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DRES

SUFFIELD TECHNICAL NOTE

NO. 257

REMOVAL OF THE REFLECTED PRESSURE PULSES FROM THE END OF A SHOCK TUBE (U)

by

W.A. Jones and F.L. McCallum

PROJECT NO. D-16-01-27
D-95-11-68

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ACKNOWLEDGEMENTS

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SUMMARY

This report summarizes the data obtained during the development of a reflection eliminator to prevent positive or negative pressure pulses, generated by shock wave interaction with the end of a shock tube, propagating back up the expansion chamber.

The study has shown that both the reflected positive and negative pressure pulses can be reduced to a very small amplitude by a flat plate placed at a predetermined distance downstream of the open end of the expansion chamber, or by a screen with adjustable openings attached to the open end of the expansion chamber.

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INTRODUCTION

1.0 Purpose

This report summarizes the various techniques developed at the Defence Research Establishment Suffield since 1963 to reduce the magnitude of the reflected pressure pulses from the end of a shock tube propagating back up the expansion chamber.

2.0 Background

Both of the Suffield Shock Tube and the Blast Simulation Laboratories are engaged in structural response research and military equipment evaluation programs. In support of this work, it has been necessary to develop techniques to eliminate the positive or negative pressure pulses generated at the end of the expansion section. When the end of the expansion chamber is open to the atmosphere, the expanding shock wave causes a rarefraction wave to propagate back up the expansion chamber. When the expansion chamber end is closed, a positive shock wave is reflected back up the expansion chamber. As the DRES shock tube driver systems have been designed to provide long positive durations in the various working sections, the propagation of either a positive or a negative pressure pulse from the end of the expansion chamber reduces the available testing time. To increase this testing time two approaches can be used. The first is to increase the overall length of the expansion chamber downstream of the working section, thus increasing the time interval between arrival of the primary shock wave and the arrival of the reflected wave. This modification to the existing Suffield shock tubes was not feasible due to the lack of available laboratory space. The second approach, which is the subject of this report, was to develop a device that would eliminate the reflected wave at the end of the expansion chamber.

The feasibility of this type of reflection eliminator was reported by Rudinger (1958). The first studies were initiated at Suffield in 1963 and led to the development of a flat plate eliminator that was attached at the end of the expansion chamber. The performance of this system was described by Muirhead (1964). Since 1964 various other authors, Zaguboylo and Tenenholtz (1964), Sadwin and Berman (1967) and Rowe (1967), have reported the use of the standoff reflection plate principle to eliminate shock tube end effects.

Using this system, standoff spacings for various incident overpressures have been established for the 2 x $1\frac{1}{2}$ inch, 2 x 12 inch, 17 x 17 inch and 72 inch diameter shock tubes.

A further series of investigations has shown that a reflection grid attached directly to the end of the expansion chamber will also act as an adequate eliminator device. A modification has also been made to the reflection plate to remove the small positive or negative pressure pulses that were not removed by the original flat eliminator devices.

The principle of operation of the eliminator is that a positive pressure wave or a rarefraction wave can be propagated back up the expansion chamber depending on the shock tube end configuration. By positioning a moveable end plate on the end of the expansion chamber and adjusting the distance between the end plate and the end of the expansion chamber, conditions can be found such that the positive and negative waves cancel one another. This shock wave interaction at the end plate is shown in the shadowgraph pictures in Fig. 1 and typical pressure time records illustrated in Fig. 2.

3.0 Test Procedures

Since eliminator systems were to be developed for the 2 x $1\frac{1}{2}$ inch (Jones, et. al, 1967), the 2 x 12 inch (Muirhead and McCallum 1957), the 17 x 17 inch (Jones, et al, 1968), and the 6 ft diameter (Patterson, 1967) shock tubes, this study was conducted in both the DRES Shock Tube and the Blast Simulation Laboratories.

The experimental data were obtained in these laboratories using the normal operating and recording equipment described by Jones, McCallum, et al (1967) for the Shock Tube Laboratory, and for the Blast Simulation Laboratory by Campbell, et al (1968). In both of these laboratories the transducer data are stored on 14 Track Tape Recorders. The pressure transducers were dynamically calibrated before and after each of the tests. Wherever possible, the incident shock wave velocity was monitored using a time interval counter placed across each of the pressure transducers, enabling the shock front overpressure to be checked by calculation. The eliminator development program was divided into the four evaluation phases listed below.

(a) Evaluation of the Reflection Plate Eliminator

To establish standoff settings or spacing between the expansion chamber and reflection plate at various overpressure levels and a relationship between various shock tube configurations and cross-sectional areas.

(b) Evaluation of Special Eliminator Configurations

(i) To establish the effects of placing a dump tank around the eliminator reflection plate.

(ii) To evaluate the use of a freely recoiling reflection plate.

(iii) To evaluate the use of a hinged reflection plate.

(c) Evaluation of a Grid Eliminator

To evaluate a variable area grid as an eliminator system.

(d) Evaluation of a Modified Reflection Plate Eliminator

To modity the original eliminator to remove all the minor returning pressure pulses not eliminated by the flat plate eliminator.

4.0 Results

4.1 Evaluation of the Reflection Plate Eliminator

To obtain reflection plate standoff settings, flat plates were attached to the end of the 2 x 12 inch and 2 x $1\frac{1}{2}$ inch shock tubes as shown in Fig. 3. On the 2 x $1\frac{1}{2}$ inch shock tube, the plate size tested was 2 x $1\frac{1}{2}$ inch; that tested on the 2 x 12 inch shock tube was 2 x 12 inch. To obtain each of the necessary standoff settings, the tubes were repeatedly fired at the same overpressure level until the proper standoff setting was established. Typical pressure-time records obtained at the end of the shock tubes are shown in Figs. 4 and 5. The standoff settings established for 5, 10, 15 and 20 psi incident overpressure levels at the end of the shock tube are listed in Table 1 and plotted in Fig. 6.

TABLE 1

Reflection Plate Standoff Settings For The 2 x $1\frac{1}{2}$ Inch, And 2 x 12 Inch Shock Tubes

Reflection Plate Size	Standoff Settings (cm) for Various Shock Tube Incident Overpressures			
	5 psi	10 psi	15 psi	20 psi
2 x $1\frac{1}{2}$ inch	0.6	0.85	1.1	1.3
2 x 12 inch	1.2	1.8	2.3	2.7

The typical pressure-time histories show that the reflected positive or negative pressure pulses can be reduced in the shock tube working section to a low amplitude, short duration pressure spike.

To allow reflection plate standoff predictions to be made for various tube sizes, the experimental data listed in Table 1 were compared using an opening constant defined as:

$$\text{Opening Constant} = \frac{\text{Inside Perimeter of Shock Tube x Gap}}{\text{Cross-Sectional Area of Shock Tube}}$$

The opening constants determined for the 2 x 12 inch and 2 x $1\frac{1}{2}$ inch shock tubes are listed in Table 2.

TABLE 2

Comparison of Opening Constants For 2 x $1\frac{1}{2}$ Inch And 2 x 12 Inch Shock Tubes

Reflection Plate Size	Opening Constant for Various Incident Overpressures			
	5 psi	10 psi	15 psi	20 psi
2 x $1\frac{1}{2}$ inch	0.56	0.78	1.02	1.20
2 x 12 inch	0.55	0.75	1.05	1.16

Since the 2 x 12 inch, and 2 x $1\frac{1}{2}$ inch opening constants were roughly equivalent, it should be possible to predict the various standoff settings for other shock tube sizes using this eliminator technique. Reference is made later in this report to the use of these opening constants to determine the standoff settings for the more complex eliminators designed for use on the 17 x 17 inch and 6 ft diameter shock tubes.

4.2 Evaluation of Special Eliminator Configurations

(a) Effect of Placing a Dump Tank Around the Eliminator Reflection Plate

To reduce internal building blast loading caused by the exhausting incident shock wave, a dump tank was constructed around the eliminator to the dimensions shown in Fig. 7. Using this system the incident shock wave is prevented from expanding directly into the laboratory.

Standoff settings were established for 5, 10 and 20 psi incident shock fronts. The established standoff settings and opening constants are listed in Table 3 and plotted in Fig. 6. The trial data indicate that slightly larger opening constant values were needed than would have been predicated using the 2 x $1\frac{1}{2}$ inch shock tube trial data. These larger opening constant values are possibly due to the restricted free field expansion limitation caused by the dump tank volume.

Typical pressure-time records obtained 465 cm upstream of the eliminator are shown in Fig. 8 and indicate that the pressure-time profile is quite similar to that obtained in the 2 x $1\frac{1}{2}$ inch and 2 x 12 inch shock tubes.

TABLE 3

Standoff Settings and Opening Constants For 2 x $1\frac{1}{2}$ Inch, 17 Inch and 6 Ft Diameter Shock Tubes

Shock Tube	Plate Size	Standoff Settings (cm) For Various Incident Overpressures (psi)				Opening Constants For Various Incident Overpressures (psi)			
		5	10	15	20	5	10	15	20
2 x $1\frac{1}{2}$ inch	2 x $1\frac{1}{2}$ inch	0.6	0.85	1.1	1.3	0.56	0.78	1.02	1.2
17 inch (with dump tank)	17 x 17 inch	7	9	12	15	0.64	0.83	1.11	1.39
6 foot	6 ft diameter	28	38	48	56	0.61	0.83	1.05	1.22

(b) Use of a Recoiling Reflection Plate

Since the horizontal force generated at the reflection plate increases with the plate frontal area, a very large translational or recoil force would be present if the 2 x $1\frac{1}{2}$ inch eliminator design were adapted for a 6 ft diameter shock tube.

For ease of operation and control of this force a reflection plate was installed on the moveable mount shown in Fig. 9, for use on the 6 ft diameter shock tube. Standoff and opening constants were obtained and the results are listed in Table 3 and plotted in Fig. 6. This trial data indicates that the opening constants are similar to the opening constant predictions established using the 2 x $1\frac{1}{2}$ inch and 2 x 12 inch shock tube data.

The pressure-time records monitored 10.4 meters upstream and shown in Fig. 10 are also similar in profile shape to that obtained in the original trials.

It was found that limited translational recoil was developed using the moveable test section (approximate weight 3.5 tons). These recoil distances are listed in Table 4. It can be seen from this data that no major recoil problem exists.

TABLE 4

Translational Recoil in the 6 Ft Diameter Shock Tube

Incident Overpressure (psi) At end of Expansion Chamber	Rolling Car Horizontal Recoil Opening Before Shot (inches)	Opening After Shot (inches)
5	10	11 3/4
5	11 3/4	11 3/4
5	11 5/8	11 5/8
10	15	35
14.5	15	55
18	18	64
18	20	113 1/2
21	18	120
	22	141 3/8

(c) Use of an Adjustable Hinged Reflection Plate

As part of the overall evaluation on various reflection plate configurations, it was decided to test the segmented hinged reflection plate shown in Fig. 11 (a). Using this configuration, the reflection plate angle could be adjusted to control the magnitude of the reflected positive or negative pressure pulses.

The evaluation study was completed on the 2 x $1\frac{1}{2}$ inch shock tube where it was found from repeated trials at an incident overpressure level of 6.0 psi and a hinge angle of 150° (total included angle between each reflection plate) this configuration functioned in a similar manner to the flat plate eliminator. The typical pressure-time records shown in Fig. 11(b) indicate that the profile shapes are similar to that obtained during all of the previous blast trials. No attempt was made to calibrate the hinged reflection plate at various other incident overpressure levels.

4.3 Evaluation of a Grid Eliminator

To reduce both the manufacturing cost and translational loading in the design of an eliminator configuration for very large shock tubes a study was made of a grid reflection eliminator to replace the normal reflection plate. Using this system the incident shock wave will reflect off the solid grid area and also expand through the grid openings. This study was completed using two grid sizes. The grids were attached to the end of the shock tube and the incident overpressures levels were increased until the level was found at which the negative and positive returning pressure pulses balanced each other. Shown in Fig. 12 are the monitored pressure-time profiles illustrating the efficiency of a grid eliminator system. In a large shock tube it is possible that the grid could be replaced by vertical steel cables. The number of cables used could control the relative strengths of the negative and positive pressure pulses, thus achieving the same effect as a reflecting plate eliminator with variable settings. It is also possible that the longitudinal force loading would be reduced using a grid system hence reducing the recoil problems on large shock tubes.

4.4 Evaluation of a Modified Reflection Plate

As the reflection plate elimination devices used by DRES could not be adjusted with sufficient accuracy to completely remove the reflection pressure pulses, a study was undertaken to find a means of removing more completely the reflected pressure pulses. The modification shown in Fig. 13 included the addition of a solid cover shroud around the reflection plate. The configuration allowed adjustments to be made to the recess of the reflection plate inside the shroud and to the normal air gap standoff setting between the shroud and the end of the tube. Using this modification the incident shock wave expands across the normal standoff setting causing a rarefraction wave to propagate back up the tube. The incident wave also travels down the shroud, reflecting from the enclosed reflection plate, and as it again crosses the standoff setting a second rarefraction wave is generated which moves back up the tube. By adjusting both the standoff setting and the reflection plate recess, it was found that the small returning positive or negative pressure pulse could be eliminated as shown in Figs. 14 and 15. The established reflection plate adjustments are listed in Table 5.

TABLE 5

Reflection Plate Standoff and Recess Setting Using a Modified Eliminator System on 2 x $1\frac{1}{2}$ Inch and 2 x 12 Inch Shock Tube

Shock Tube Size	Eliminator Settings	Settings (cms) For Various Incident Overpressure Levels			
		5 psi	10 psi	15 psi	20 psi
2 x $1\frac{1}{2}$ inch	- Standoff setting	0.6	0.85	1.1	1.3
	- Recess setting	1.4	1.65	1.9	2.1
2 x $1\frac{1}{2}$ inch	Original Reflection Plate Standoff	0.6	0.85	1.1	1.3
2 x 12 inch	- Standoff setting	0.9	1.6	2.3	2.6
	- Recess setting	1.3	2.0	2.7	3.0
2 x 12 inch	Original Reflection Plate standoff	1.1	1.8	2.3	2.7

CONCLUSIONS

The results of this development program are:

(a) Reflection eliminators have been successfully developed for use on various DRES shock tubes.

(b) Using the opening constants established in the various DRES shock tubes, eliminator design parameters have been established for various sizes of shock tubes.

(c) The eliminator will function inside a dump tank.

(d) A recoiling reflection eliminator configuration can be used on larger shock tubes.

(e) The reflecting plate if mounted in a cavity will allow complete removal of reflection pressure pulses.

FURTHER STUDIES

On the basis of this work, the following studies are proposed:

(a) An investigation to determine if the shock wave air particle velocity in the shock tube working section is affected by the use of an eliminator.

(b) The evaluation of the grid eliminator principle on the 6 ft diameter shock tube.

REFERENCES

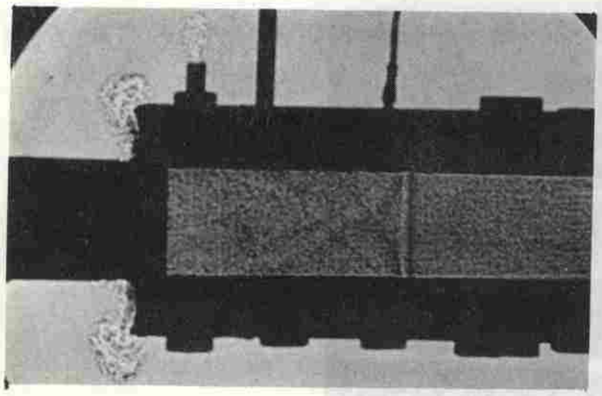
Campbell, R. L., W. A. Jones and J. S. Watson	1968	"DRES Blast Simulation Complex". Suffield Technical Note No. 233. UNCLASSIFIED.
Jones, W. A. and F. L. McCallum	1967	"Method of Increasing Shock Wave Positive Duration with DRES Shock Valves". Suffield Memorandum No. 100/67. UNCLASSIFIED.
Jones, W. A., F. L. McCallum and L. W. Tamke	1968	"Construction and Evaluation of a 17 inch Flexible Diaphragm Shock Wave Valve". Suffield Memorandum No. 32/68. UNCLASSIFIED.
Jones, W. A. and F. L. McCallum	1968	"DRES Shock Tube Facilities". Suffield Memorandum No. 14/68. UNCLASSIFIED.
Muirhead, J. C.	1964	"The Applied Physics Group - A Reference Manual". Suffield Special Publication No. 44. UNCLASSIFIED.
Muirhead, J. C. and F. L. McCallum	1960	"Suffield Experimental Station Shock Tube Instrumentation. IV. Calibration of the 12" Shock Tube". Suffield Technical Note No. 41. UNCLASSIFIED.
Patterson, A. M.	1967	"Canadian Blast Simulation Facilities". Suffield Memorandum No. 15/67. UNCLASSIFIED
Rowe, R.	1967	"Design of a Reflection Elimination Device for Use on the AWRE Tube". Private Correspondence.

REFERENCES (continued)

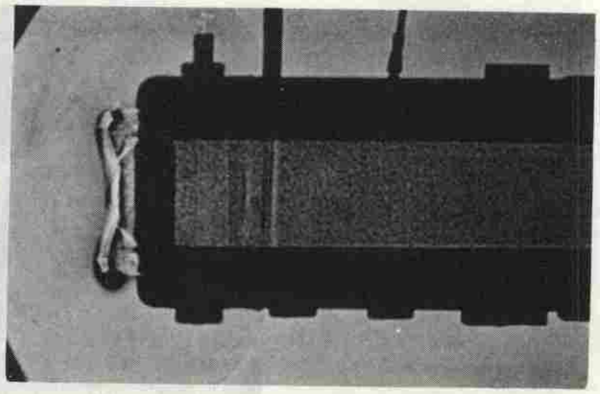
Rudinger, G. 1958 "A Shock Tube Technique to Determine Steady Flow Losses of Orifices and Other Duct Elements". Trans. A. S. M. E. Paper No. 59, HYD-13.

Sadwin, I. D. and J. Berman 1967 "Reflection and Rarefraction Elimination in Conical Tubes". Military Applications of Blast Simulators, DRES, 18-21 July, 1967.

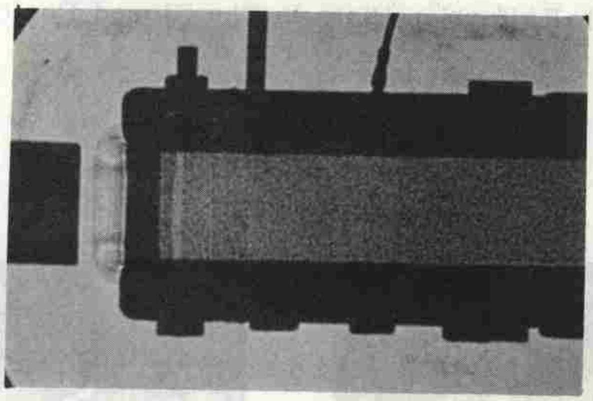
Zaguboylo, W. and S. D. Tenenholtz 1964 "The Effect of a Baffle on Shock Wave Modifications Due to Reflected Waves". Jr. of Environmental Sciences, Vol. 7, No. 2.



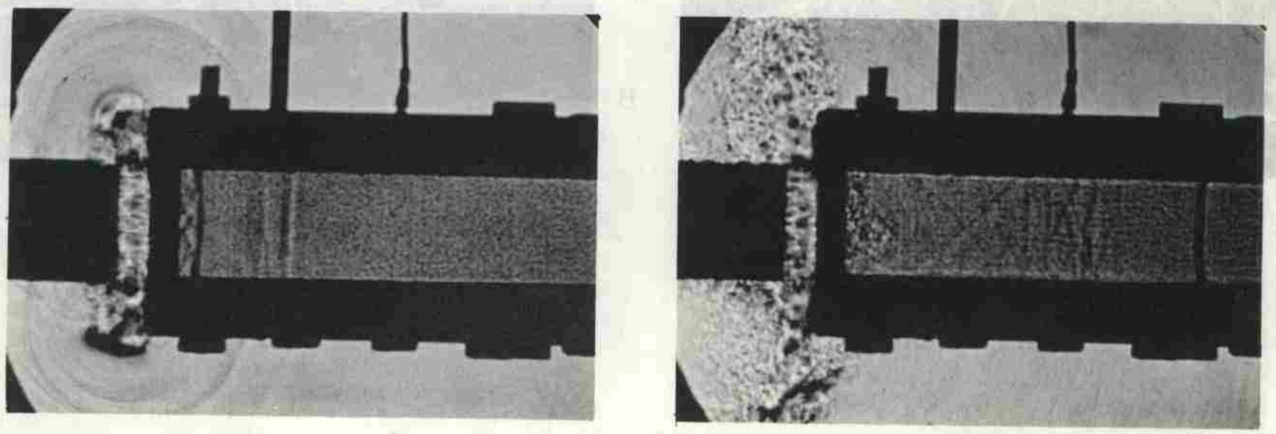
Open End



Closed End

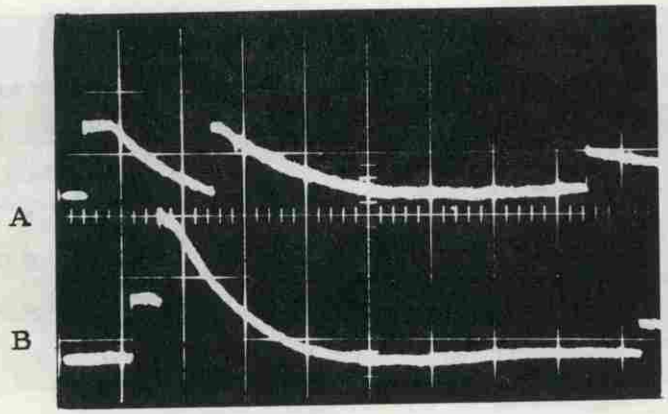


Initial Shock Wave Expansion

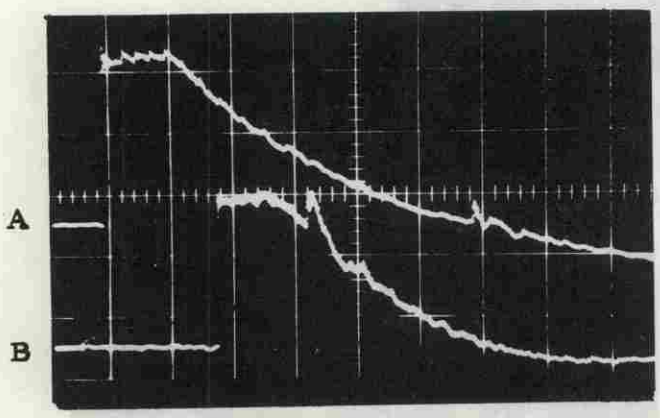


Rarefraction and Reflected Waves Propagating Back Up The Tube

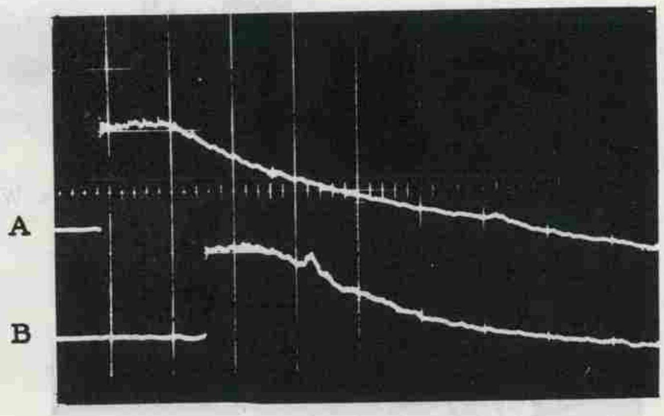
FIG 1 - INCIDENT SHOCK WAVE INTERACTION WITH REFLECTION PLATE ELIMINATOR MOUNTED ON 2" x 1/2" SHOCK TUBE



(A) Reflection Plate In The Closed Position
ΔP_4 - 37 P.S.I.G.
Sweep - 10 msec/div.



ΔP_4 - 37 P.S.I.G.
Sweep - 5 msec/div.
Plate size - 8" x 14"
Standoff - 2cm



ΔP_4 - 70 P.S.I.G.
Sweep - 5 msec/div.
Plate size - 8" x 14"
Standoff - 2.5cm

Trace "A" Position 158.6cm From Tube Termination
Trace "B" Position 54.2cm From Tube Termination

FIG 2 - TYPICAL PRESSURE-TIME RECORDS USING REFLECTION PLATE ELIMINATOR ON 2" x 1 1/2" SHOCK TUBE

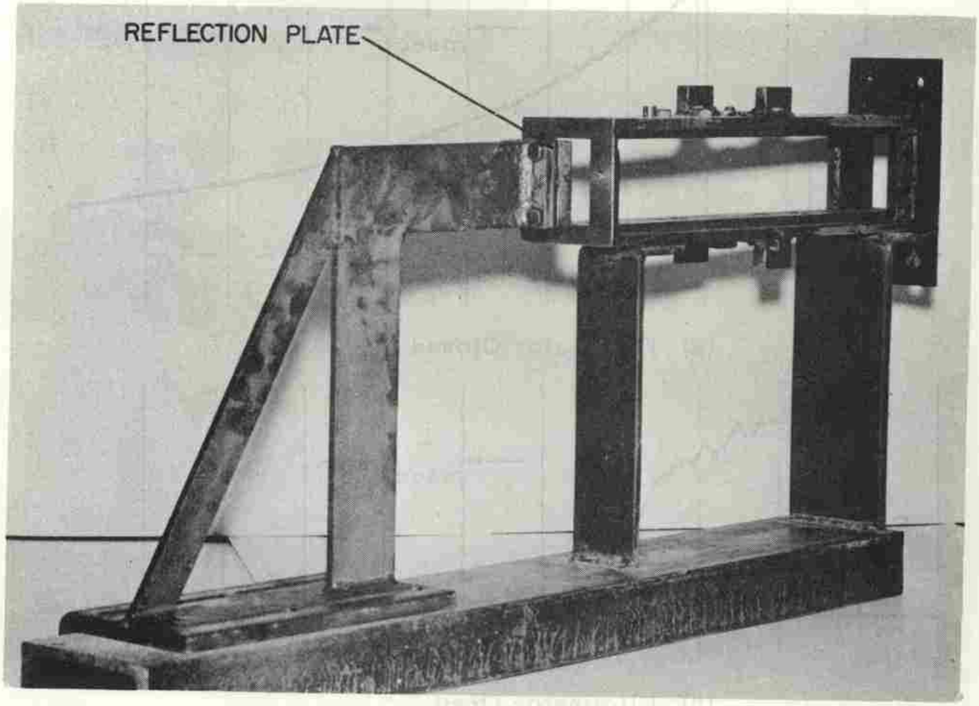


FIG 3a - ADJUSTABLE REFLECTION PLATE ATTACHED TO 2" x 1 1/2" SHOCK TUBE

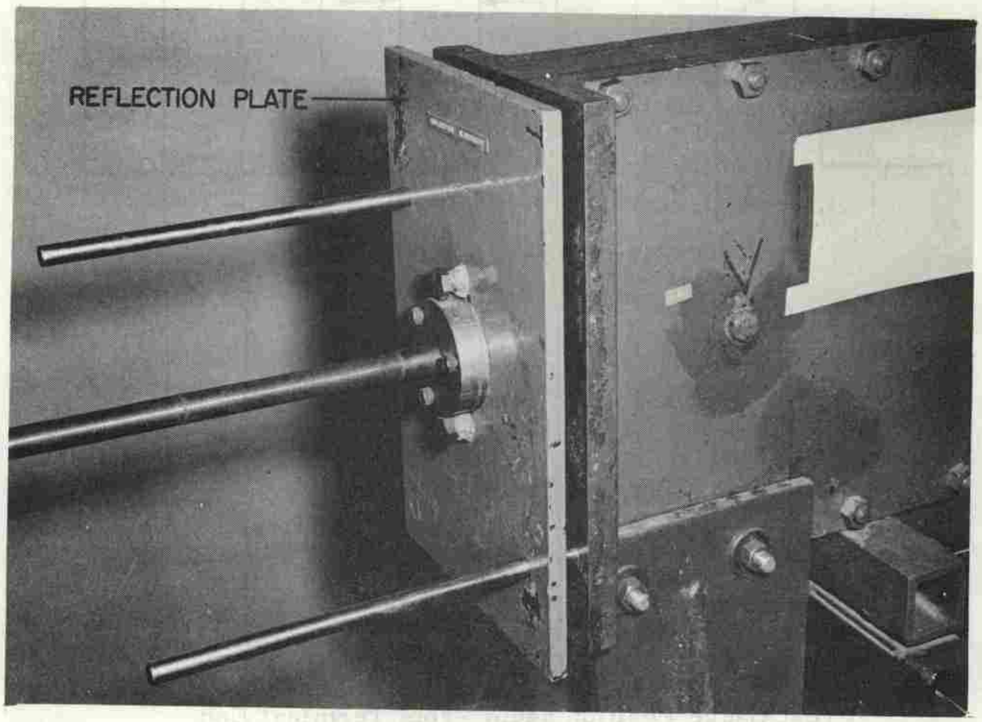
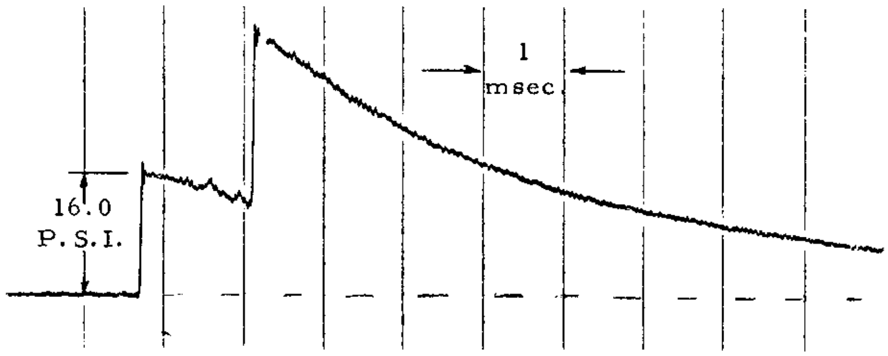
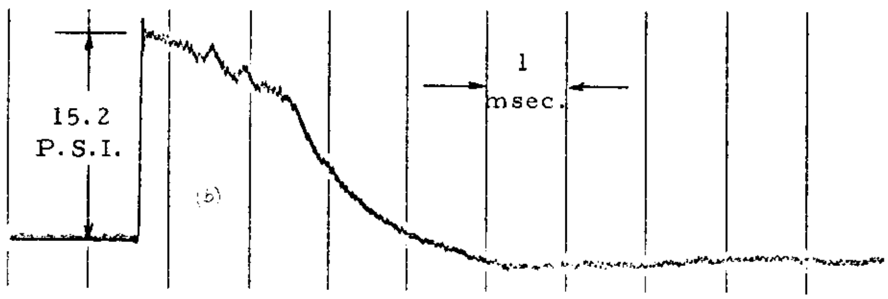


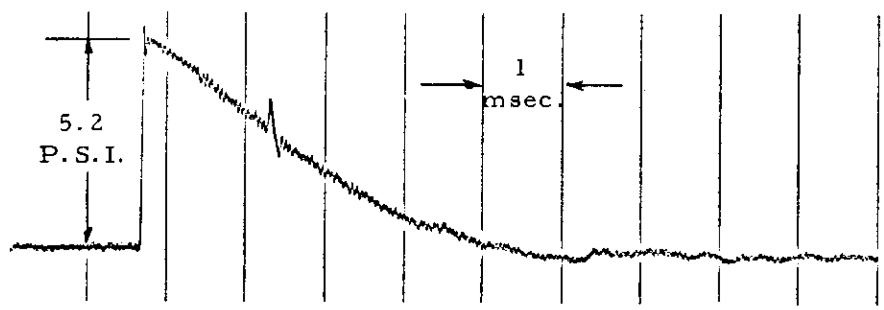
FIG 3b - ADJUSTABLE REFLECTION PLATE ATTACHED TO 2" x 12" SHOCK TUBE



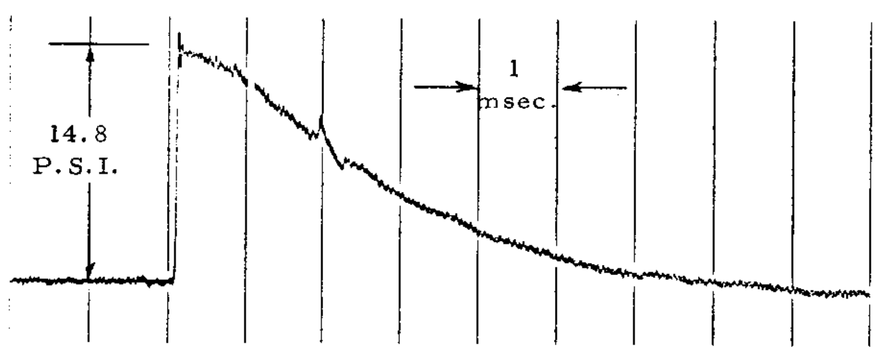
(a) Eliminator Closed



(b) Eliminator Open



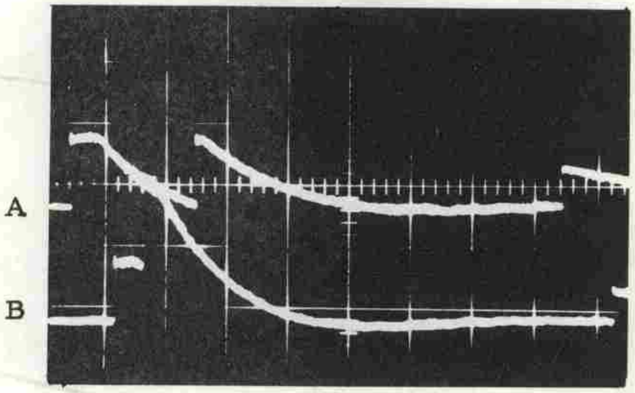
(c) Eliminator Standoff - .5cm



(d) Eliminator Standoff - 1.3cm

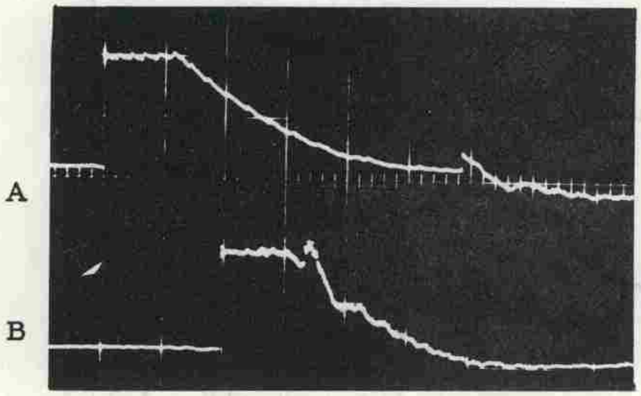
Test Gauge Position 54cm From Terminal End

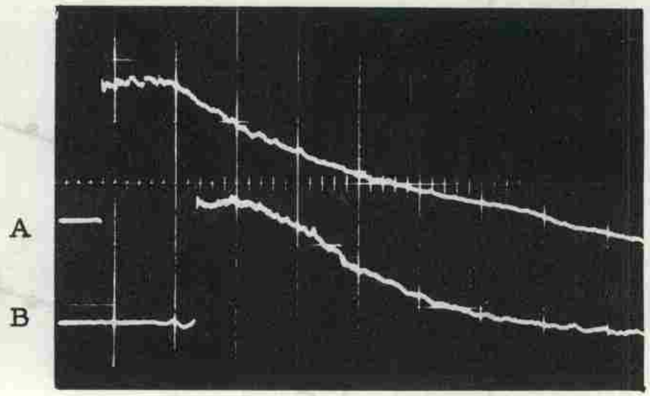
FIG 4 - TYPICAL PRESSURE-TIME RECORDS USING REFLECTION PLATE ELIMINATOR ON 2" x 1 1/2" SHOCK TUBE



(A) Eliminator Closed

Horizontal Sweep - 5 msec/div.
Nominal Incident Overpressure - 10 P.S.I.
Standoff Setting - Closed





(B) Eliminator Adjusted

Horizontal Sweep - 2 msec/div.
Nominal Incident Overpressure - 10 P.S.I.
Standoff Setting - 1.8cm

(C) Eliminator Adjusted

Horizontal Sweep - 2 msec/div.
Nominal Incident Overpressure - 20 P.S.I.
Standoff Setting - 2.8cm

Test Position "A" 198cm From Terminal End
Test Position "B" 30cm From Terminal End
Reflection Plate Size - 2" x 12"

FIG 5 - TYPICAL PRESSURE-TIME RECORDS USING REFLECTION PLATE ELIMINATOR ON 2 x 12 INCH SHOCK TUBE

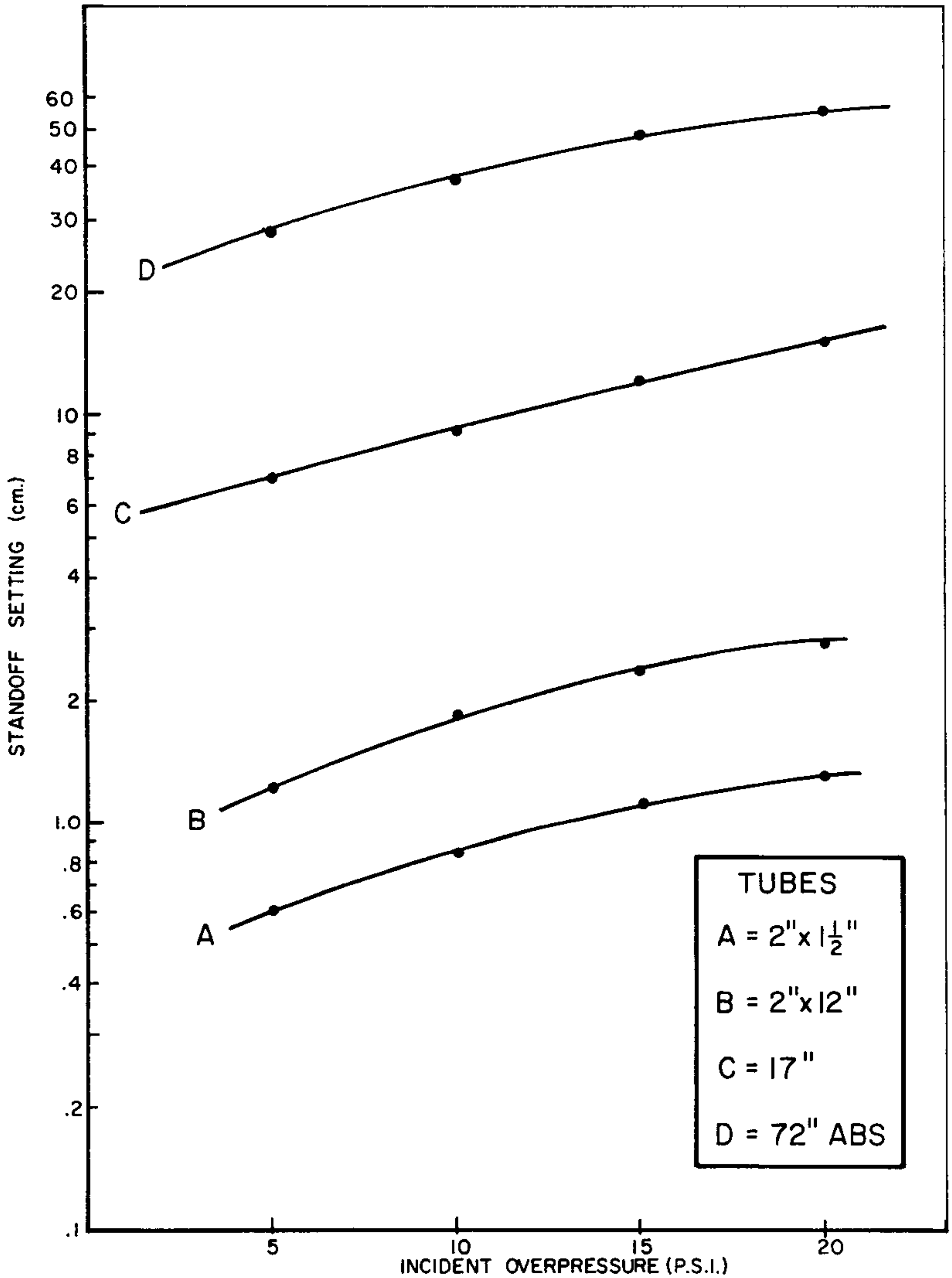


FIG. 6 REFLECTION PLATE STANDOFF SETTINGS 2 x 1½, 2 x 12, 17 & 72 INCH SHOCK TUBES

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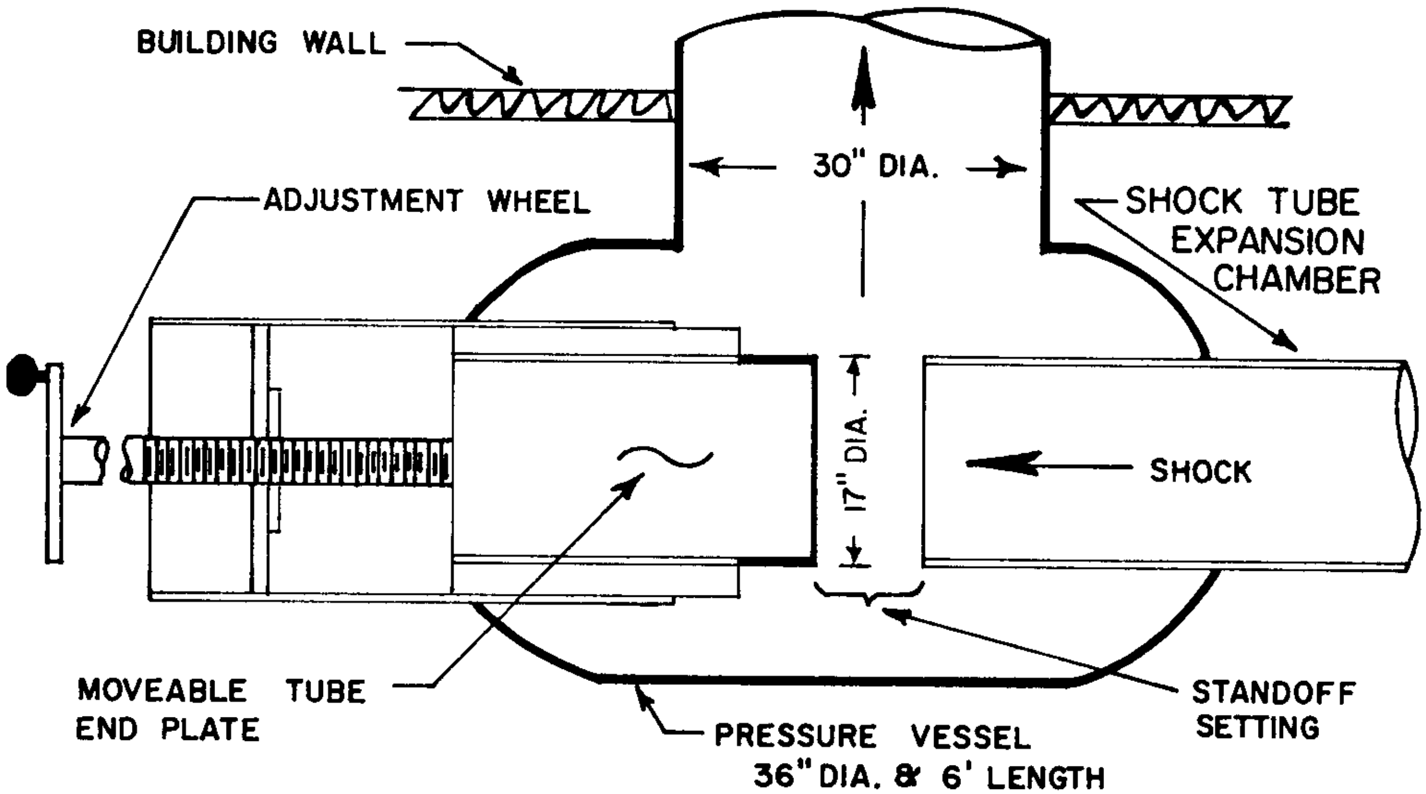

FIG. 7 LAYOUT OF DUMP TANK REFLECTION ELIMINATOR SYSTEM USED ON 17 x 17 INCH SHOCK TUBE

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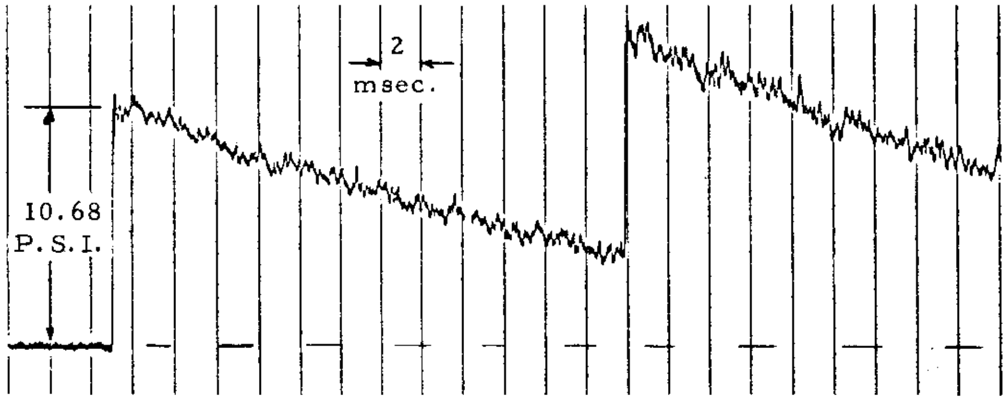
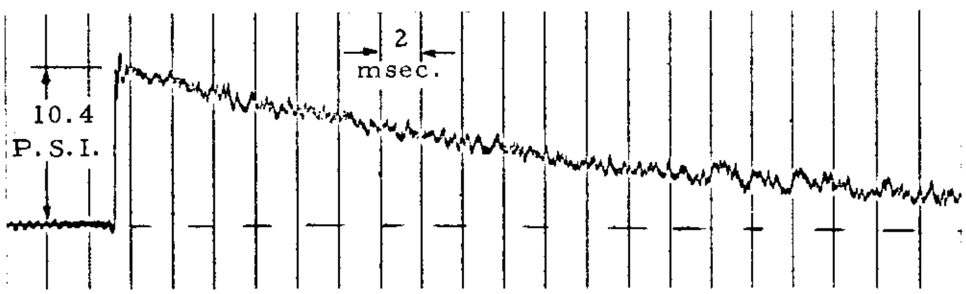
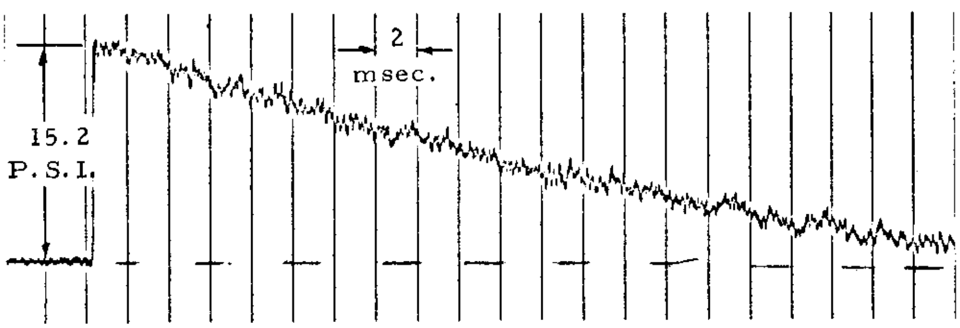


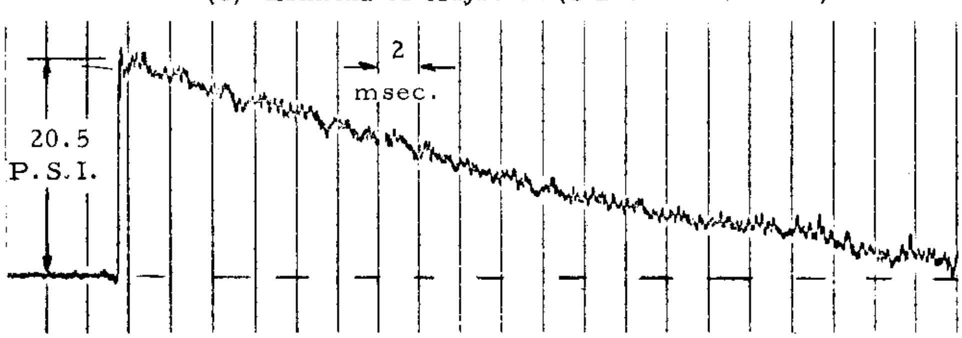
(a) Eliminator Closed



(b) Eliminator Adjusted (Standoff - 9cm)



(c) Eliminator Adjusted (Standoff - 11.5cm)



(d) Eliminator Adjusted (Standoff - .14cm)

Gauge Positioned 465cm From Shock Tube Termination

FIG 8 - TYPICAL PRESSURE-TIME RECORDS OBTAINED USING A REFLECTION PLATE DUMP TANK SYSTEM ON 17 x 17 INCH SHOCK TUBE

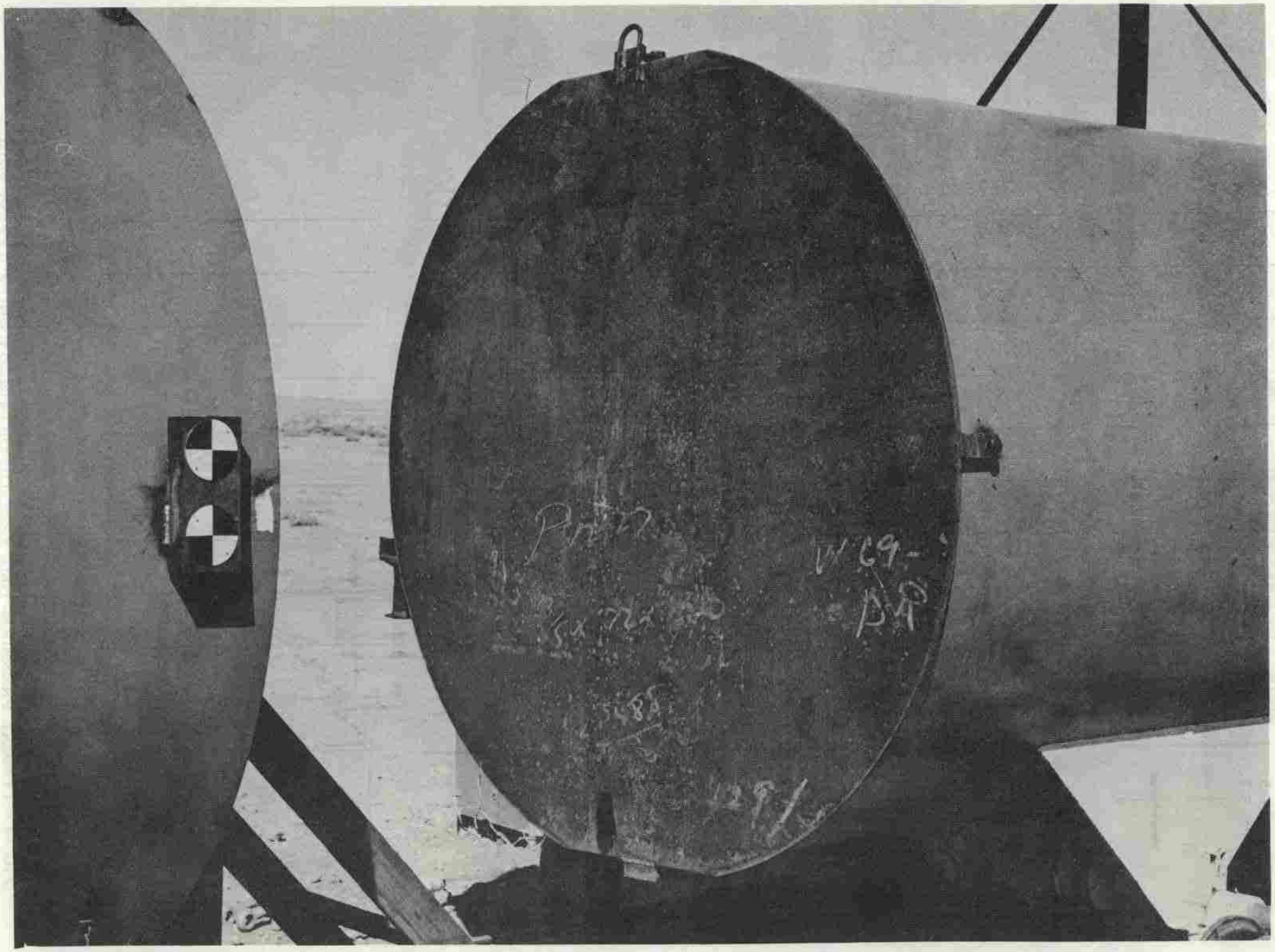
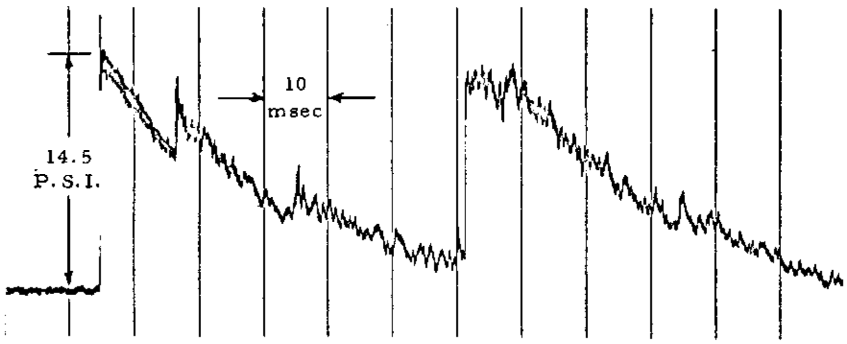
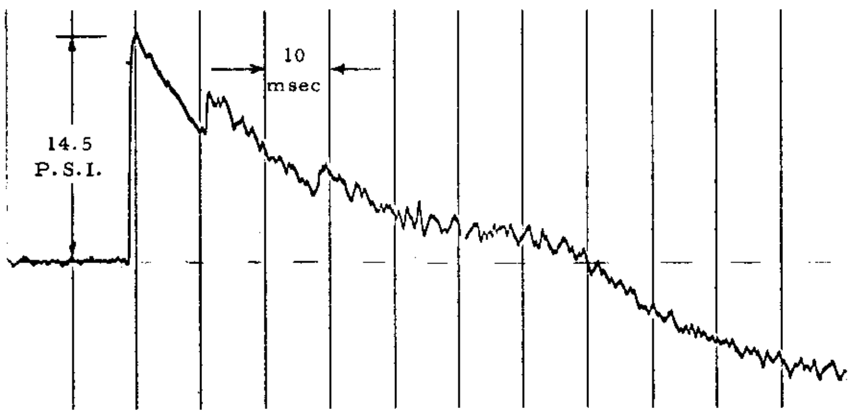


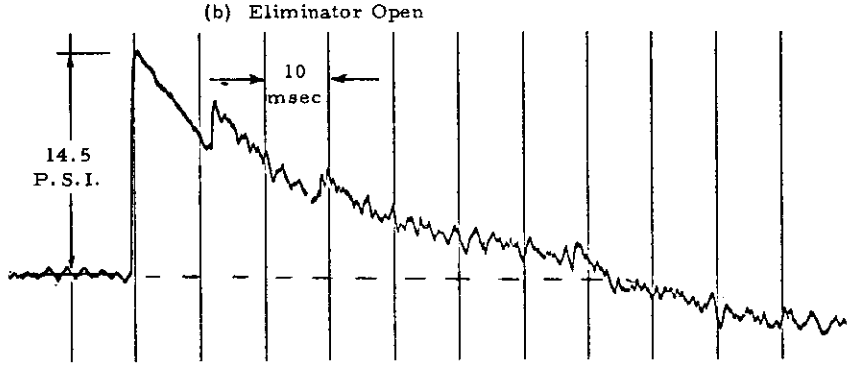
FIG 9 - ATTACHMENT OF ELIMINATOR ON SIX FOOT DIAMETER SHOCK TUBE



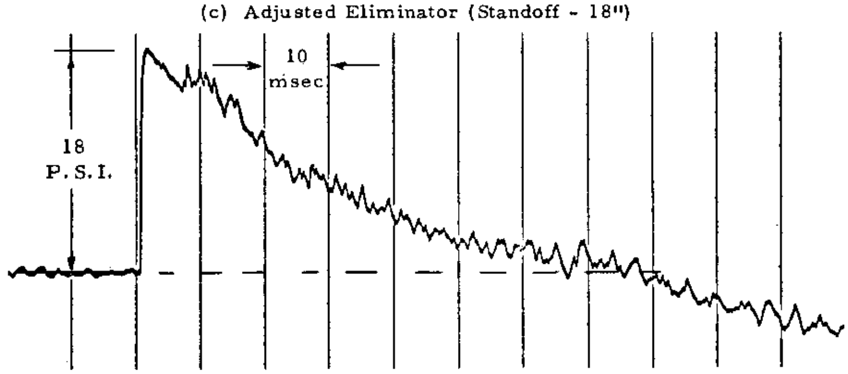
(a) Eliminator Closed



(b) Eliminator Open



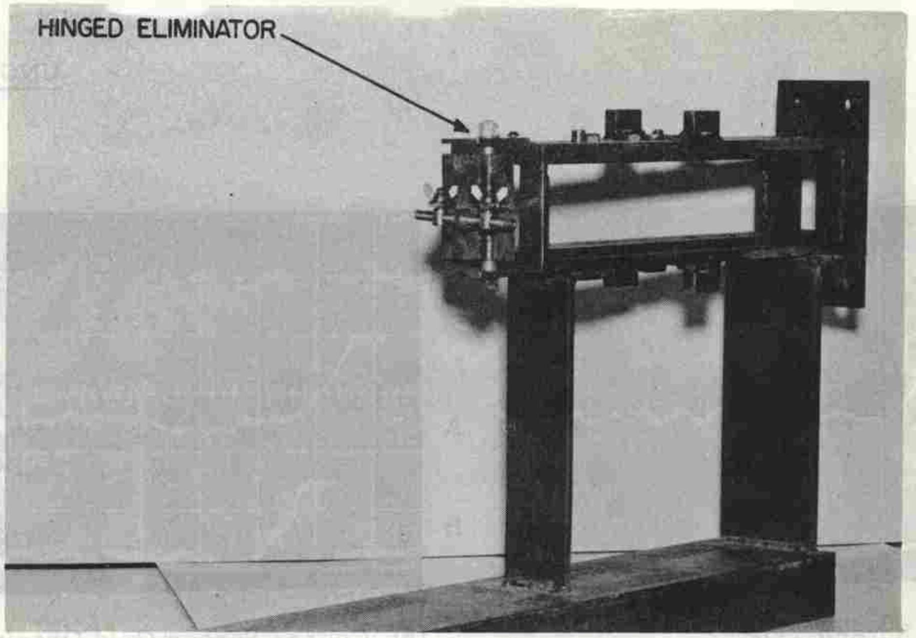
(c) Adjusted Eliminator (Standoff - 18")



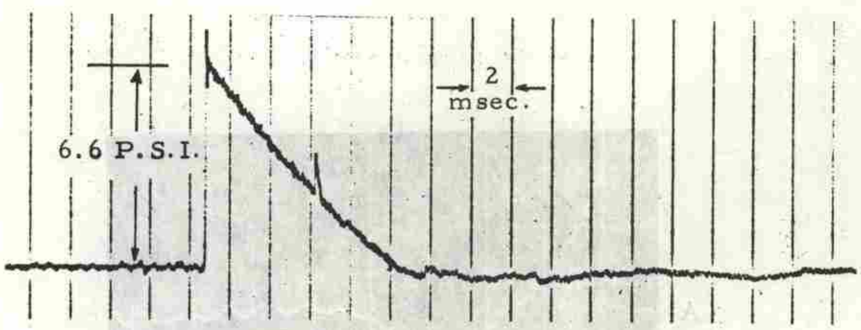
(d) Adjusted Eliminator (Standoff - 20")

Gauge Positioned 1040cm From Shock Tube Termination

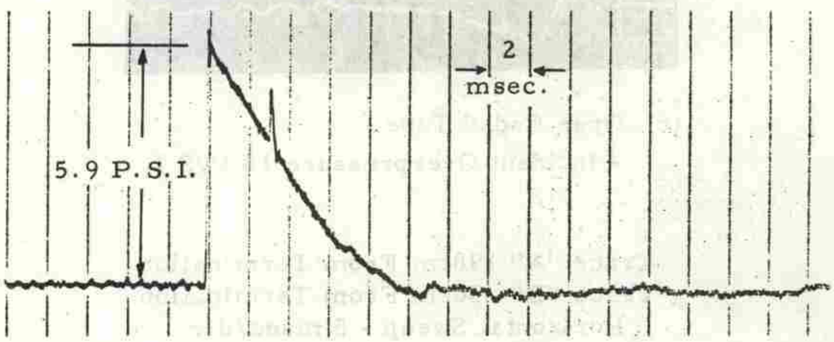
FIG 10 - TYPICAL PRESSURE-TIME RECORDS OBTAINED USING A REFLECTION PLATE ELIMINATOR ON SIX FOOT SHOCK TUBE



(a) 2" x 1 1/2" Hinged Eliminator Attached to 2" x 1 1/2" Shock Tube



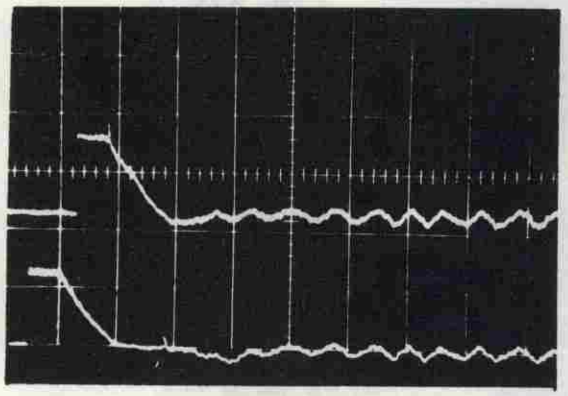
(1) Adjusted Eliminator (P_4 16 P.S.I.) Gage Located 94.4cm From Termination



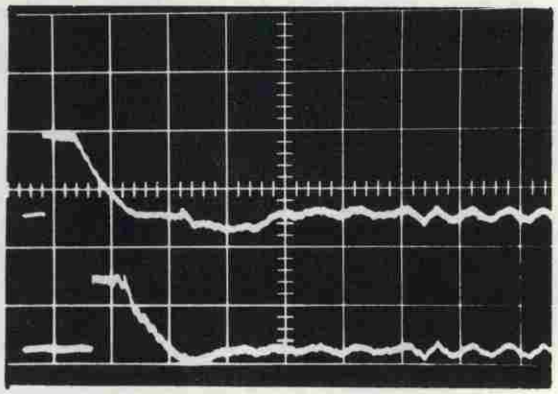
(2) Adjusted Eliminator (P_4 16 P.S.I.) Gage Located 54.2cm From Termination

(b) Typical Pressure-Time Data

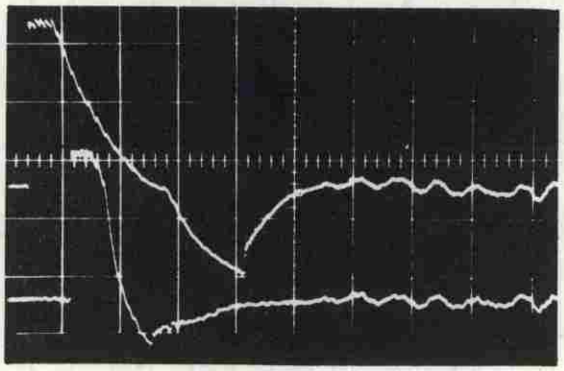
FIG 11 - 2" x 1 1/4" HINGED ELIMINATOR AND TYPICAL PRESSURE-TIME DATA

A
B


(a) Fine Screen Type
00A-359-H14
- Incident Overpressure 7 P.S.I.

A
B


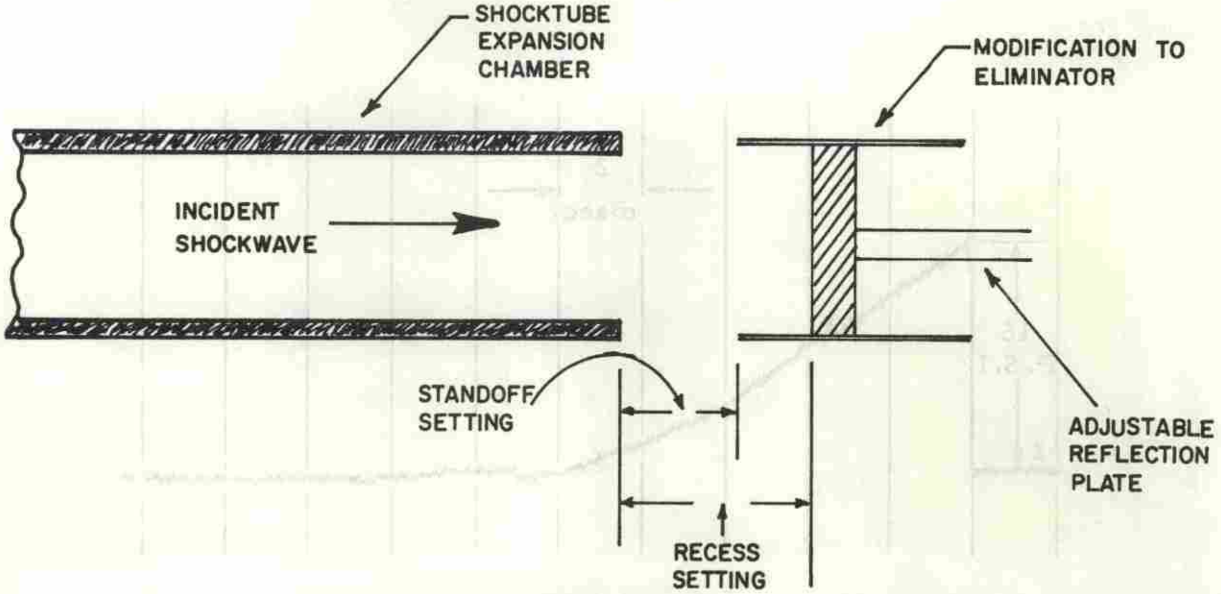
(b) Course Screen Grid Opening
(1" x 2")
- Incident Overpressure 18 P.S.I.

A
B


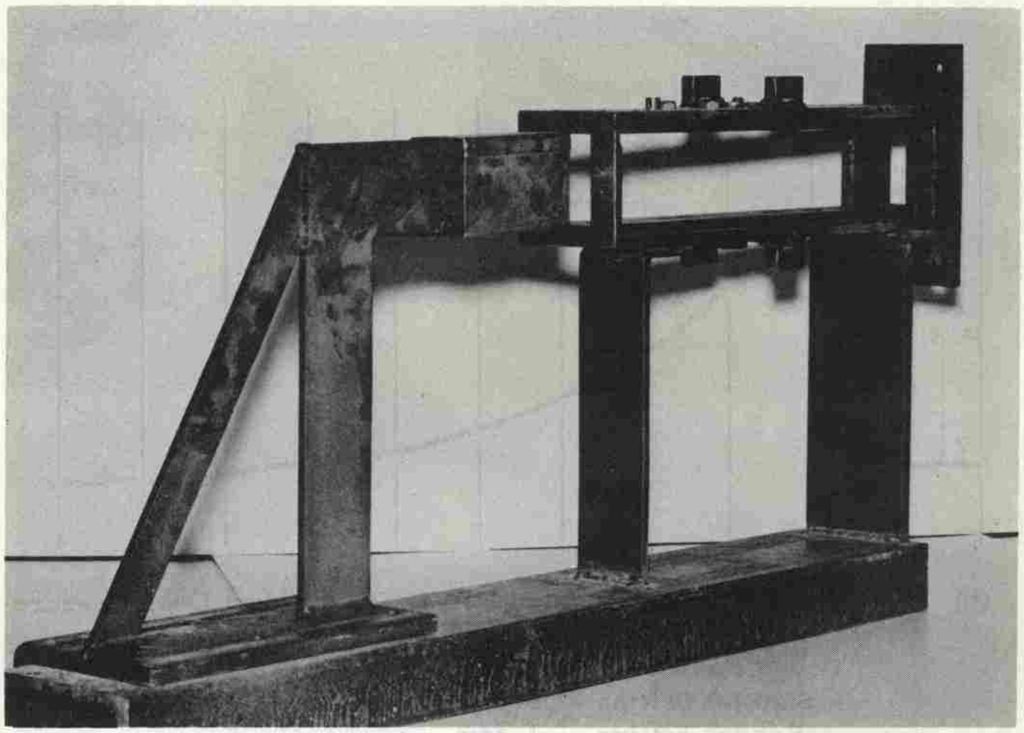
(c) Open Ended Tube
- Incident Overpressure 18 P.S.I.

Trace "A" 198cm From Termination
Trace "B" 30cm From Termination
Horizontal Sweep - 5 msec/div.

Fig. 12 - TYPICAL P-T RECORDS OBTAINED USING A NOMINAL GRID AS A REFLECTION ELIMINATOR 2" x 12" SHOCK TUBE

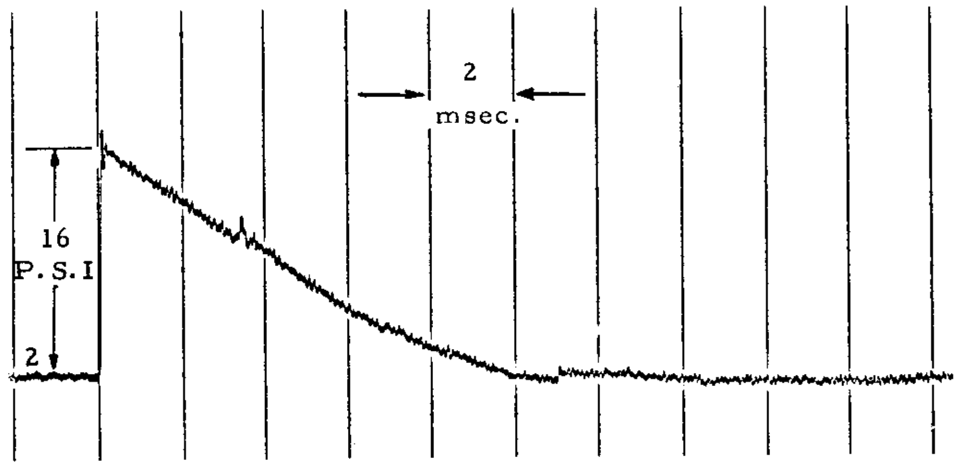


(a) LAYOUT OF MODIFIED REFLECTION PLATE ELIMINATOR



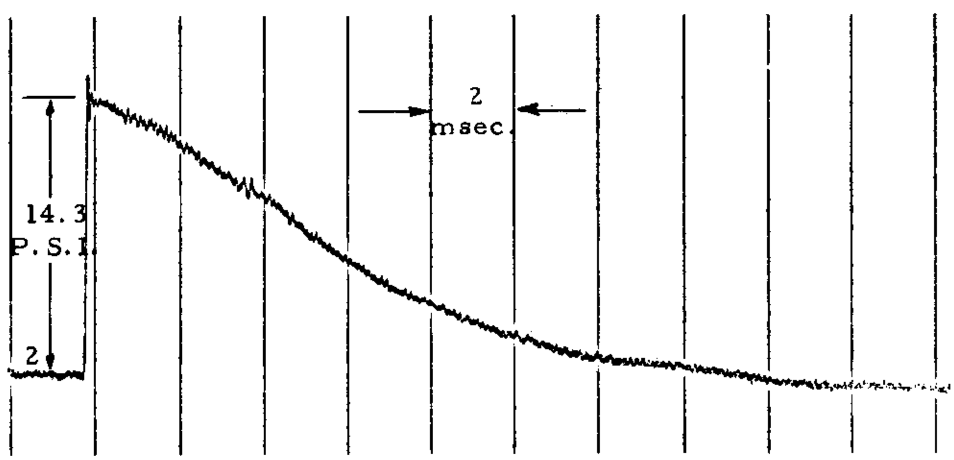
(b) ELIMINATOR ATTACHED TO 2"x $1\frac{1}{2}$" SHOCK TUBE

Fig. 13 MODIFIED REFLECTION PLATE ELIMINATOR



(a) Modified Eliminator Adjusted For 5 PSI Incident Overpressure

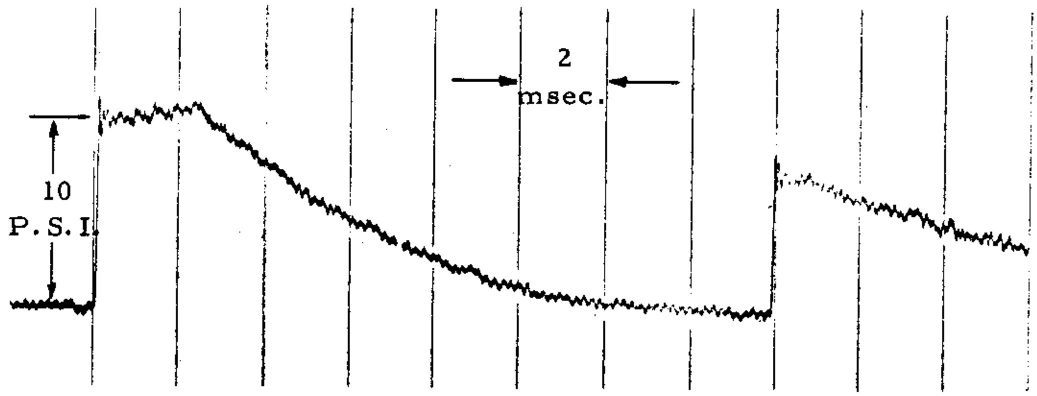
Gauge Positioned - 54.2cm From Terminal End
Standoff Setting - 0.6cm
Recess Setting - 1.4cm



(b) Modified Eliminator Adjusted For 15 PSI Incident Overpressure

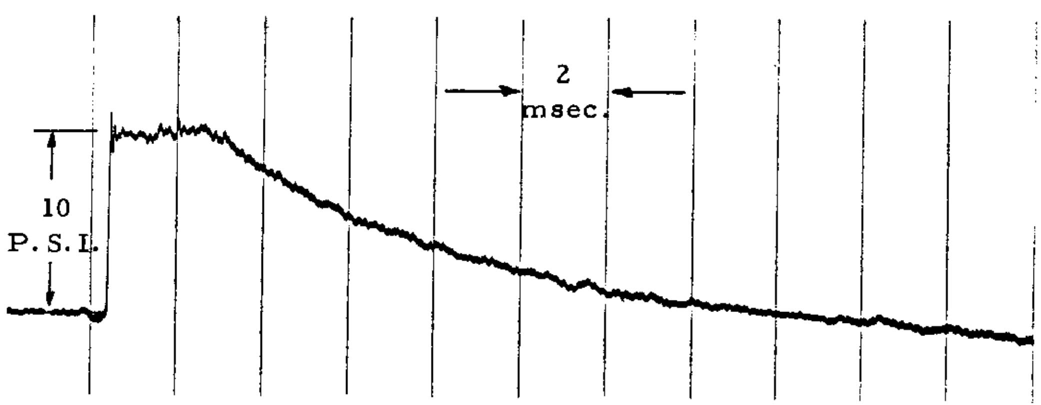
Gauge Positioned - 54.2cm From Terminal End
Standoff Setting - 0.6cm
Recess Setting - 1.4cm

Fig. 14 - TYPICAL PRESSURE-TIME RECORDS USING MODIFIED REFLECTION ELIMINATOR ON 2" x 1 1/2" SHOCK TUBE



(a) Closed (ΔP_4 36 P.S.I.)

Gauge Positioned 198cm From Tube Termination



(b) Adjusted Modified Eliminator (ΔP_4 36 P.S.I.)

Standoff Setting - 1.6cm
Recess Setting - 2.0cm
Gauge Positioned - 198cm From Tube Termination

Fig. 15 - TYPICAL PRESSURE-TIME RECORDS USING MODIFIED ELIMINATOR ON 2" x 12" SHOCK TUBE