SSC-286

(SL-7-25)

RESULTS OF THE FIRST FIVE "DATA YEARS" OF EXTREME STRESS SCRATCH GAUGE DATA COLLECTED ABOARD SEA-LAND'S SL-7's

SHIP STRUCTURE COMMITTEE

1979

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Ship Structure Committee

An Interagency Advisory Committee
Dedicated to Improving the Structure of Ships

Address Correspondence to:
Secretary, Ship Structure Committee
U.S. Coast Guard Headquarters,(G-M/82)
Washington, D.C. 20590

SR-1245
JUNE 1979

This report is one of a group of Ship Structure Committee Reports which describes the SL-7 Instrumentation Program. This program, a jointly funded undertaking of Sea-Land Service, Inc., the American Bureau of Shipping and the Ship Structure Committee, represents an excellent example of cooperation between private industry, regulatory authority and government. The goal of the program is to advance understanding of the performance of ships' hull structures and the effectiveness of the analytical and experimental methods used in their design. While the experiments and analyses of the program are keyed to the SL-7 Containership and a considerable body of the data developed relates specifically to that ship, the conclusions of the program will be completely general, and thus applicable to any surface ship structure.

The program includes measurement of hull stresses, accelerations and environmental and operating data on the S.S. Sea-Land McLean, development and installation of a microwave radar wavemeter for measuring the seaway encountered by the vessel, a wave tank model study and a theoretical hydrodynamic analysis which relate to the wave induced loads, a structural model study and a finite element structural analysis which relate to the structural response, and installation of long term stress recorders on each of the eight vessels of the class. In addition, work is underway to develop the initial correlations of the results of the several program elements.

Results of each of the program elements are being made available through the National Technical Information Service, each identified by an SL-7 number and an AD- number. A list of all SL-7 reports available to date is included in the back of this report.

This report documents the installation of the long-term stress recorders and the method involved in selecting and converting the raw stress data to histograms. The reduction of a five-year collection of these data are presented.

Henry H. Bell
Rear Admiral, U. S. Coast Guard
Chairman, Ship Structure Committee

Technical Report Documentation Page

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16. Abstract

This report covers the installation of Extreme Stress Gauges mounted on each of SEA-LAND's SL-7's. Data collected from each ship over a five-year period is presented in histogram form.

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SSC-286

(SL-7-25)

FINAL REPORT

on

Project SR-1245

"Reduction of SL-7 Scratch-Gauge Data"

RESULTS OF THE FIRST FIVE "DATA YEARS" OF EXTREME STRESS SCRATCH-GAUGE DATA COLLECTED ABOARD SEA-LAND'S SL-7'S

by

R. A. Fain

and

E. T. Booth

TELEDYNE ENGINEERING SERVICES

under

Department of Transportation
United States Coast Guard
Contract No. DOT-CG-61712-A

This document has been approved for public release and sale; its distribution is unlimited.

U. S. Coast Guard Headquarters
Washington, D.C.
1979

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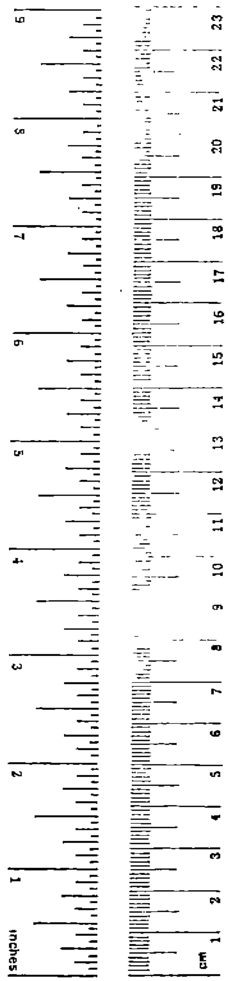
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

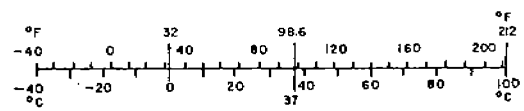
Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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I. BACKGROUND

This five-year data collection program has been conducted in two phases. The first three years of the program were conducted under the Department of the Navy, Contract N00024-73-C-5140, Serial No. SF35422306 Task 2022, SR 215. The last two years have been under the Coast Guard Contract DOT-CG-61712A.

Nine N.C.R.E. strain gauge recorders were installed on the eight SL-7 vessels on SEA-LAND service and operated while the vessels saw service on both Atlantic and Pacific routings.

II. FUNCTIONAL DESCRIPTION

The purpose of this program has been, and is, to obtain as much midships bending stress data from the SL-7's in the simplest most direct manner possible. To meet this requirement, N.C.R.E. (Naval Construction Research Establishment) - maximum reading strain gauge recorders and clock units (see Figures 1 and 2) were obtained from Elcomatic Limited of Glasgow, Scotland. The units were installed at approximately midships in the starboard tunnels (see Appendix A for installation details) of all eight SL-7's and data collection began.

Basically, the N.C.R.E. gauge consists of gauge points 10 inches apart and a mechanical linkage which provides a magnification of approximately 100:1 at the stylus. The stylus moves against a pressure-sensitive recording paper causing a positive and negative deflection (Figure 3). The paper is indexed about 0.1 inch every four hours. Once every sixth interval i.e. every 24 hours, the index is 0.4 inches wide. Each vertical marking has a length which represents the maximum peak to maximum trough stress which has occurred during the four-hour sampling period.

In data interpretation, it is important to remember the following characteristics of this system:

1. The record indicates the combined wave-induced and first-(or higher) mode vibratory stresses; there is no way to separate the various effects.

2. The maximum peak, and maximum trough stresses indicated on the record may not have occurred as part of the same cycle i.e. they may have occurred at different times during the four-hour record interval (Figure 4).

3. Slow "static" changes in the average stress caused by thermal effects, ballast changes, etc., will contribute to the total length of the scratched line.

Prior to installation, each recorder was calibrated on a Bridgeport Miller using a moveable table and a fixed collet to generate strain. The table was moved in increments of 0.001 inches using a dial indicator to measure the motion in both tension and compression. A calibration table and plot for each recorder is provided in Appendix B of this document.

N.C.R.E. -maximum reading STRAIN GAUGE RECORDER

The analysis of wave-induced stresses imposed on the steel hull of a surface vessel involves the use of data relating to maximum bending moments applied to the hull girder. In the course of such analysis, scientific staff of the Naval Construction Research Establishment, Dunfermline, Scotland, adopted a method of recording maximum strain variations during specified time intervals by means of a maximum-reading strain gauge incorporating a strip chart.

Prototype quantities of the NCRE designed recorder were produced within the Establishment, subsequently evaluated and used as highly successful data acquisition instruments in the arduous environments experienced by Royal Navy warships at sea. To meet a demand for further models, it was decided by NCRE to permit a strain instrumentation company to manufacture the device commercially. Elcomatic Limited of Glasgow was chosen, and the NCRE recorder now is available as a standard Elcomatic product.

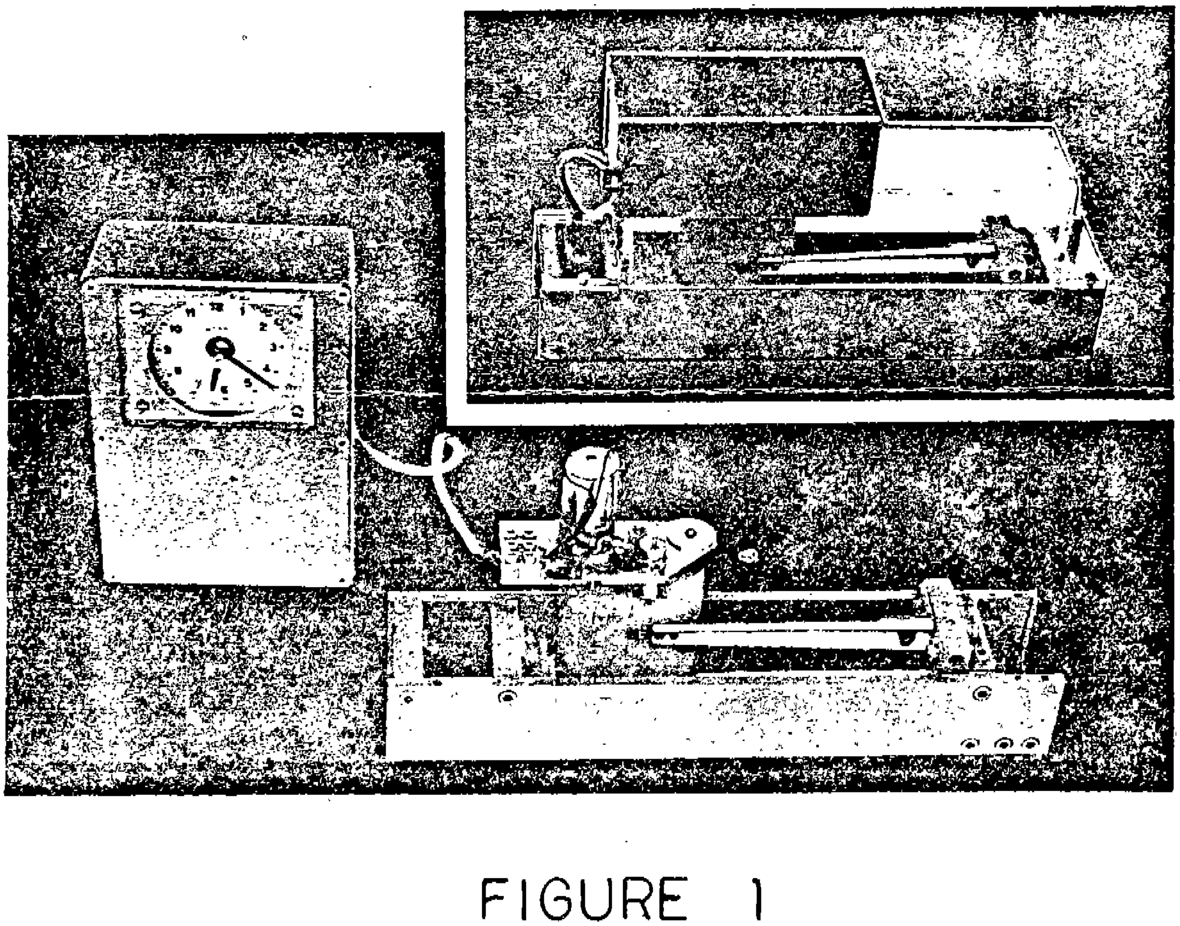
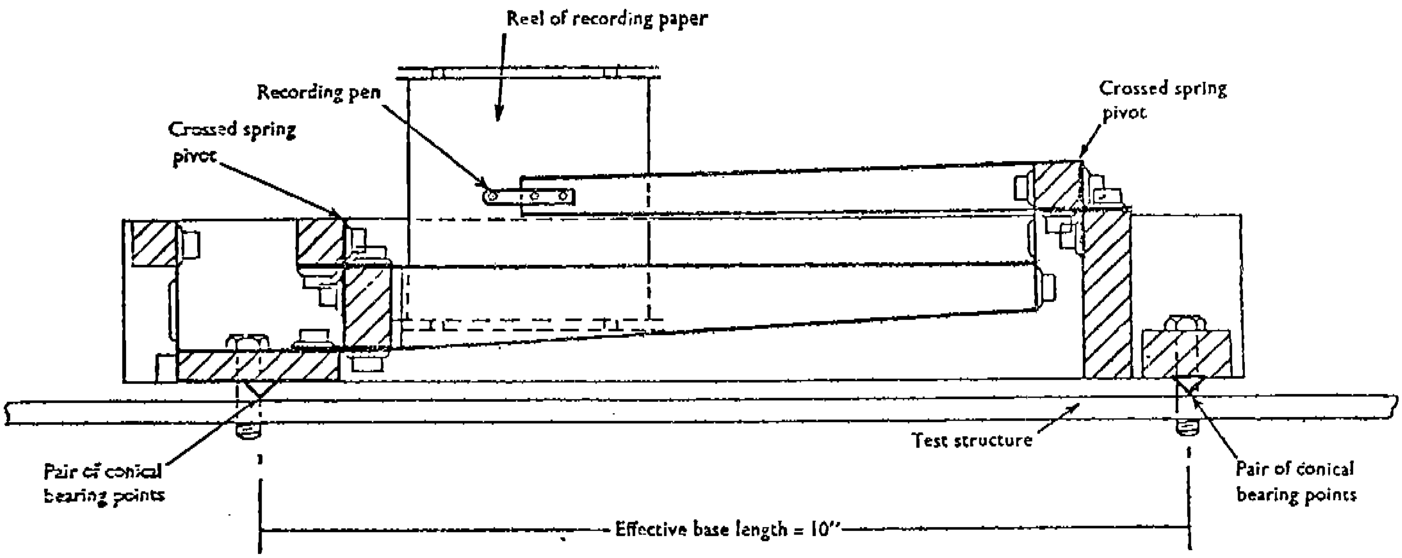


FIGURE 1

Gauge Action:

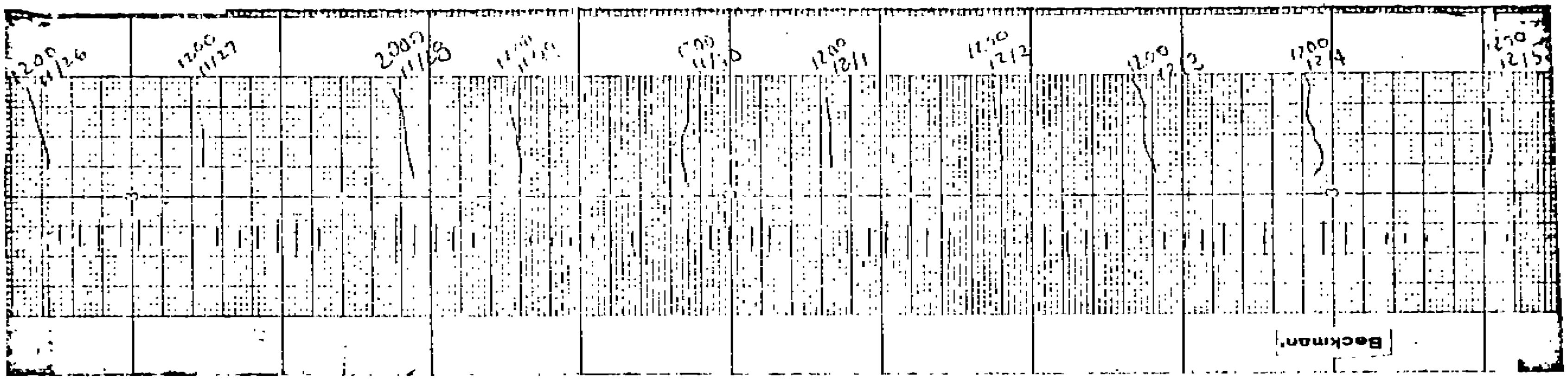
As shown in the sectional diagram below, the lever system is actuated by distortion of the structure under test and requires no external power supply. The instrument is bolted in position, bearing against the test surface on two sets of hardened conical studs. Any change in separation of bearing points is magnified by the lever system which drives the recording pen across the stationary reel of carbon-backed paper. Time related maximum strain records are obtained by forward movement of recording paper programmed by a precision battery-rewound clock and powered by a small motor also battery powered.



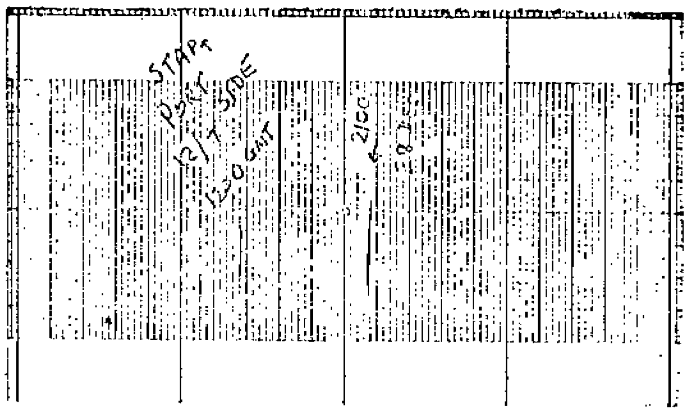
Details:

Prime function	Fully automatic recording of maximum strain.
Duration of Continuous unattended operation	Three months depending on programme.
Magnification Factor	Nominally 100—subject to precise calibration by a dial gauge reading to 0.0001".
Resolution	A strain change of 0.001 will produce a 1" pen deflection.
Linearity	Substantially linear over strain range of 0.0025.
Temperature effects	Uniform temperature changes of gauge and steel test structure produce no discernible pen movement.
Vibration	Tested by dynamic strains of double amplitude 0.0008 at frequencies 25 to 200 cycles per minute—no significant inaccuracy.
Chart loading	Cassette.

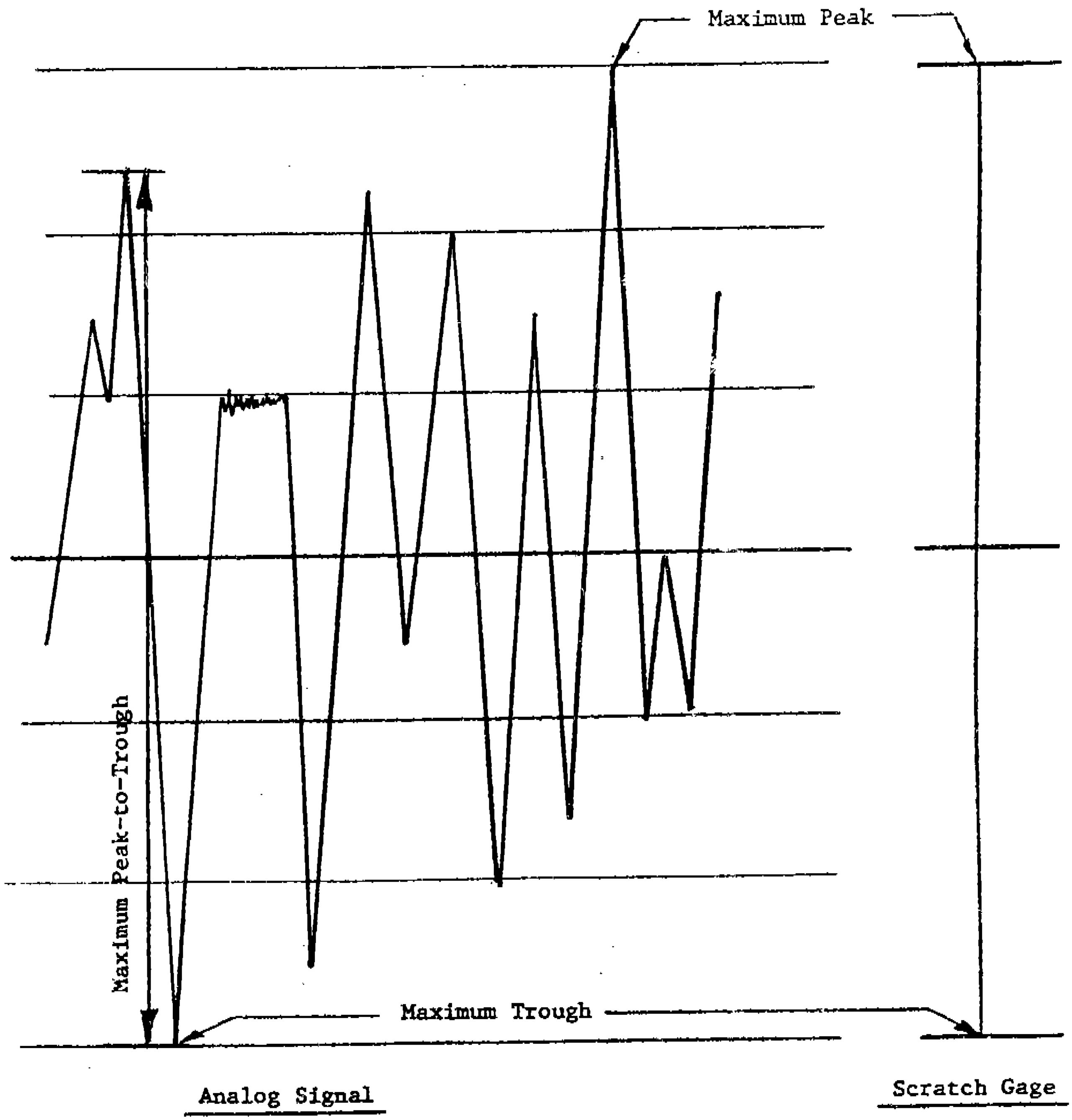
FIGURE 2



SEALAND McLEAN
VOYAGE #5
PORT SIDE



SAMPLE DATA TAPE
FIGURE 3



ILLUSTRATED EXAMPLE OF THE COMPARISON
OF AN ANOLOG SIGNAL WITH THE SCRATCH GAGE

FIGURE 4

III. VESSEL DEPLOYMENT AND EQUIPMENT HISTORY

The following section is a brief summary of each vessel's routing assignment from the time the scratch gauge(s) were installed to the present, along with comments concerning the operation of the equipment. The sequence is in the order in which the equipment was installed and placed in service.

The eight SL-7's have historically been assigned either to Atlantic or Pacific routings. Atlantic crossings usually involve some or all of the following ports: Port Newark, N. J., USA; Portsmouth, Virginia USA; Bremerhaven, Germany, Rotterdam, The Netherlands and Algeciras, Spain. Those vessels assigned to Pacific duty visit the ports of Seattle, Washington, USA; Long Beach, California USA; Oakland, California USA; Yokohma, Japan; Kobe, Japan and Hong Kong (British).

1. SEA-LAND McLEAN

This vessel is unique for not only were two scratch gauges installed (Serial No. BS72E001 in the port tunnel* and Serial No. 026 in the starboard tunnel) on October 7, 1972, but Teledyne engineers rode this vessel during the winters of 1972-1975 and serviced the instruments. The McLEAN spent her initial years in Atlantic service. In May of 1975, she dry-docked at Newport News, Virginia and then proceeded to the Pacific where she has been in operation ever since.

Both instruments have performed well and other than replacing a defective clock unit in May of 1978, performance has been excellent.

2. SEA-LAND GALLOWAY

The GALLOWAY had gauge unit Serial No. BS 73A 007 installed in her starboard tunnel on March 10, 1973. A problem of unexpected condensation was found and solved by placing a plexiglass enclosure around each gauge containing a 40-watt lamp as a heat source. Both the GALLOWAY and the McLEAN were retrofitted with this arrangement and it was provided for all subsequent vessels. The GALLOWAY began her service with Atlantic duty and then transferred to the Pacific in September of 1973. She remained on Pacific routings until she dry docked in Victoria, B.C., in December of 1975. She then returned to Atlantic duty where she is still presently operating.

The output of data from the GALLOWAY have been low for several reasons. The various problems encountered included such things as broken wires, improper stylus pressure, defective clock but mainly from plain old lack of attention by on-board personnel during the early years.

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*In order to ascertain if the calibration curve for an installed unit had shifted with time, the McLEAN port tunnel gauge, Serial No. BS 72E 001 was removed on October 18, 1975 and replaced with the spare unit. Serial No. BS 73E 001. The removed unit was returned to TES and recalibrated. See Appendix B for the results of this test.

3. SEA-LAND COMMERCE

Scratch gauge Serial No. BS 73A 002 was installed in the starboard tunnel on May 8, 1973 in Elizabeth, New Jersey just prior to the vessel transferring to Pacific duty. The COMMERCE has been in Pacific service ever since.

Early problems were encountered associated with a defective drive assembly which had to be replaced. Operation was good until May of 1976 when the clock failed and a new unit was installed. In May of 1978 a broken switch in the recorder had to be replaced. Since that time operation has been normal.

4. SEA-LAND EXCHANGE

The installation of gauge Serial No. BS 73A 004 in the starboard tunnel was performed on May 13, 1973 at Elizabeth, New Jersey. This ship stayed in Atlantic service until November of 1973 at which time she was transferred to the Pacific where she has remained ever since. Scratch gauge operation has been good with the exception of clock troubles in 1975. The chief aboard the vessel has been exceptional and most of the credit for the good quality of the data can be attributed to his efforts.

5. SEA-LAND TRADE

Scratch gauge Serial No. BS 73A 008 was installed in the starboard tunnel on May 22, 1973 at Elizabeth, New Jersey. This vessel also was transferred to Pacific service at this time and has remained there ever since. This particular system has performed well until May of 1976 when the dynamic response fell off. In September of 1977 Unit No. BS 73A 008 was removed and Serial No. BS 72E 001 (the original McLEAN port gauge) installed. The quality of the data returned to normal and have been excellent ever since.

6. SEA-LAND FINANCE

Scratch gauge, Serial No. BS 73A 005, was installed in the starboard tunnel of the FINANCE in Elizabeth, New Jersey on October 3, 1973 just before the vessel sailed for her Pacific assignment. She has remained on the Pacific routings since her deployment. Early problems with the system included the replacement of a broken mounting stud. The vessel had operational problems and went into dry dock in Vancouver, B.C. in July of 1974 and to the Todd Shipyard in Seattle in October of 1975. Her most recent dry docking was in Victoria, B.C. in May of 1977. Data from October '75 to the present have been good.

7. SEA-LAND MARKET

Scratch gauge, Serial No. BS 73A 003, was installed in the starboard tunnel of the MARKET in Elizabeth, New Jersey on November 5, 1973. The vessel has remained in Atlantic service during her operational life. The vessel dry docked at Newport News, Virginia in November of 1974, March 1975 and again in October of 1976.

A defective clock had to be replaced early in the program. Only minor operating difficulties have been encountered over the years and, in general, the data have been quite good.

8. SEA-LAND RESOURCE

The last system installation was performed aboard the RESOURCE in Elizabeth, New Jersey, on December 13, 1973, when scratch gauge, Serial No. BS 73A 006 was installed in the starboard tunnel. The RESOURCE was originally assigned to Pacific duty but returned to the Atlantic in late 1974. She has remained on the Atlantic run since that time. After early operational problems, the system ran well until April of 1975, when a series of problems developed. Stylus pressure became too tight and the tape tore as it was being pulled under the stylus. No sooner was this problem corrected then the clock unit malfunctioned. A new clock was installed in January of 1976. Operation was normal until June of 1977 when the clock unit again had to be replaced. Data since that time have been good.

SUMMARY

Once early problems were overcome, most of the systems have performed in the expected manner. Clock units have caused a number of problems and are the weak point in the system. As the program continued, cooperation from the crews has become excellent and the quality and amount of data collected have increased proportionally.

IV. DATA PRESENTATION AND INTERPRETATION

As previously stated, the data have been collected on rolls of pressure sensitive paper. Each roll represents approximately three months time and usually, at least, 2 rolls of tape are collected during each six-month visit to the vessel. In order to protect the data and facilitate analysis, each data roll was subsequently mounted on 8 1/2 x 11" card stock with usually 3 trips of the roll mounted per sheet. A copy of all data folders has been made and they are kept in a master data book arranged by vessel.

The length of each data marking has been measured to the nearest 0.02 inches and the results tabulated for each vessel over the five data years of information collected. It is this tabulation data which supplies the basis for the histograms which are presented in the following pages. In order to present the data in a more useful form, i.e. psi of midships bending stress vs. number of occurrences, it was necessary to perform the following transformation:

Since the scratch gauge is substantially linear, its calibration curve is approximately by a straight line and this by the equation

$$y = Mx + B$$

where

y = pointer (stylus) deflection in inches

X = elongation in 10 inches

B = slope intercept

M = slope of the calibration curve around the point of interest

If we assume the scratch gauge operates around the zero point; i.e. there is no constant stress and any offset due to loading is ignored, "B" the slope intercept is zero.

Solving for X:

$$X = \frac{Y}{M}$$

Stress (psi) = (E, Young's Modulus for Steel) (Elongation in 1 inch)

$$\sigma = (30 \times 10^6)\ (\frac{Y}{M} \times 10^{-1})$$

and

$$\sigma = (3 \times 10^6)\ \frac{Y}{M}$$

or

$$\sigma_{psi} = \frac{(3 \times 10^6)\ \text{(length of scratch line in inches)}}{\text{(slope of the best straight line approximation)}}$$

The lengths of the scratch lines have been tabulated. The slope of the calibration curve for each vessel has been derived from the calibration plots of Appendix B and are tabulated on Table I. Since the majority of the data points lie between a gauge deflection of +0.4 inches to -0.4 inches, the slope of the line was calculated between these two values. We, therefore, have reached the point where the stress value for each data interval can be calculated from:

$$\sigma_{psi} = \text{(length of scratch line in inches)} \times \text{(scale factor)}$$

The multiplication scale factors have been calculated for each gauge and are presented on Table II.

TABLE I

SLOPES OF CALIBRATION CURVES

Scratch Gauge	Calibration Curve (Fig.)	Page	Slope Value
McLEAN PORT,			
Original	B-1	B-2	87
Recalibration	B-2	B-4	88
Spare (Replacement)	B-3	B-6	96
McLEAN STBD	B-4	B-8	94
GALLOWAY	B-5	B-10	91
COMMERCE	B-6	B-12	88
EXCHANGE	B-7	B-14	91
TRADE	B-8	B-16	97
FINANCE	B-9	B-18	99
MARKET	B-10	B-20	82
RESOURCE	B-11	B-22	86

TABLE II

DATA MULTIPLICATION SCALE FA

SCRATCH GAUGE
McLEAN PORT
Original
Spare (Replacement)
McLEAN STBD
GALLOWAY
COMMERCE
EXCHANGE
TRADE
FINANCE
MARKET
RESOURCE

Thus, all the information to prepare histograms of stress levels versus the number of occurrences has been developed.

The histograms are arranged in the order of data years. One histogram is provided for each gauge for each year. (In data year five, 2 histograms are provided for the SEA-LAND TRADE as two gauges of different calibration factors were used.)

Associated with each year 3 additional plots are included. A summary plot of all Atlantic data, a summary plot of all Pacific data, and a final plot of all data collected within the year. Finally, three summary total histograms are included: A five-year Atlantic summary, a five-year Pacific summary, and a summary of all data collected during the five-year period. Thus, a total of 63 histograms are presented (Figures 5 through 68, inclusive).

To facilitate data presentation, the data have been divided into "Data Years" as follows:

Data Year (1)

September, 1972 to May 1, 1974

The first year has been broadened to include the early contractual period which started in September of 1972 rather than starting with May 1, 1973, primarily because only the McLEAN and GALLOWAY had their installations in operation prior to the May 1, 1973 date.

Data Year (2)

May 1, 1974 - May 1, 1975

Data Year (3)

May 1, 1975 - May 1, 1976

Data Year (4)

May 1, 1976 - May 1, 1977

Data Year (5)

May 1, 1977 - May 1, 1978

V. DISCUSSION

Over 36,000 measurable readings of midships bending stress have been tabulated and presented in the following section. The scratch gauge recorders, normally operating continuously, have also recorded numerous 4-hour intervals where no noticeable change has occurred. These intervals, such as periods alongside docks, operating in calm waters, in yards for repairs, etc., must be considered when evaluating the overall data collection program.

The scratch-gauge recorder captures the stress history of the vessel and,if the individual reading the tapes is observant,he can establish many interesting events. It is possible to tell when the vessel is loading, when it is moving along the coast and naturally when it has encountered a storm or high seas. We have recorded stress changes of the various vessels going on and off dry docks and this information,if properly correlated with the vessel's status at the time i.e., loads and their distribution, could provide useful information on the hull response. It's even possible, under close observation, to tell when the weather is sunny.

Thus, we have only scratched the surface with the data tabulated in this report. The cautions to be observed when using the data have been amply explained and all the original data and summaries developed for this report are available in the SL-7 data library maintained at the Waltham, Massachusetts facilities of TES.

VI. SUMMARY

This five-year program has been very successful with more and more quality data being obtained each year as the program progresses. Cooperation from the vessels and port personnel on both coasts has been excellent.

At this time,all installations are functioning and we anticipate that additional years of data collection will be authorized shortly.

ACKNOWLEDGEMENT

The data presented in this report could not have been collected without the interest and assistance of the Master and Crew of each SL-7. Particular thanks is made to the Chief and/or First Engineer of each vessel who have provided the on-board attention these installations have required. Last, but certainly not least, our appreciation to the Sea-Land terminal personnel on both coasts who have assisted us during this program.

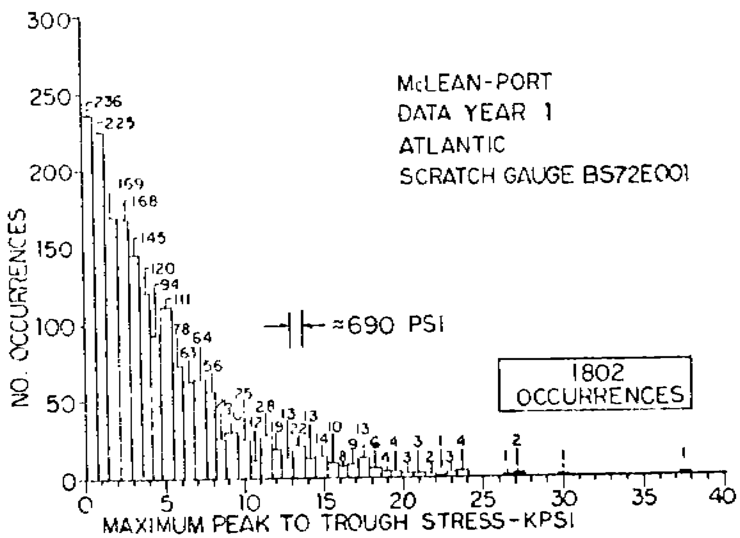
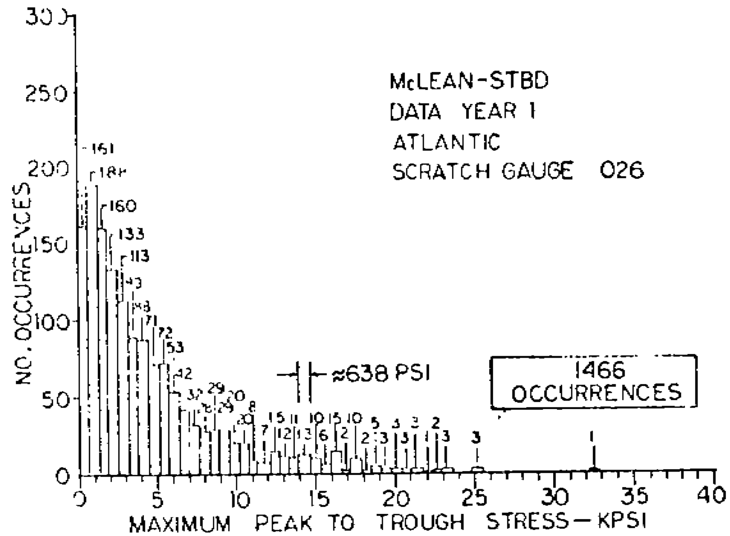


FIGURE 5



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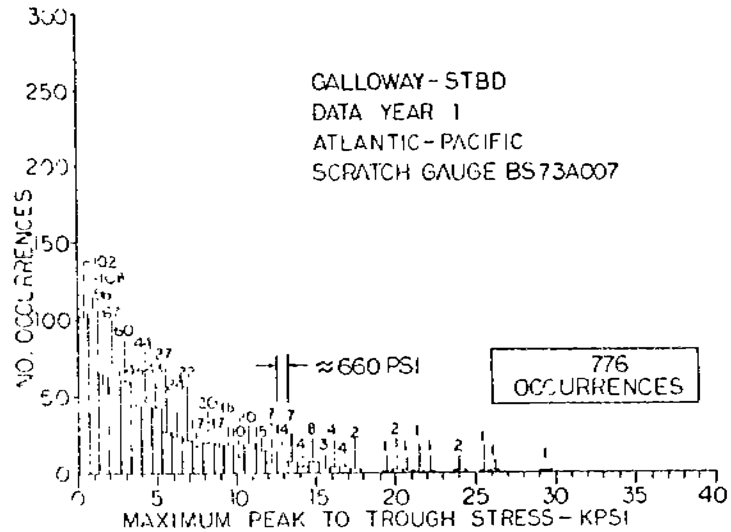

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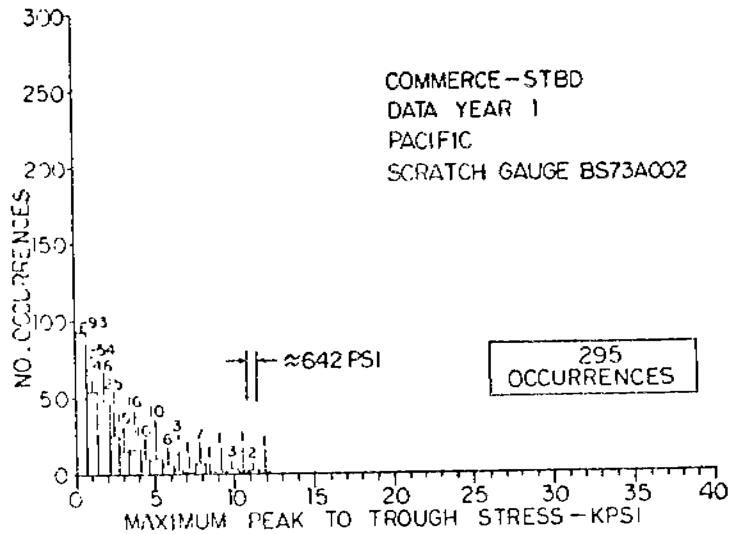

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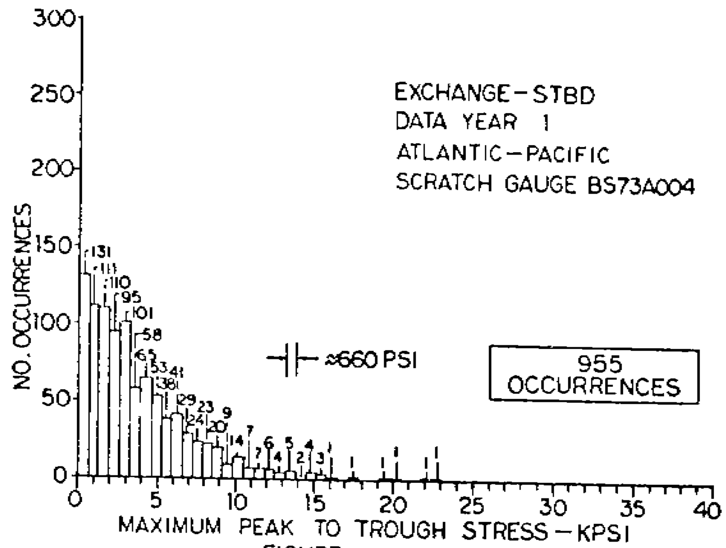

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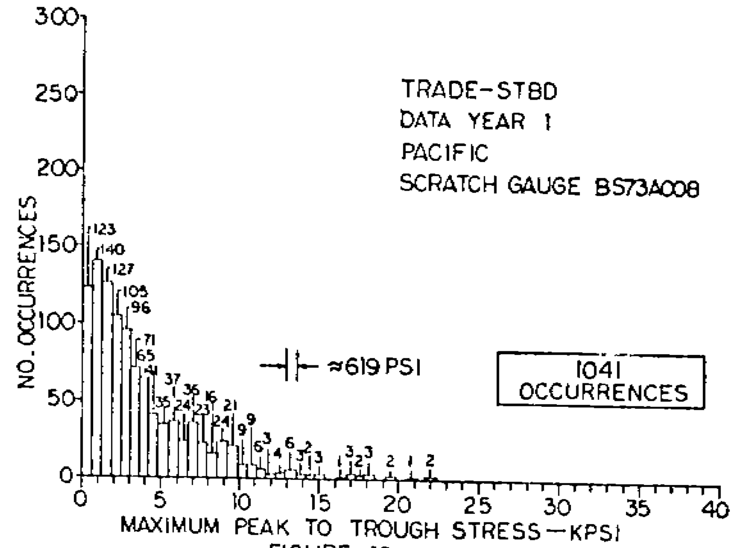

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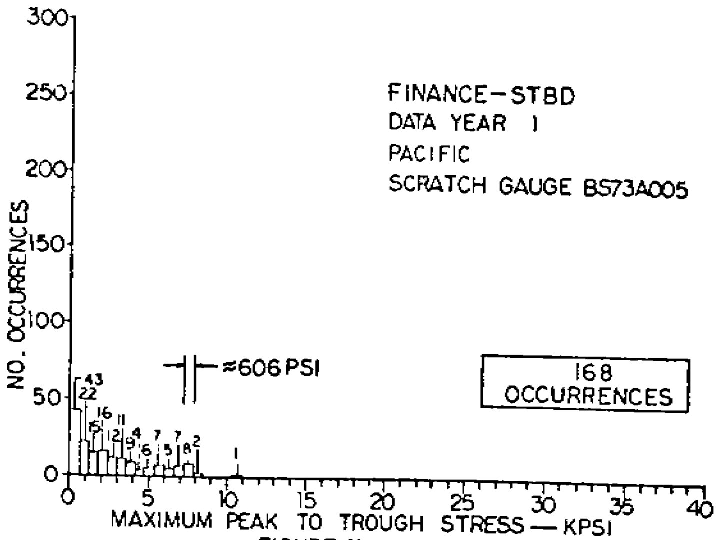

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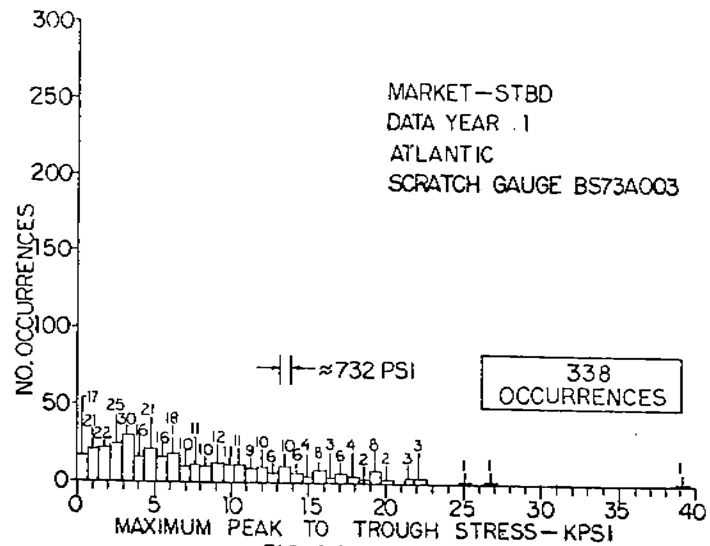

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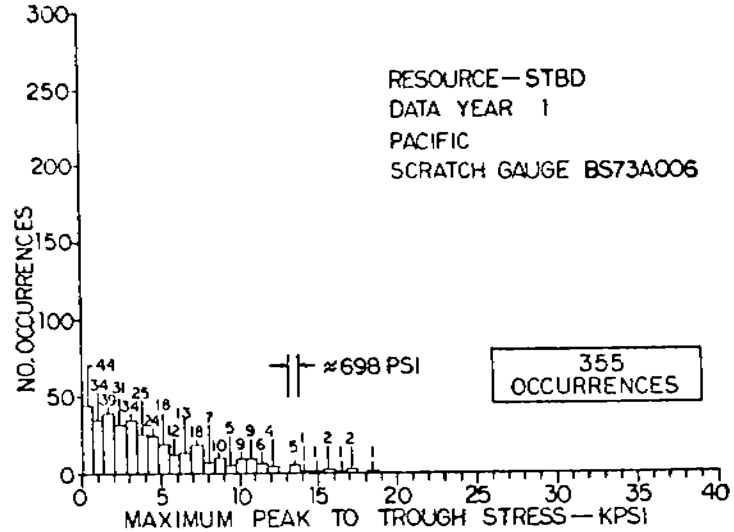

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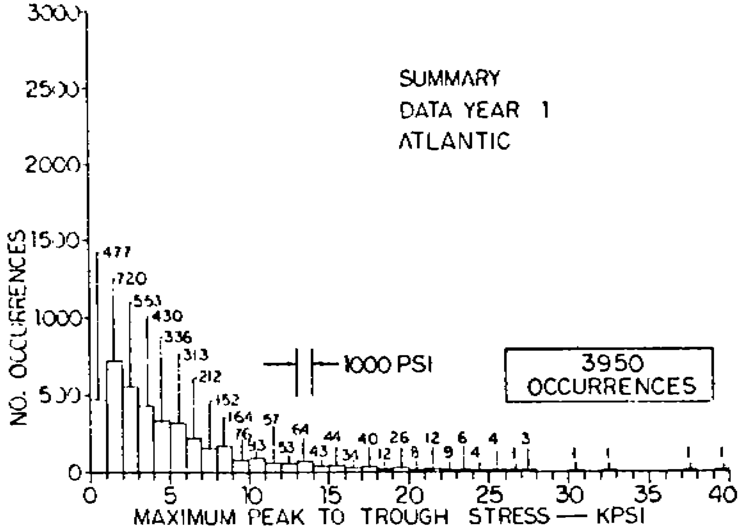

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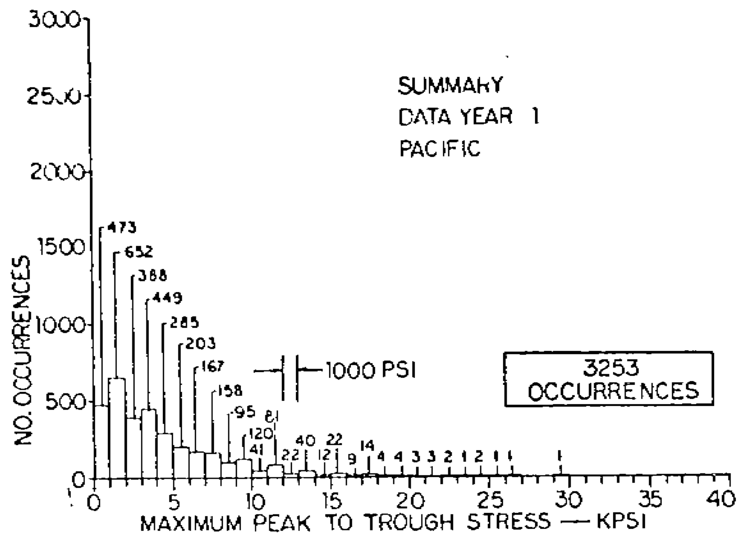

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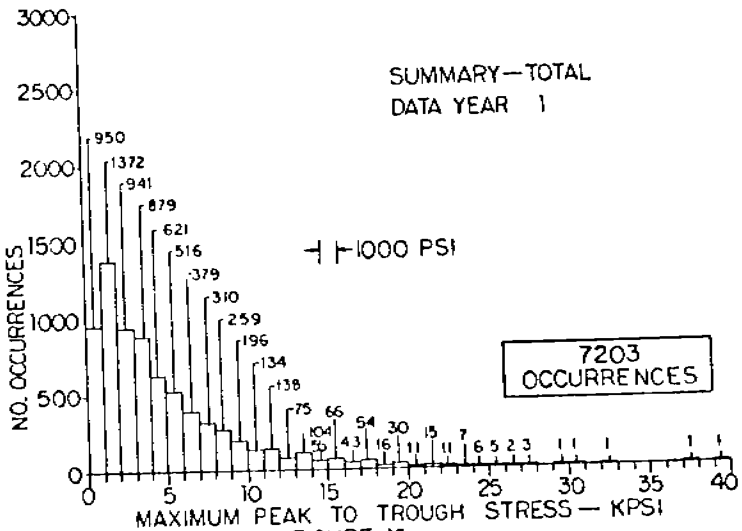

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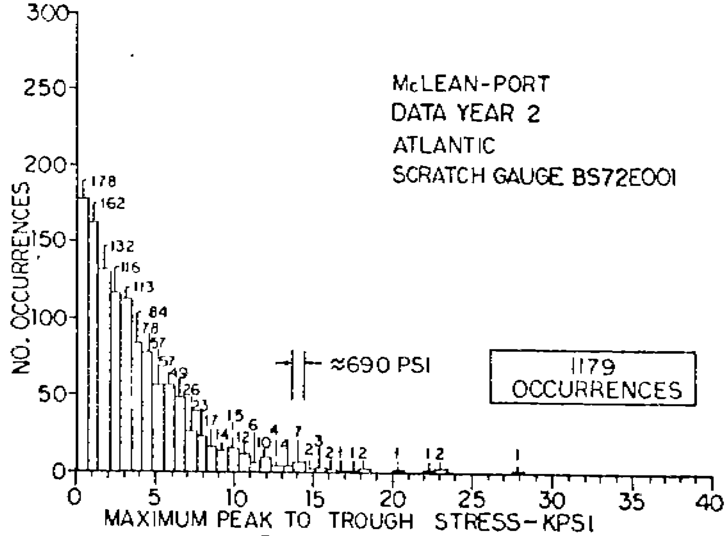

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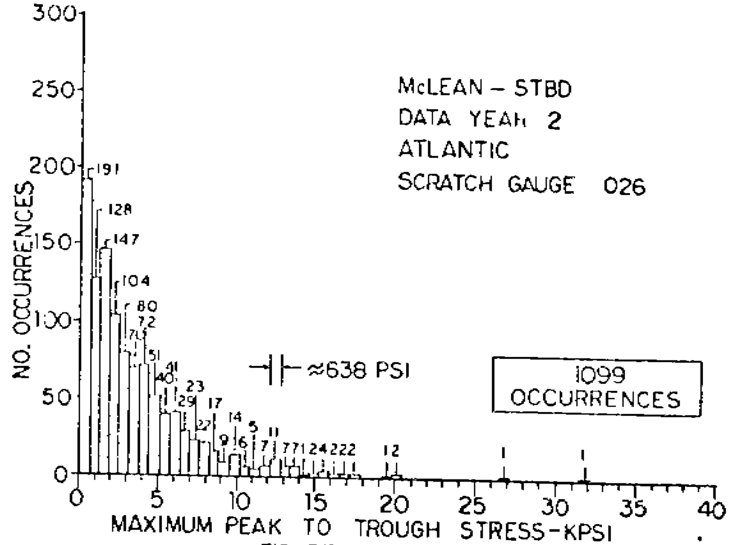

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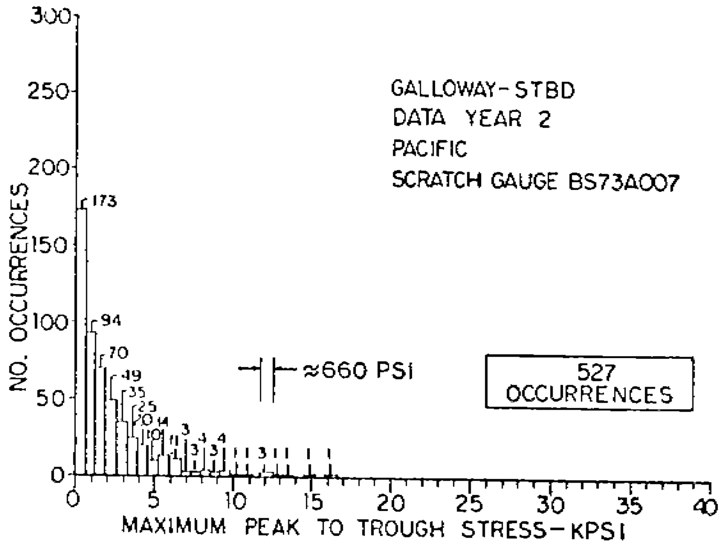

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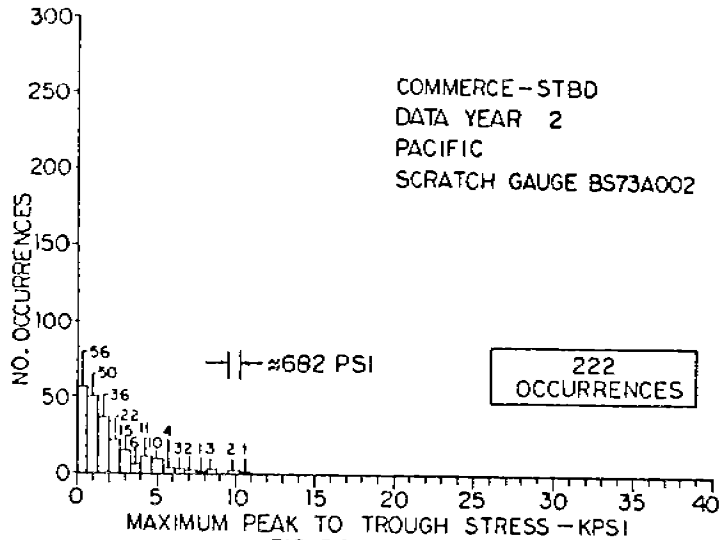

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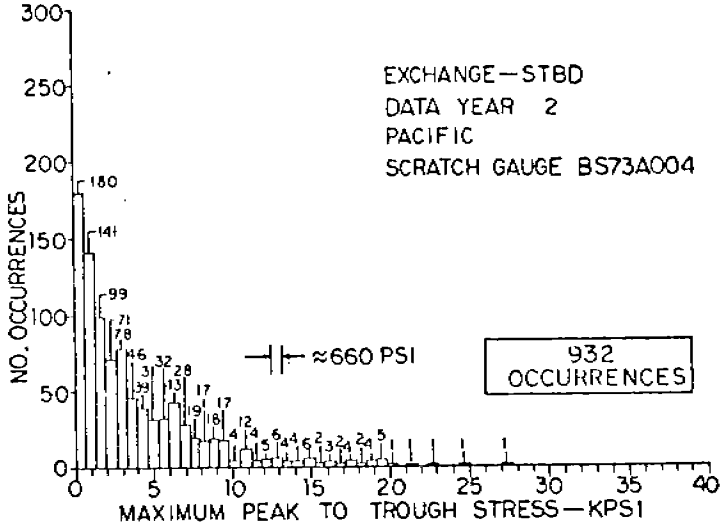

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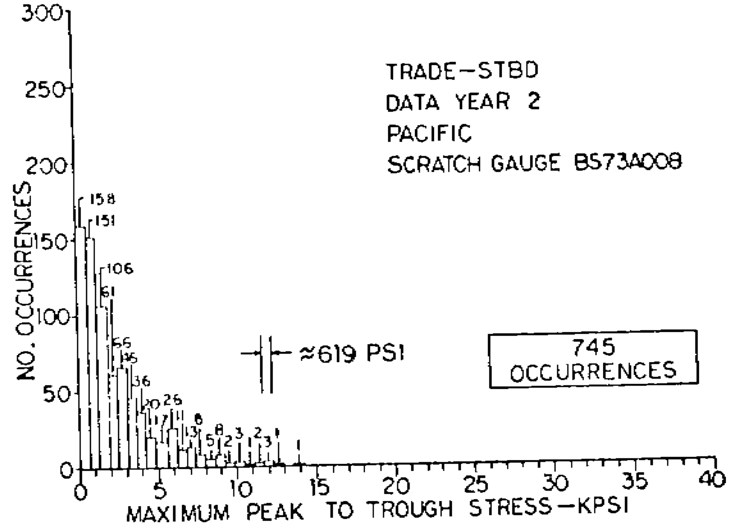

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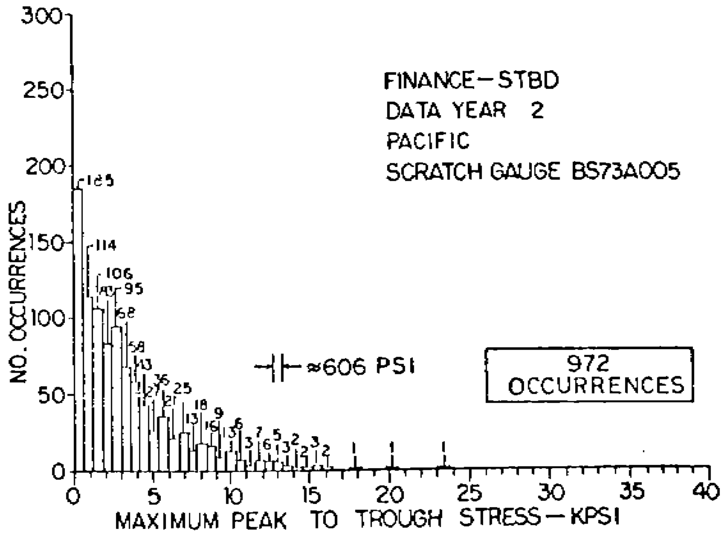

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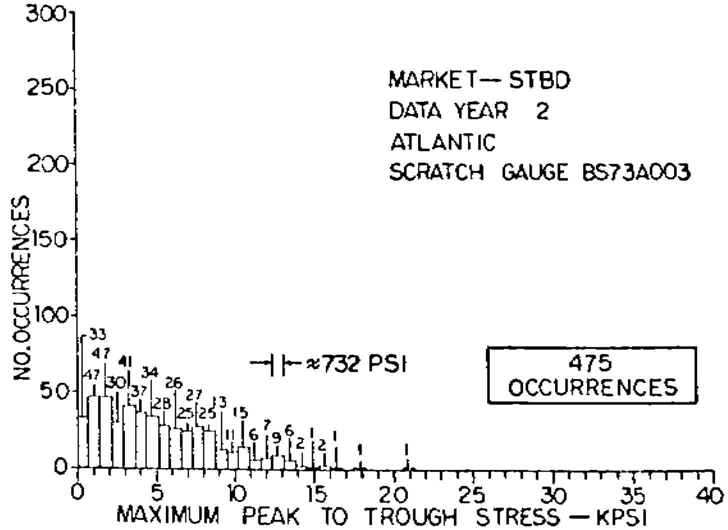

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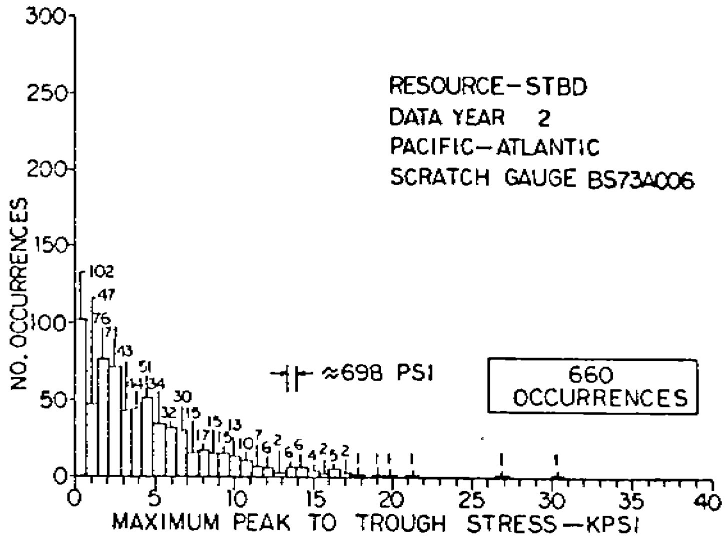

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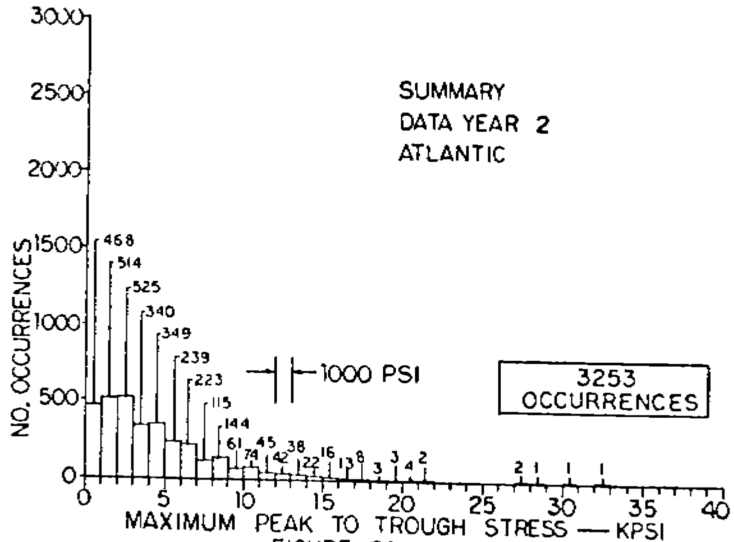

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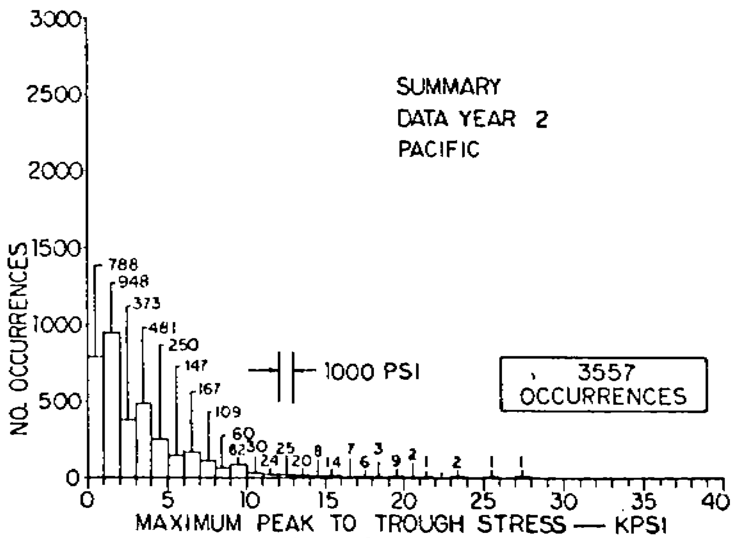

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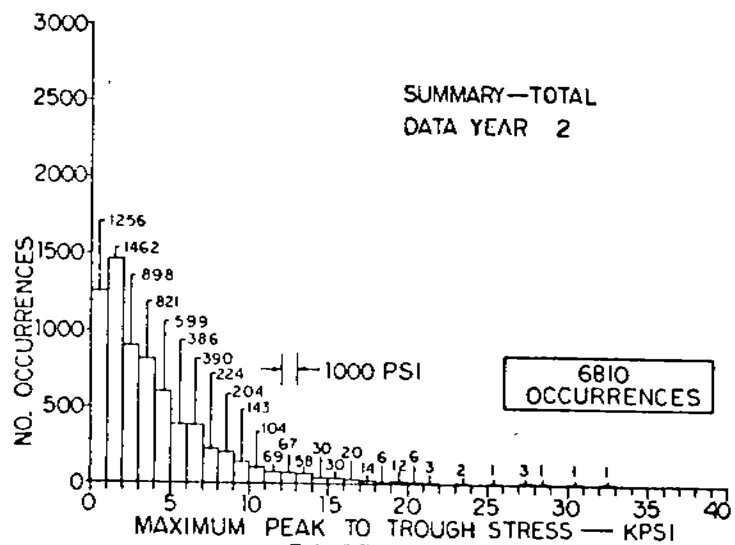
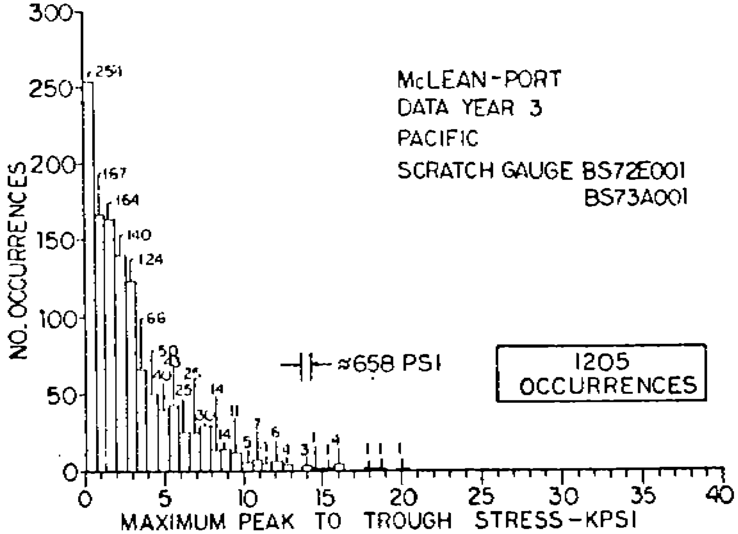


FIGURE 28



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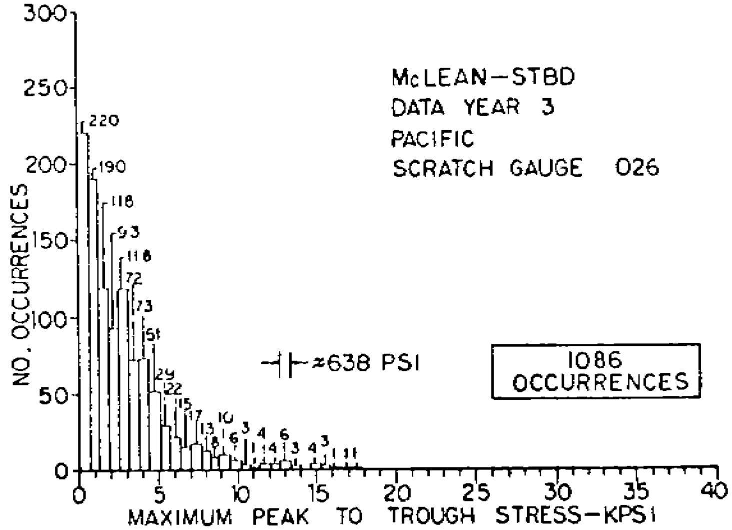
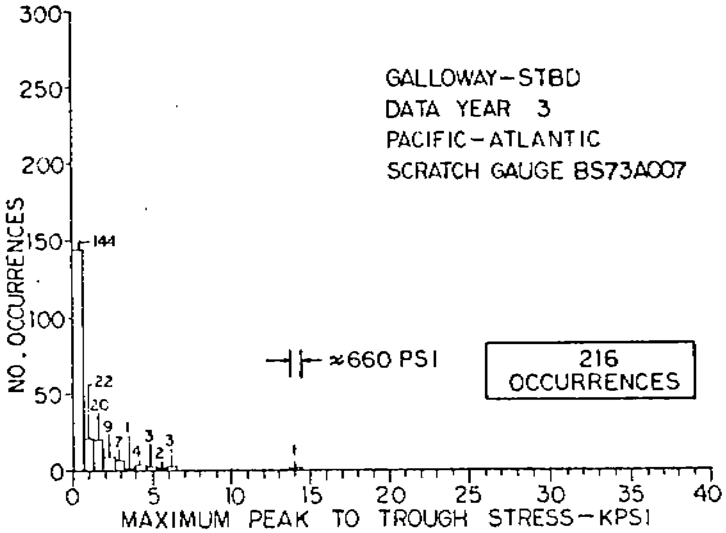


FIGURE 30



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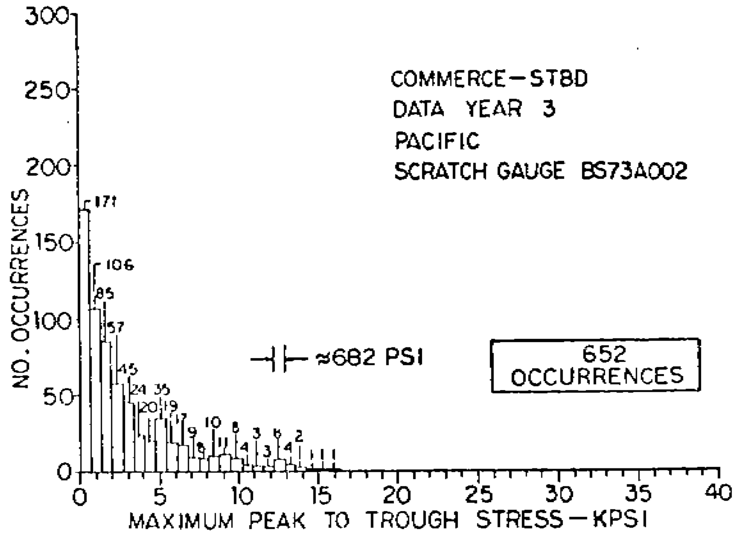

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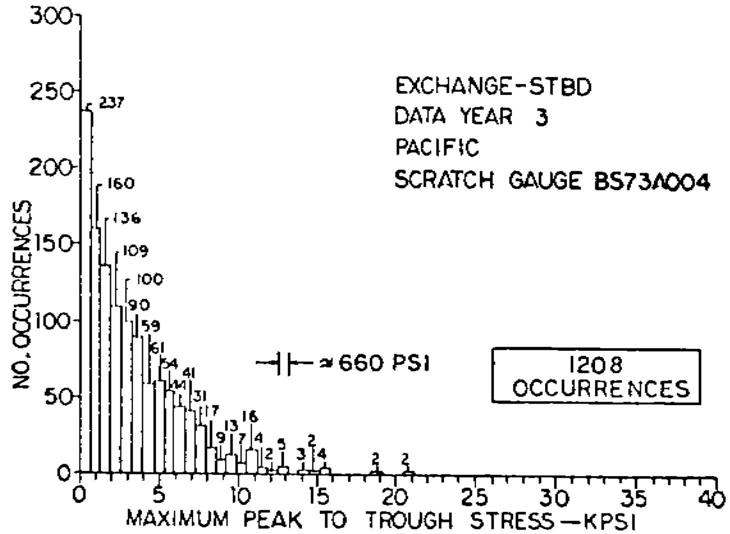

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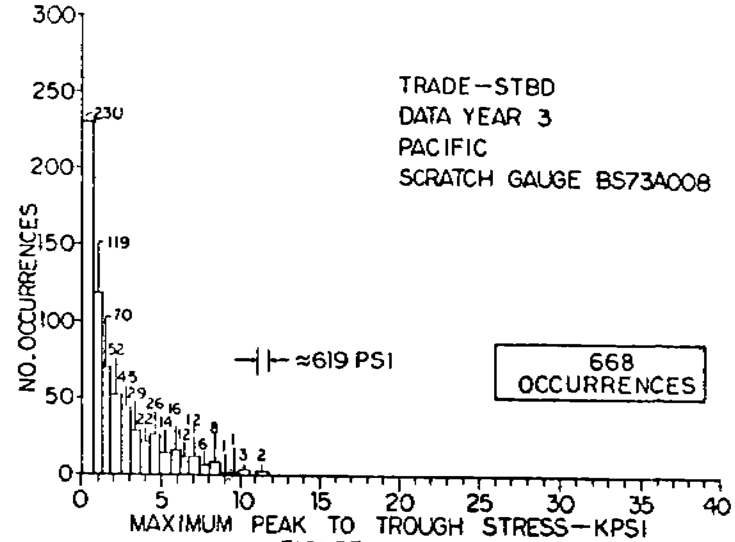
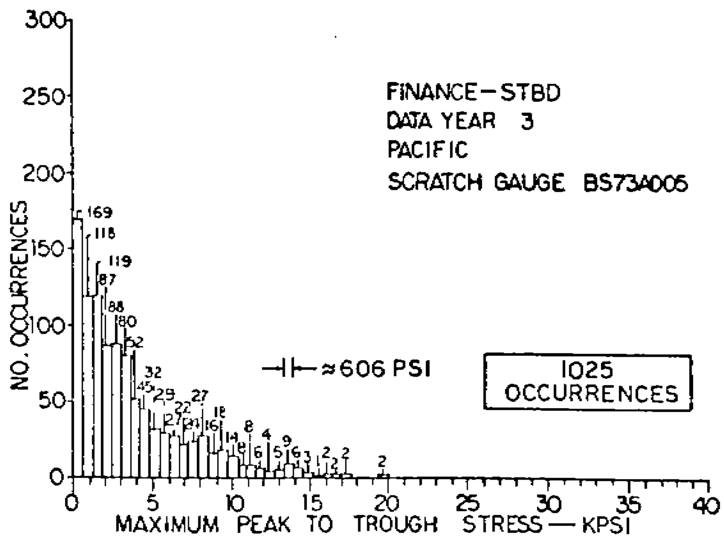


FIGURE 34



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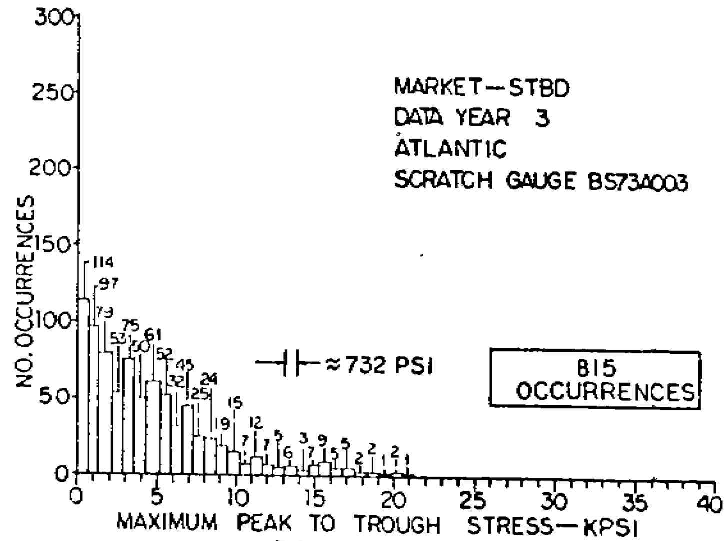

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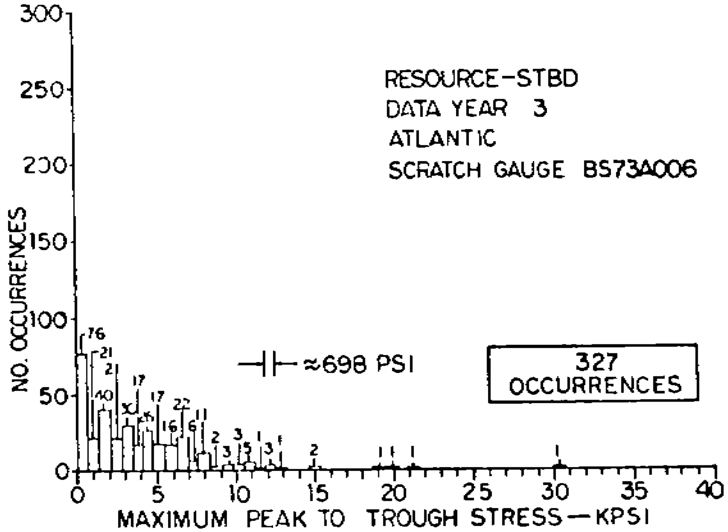

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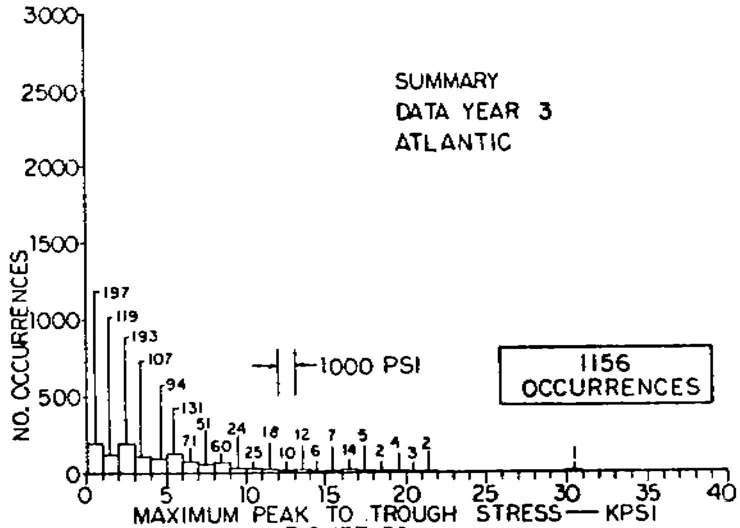
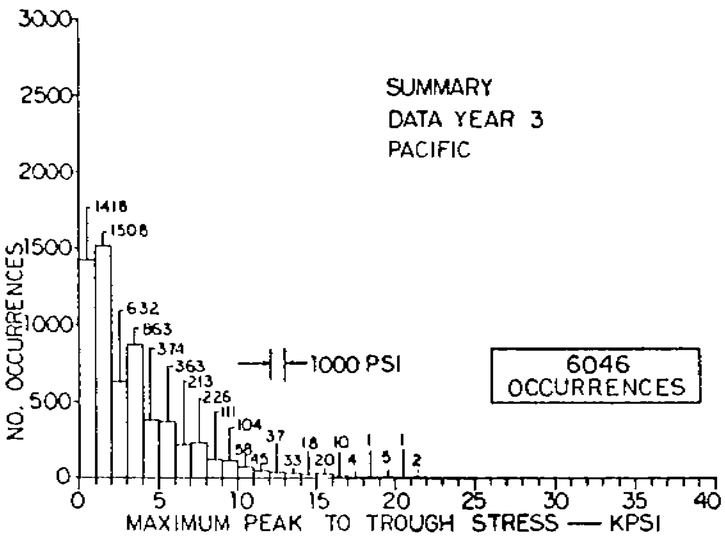


FIGURE 38



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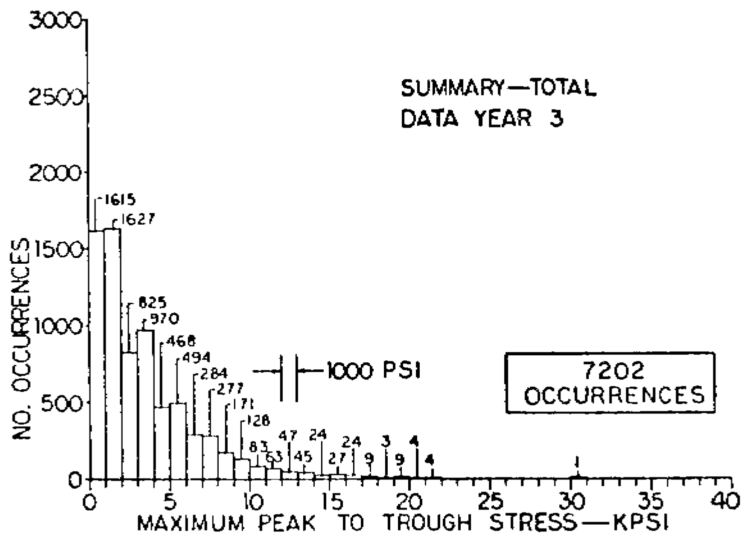

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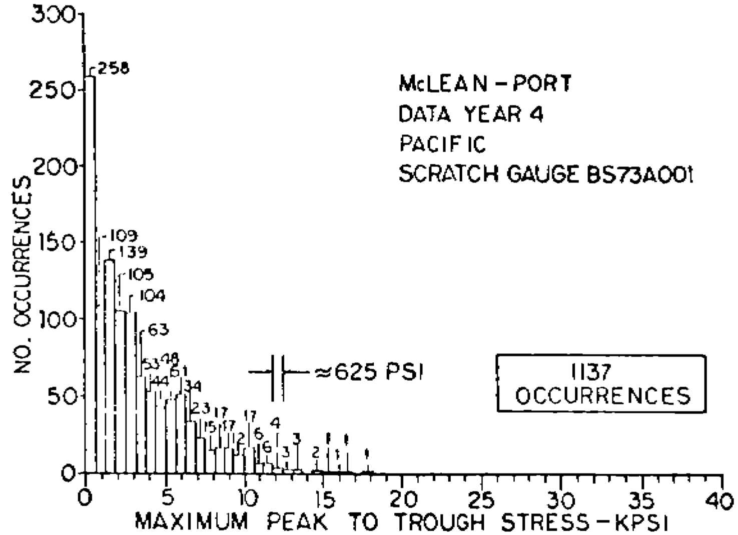

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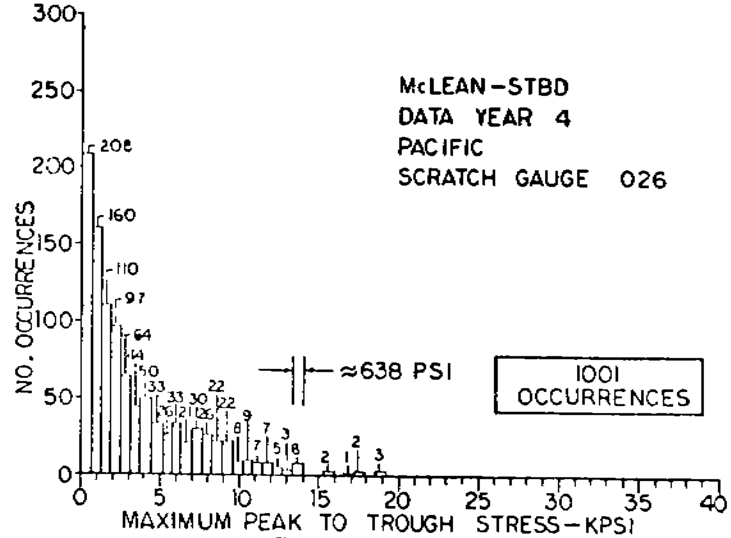

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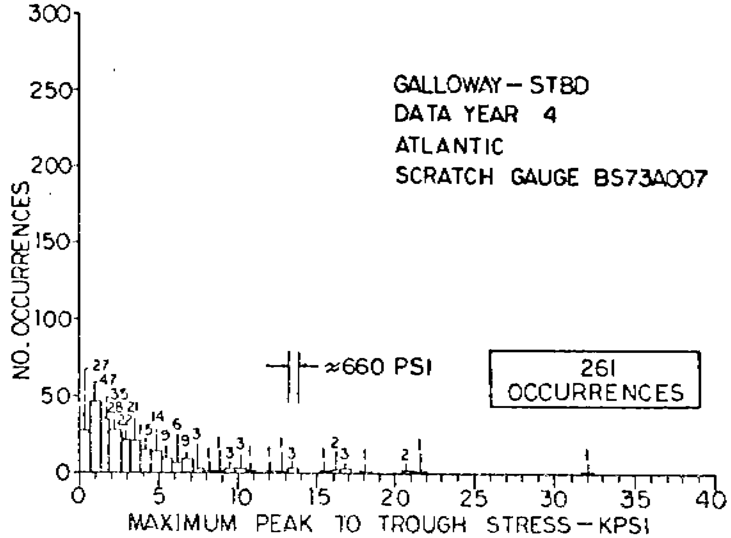

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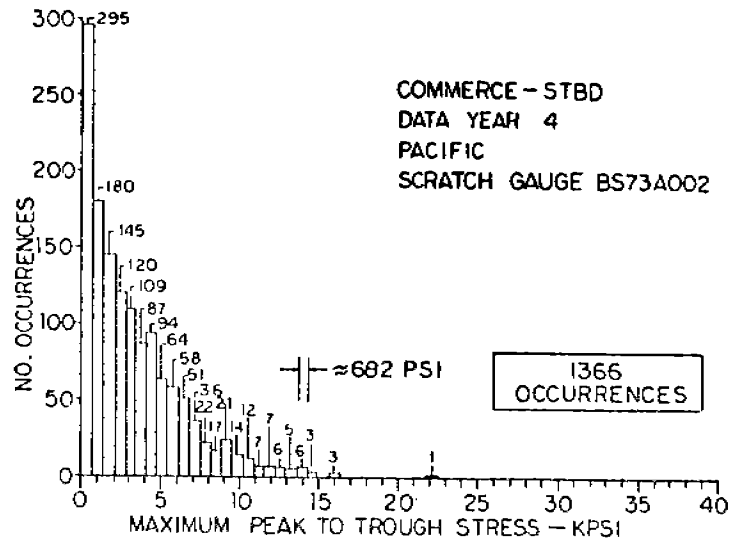

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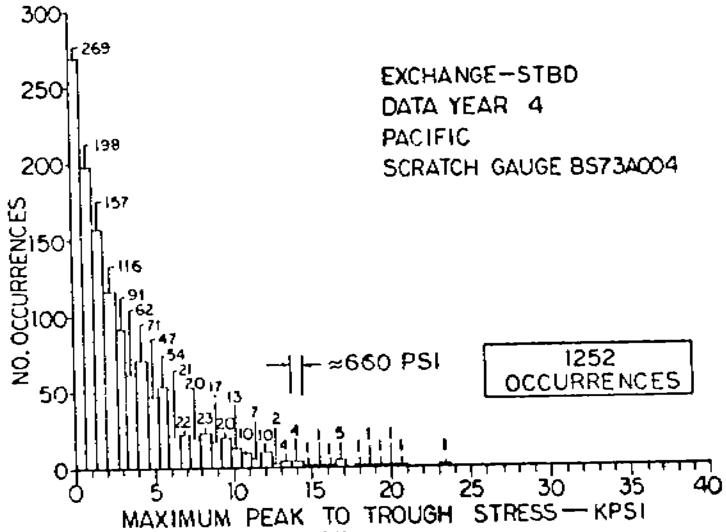

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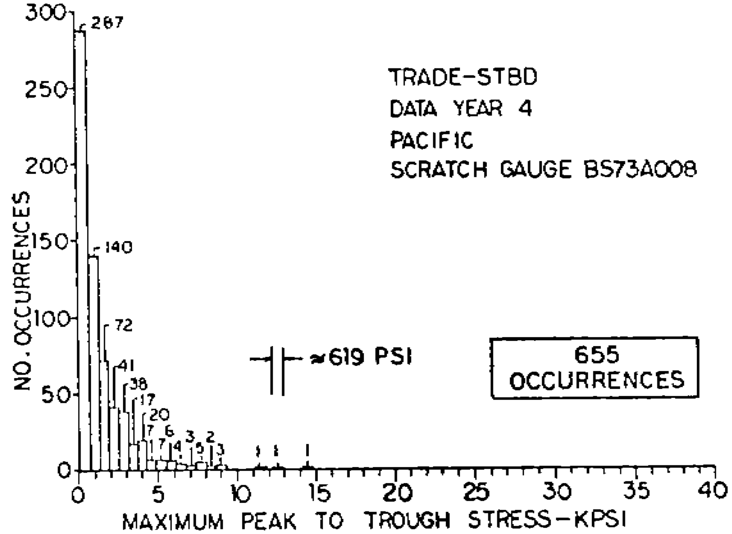

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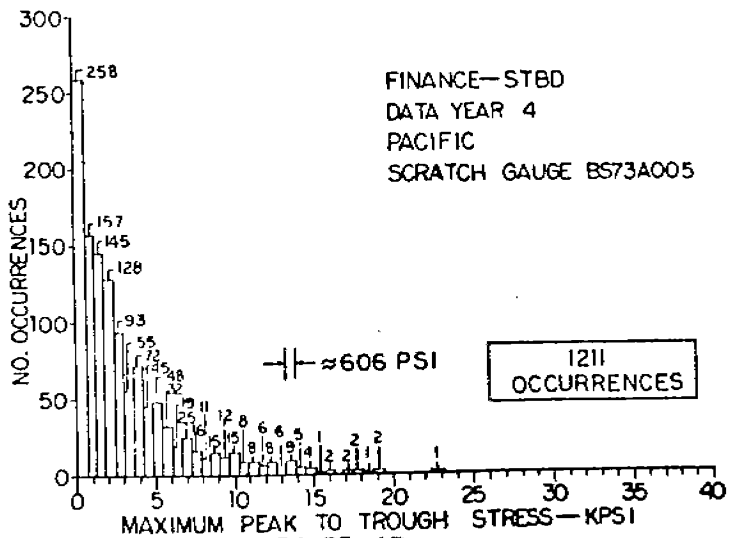

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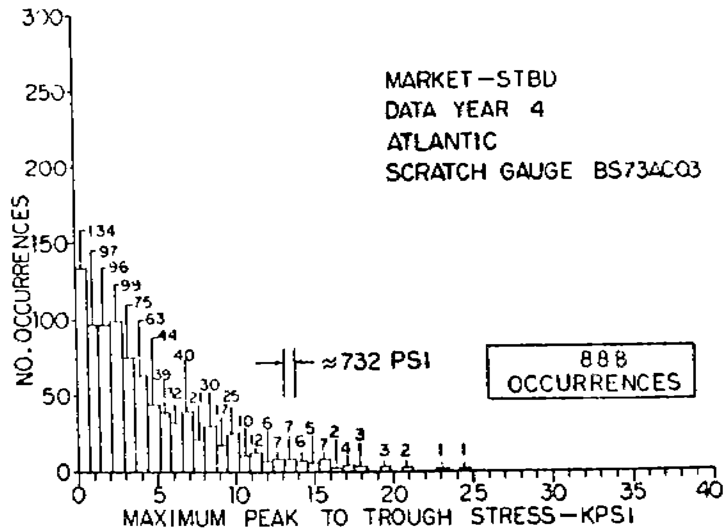
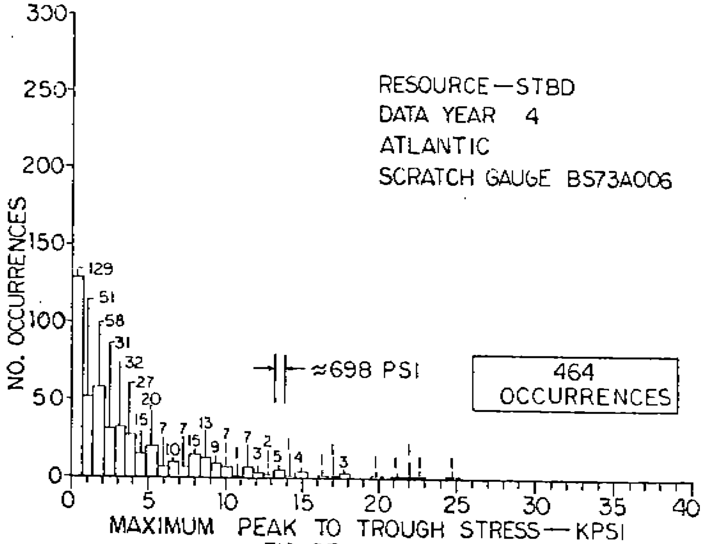


FIGURE 48



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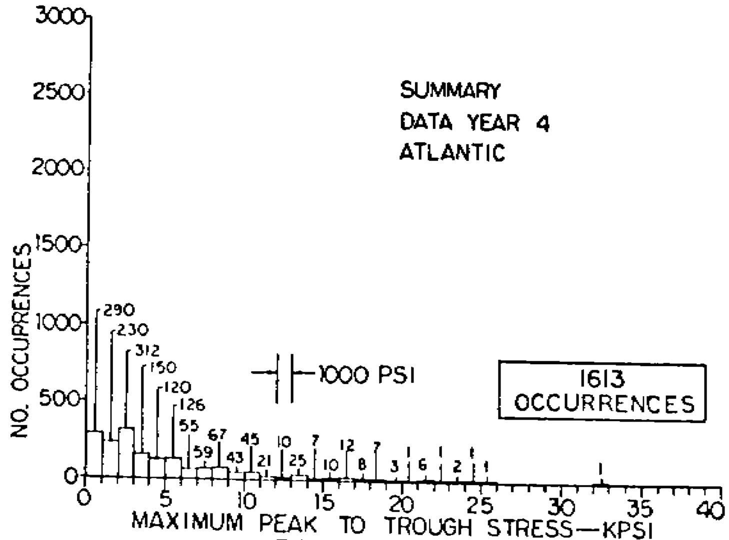


FIGURE 50

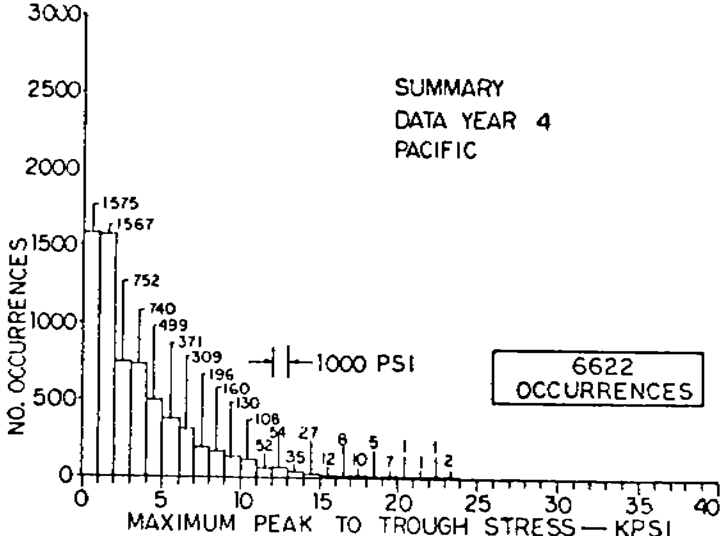


FIGURE 51

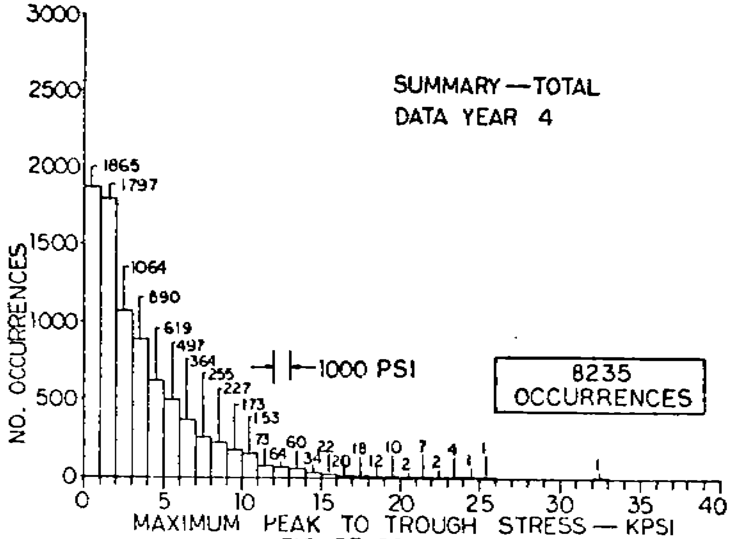


FIGURE 52

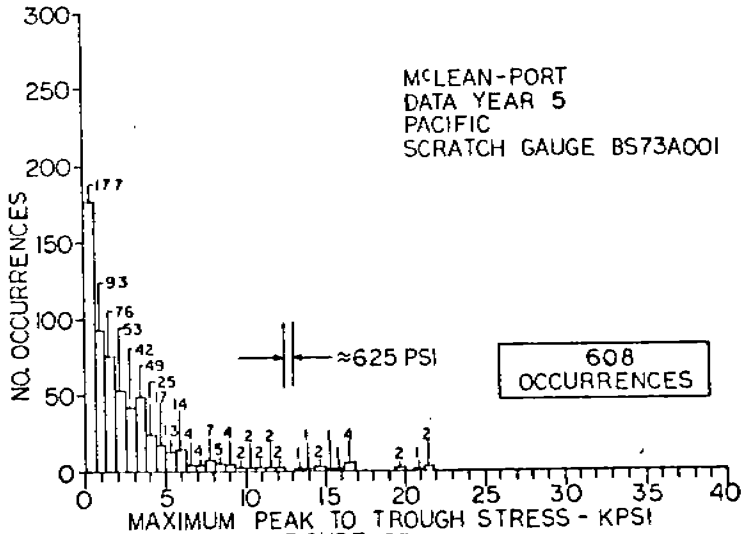
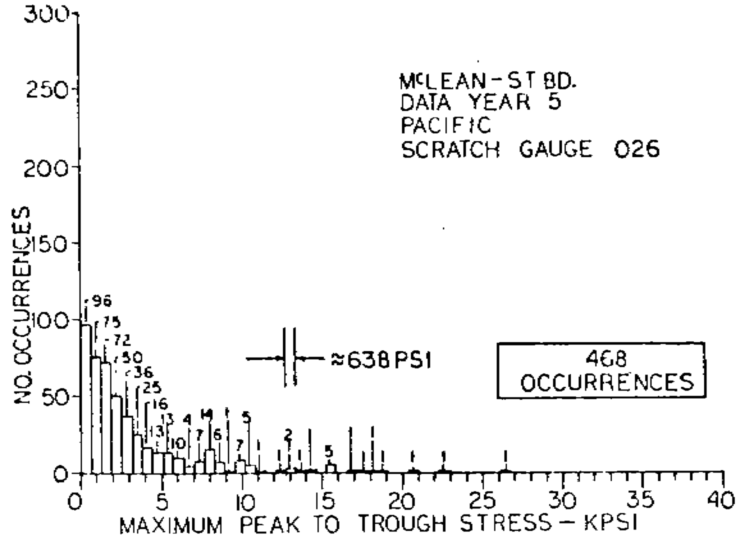


FIGURE 53



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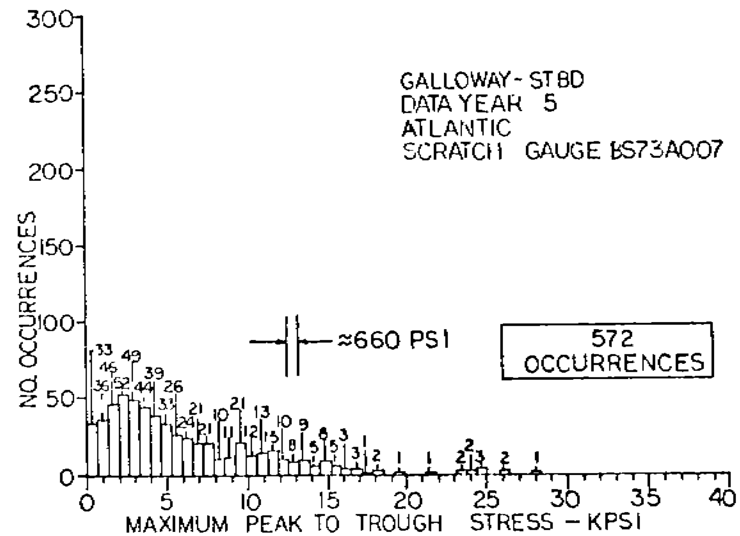
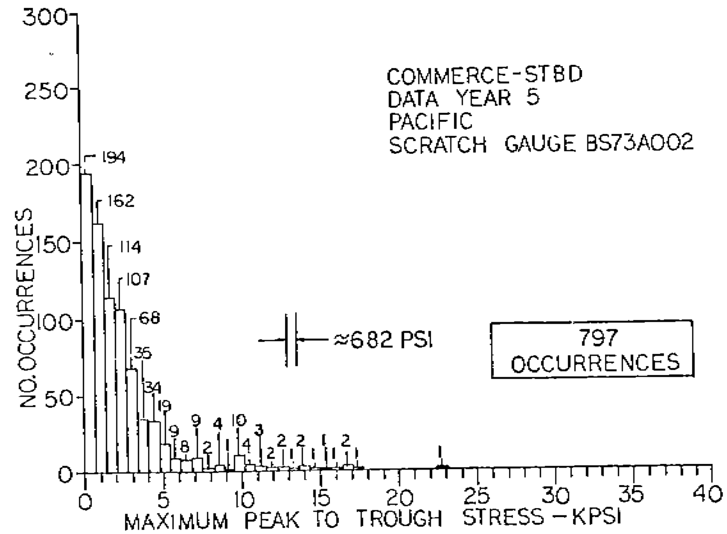


FIGURE 55



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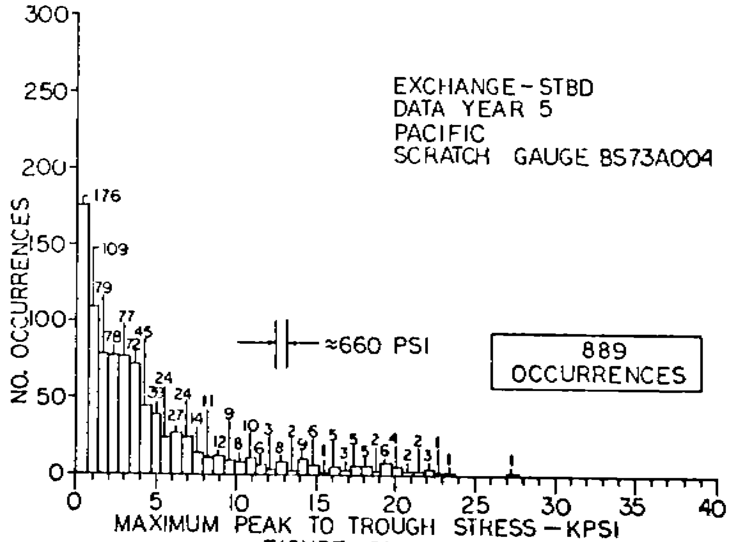

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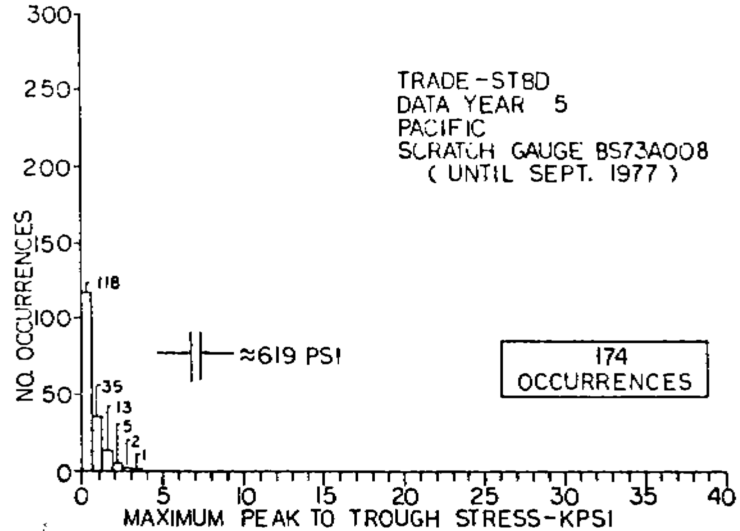

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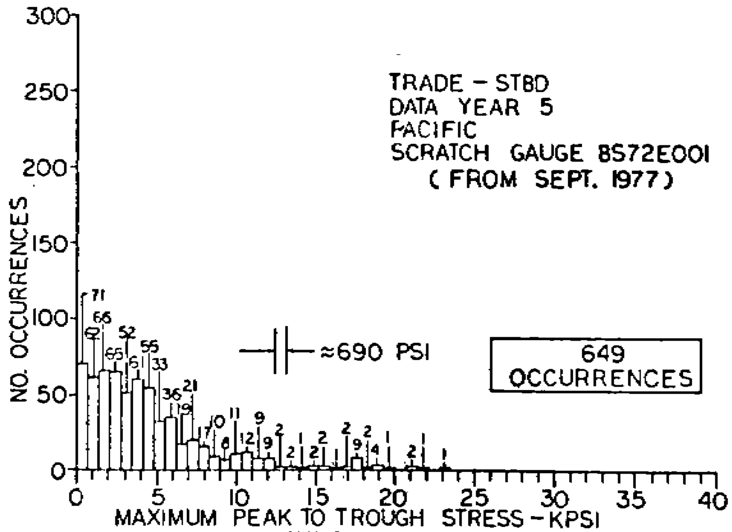

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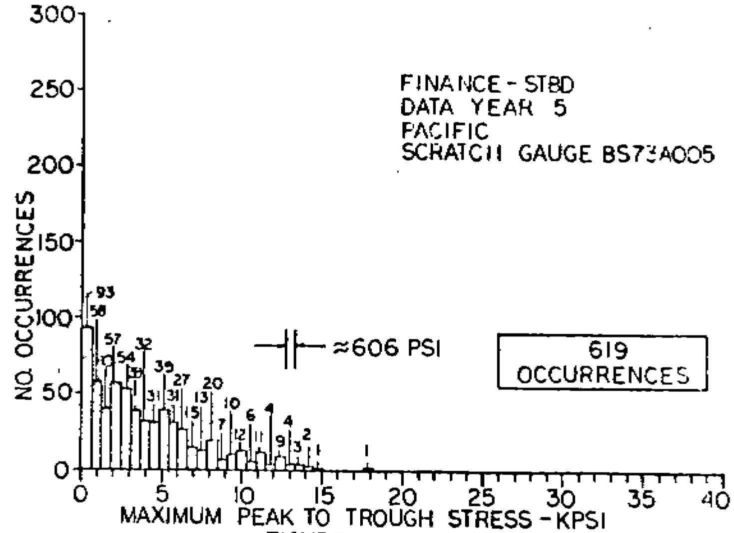

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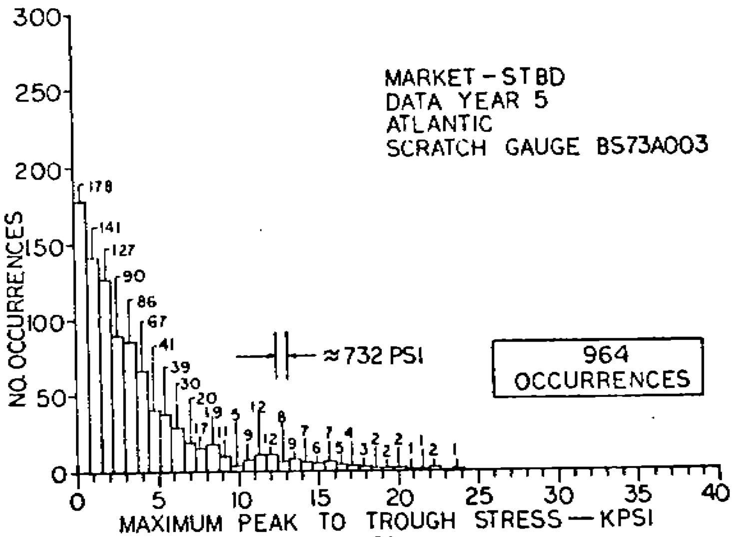


FIGURE 61

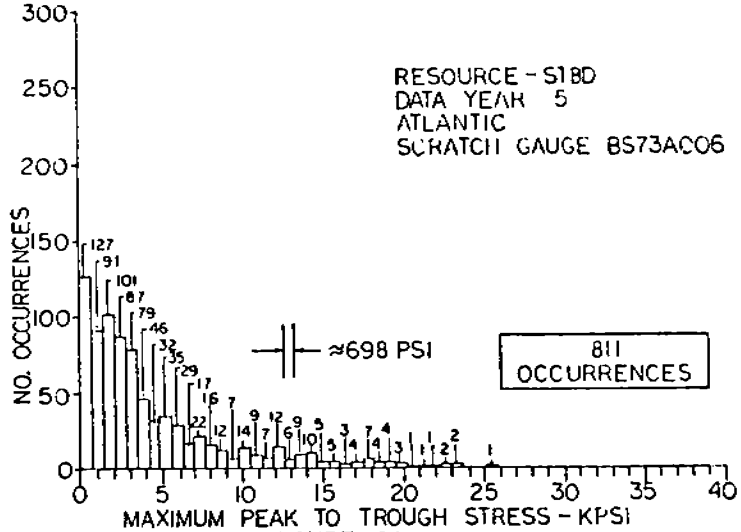


FIGURE 62

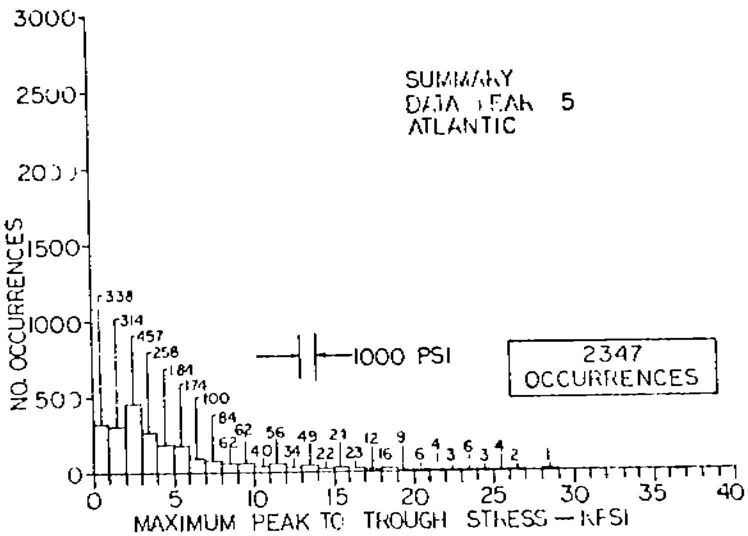


FIGURE 63

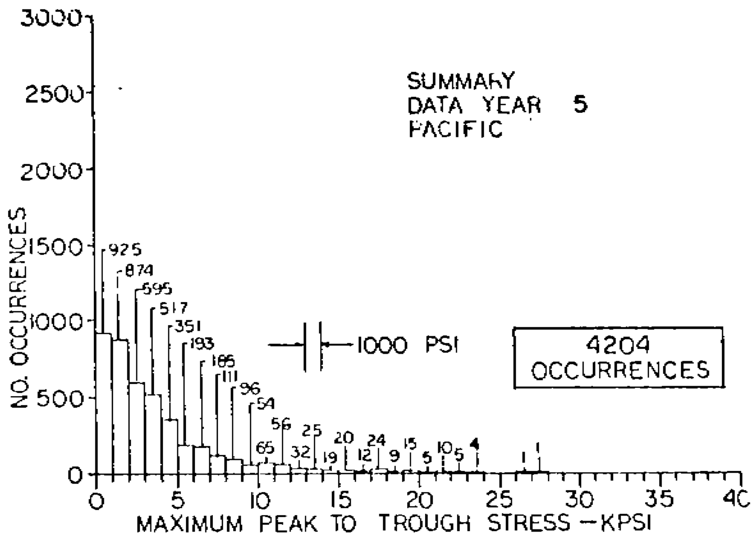


FIGURE 64

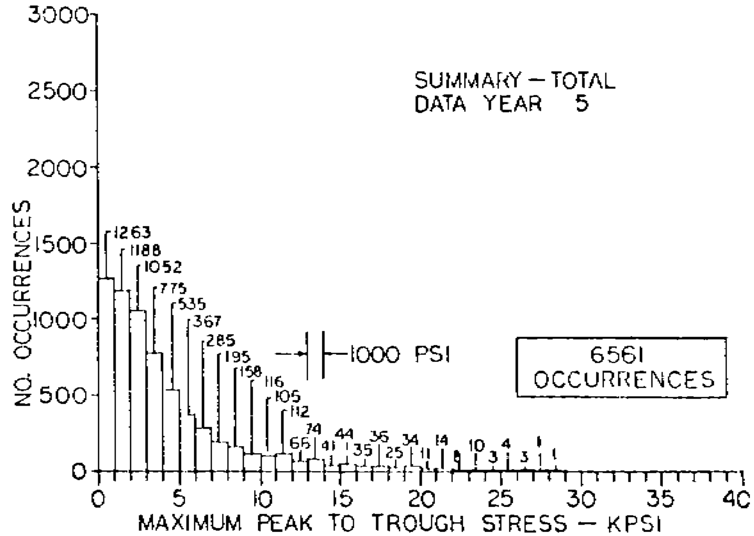


FIGURE 65

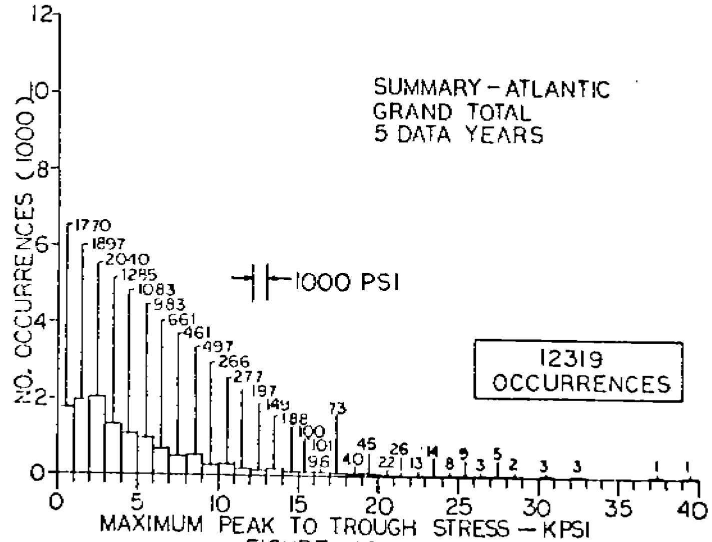


FIGURE 66

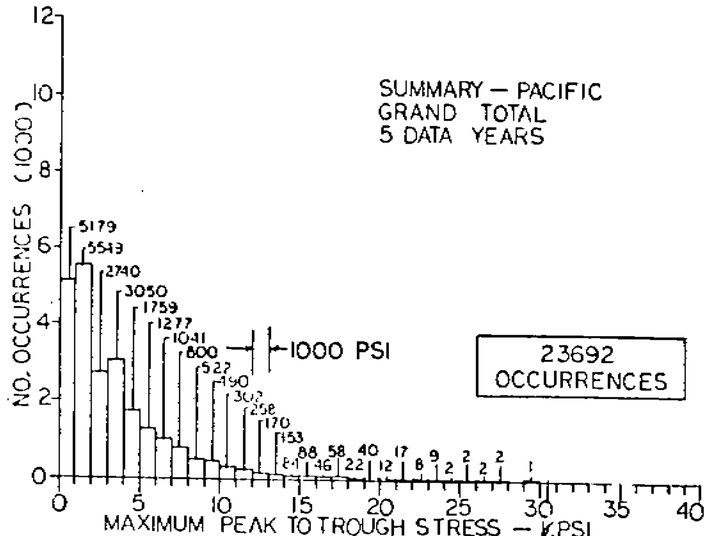


FIGURE 67

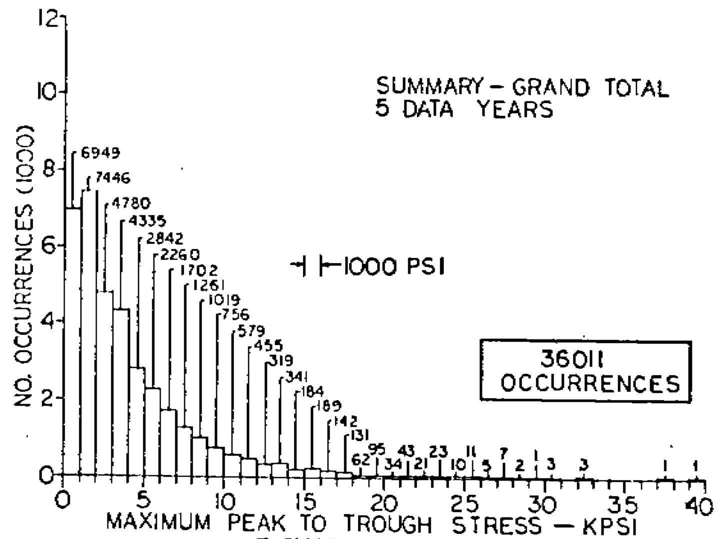


FIGURE 68

APPENDIX A

SCRATCH GAUGE INSTALLATION

1. GENERAL

The installation of a scratch-gauge recording system aboard an SL-7 involves the mounting and wiring of three major components; the gauge itself, the clock assembly and the protective enclosure. With the exception of the McLEAN, all vessels have single recorder installations located at approximately Frame 186 in the starboard longitudinal box girder (tunnel). The McLEAN has installations in both the port and starboard tunnels. Figure A-1 shows the physical relationship of the recorder location to the rest of the vessel. The installation is made on the second-from-the-deck outboard longitudinal girder either at Frame 186 1/4 or 186 3/4 depending upon local interference problems.

2. PREPARATION

At the installation site, all components are physically placed in position and clearances checked. To ensure a minimum of effect on the vessel structure, all components are bolted to 1/2 - 20 studs, which are welded to the steel with a stud welding machine. The first task is to mark all stud locations: six for the recorder,* four for the clock assembly and eight for the enclosure assembly.

Once the stud locations are marked each area is cleaned to bare metal with a handheld grinder and a center punch used to mark the stud center. This ensures that when the stud is welded a good clean weld is achieved.

---

*Although only 2 studs are required to mount the recorder, three pairs i.e. six studs were installed to provide spares in case of stud failure during the operational life. One such failure has occurred and the quick movement of the recorder to a spare set of studs was accomplished with a minimum of data loss.

3. INSTALLATION (Ref. Fig. A-2)

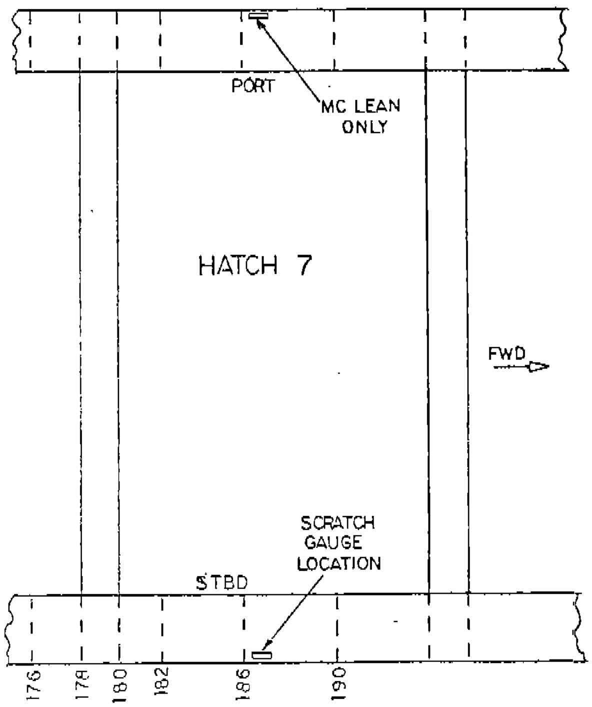
The clock assembly, the clock and its mounted plate, is bolted to the studs on the side shell. Next, the recorder is positioned and tightly secured. It is very important that the recorder studs be tight to ensure that the conical bearing points of the instrument are making good contact with the steel shelf.

The connecting cable from the clock to the recorder is then positioned and connected. With batteries in the clock unit, the hands are then physically turned to ensure the recorder advances at the desired 4-hour increments. When operation is satisfactory, the plexiglas enclosure (Fig. A-3) is positioned and bolted in place. Clear RTV (Room Temperature Vulcanizing) silicon rubber is then put around all edges to make a nearly watertight seal around the enclosure.

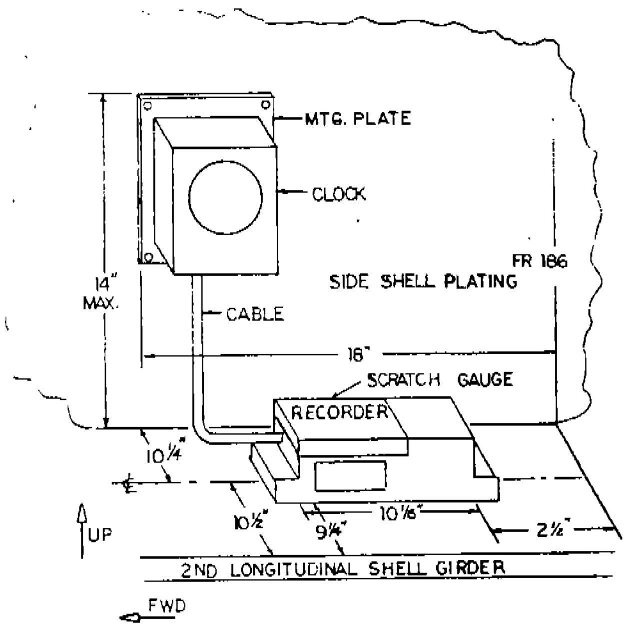
The lamp unit on the enclosure is wired to a local service of 115 V, 60 Hz, Single Phase power to operate the 40-watt lamp in the top.

A final check of the recorder ensures free movement of the stylus arm, and proper marking pressure on the paper tape. The clock is set to GMT and the front door of the enclosure closed.

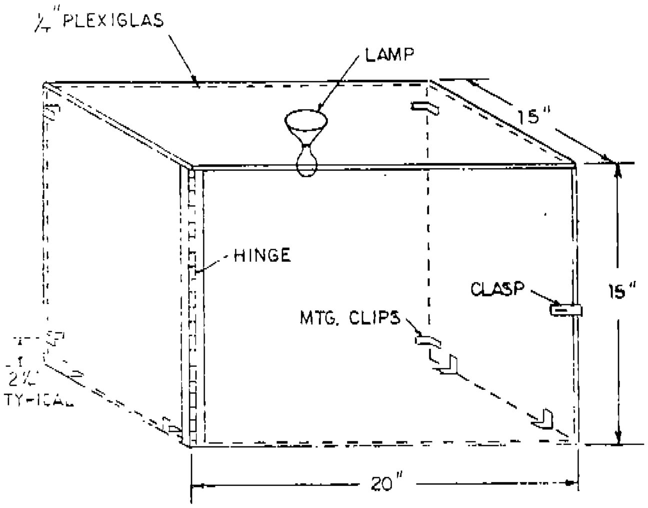
We have requested that the chief engineer mark the tape with the date at least once a week. Each roll of tape lasts approximately 3 months at which time both the tape and clock batteries should be changed. Spare tape, batteries, and lamp are kept inside each enclosure.



SHIP GAUGE LOCATION
FIGURE A-1



COMPONENT LAYOUT
FIGURE A-2



SCRATCH GAUGE ENCLOSURE

FIGURE A-3

TABLE B-1

STRAIN-GAUGE RECORDER CALIBRATION DATA
(Original)

GAUGE SERIAL NO. BS 72E 001 McLEAN
STBD TUNNEL FR 186 1/4

INDICATOR Compression (in)	DEFLECTION Tension (in)	POINTER DEFLECTION (IN)
0.0	0.0	0.0
0.002		0.176
0.004		0.350
0.006		0.540
0.008		0.688
0.009		0.768
0.0	0.0	0.00
	0.002	0.172
	0.004	0.338
	0.006	0.536
	0.008	0.692
	0.01	0.85

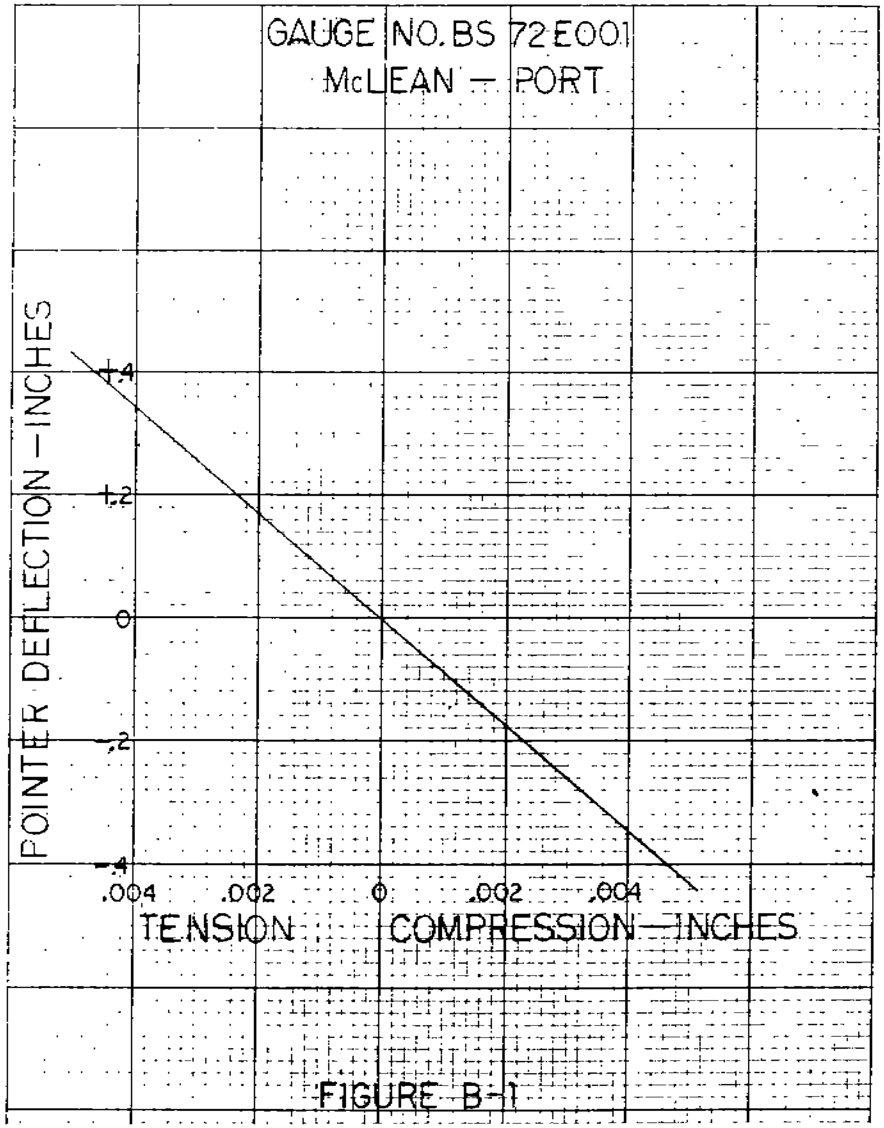


FIGURE B-1

TABLE B-2

STRAIN GAUGE RECORDER CALIBRATION DATA

GAUGE SERIAL NO. BS 72E 001
RECALIBRATION 11/26/75
OF McLEAN PORT GAUGE

INDICATOR Compression (inch)	DEFLECTION Tension (inch)	POINTER DEFLECTION (IN)
0.0	0.0	0.0
0.002		0.15
0.004		0.33
0.006		0.53
0.008		0.72
0.100		0.91
	0.0	0.0
	0.002	0.2
	0.004	0.37
	0.006	0.57
	0.008	0.76
	0.010	0.95

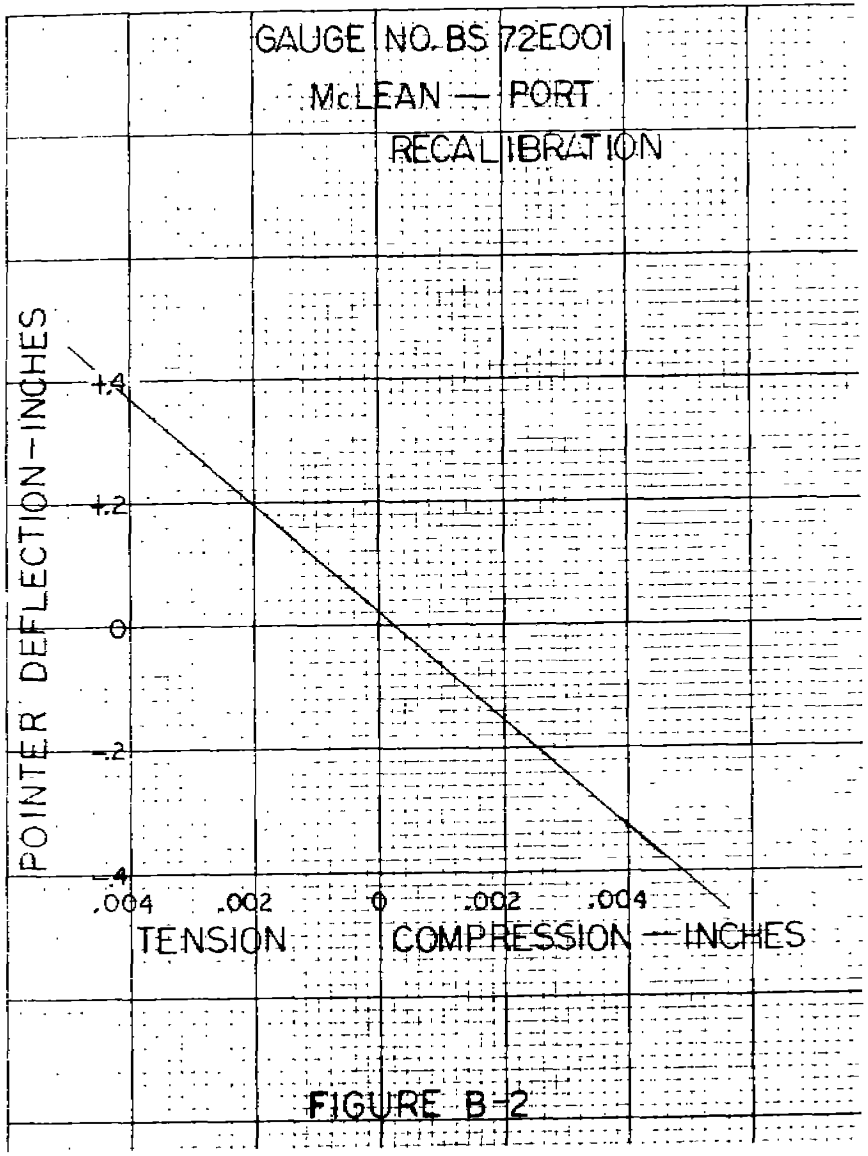


FIGURE B-2

TABLE B-3

STRAIN GAUGE RECORDER CALIBRATION DATA

GAUGE SERIAL NO. BS 73A 001
(SPARE UNIT INSTALLED AS
McLEAN PORT 10/18/75)

INDICATOR Compression (in)	DEFLECTION Tension (in)	POINTER DEFLECTION (in)
0.0	0.0	0.0
0.001		0.100
0.002		0.20
0.003		0.28
0.004		0.37
0.005		0.47
0.006		0.55
0.007		0.68
	0.0	0.0
	0.001	0.10
	0.002	0.20
	0.003	0.30
	0.004	0.38
	0.005	0.49
	0.006	0.58

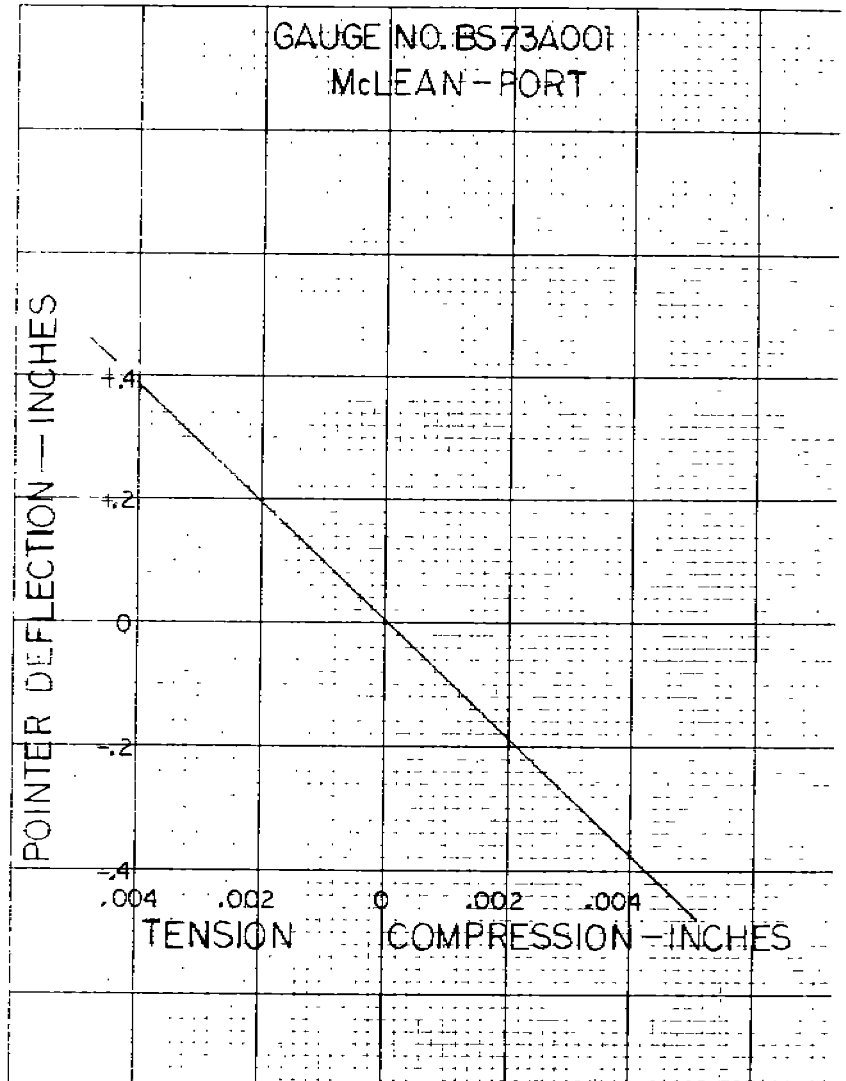


FIGURE B-3

TABLE B-4

STRAIN GAUGE RECORDER CALIBRATION DATA
GAUGE SERIAL NO. 026 McLEAN
STARBOARD TUNNEL FR 186 1/4

INDICATOR Compression (in)	DEFLECTION Tension (in)	POINTER DEFLECTION (IN)
0.0	0.0	0.0
0.002		0.170
0.004		0.378
0.006		0.558
0.008		0.716
0.0	0.0	0.0
	0.002	0.198
	0.004	0.388
	0.006	0.560
	0.008	0.712
	0.01	0.874
0.0	0.0	0.0

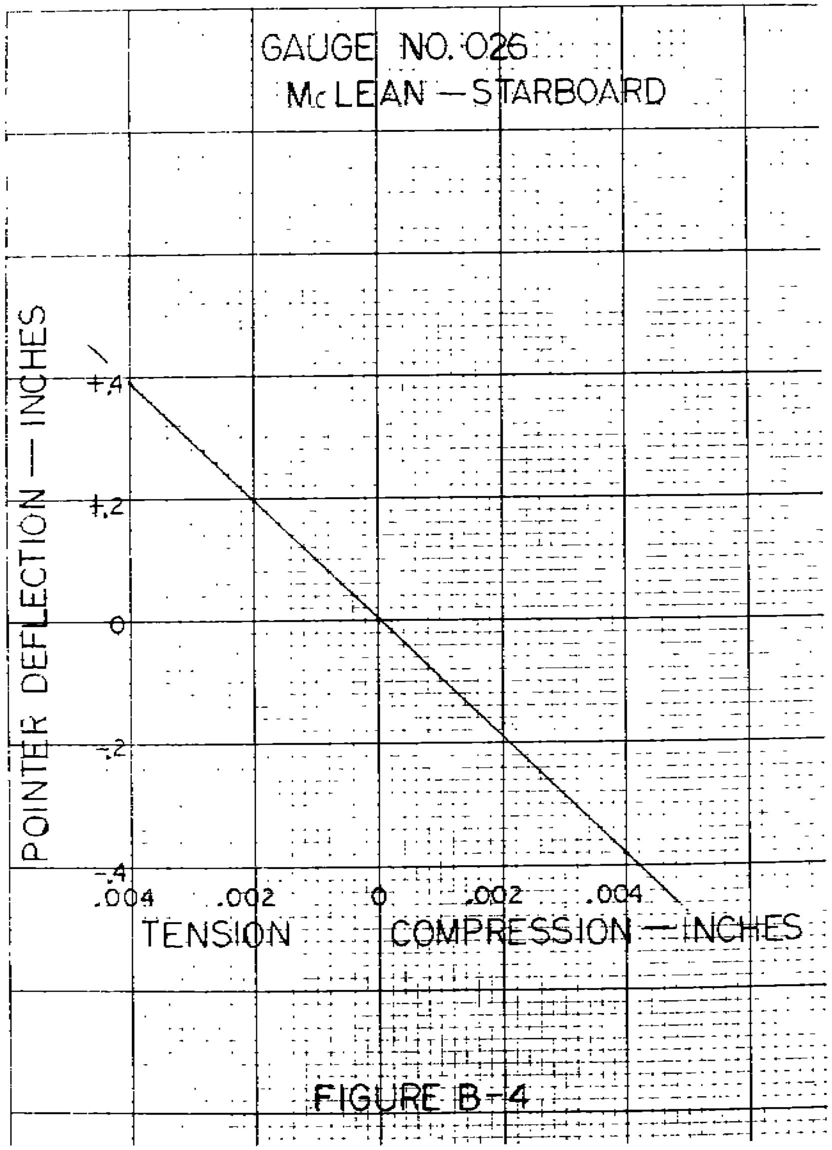


FIGURE B-4

TABLE B-5

STRAIN GAUGE RECORDER CALIBRATION DATA
GAUGE SERIAL NO. BS 73A 007 GALLOWAY
STBD TUNNEL FR 186 1/4

INDICATOR Compression (in)	DEFLECTION Tension (in)	POINTER DEFLECTION (IN)
0.0	0.0	0.0
.002		0.2
.004		0.38
.005		0.48
.006		0.51
.005		0.48
.004		0.39
.003		0.30
.002		0.16
.001		0.072
0.0	0.0	0
	.001	.12
	.002	.16
	.003	.28
	.004	.33
	.005	.45
	.006	.53
	0.0	0

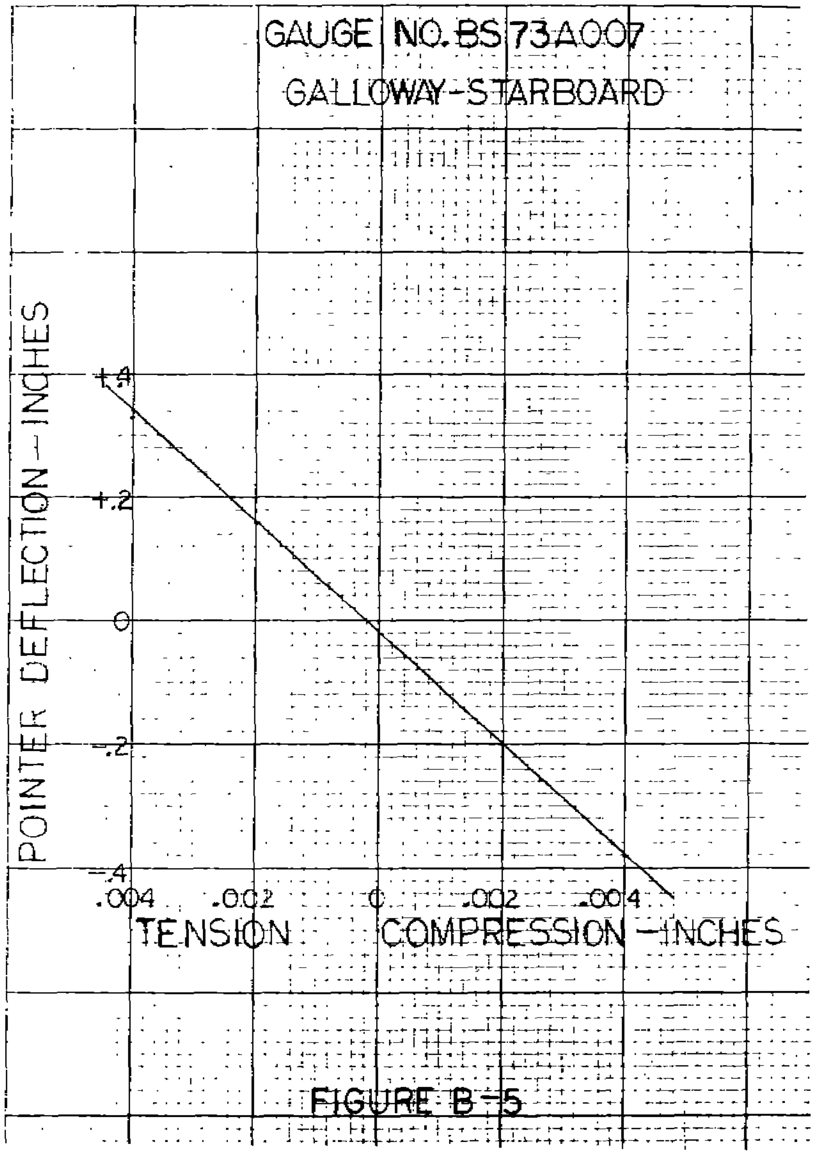


FIGURE B-5

TABLE B-6

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE NO. BS 73A 002
SEA-LAND COMMERCE STBD
TUNNEL FR 186 1/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.0		0.0
0.002		0.2
0.004		0.38
0.005		0.48
0.006		0.51
0.005		0.48
0.004		0.39
0.003		0.30
0.002		0.16
0.001		0.072
	0.0	0.0
	0.001	0.12
	0.002	0.16
	0.003	0.28
	0.004	0.33
	0.005	0.45
	0.006	0.53

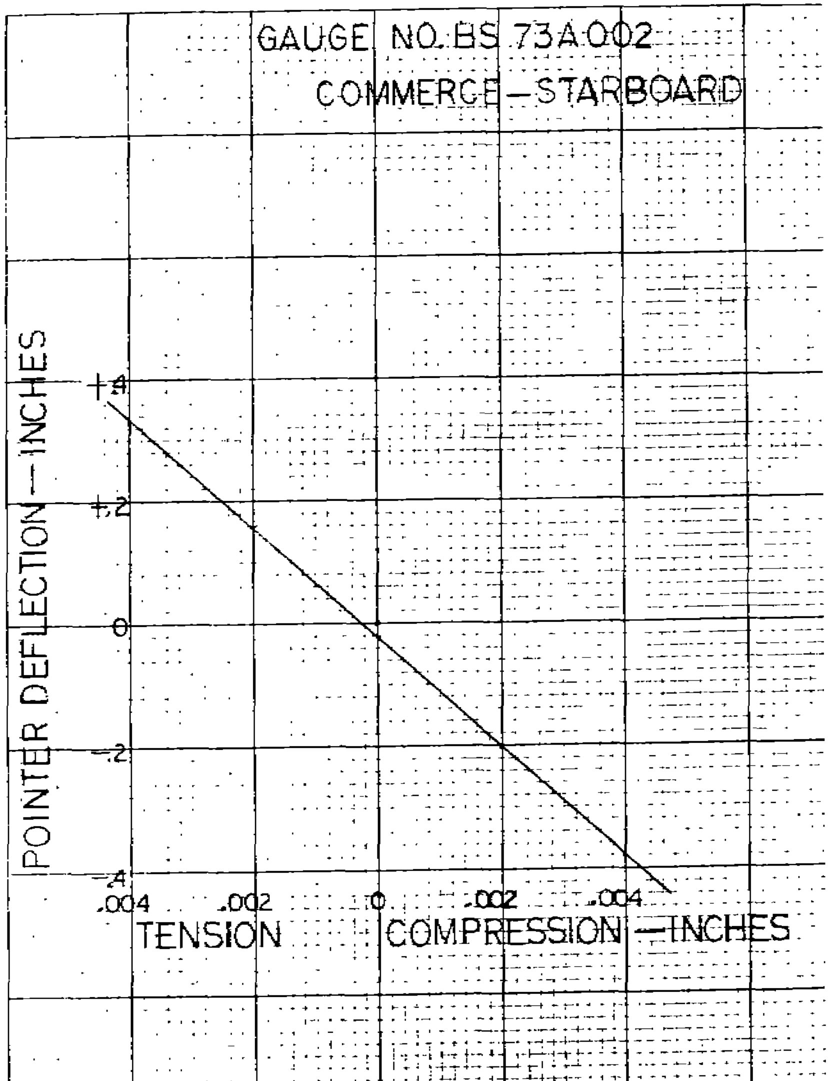


FIGURE B-6

TABLE B-7

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE SERIAL NO. BS 73A 004
SEA-LAND EXCHANGE STBD
TUNNEL FR 186 3/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.0		0.0
0.001		0.08
0.002		0.18
0.003		0.26
0.004		0.36
0.005		0.46
0.006		0.552
0.007		0.64
0.008		0.72
	0.0	0.0
	0.001	0.1
	0.002	0.18
	0.003	0.36
	0.004	0.44
	0.005	0.54
	0.006	0.64

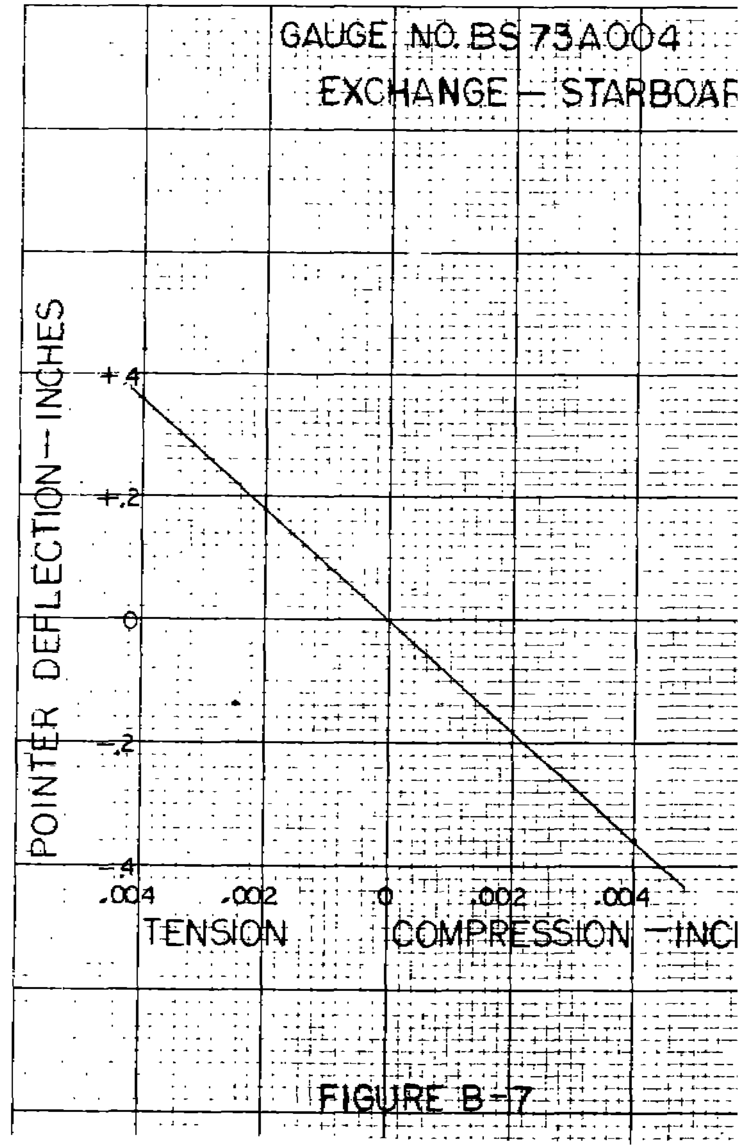


FIGURE B-7

TABLE B-8

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE SERIAL NO. BS 73A 008
SEA-LAND TRADE STBD
TUNNEL FR 186 3/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.0		0.0
0.001		0.128
0.002		0.232
0.003		0.252
0.004		0.408
0.005		0.50
0.006		0.60
	0.0	0.0
	0.001	0.06
	0.002	0.20
	0.003	0.28
	0.004	0.36
	0.005	0.46
	0.006	0.56

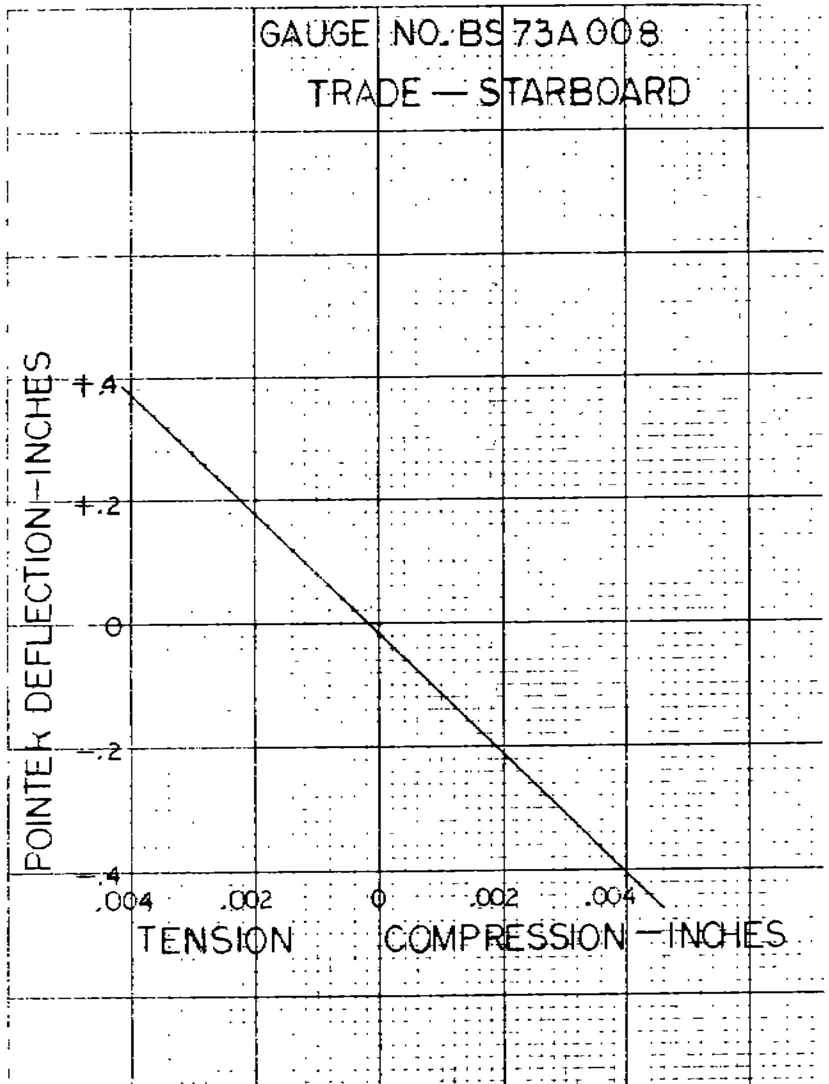


FIGURE B-8

TABLE B-9

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE SERIAL NO. BS 73A 005
SEA-LAND FINANCE STBD
TUNNEL FR 186 3/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.0		0.0
0.001		0.1
0.002		0.2
0.003		0.24
0.004		0.392
0.005		0.48
0.006		0.58
0.007		0.66
	0.0	0.0
	0.001	0.12
	0.002	0.20
	0.003	0.30
	0.004	0.40
	0.005	0.488
	0.006	0.60
	0.007	0.66
	0.008	0.76

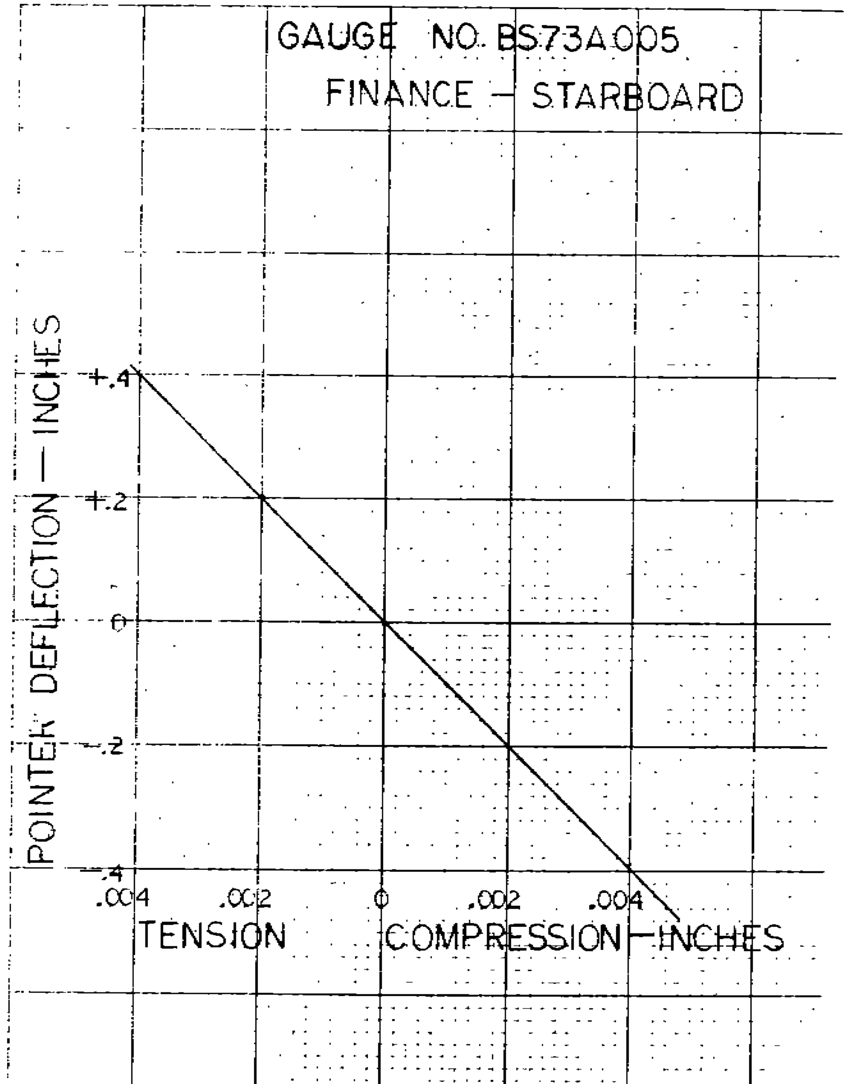


FIGURE B-9

TABLE B-10

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE SERIAL NO. BS 73A 003

SEA-LAND MARKET STBD

TUNNEL FR 186 1/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.0		0.0
0.001		0.1
0.002		0.18
0.003		0.26
0.004		0.34
0.005		0.41
0.006		0.48
0.007		0.58
	0.0	0.0
	0.001	0.1
	0.002	0.17
	0.003	0.26
	0.004	0.34
	0.005	0.42
	0.006	0.49
	0.007	0.56
	0.008	0.64

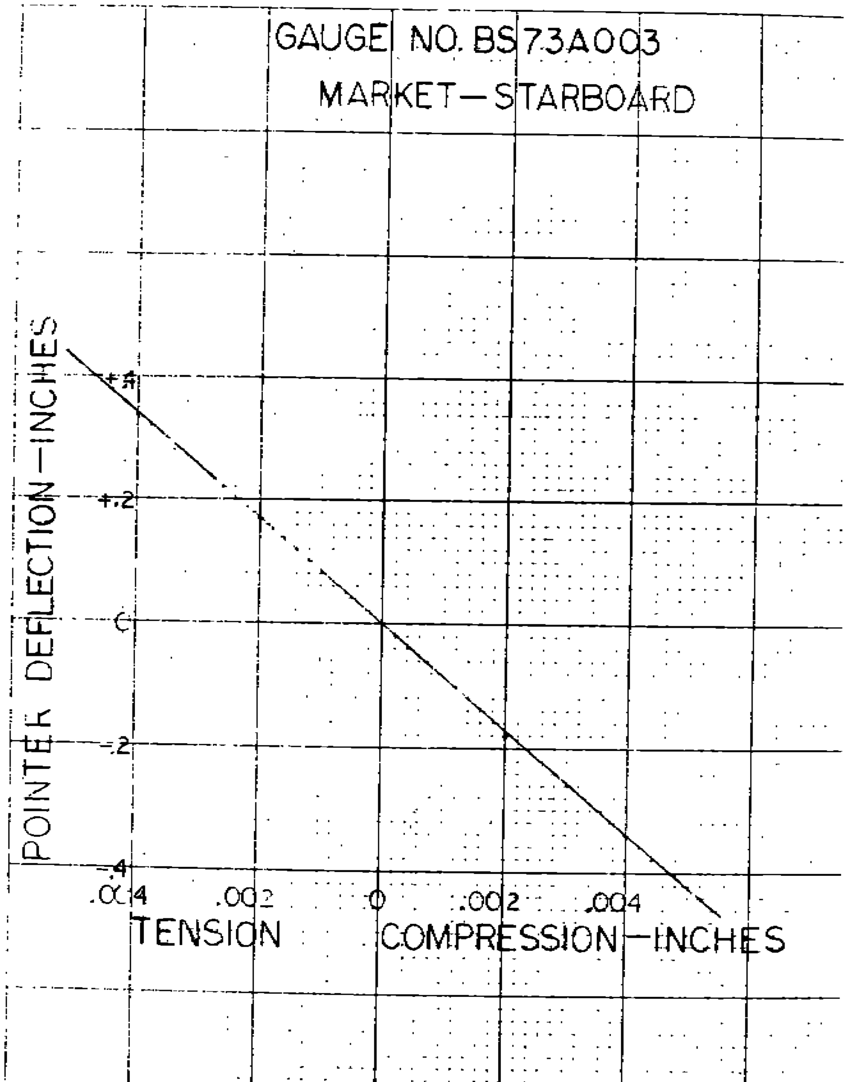


FIGURE B-10

TABLE B-11

STRAIN GAUGE RECORDER CALIBRATION
DATA GAUGE NO. BS 73A 006
SEA-LAND RESOURCE
STBD TUNNEL FR 186 1/4

INDICATOR Compression (In)	DEFLECTION Tension (In)	POINTER DEFLECTION (IN)
0.000		0.0
0.001		0.08
0.002		0.16
0.003		0.24
0.004		0.33
0.005		0.40
0.006		0.48
	0.000	0.00
	0.001	0.09
	0.002	0.18
	0.003	0.28
	0.004	0.36
	0.005	0.44
	0.006	0.54
	0.007	0.62
	0.008	0.70

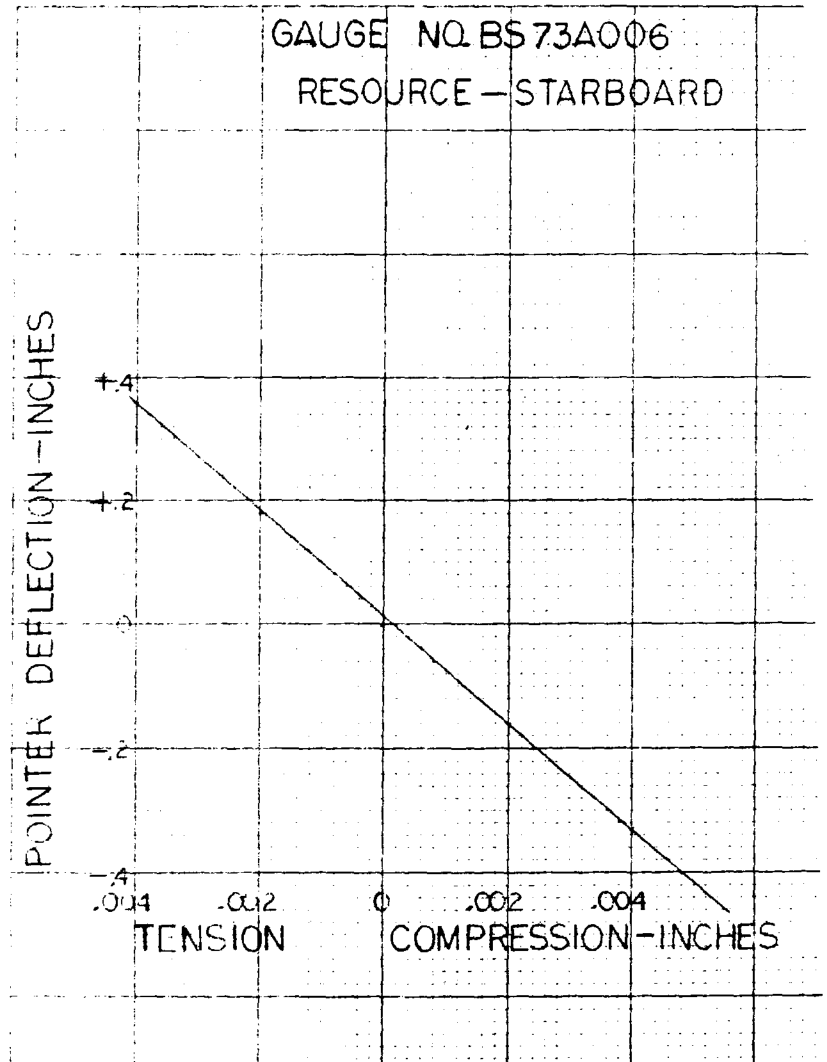


FIGURE B-11

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