Title

A SPECIAL COUPLER PIN DEVELOPMENT FOR MEASURING RAILROAD LOCOMOTIVE DRAWBAR FORCES

Author

Gunn, J.T.

Publication Date

1982-02-01

LBL-14024

Lawrence Berkeley Laboratory
UNIVERSITY OF CALIFORNIA

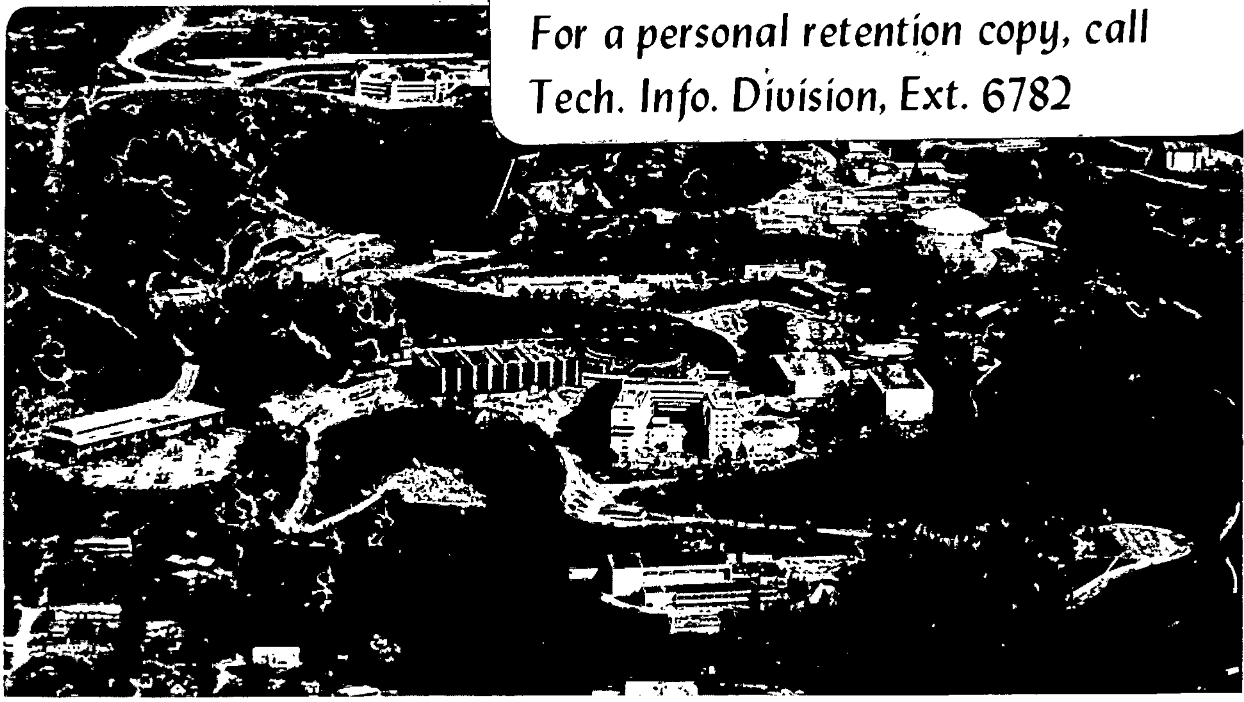
Engineering & Technical Services Division

To be published in the Proceedings of the Joint Spring Meeting of the Japan Society of Mechanical Engineers/ Society for Experimental Stress Analysis, Honolulu, HI, May 22-30, 1982

A SPECIAL COUPLER PIN DEVELOPMENT FOR MEASURING RAILROAD LOCOMOTIVE DRAWBAR FORCES

J.T. Gunn, T. Lauritzen, L. Resnick,
D.T. Scalise and John Koper

February 1982



Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48

A SPECIAL COUPLER PIN DEVELOPMENT FOR MEASURING RAILROAD LOCOMOTIVE DRAWBAR FORCES

by

J.T. Gunn, T. Lauritzen, L. Resnick and D.T. Scalise
Lawrence Berkeley Laboratory
University of California
Berkeley, California

Foreward by

John Koper
U.S. Federal Railroad Administration
Washington, D.C.

Abstract:

A new method has been developed for measuring the drawbar dynamic forces exerted by a railroad locomotive while pulling its payload. Such data are necessary to determine the effect of train handling on fuel economy and on locomotive performance.

Previous methods modified the bulky locomotive coupler for use as the force-sensor. This resulted in expensive devices which were difficult to transport because of their bulk and which had strain-gage exposures vulnerable to damage in the severe environment of railroad operations.

The new method uses a specially-designed coupler pin as the force-sensor. In this special pin, the shear-forces (imposed by the locomotive drawbar) are first transformed into bending streses and then measured by strain-gages located inside small longitudinal holes in the shear pin. This results in important advantages over the previous methods; the new sensor is much less expensive, more easily portable (30 vs. 400 pounds) and more reliable and less susceptible to damage.

A prototype pin has been built and successfully tested in the laboratory at full operating load and the load resolution has met design specifications. This paper describes the design, construction, and testing of the pin.

Foreward:

The Department of Transportation's Federal Railroad Administration has sponsored the design and development of a portable Locomotive Data Acquisition Package (LDAP) at the Lawrence Berkeley Laboratory/ Department of Energy. LDAP is a complete system for recording and analyzing data from diesel-electric locomotives being used in normal railroad operation.

Basically, the LDAP system includes:

- A network of transducers to accurately measure important locomotive parameters.
- A rugged, portable data recorder and mini-computer capable of recording onto magnetic tape the signals from the transducers.
- Data reducing and analysis techniques for converting the recorded data into convenient formats.

The LDAP has been designed as a research tool and, as part of the developmental effort, sensing techniques that prove to be the most reliable and accurate have been studied. In measurements such as traction motor performance, locomotive coupler drawbar forces (tensile-compressive), fuel consumption and train speed there are numerous sensors and techniques available. This paper describes the development, design and laboratory testing of a highly portable sensor for measuring locomotive drawbar forces during railroad operation.

Introduction:

Train safety has always been of paramount importance to railroad operations; consequently the effective measurement of drawbar dynamic forces has drawn the attention of design engineers. Furthermore, over the last dozen years the cost of locomotive diesel fuel has increased more than tenfold. Accordingly, fuel consumption per revenue ton-mile has become a matter of great economic interest to both railroad management and governmental fuel strategists. This has emphasized the need to measure the drawbar dynamic forces under actual operating conditions. These measurements permit the evaluation of train structural safety margins and the determination of the effects of train handling on locomotive performance. Such data can be used to design lighter, safer trains and to establish effective procedures for preventive maintenance and for locomotive system failure management.

The necessary accuracy of the drawbar force measurement is set by the uncertainties in how well other factors are known; notably, by the train weights used in revenue ton-miles. Three to five percent is judged adequate at this time.

The maximum drawbar force to be measured is set by the locomotive rating and is currently about 300,000 lbs. The pin must be capable of withstanding three times that amount in compression under emergency situations while the emergency maximum load in tension is set at 560,000 lbs. at which level the locking knuckle of the coupler fails. This disconnects the train from the locomotive.

Design:

Normally, the standard coupler pin sees the draft load as shear forces (on 4 shear planes). The novel method of sensing this load uses 4 raised lands on the pin outside diameter to convert the pin to a beam loaded in flexure. The lands serve to define the point of application of the load so as to create the common 4-point load case for a simply supported beam. For equal loads at each of the 4 points this creates a constant bending moment over the length between the two middle loads. This length is convenient for strain gage location.

Strain gages are mounted symmetrically about the neutral axis of the pin and within small longitudinal holes in the pin. Self-temperature compensated gages are used. (See Figure 1.)

It can be seen from the moment diagram that load shifts anywhere between the two center lands produce minimal changes in the combined output of gages located symmetrically in either side of the midpoint. (See Figures 2 and 3.) This feature is desirable because wheel diameter of various cars may differ by modest amounts.

A fifth land of reduced diameter is added at the midpoint to limit the excursion (and peak stress) under overload conditions. Under normal conditions it does not contact the bore. This feature provides good resolution of normal draft loads and yet prevents pin failure under very heavy loading.

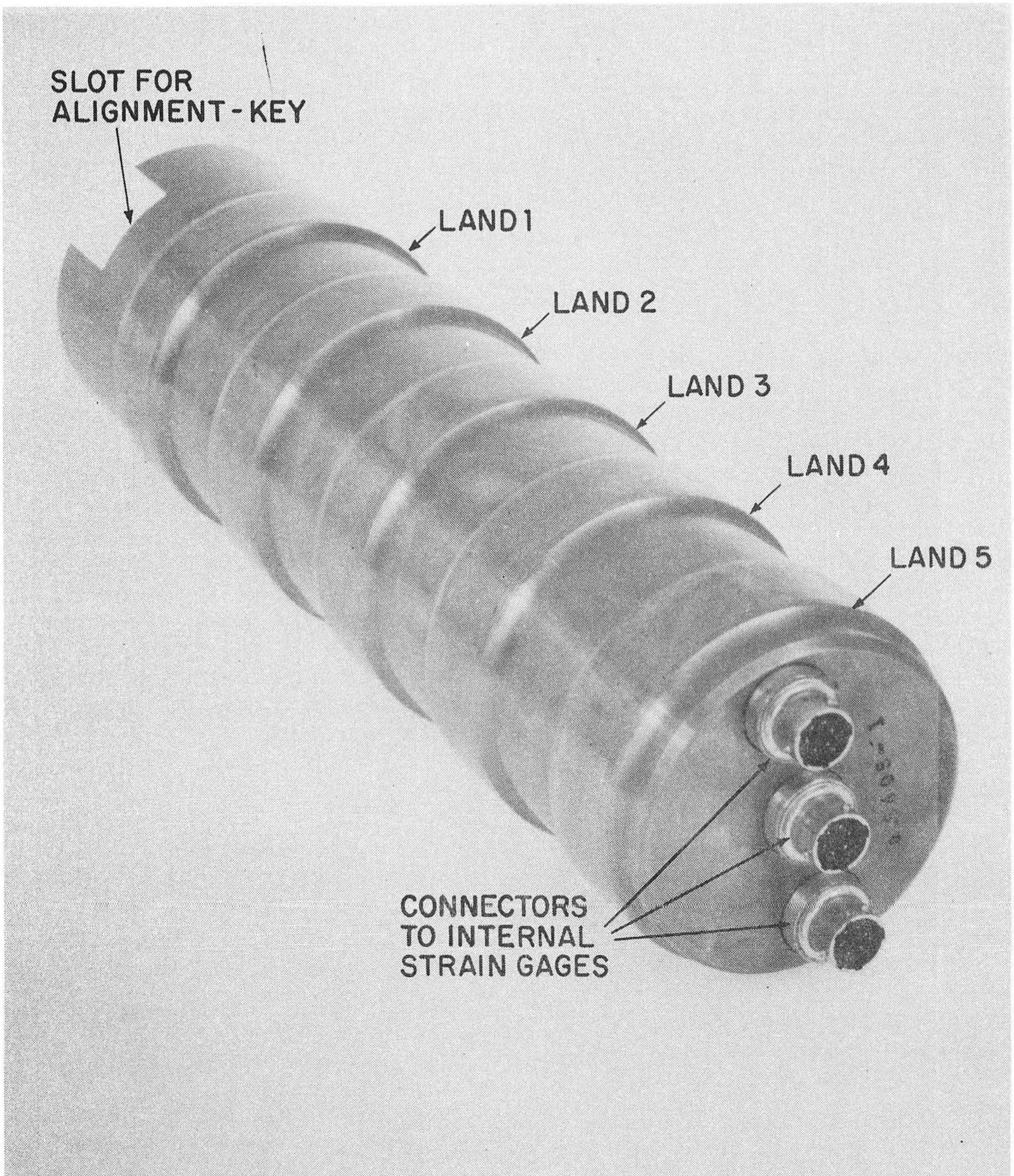
The central hole permits strain gage installation on the neutral axis of the flexure for developmental checking. It would be omitted in production pins.

The pin is in reality a short, bulky object which departs significantly from an ideal flexure specimen. Nonetheless, the departure errors are repeatable and able to be calibrated, even if not readily calculable. (See Figure 4.) Careful selection of pin material and its skillful heat treatment produce a strong, tough and isotropic material. Stainless steel alloy 17-4 PH, condition H 1025 was used. Land width and crown were carefully controlled to minimize Brinelling of the mild steel mating surface. Some minor Brinelling was observed. This could readily be eliminated by use of higher strength material for the coupler bushings.

Installation of strain gages deep within small diameter holes requires special tooling and techniques. This special service is available commercially (vendors name furnished upon request).

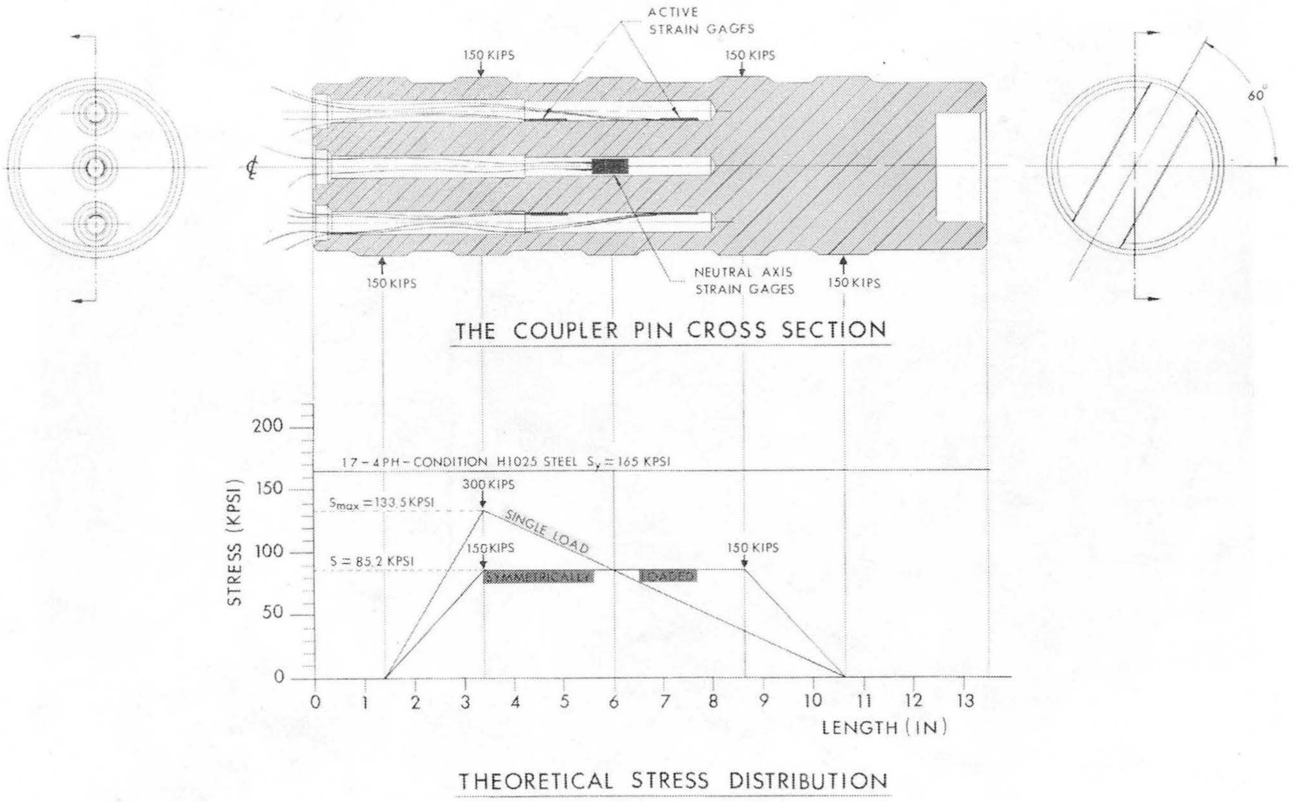
Acknowledgment:

This work performed with support from the U.S. Federal Railroad Administration and the U.S. Department of Energy under Contract W-7405-ENG-48.



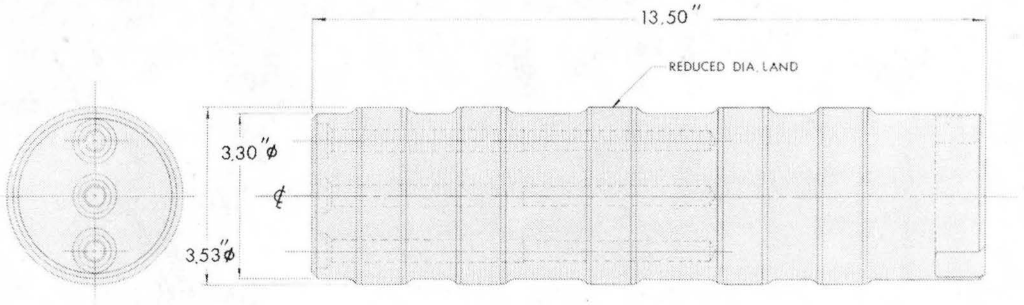
CBB 813-2230A

Fig. 1 Photograph of Coupler Pin

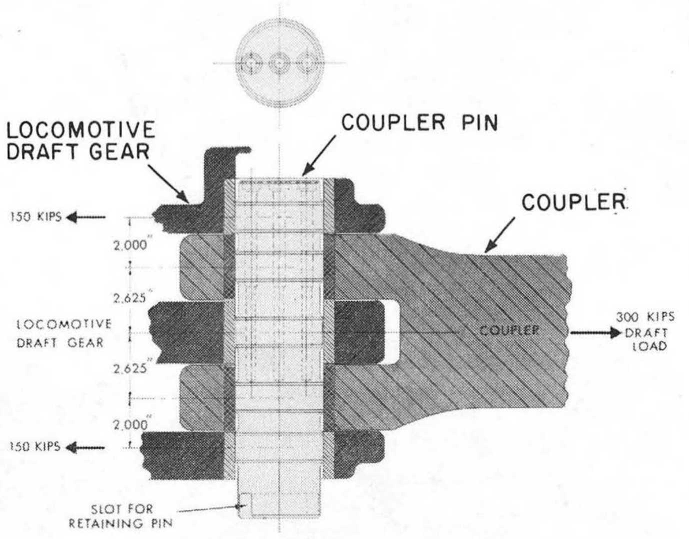


CBB 811-781

Fig. 2 Theoretical Stress Distribution on Coupler Pin Cross-Section Showing Strain Gage Location



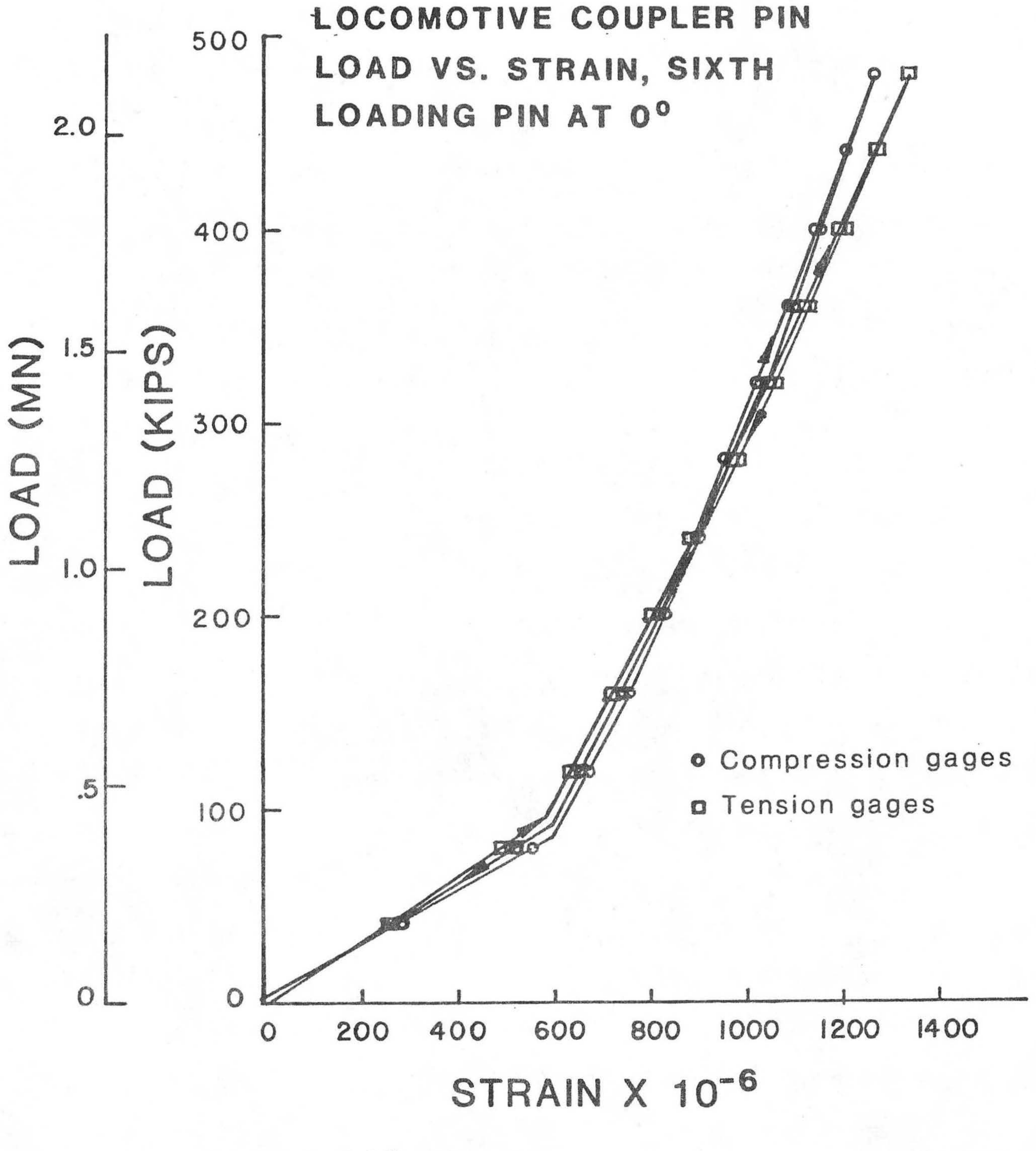
THE COUPLER PIN (APPROX. WT. 30 LB)



INSTALLATION

CBB 811-779A

Fig. 3 Coupler Pin Installation



Pounds X 4.448= Newtons

XBL 822-8024

Fig. 4 Load vs. Strain Curve

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720