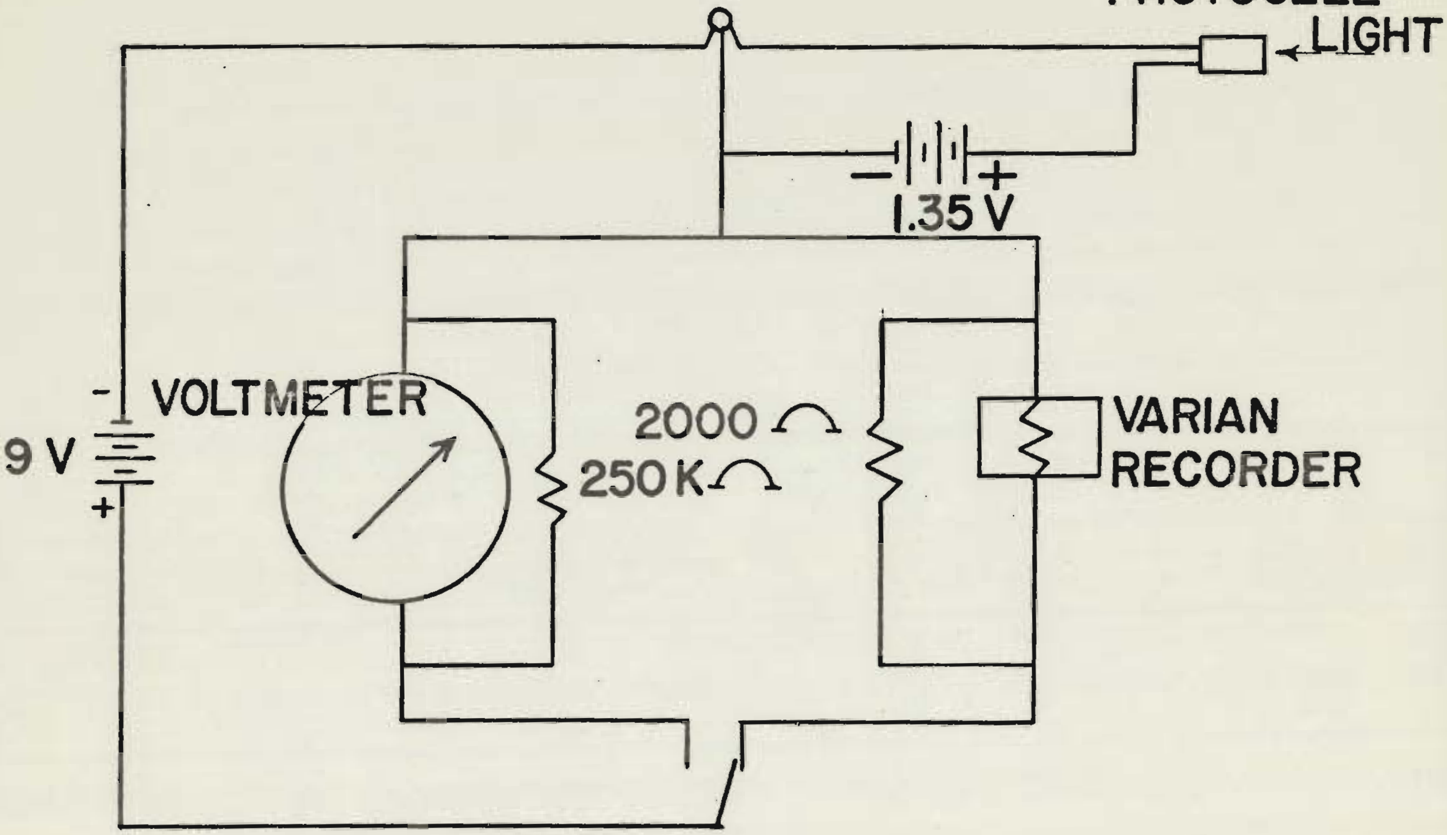
Test section number two on the seal coat is not comparable to other sections due to considerable cross traffic from a rest area approach. The paint in this area had chipped very badly and consequently produced very little reflectance.

Microphotographs of cores taken from the paint stripes after six months of exposure are shown in Appendix C. These were taken through a 50 power microscope and are included to show some of the differences in the beads and their adherance to the paint, and the affect of traffic and the atmosphere upon the paint.

The nonfloating beads presently cost about eleven cents per pound, while the floating beads are expected to cost about two cents per pound more. The floating beads exhibit better retroreflectivity when applied at 80 percent of the present application rate making the effective cost comparable.

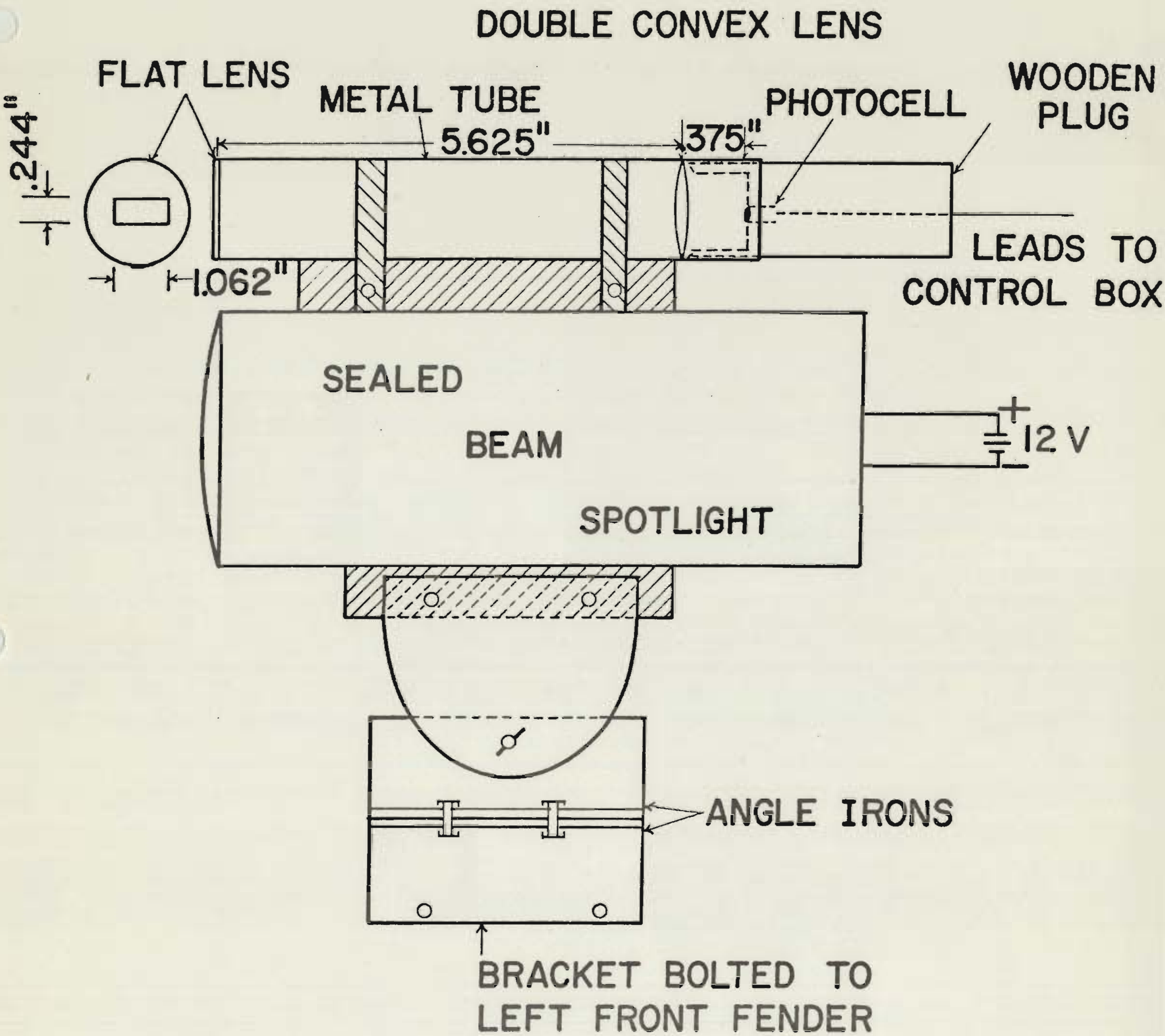
APPENDIX A

PHOTOMETER EQUIPMENT

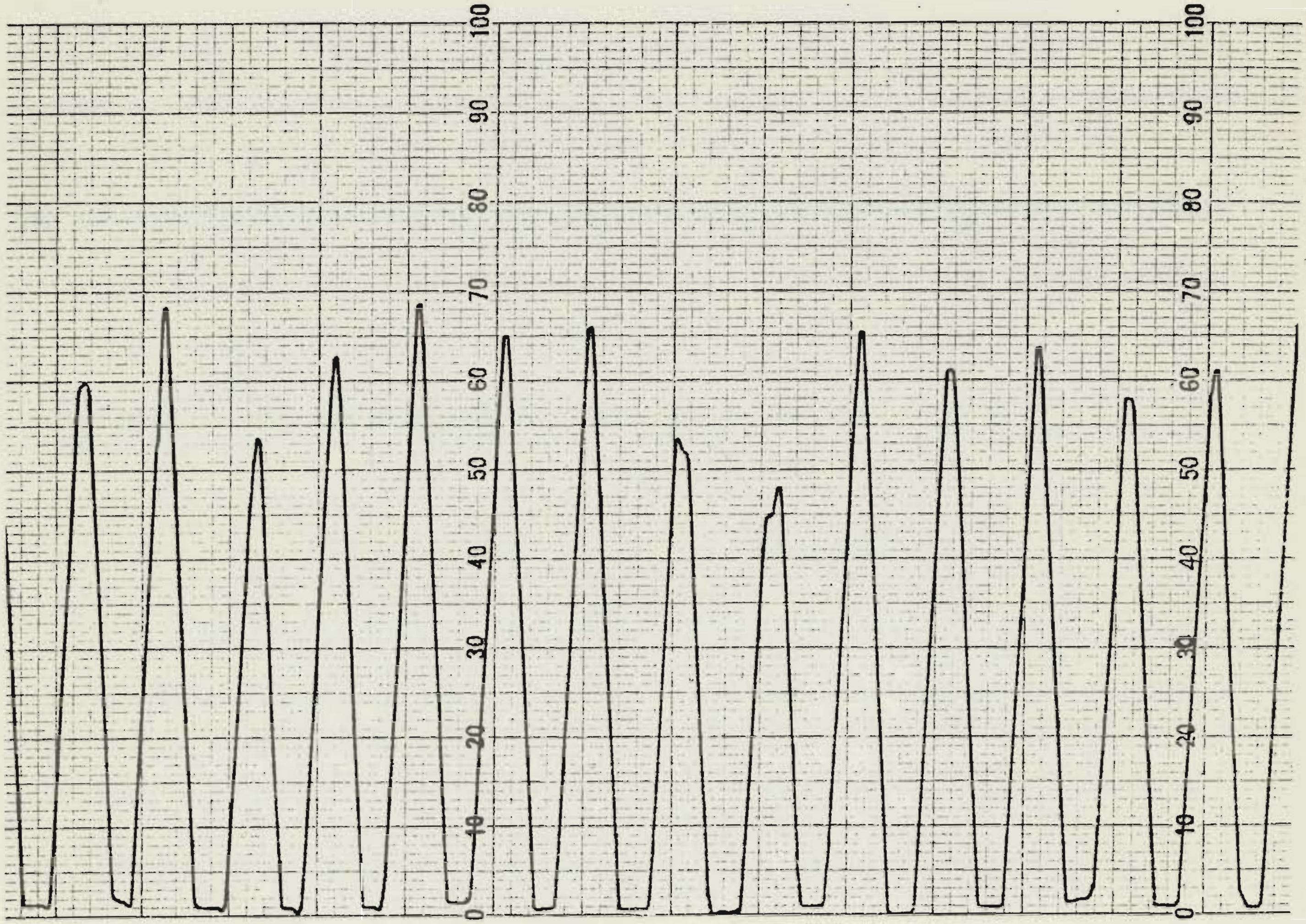


SCHEMATIC OF THE

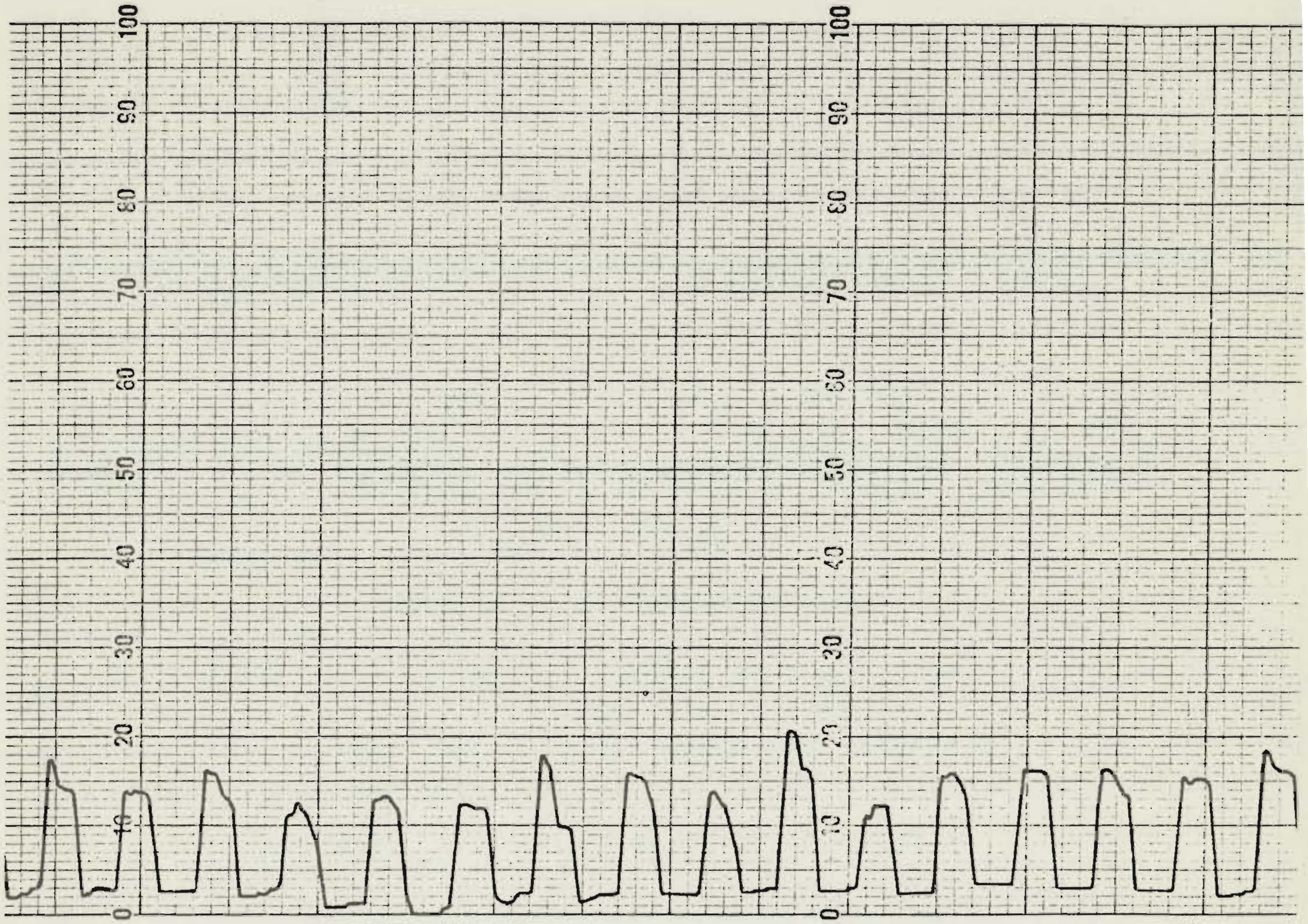
IDAHO NIGHTTIME PHOTOMETER



SPOTLIGHT-PHOTOCELL APPARATUS



GOOD PHOTOMETER RESPONSE

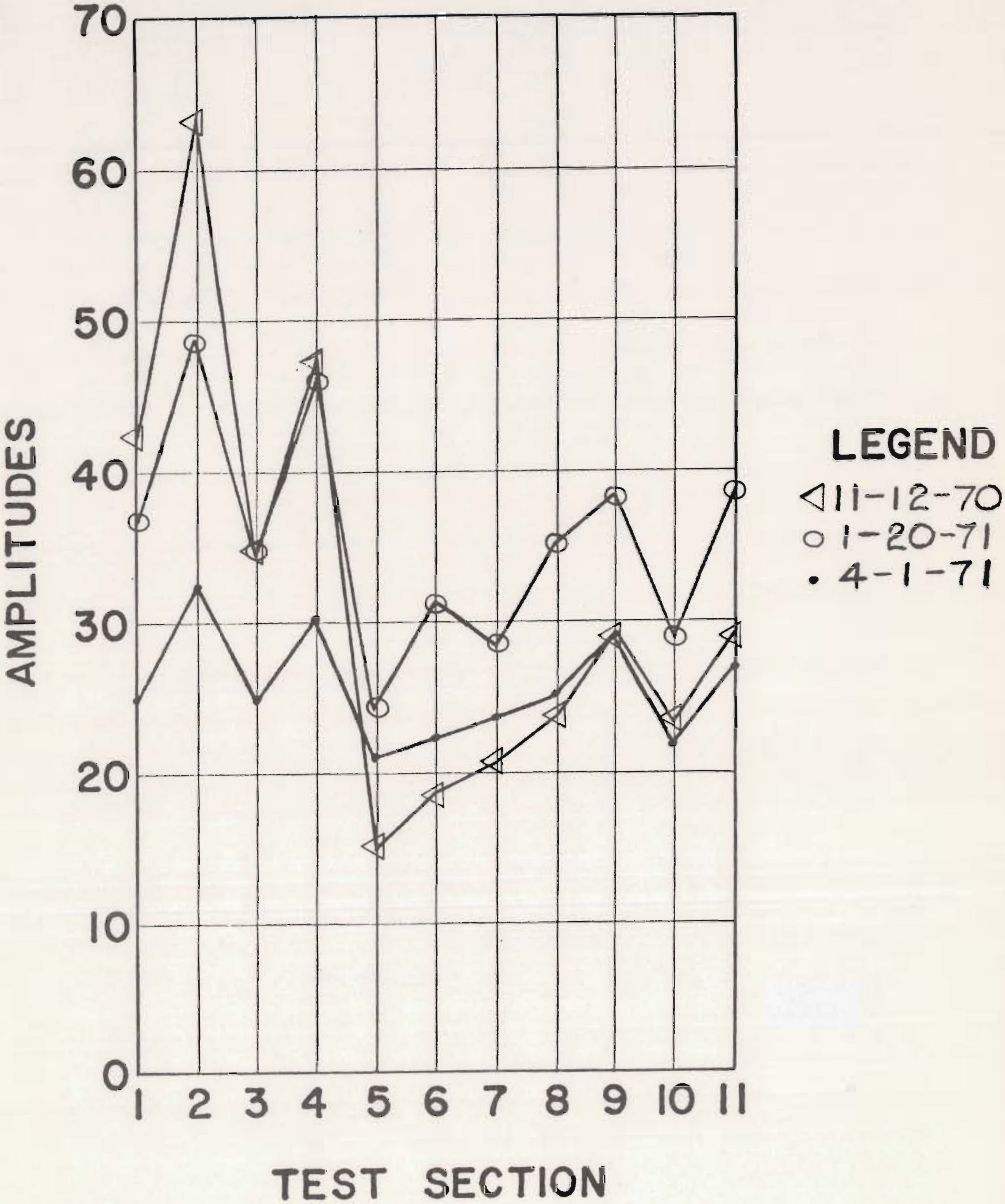


POOR PHOTOMETER RESPONSE

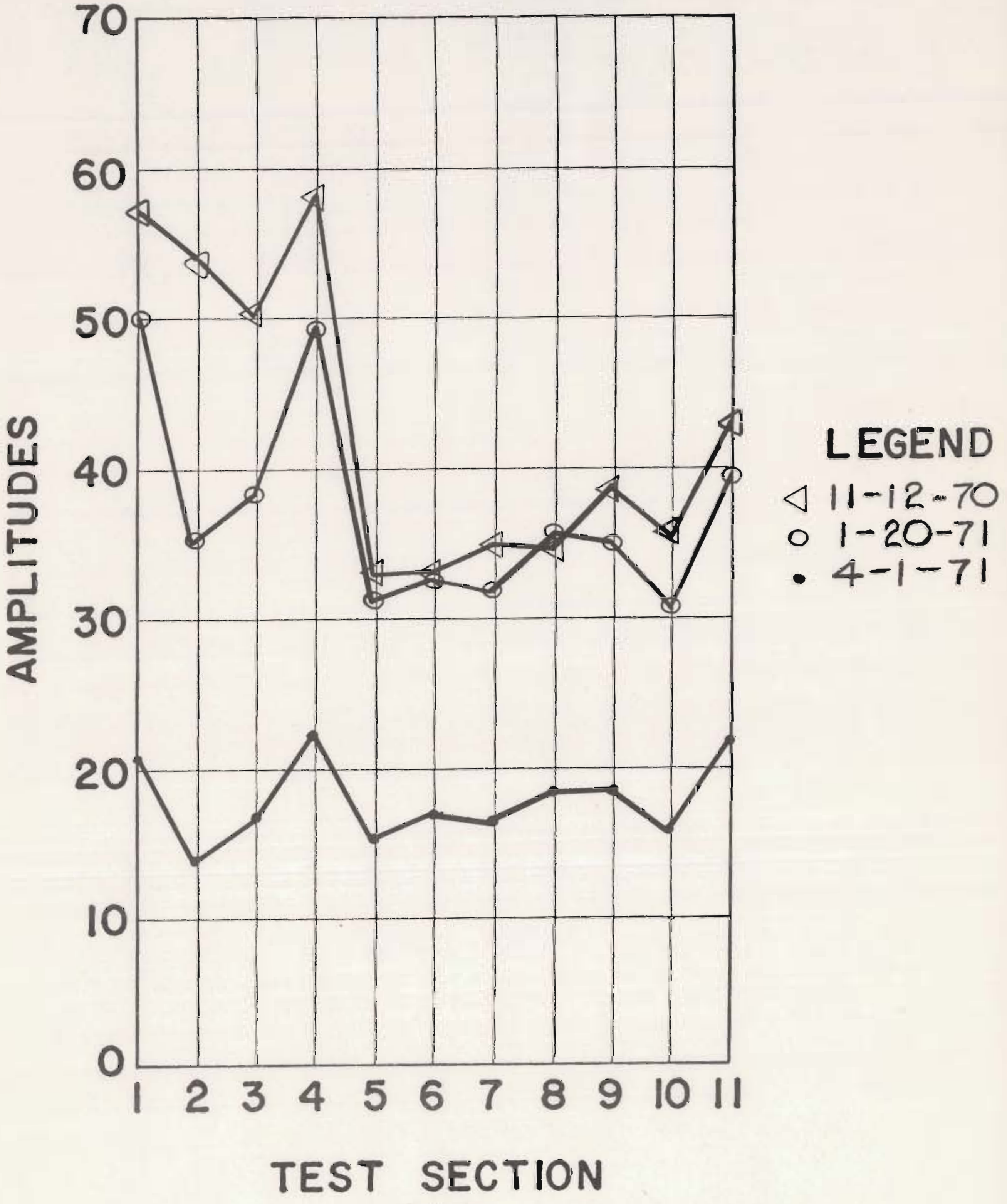
APPENDIX B

AMPLITUDE CURVES

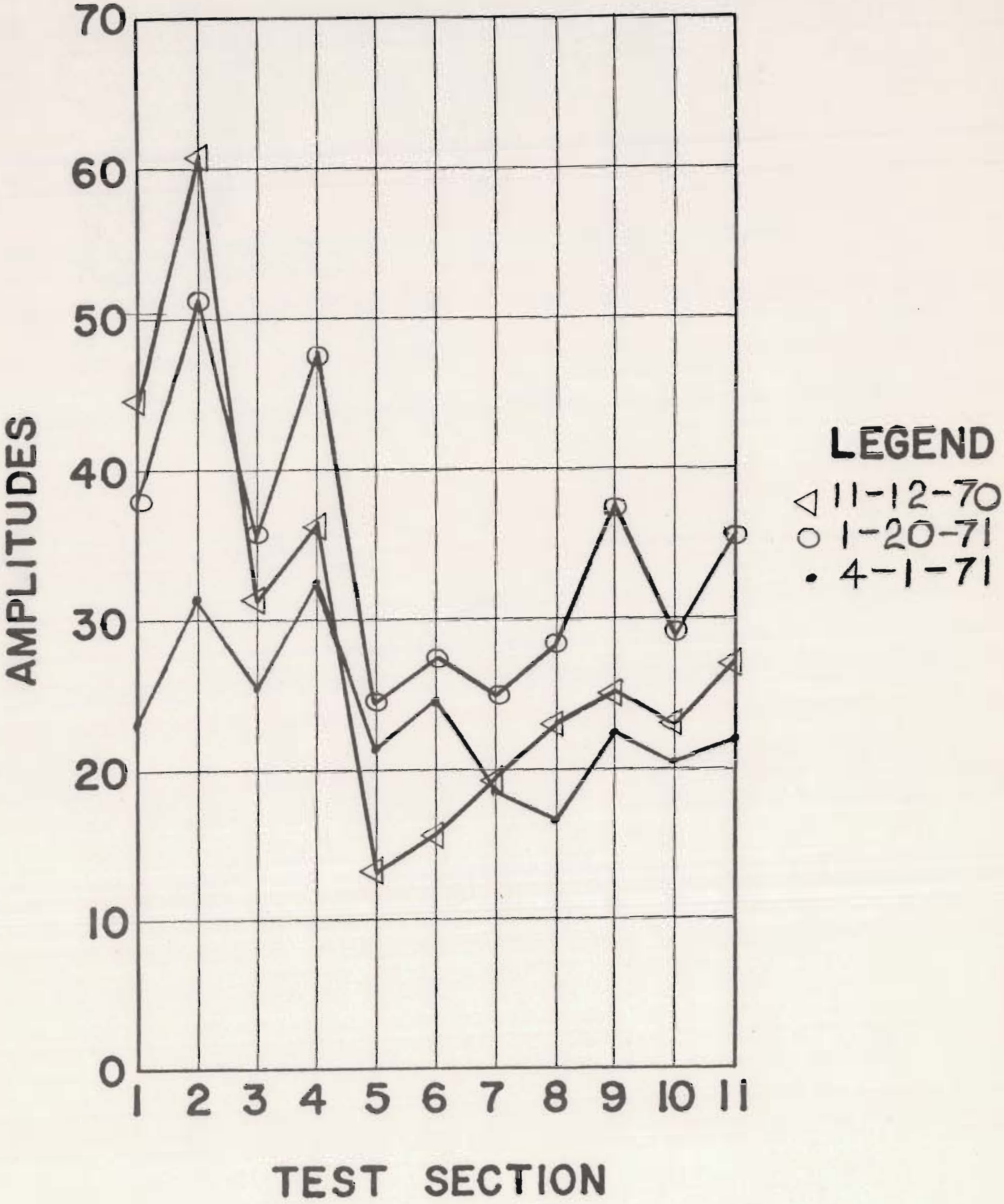
PLANTMIX AMPLITUDES



SEAL COAT AMPLITUDES

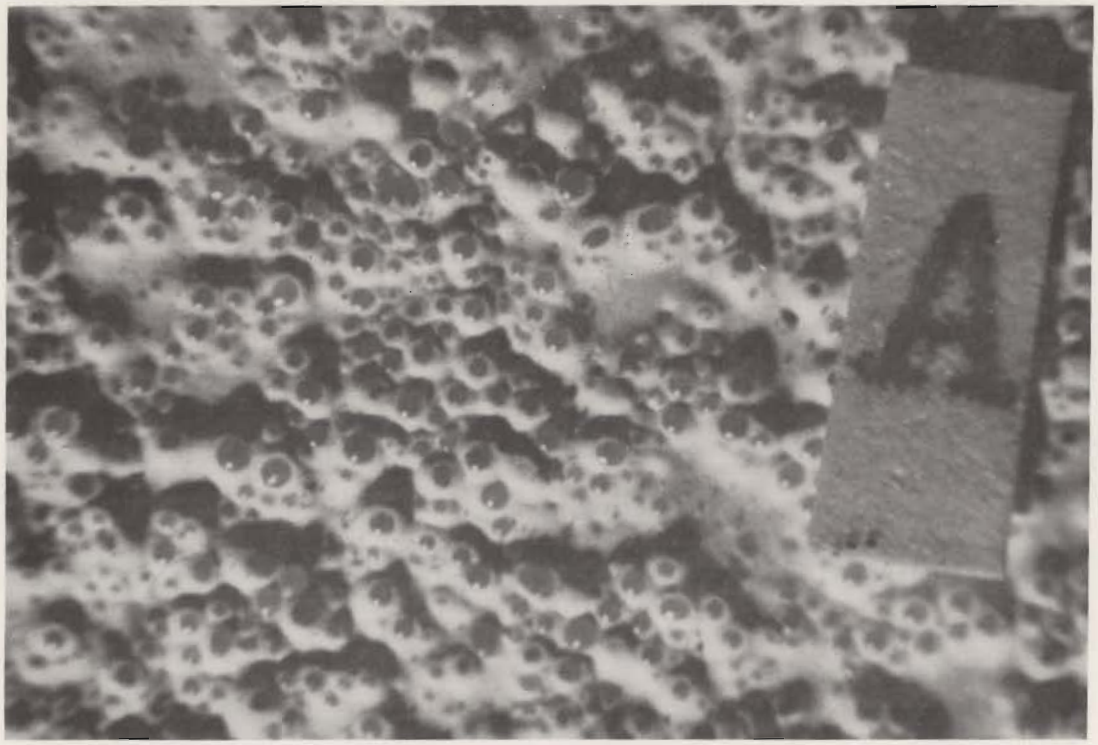


CONCRETE AMPLITUDES



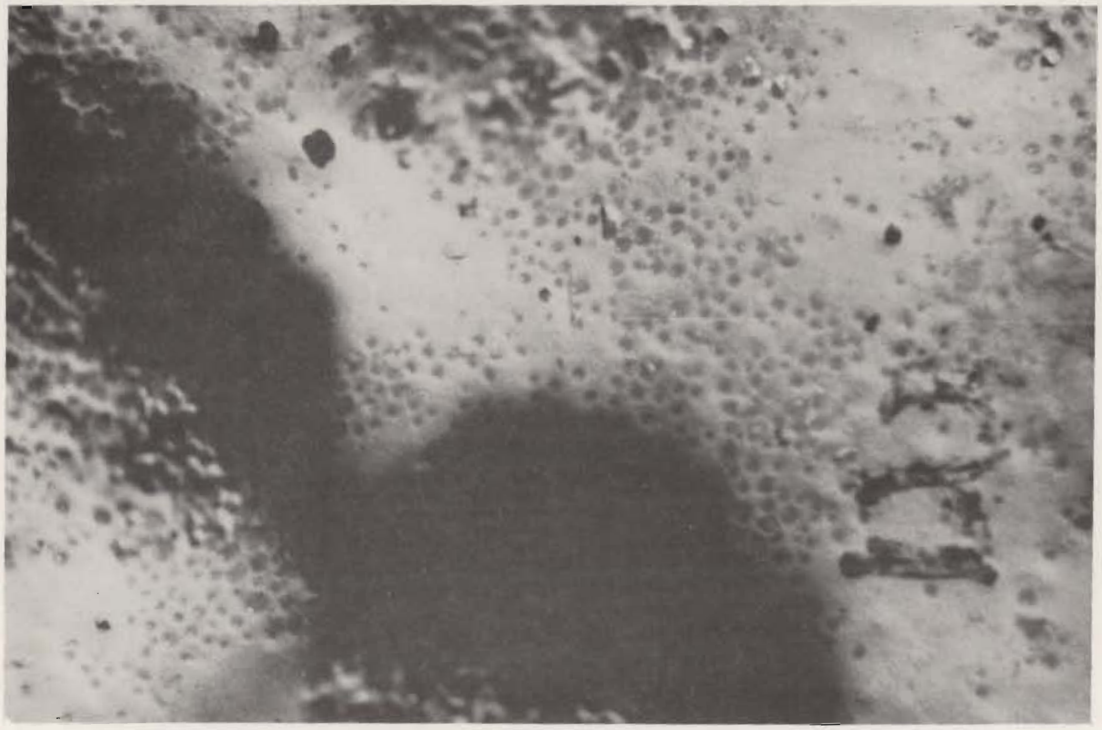
APPENDIX C

GLASS BEAD MICROPHOTOGRAPHS

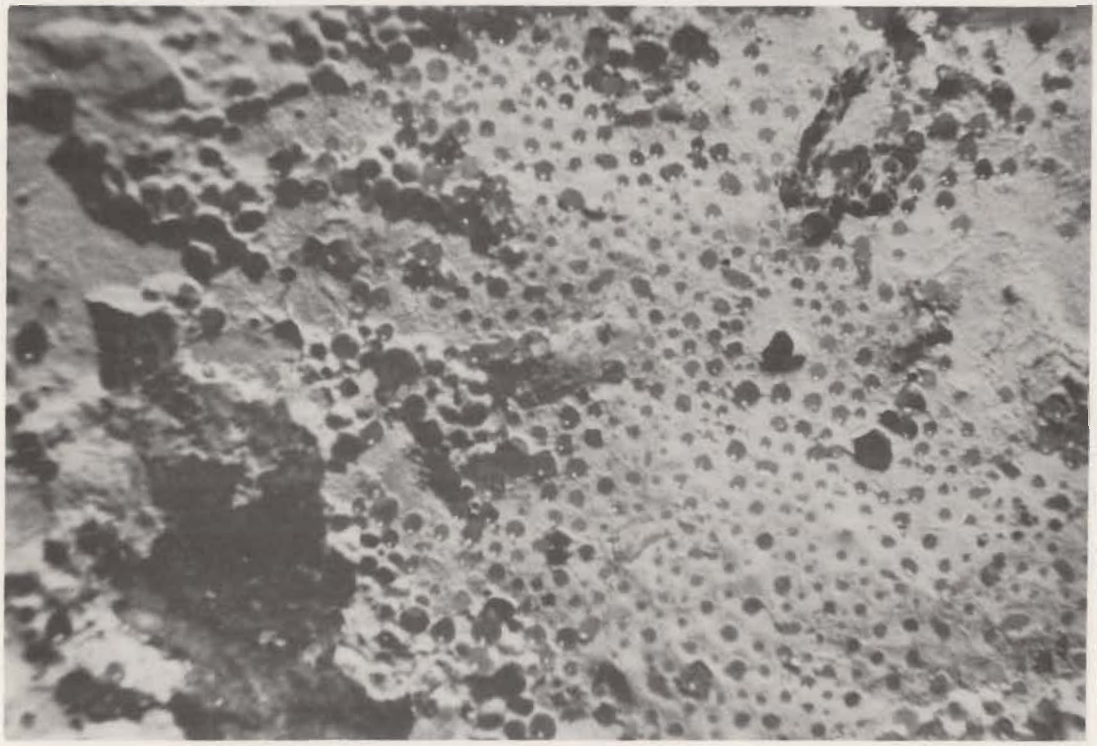


Present non-floating bead before exposure to traffic. Note that the paint crept up the edges of the glass.

Floating beads with much of their surface area exposed after traffic exposure. Note the bead sockets and paint chip on left.



Non-floating beads on a seal coat aggregate and trough. Note that the beads on the side of the aggregate are in a shadow.



Non-floating beads with very little of their surface area exposed above the paint.