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CALIBRATION OF A TEXTILE CORD LOAD TRANSDUCER

Final Report

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Prepared for

Tire Systems Section
Office of Vehicle Systems Research
NATIONAL BUREAU OF STANDARDS
Washington, D.C. 20234

CST-377

This report was prepared in fulfillment of the National Bureau of Standards Contract CST-377 (funded by the National Highway Safety Bureau through the NBS, Contract FH-11-6090). The opinion, findings, and conclusions expressed in this publication are those of the authors and not necessarily those of the National Bureau of Standards nor the National Highway Safety Bureau.

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April 1969

I. INTRODUCTION

In a previous report the concept of a load transducer for a tire cord was proposed, techniques were described for fabricating such a transducer, and some preliminary results were given for the cord loads in typical automotive tires. Almost all cord loads which were measured were tensile loads, primarily due to the strong pretensioning effect of the inflation. However, under overload or under-inflation conditions, or under a combination of these, various parts of the tire exhibited compressive cord loads. Since the load transducers used were only calibrated in tension, a question arises as to the meaning of the compressive signals obtained. For that reason a program was undertaken to calibrate typical transducers in compression as well as tension.

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II. SUMMARY OF RESULTS

The signal output of the transducers is slightly larger per unit of load in compression than per unit of load in tension. This difference is not large, and for purposes of a first approximation the calibration taken in tension for the bare cord may be used as a compression calibration.

III. TRANSDUCER CALIBRATION

A cylindrical rubber specimen was made by rolling calendered tire carcass fabric onto a round mandrel. Inserted in the fabric were three cords having load transducers in series, these cords being identical in all other respects with the other cords which were not instrumented. The specimen is shown in Fig. 1, which also illustrates transducer placement. All cords run parallel to centerline of the cylinder.

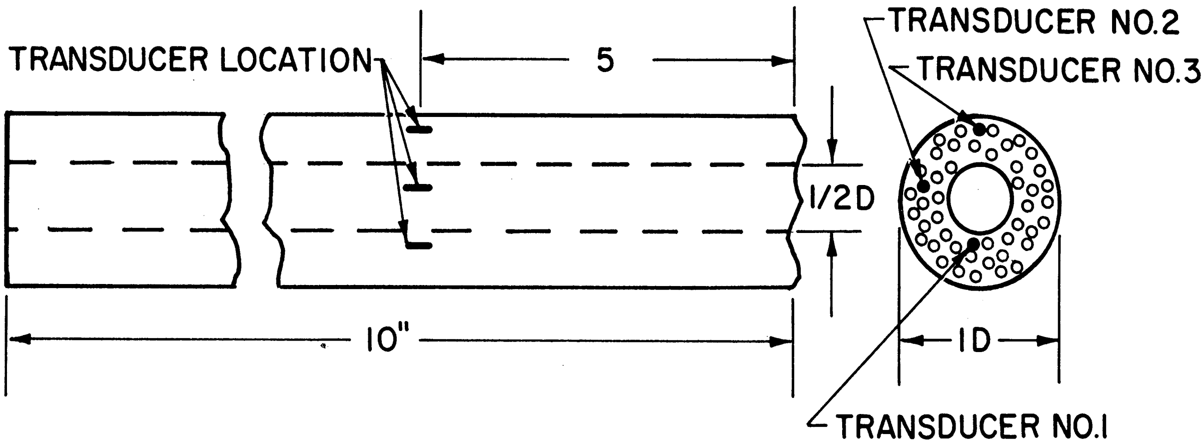

Fig. 1. Calibration test specimen.

Although transducer placement is somewhat arbitrary, it was felt desirable to locate one near the inner surface of the cylinder, one in the center, and one near the outer surface, all near the midpoint of the specimen.

The specimen was cured at 340°F for 30 minutes.

The transducers were individually calibrated as bare cords prior to building into the specimen. The calibration in all cases was linear and repeatable, as has been customarily found with these units. The transducers are beryllium-copper tube transducers as previously described by Bourland, Clark, and Dodge in The University of Michigan, Office of Research Administration, Technical Report 01193-1-T, "Development of a Textile Cord Load Transducer." Drawings and a photograph of the transducer are given in Figs. 2 and 3.

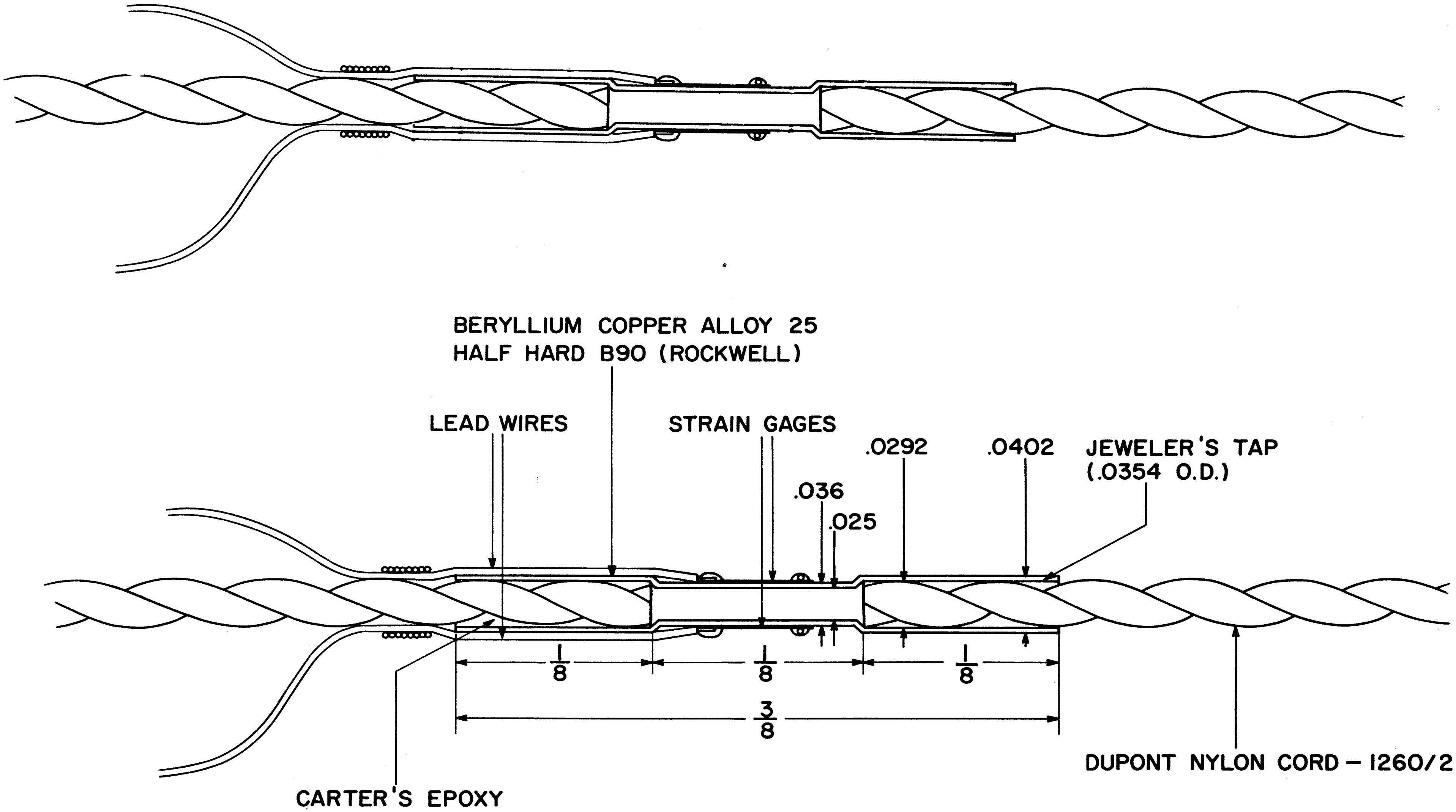

Fig. 2. Cord load transducer.

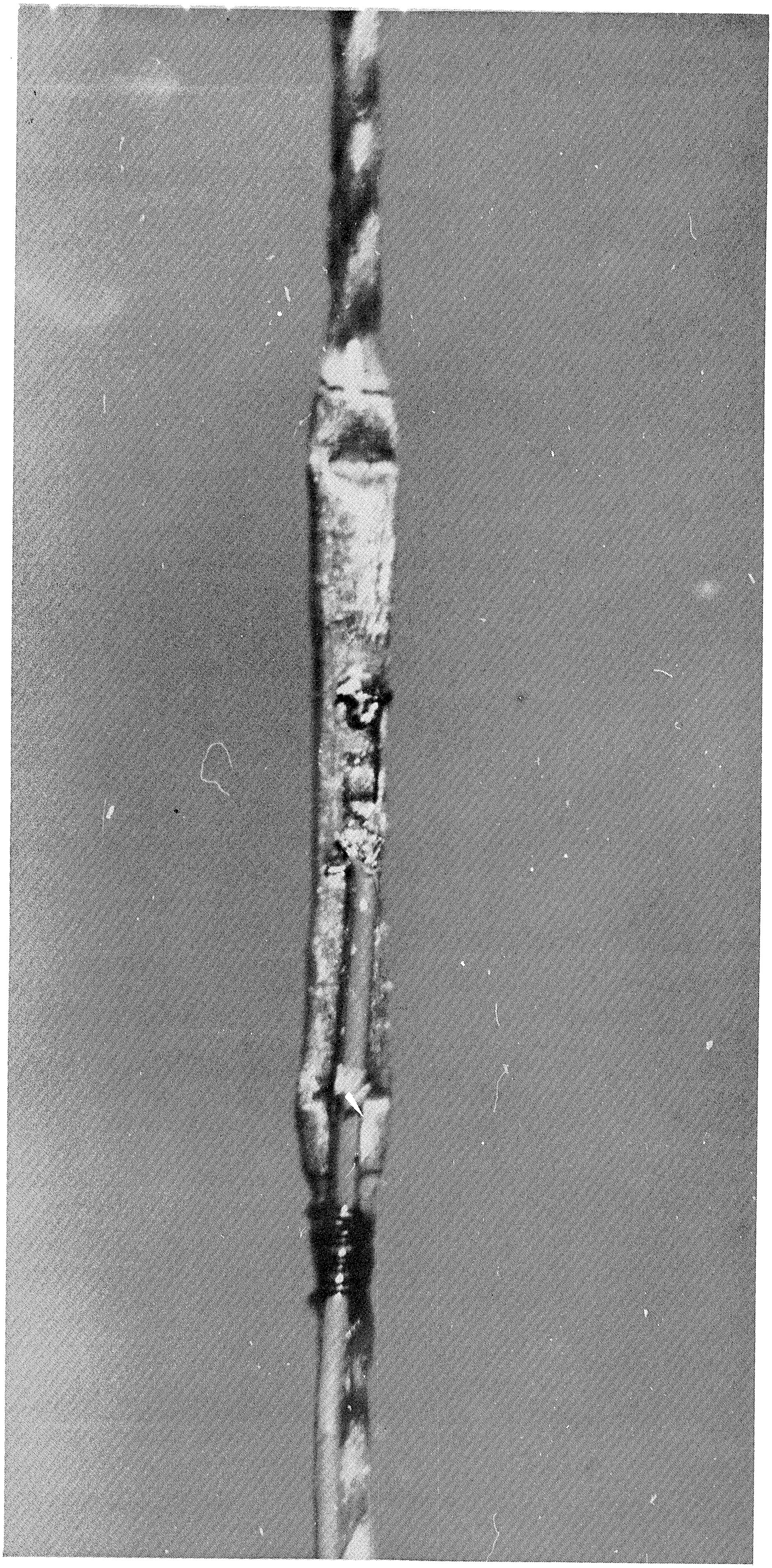

Fig. 3. Enlarged photograph of force transducer

After curing the specimen was mounted in an Instron testing machine using a steel plug and hose clamp at each end, so that both tension and compression loads could be applied.

The testing method used was to record a zero value of the cord load transducer signal with no external forces on the specimen. Tension loads were first applied, and transducer signal readings were taken. This was followed by compressive loads and similar signals.

There is no assurance that each of the individual cords carry the same load, and in fact it would be quite surprising if they did. This was borne out by the test results, where two of the transducers showed about the same response while the third showed a smaller response. The signal output for each of the transducers is plotted in Figs. 4a-c against the average load per cord. Note that this agrees well with the calibration results for transducers nos. 2 and 3 but not for transducer no. 1, which carries less than the average cord load.

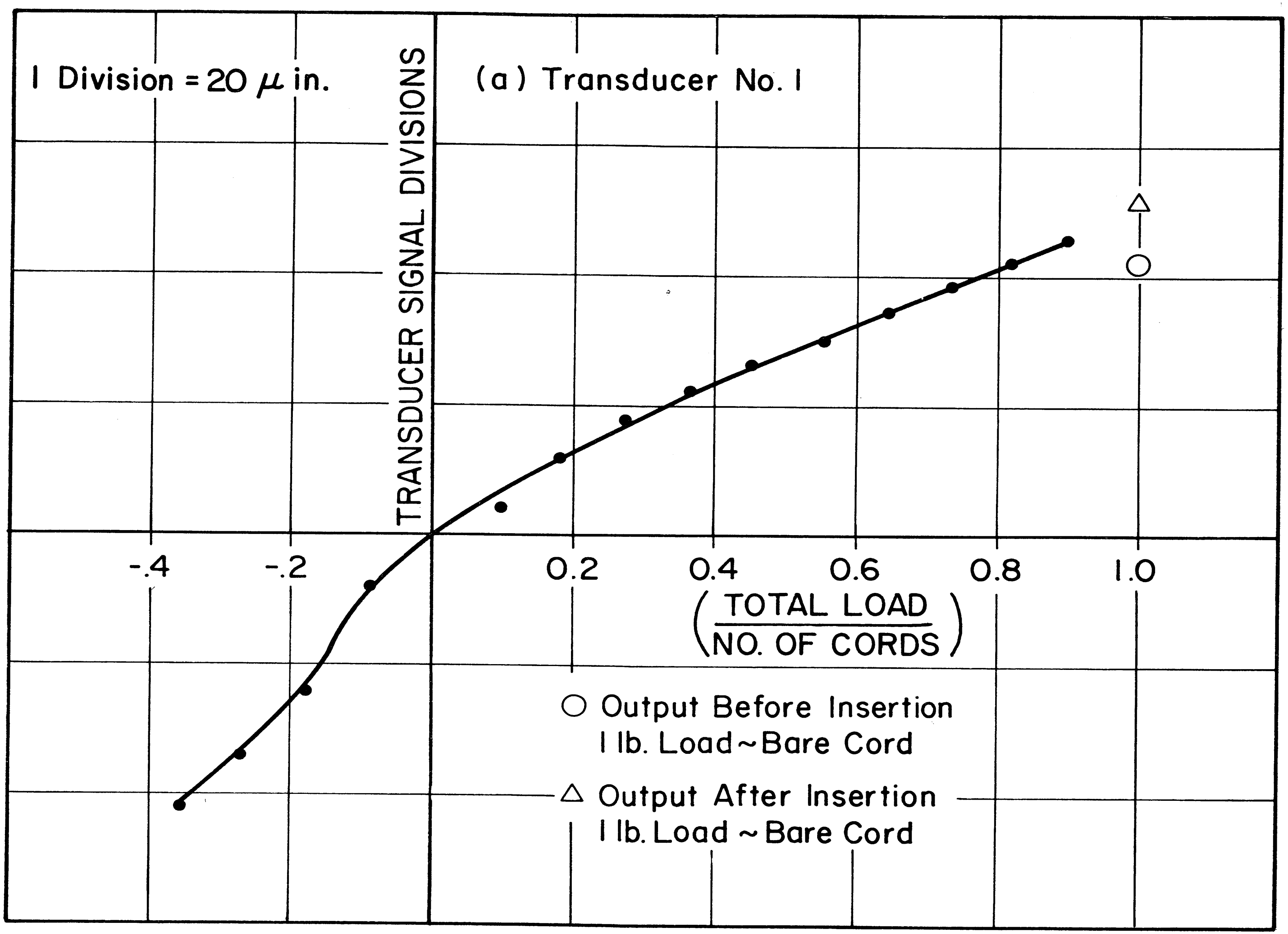

Fig. 4. Transducer output vs. load.

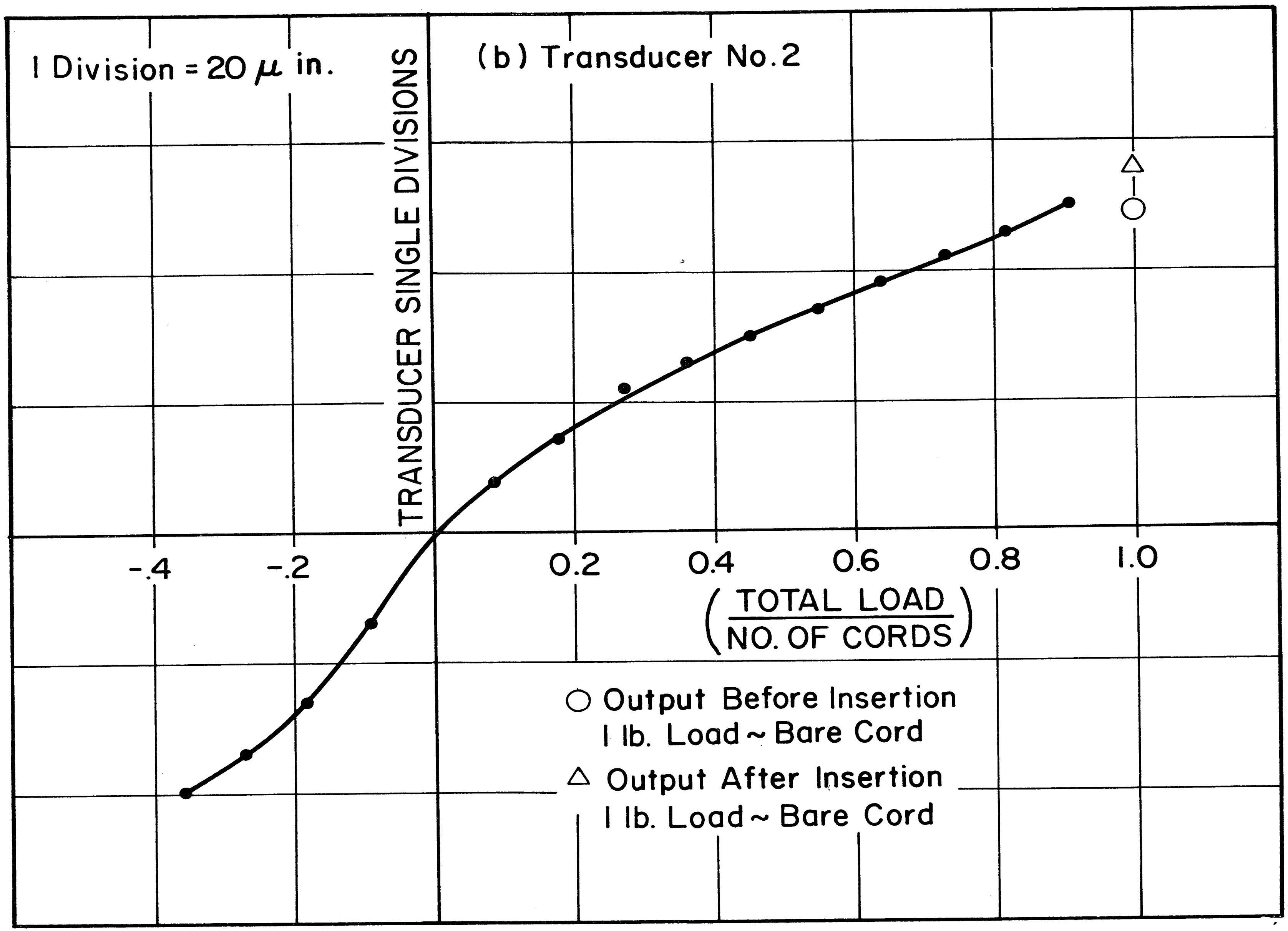

Fig. 4. (Continued)

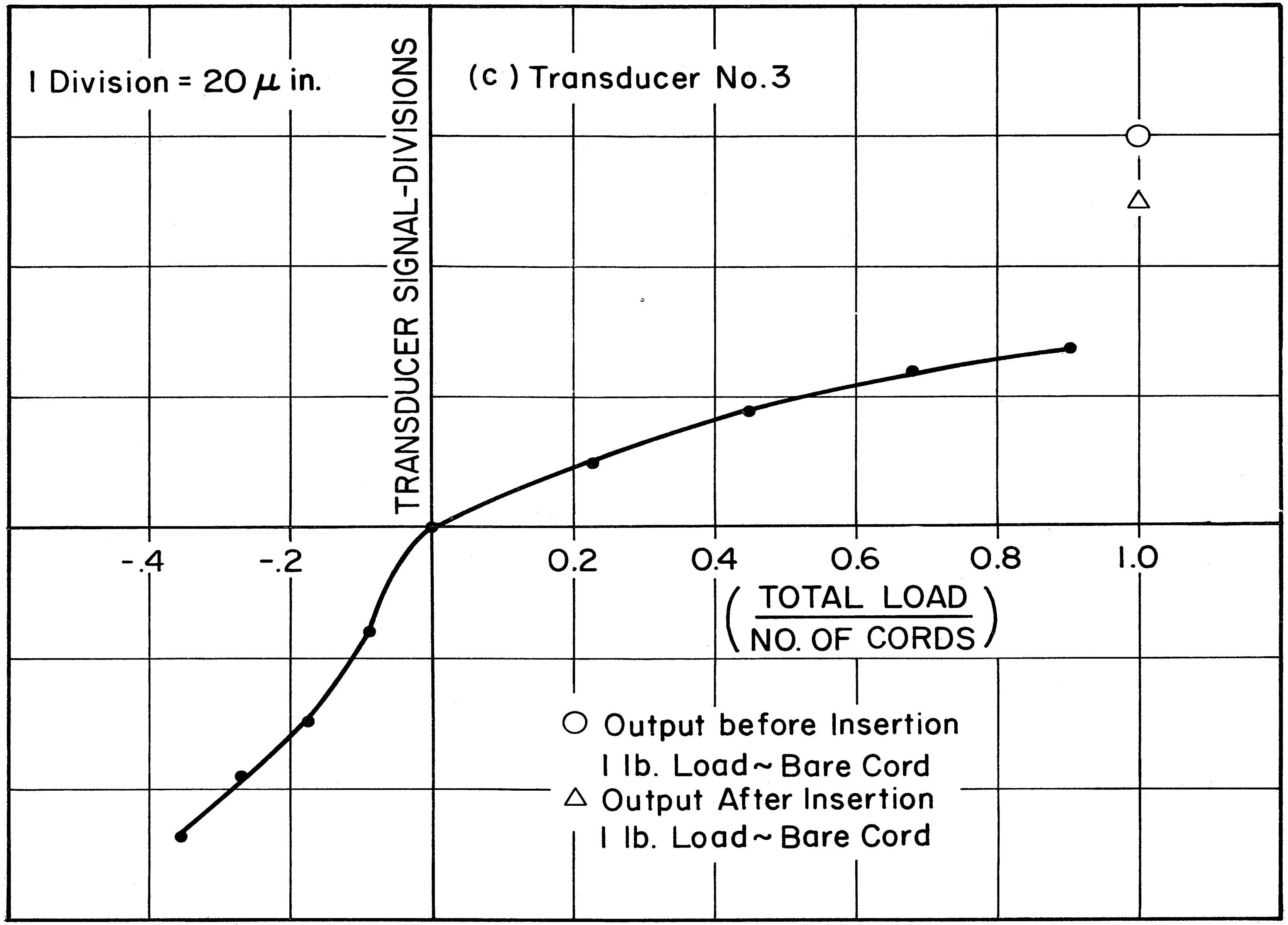

Fig. 4. (Concluded)

IV. CONCLUSIONS

All three transducers exhibit a nonlinearity near the origin of the load vs. signal output curve. However, it should be noted that buckling of the specimen severely limits the compressive loads which can be applied, so that only small loads are shown in Figs. 4a-c. It seems quite possible that larger loads in compression would cause the reestablishment of the same signal-load relation as in tension, but of course this is only speculative.

One of the probable reasons for the nonlinearity near the origin of load vs. signal output is the redistribution of load in this region. When tension loads are appreciable, practically all load is carried by the cords and the total load divided by the total number of cords is a good measure of the <u>average</u> load per cord. When the loads are compressive, and in particular when they are small so that the cord is still in the soft stretch region, the loads are shared between the rubber and the cord. In this region the total load divided by the total number of cords is not a good measure of the average cord load. A similar conclusion holds, but with less certainty, in the region of small tensile loads for here the soft stretch region is also applicable, so that the rubber participates more fully in the load carrying process.

The nonlinearities observed are not large, and to a first approximation the tensile calibration may be used as a measure of the compressive load vs. signal output relation.