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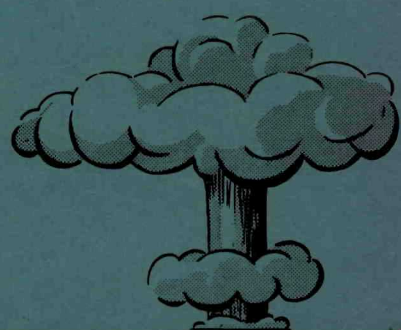
Operation

JANGLE

NEVADA PROVING GROUNDS
OCTOBER-NOVEMBER 1951

Project 1.4

FREE AIR PRESSURE MEASUREMENTS



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OPERATION JANGLE

PROJECT 1.4

FREE AIR PRESSURE MEASUREMENTS

By

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R. D. JONES

19 February 1952

SANDIA CORPORATION

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ABSTRACT

Records of air overpressure versus time were made at essentially ground-level stations for both surface and underground atomic explosions of approximately one kiloton yield as part of Operation JANGLE in November 1951. For the surface shot several instruments were placed on a line extending from an overpressure region of 13 psi to a region of less than one psi; the air measurements for the underground shot ranged from 32 to 2 psi.

SECTION 1

INTRODUCTION

1.1 OBJECTIVE

The responsibility of Project 1.4 was to record the pressure-time wave form of the air blast at stations throughout the areas where structural damage was to be investigated; measuring stations were to be set up along a radius (the major blast line) from the predicted edge of the crater-throwout to a pressure region of approximately 2 psi. The measuring system was to have an over-all response of 500 cps or better and an accuracy of 5 per cent.

Although not a part of the mission assigned to Project 1.4, a rough examination of the symmetry of the divergent air shock wave was made by means of Naval Ordnance Laboratory indenter gauges.*

1.2 METHOD OF OBTAINING DATA

Free air pressure was measured along the ground from an over pressure region of 13 psi to a region of less than one psi on the surface shot and from 32 to 2 psi on the underground shot. All pressure measurements were made by means of Wiancko pressure gauges except that for the 4,200 foot station which was made by means of a self recording interferometer gauge.

In general two Wiancko gauges were used at each instrument station to obtain duplicate pressure measurements. Data transmission from each gauge was effected either by a wire link or by a radio telemeter link. Unless otherwise noted, the data presented in Tables 3.1 and 3.2 were transmitted over a wire link.

All wire-link channels have an over-all system frequency response which is flat from 0-500 cps while the radio telemeter channels have an over-all system frequency response which is flat from 0 - 1,500 cps. The linearity of both systems was within 1 per cent. Signal amplitudes for the wire-link channels were approximately twice those of the radio telemeter channels.

*Shafer, P. E., Operation SANDSTONE, Part II, Ch 9, Vol 21, 1948

PROJECT 1.4

At the time of detonation a burst of noise occurred on all channels (Figure 3.1), and the beginning of this burst of noise was used as zero for the time base.

To examine the symmetry of the divergent air shock wave five instrument stations consisting of four Naval Ordnance Laboratory indenter gauges each were placed on the circumference of a circle having a radius of 1,700 feet about ground zero. For the underground shot four instrument stations consisting of four indenter gauges each were placed on the circumference of a circle having a radius of 1,200 feet about ground zero.

Locations of all instrument stations for the surface and underground shots with respect to ground zero are shown in Figures 1.1 and 1.2. Instrumentation is discussed in Section 2.

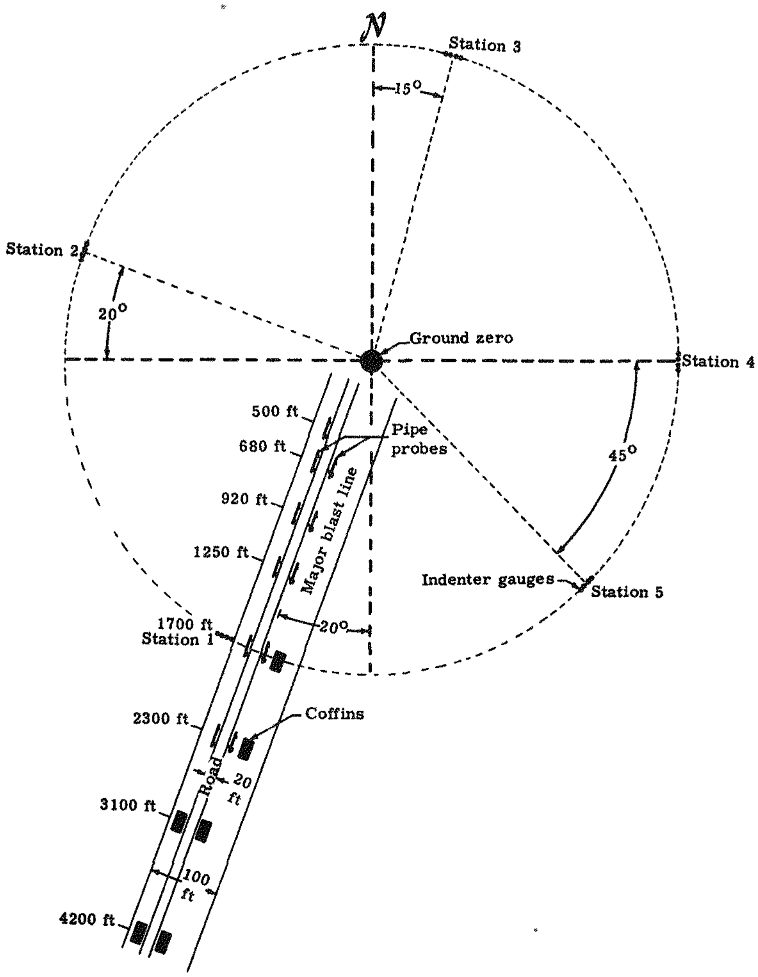

Fig. 1.1 Surface Shot Plan

PROJECT 1.4

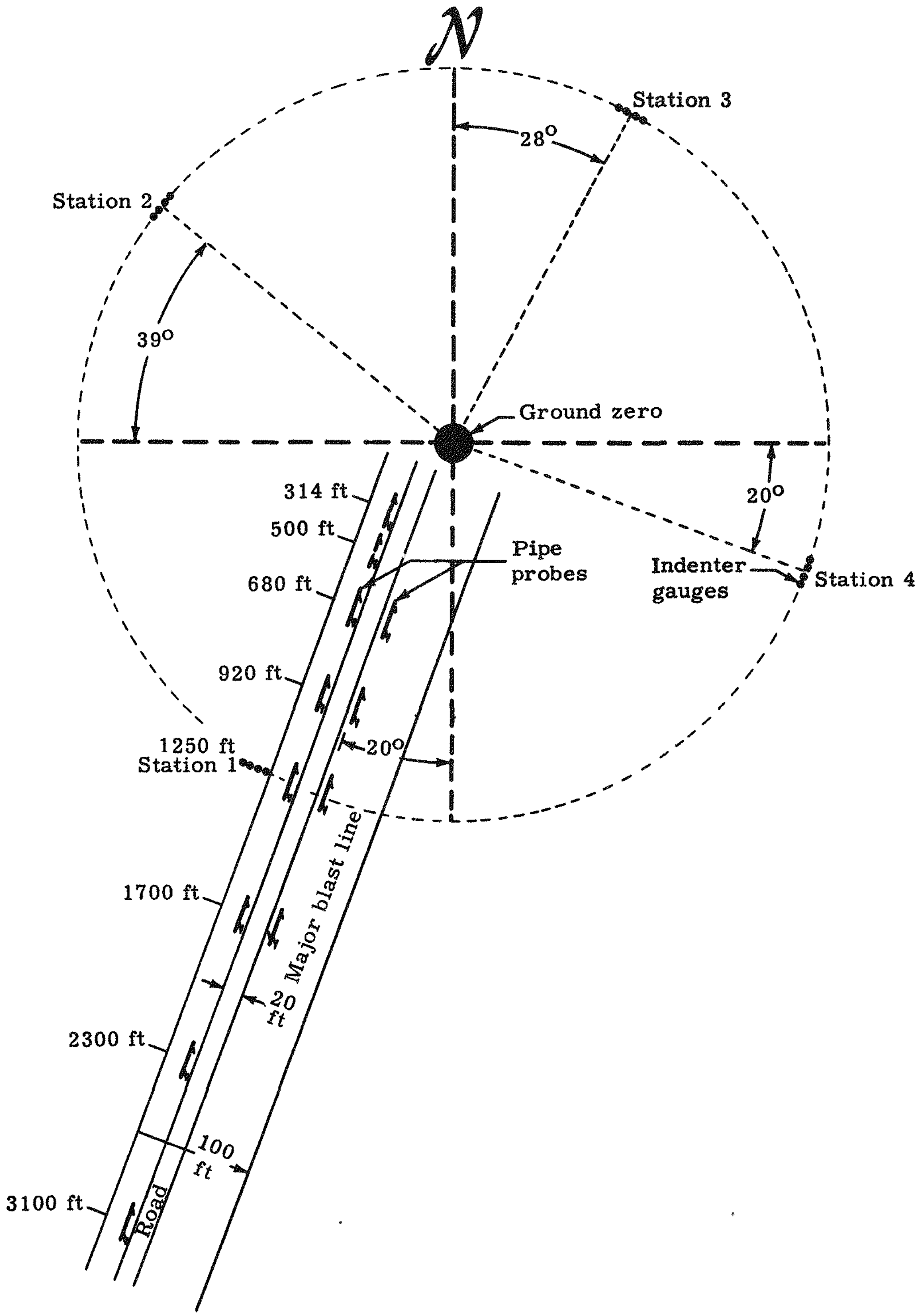

Fig. 1.2 Underground Shot Plan

SECTION 2

DISCUSSION OF INSTRUMENTATION

2.1 WIANCKO PRESSURE GAUGES

For close-in pressure measurements, variable-reluctance gauges manufactured by the Wiancko Corporation were chosen for two reasons. The Weapons Effects Department of Sandia Corporation made an extensive survey of the entire field of pressure-measuring instruments in connection with participation in Operation GREENHOUSE.* It was found that the Wiancko Type 3-PAD exhibited desirable characteristics for this type of operation, namely, short rise time with adequate damping, good response to near static pressures such as occur in the negative phase of a shock wave, high-level signal, and relatively little response to acceleration. The last characteristic indicated that the Wiancko gauge would be an excellent choice for Operation JANGLE since large accelerations resulting from earth shock were anticipated. Moreover, the variable-reluctance gauge readily lends itself to applications involving carrier current systems such as the Consolidated System D** equipment available at the Sandia Corporation.

The second reason for choosing the Wiancko gauge was its availability. A number of these gauges were procured for Operation GREENHOUSE. The gauges were returned from the Pacific Proving Grounds in time for use in the November tests. Thus the choice of this gauge gave a satisfactory solution to a major logistic problem of procurement without further overloading instrument manufacturers.

The Wiancko gauge consists of a twisted Bourdon tube, an iron vane, a small E-coil, and the associated canister necessary to support and house these components. The iron vane is mounted on the free end of the Bourdon tube and oriented in such a way that the twist of the Bourdon tube gives rise to an angular motion of the vane, thus increasing the inductance of one leg of the E-coil while decreasing the inductance of the other. Northrop* has given a complete description of the Wiancko gauge.

Since a relatively small number of the available gauges was required for Operation JANGLE, it was possible to give considerable attention to selecting those gauges having optimum characteristics. To determine the gauges having the best characteristics, a conventional four-arm inductance bridge was employed in which the Wiancko E-coils formed the two adjacent active arms. The bridge was excited from a 10-kc source, and provision

* Northrop, P. A., Operation GREENHOUSE, Scientific Directors Report, Annex 3, 4, Part 1, Ch 1, 1951.

**Static-Dynamic Recording Measurement System D, Consolidated Engineering Corporation, Pasadena, California.

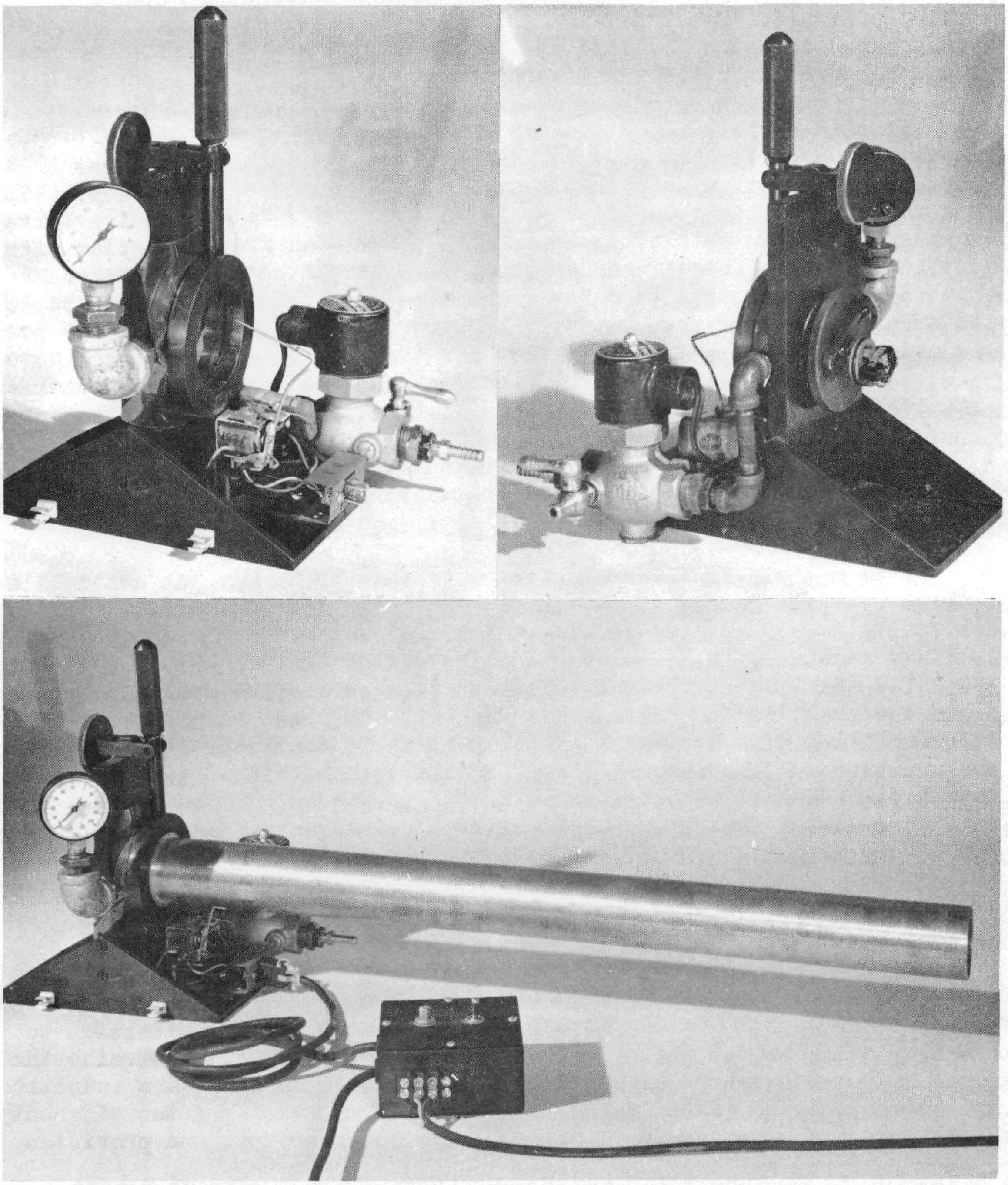

Fig. 2.1 Damping Jig with Shock Tube - Upper Photos are Damping Jigs Alone

was made for amplitude and phase balance of the bridge. Application of pressure to the gauge resulted in a bridge unbalance proportional to the applied pressure. Pressure standards were Wallace and Tiernan aneroid-type gauges and Heise Bourdon-tube gauges which were calibrated by the Sandia Corporation Standards Laboratory.

Using this system, a linearity check was made of all gauges. The output of the bridge was observed as pressure was changed from atmospheric (zero) to the maximum gauge rating and back through zero to a negative pressure approximately one fourth the maximum gauge rating. Calibration curves relating output and pressure were drawn, and from these the percentage deviation from linearity was determined. These calibration runs were repeated from time to time to check repeatability. At the same time the sensitivity and hysteresis of the gauge were determined. A catalog was made of the gauge sensitivities, and the most sensitive gauges were reserved for those positions in which the expected peak overpressures were relatively small (1/5 to 1/2 of the maximum gauge ratings).

In general all gauges were within the specified manufacturer's tolerances of less than 1.5 per cent of the measured pressure with respect to total hysteresis, drift, nonrepeatability, and nonlinearity.

After a study of climatological data for the Nevada Test Site it was decided that the gauges should be from 60 to 90 (75 nominal) per cent critically damped at a temperature of 40°F. Moreover, the damping should remain essentially the same over a range extending from 20° to 60°F if possible. Various mixtures of silicone oils were tried and rejected because their use led to extreme overdamping. The best results were obtained by applying a small amount of Dow-Corning DC-4 silicone grease between the armature and the damping plate secured to the core of the E-coil. Actual temperature measurements at the test site on surface and underground shot days showed the 20° to 60°F range to be adequate.

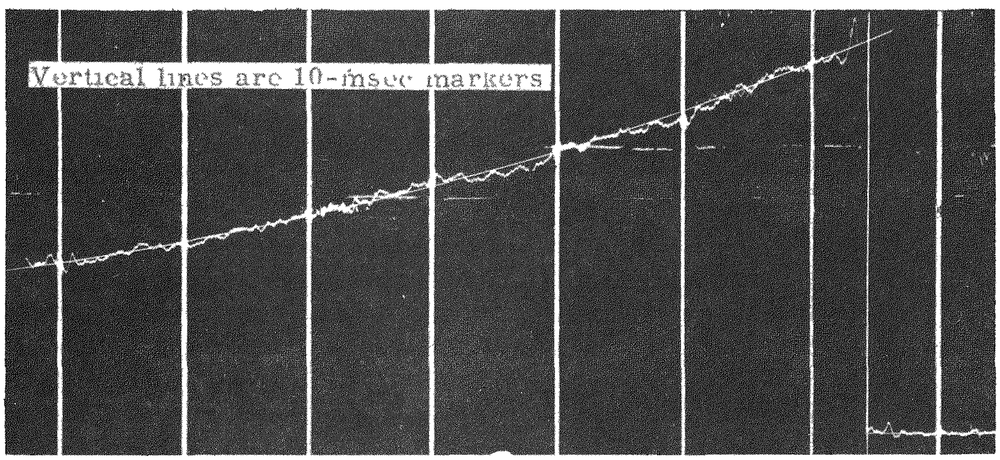

Fig. 2.2 Surface Shot—680-ft Station

To facilitate the damping adjustment, a special damping jig was constructed (Fig. 2.1) in which air under pressure is introduced into a reservoir enclosed by one or more sheets of cellophane. When the desired pressure is reached, the cellophane is punctured, and a rapid decrease of pressure results. The Bourdon-tube assembly is clamped in the jig in such a way that the reservoir pressure is applied to the tube while the armature and damping plate are accessible to the operator. Both rise time and damping can be determined from an analysis of the photograph of the gauge response as presented on an oscilloscope screen. Provision was made for the synchronization of the cellophane puncture with the start of the oscilloscope trace.

When DC-4 grease is used as the damping agent, a gauge properly damped at 40°F has an overshoot of about 15 per cent at 75°F. The gauge and damping jig were placed in a Bowser pressure-temperature chamber operated by the Electro-Mechanical Test Department of Sandia Corporation. The gauge response was examined at 10° steps from 70° to 0°F. Intervals varying from one-half to one hour were required for thermal equilibrium at each step. The relative humidity was held constant at 14 per cent. The shift in the balance point and changes in sensitivity were negligible over this temperature range.

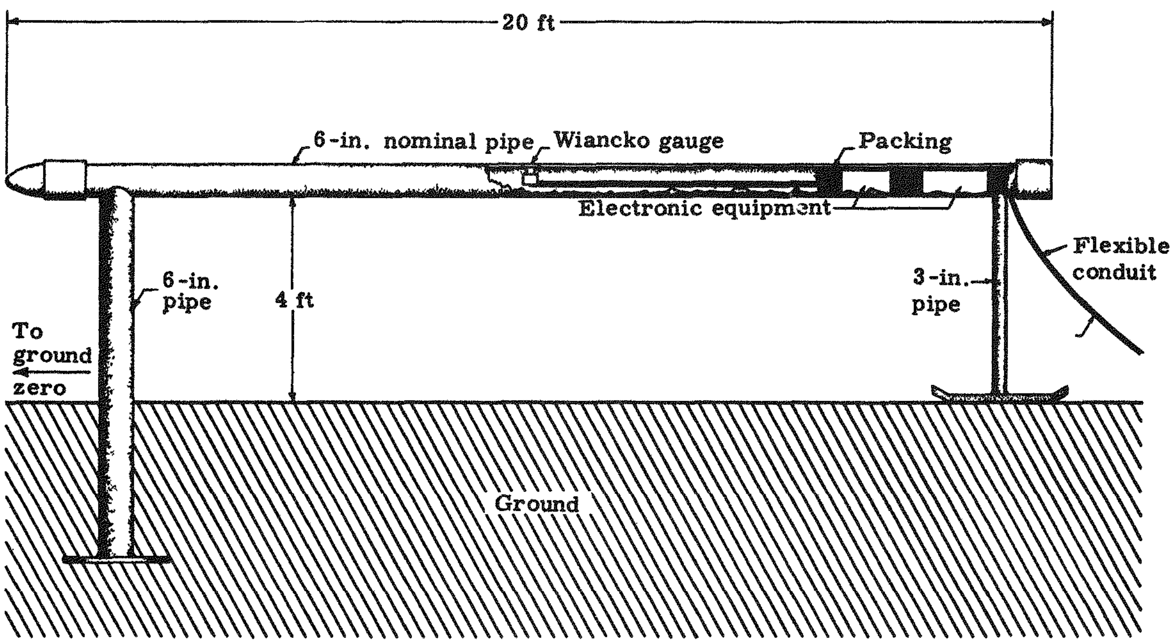

Fig. 2.3 Pipe Probe

Analysis of the oscillographs of the dynamic responses of the gauges at these temperatures showed that the gauges were somewhat overdamped at 20°F and somewhat underdamped at 50°F. When 10-psi gauges were checked dynamically in the Bowser chamber, the damping ranged between 70 and 80 per cent critical at 40°F, and a rise time of 0.40 ± 0.10 msec to 95 per cent of the final pressure was observed. Thus it was concluded that this damping criterion was justified, i.e., the damping should allow a 15 per cent overshoot at 75°F.

Figure 2.2 gives a representative trace from the oscillographic record of the surface shot. An average curve drawn through the overshoot and the noise envelope is superimposed on this record. The intersection of this curve with a vertical line drawn from the point of initial trace deflection was taken as the peak overpressure. Subsequent points were also obtained from the average curves on those channels in which the signal-to-noise ratio was low.

2.2 PIPE PROBE

The design of a baffle for measuring true 'free air' pressures was originally predicted on Operation WINDSTORM using a nominal A-bomb. For convenience the tested and accepted full-scale baffle was used for Operation JANGLE.

A search was made for a stationary platform that would not change attitude as a result of blast buffeting or the ground motion anticipated from the burst of a full-scale weapon. The baffle which seemed to fill the requirements best was a one-dimension baffle having a large fineness ratio and supported at the extreme ends to minimize pitch angle variation resulting from ground motion (Fig. 2.3). By using a 4-ft support an added advantage was realized in that measurements were made in the medium where the effects of surface-flow anomalies were less pronounced. The use of 6-inch steel pipe provided a rigid structure having a convenient mounting space (inside the pipe) for electronic gear. Using a 20-ft length of pipe in which the sensing element is at the top center of the span, calibration tests were made using high-explosive charges as great as 1.6 tons of TNT. No detectable discrepancy existed between measurements made using Wiancko gauges in the pipe baffle and mounted flush with the ground in a plane baffle. These data agreed within 1 per cent with interferometer gauge* readings from the same distance.

Choice of footings for the pipe was made on the basis of observations from previous tests, where permanent displacements were noted in the earth's surface near large craters. Consequently the front leg of 6-inch pipe was welded to a foot 18 inches in diameter and buried to a depth of 4 feet. The rear leg rested on the ground and terminated in a sled runner to permit surface motion.

The face of the Wiancko gauge was contoured to conform to the surface of the pipe. All gauges faced up since the pipe was more likely to change orientation because of yaw than because of pitch and since it was desirable to stay as far away from ground-roughness perturbations as possible.

2.3 INTERFEROMETER GAUGES

Self-recording interferometer gauges were installed at distances from surface-shot ground zero at which the anticipated radiation level was sufficiently low. To further minimize radiation effects and to provide air-baffling for such bulky equipment the gauges were buried flush with the earth (Fig. 2.4).

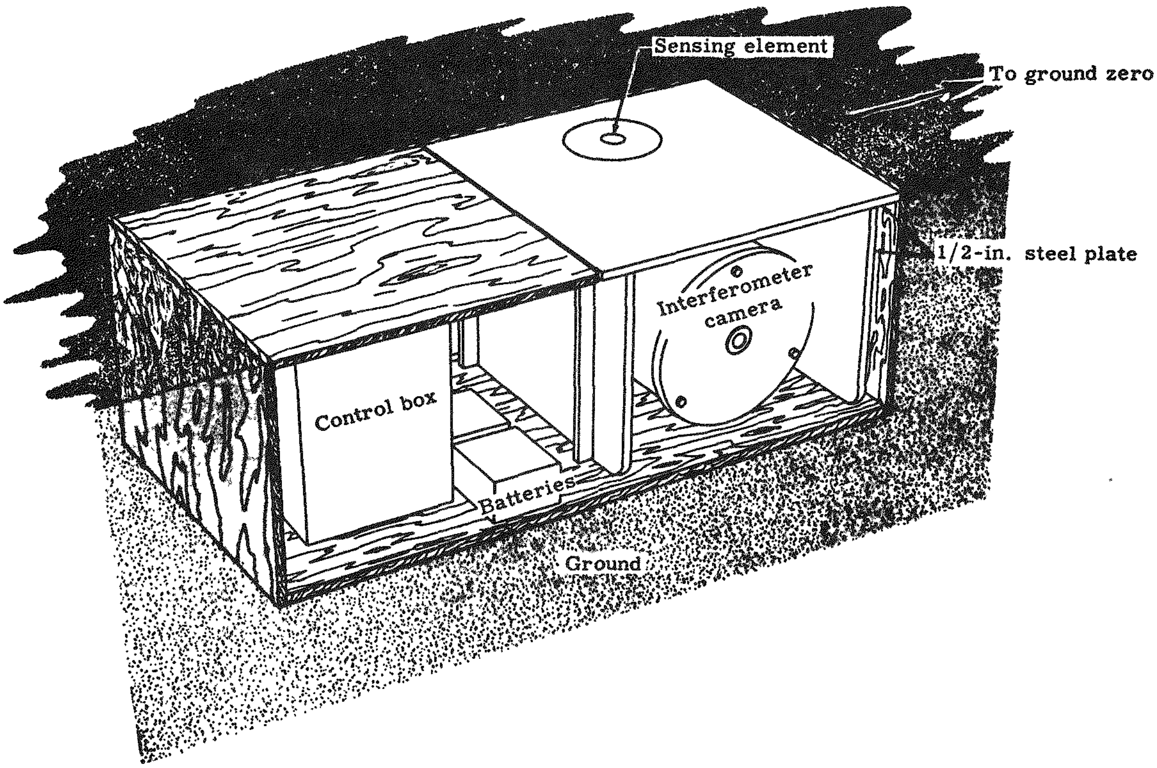

Fig. 2.4 Interferometer Coffin

Linegraph Ortho 35-mm film in 100-ft spools was chosen as the recording medium because of its high contrast, relative low sensitivity to radiation contamination, and availability. Tests conducted by the Bureau of Standards using 1,400-kv X-radiation indicate that data could be easily reduced after a 20-r radiation dose and could be reduced with some accuracy even after a 40-r dose.

Using quartz sensing elements having a maximum range of 3 to 5 psi and a recording speed of 30-40 ft/sec, a system response in excess of 2000 cps was assured.

The control system used for the interferometer received a turn-on signal and a 1000-cps timing pulse from the manned station, delivered over one pair of W-110-B wires serving all gauges. The coffin for each gauge contained batteries and delay-time relays set to insure film operation at the correct time. No tie-in to zero time or time correlation to the other recorder system was effected.

Two interferometer gauges were the only instrumentation employed at each 3,100 and 4,200-ft station for the surface shot. Since the radiation hazard to film was undetermined, one additional gauge was installed at both 2,300 and 1,700 feet to establish the marginal point for operation of the underground shot. However, results from the surface shot were so discouraging (extensive contamination made data reduction impossible even at 3,100 feet) that the system was scrapped for the underground shot and the remote-recording Wiancko equipment used throughout.

2.4 INDENTER GAUGES

A complete discription of the Naval Ordnance Laboratory indenter gauges used by this project is given in the Final Report of Operation SANDSTONE, Part II, Chapter 9, Volume 21, 1948. No attempt was made to baffle the gauges. The assembled instruments were installed flush with the ground on steel-stake mounts.

2.5 TRANSMISSION AND RECORDING SYSTEM

For the surface shot, two parallel intelligence-transmission systems were used. At each pressure-measuring station, two pipe probes were spaced so as to minimize the danger of missile damage. (A single pipe probe was located at 500 feet, but no record was obtained.) One probe was linked by radio telemetering equipment to a manned K35 trailer outfitted as a mobile recording laboratory. The other probe was linked to the same trailer by twisted-pair steel-copper telephone cables (Signal Corps W-110-B). Five such instrument stations were spaced logarithmically from 680-2, 300 feet. The positions of these stations relative to ground zero are given in Figure 1.1.

For the underground shot eight instrument stations were spaced logarithmically from 314-3, 100 feet. The positions of these stations relative to ground zero are given in Figure 1.2. Single pipe probes were used at each of the other stations. Radio telemetering was used only at the 1,700-ft station since preliminary evaluation of the surface shot data led to the conclusion that the wire link was more reliable. The pipe probe at 500 feet contained two Wiancko gauges in the wire link, one at 498 and one at 500 feet.

2.5.1 Wire Transmission System

A Static-Dynamic Recording Measurement System D, manufactured by the Consolidated Engineering Corporation, was used to excite the Wiancko gauge and demodulate the returning signal. The Consolidated equipment provides a 3000-cps carrier and a means of null-balancing the return carrier both in magnitude and phase. The Consolidated equipment was located in the K35 trailer, five miles west of the blast areas.

Signal Corps Type W-110-B field telephone cable was used to carry the carrier wave to the gauge and to return the modulated signal to the recording equipment.

The equipment, which was located in probes using this wire-linked system, consisted of the gauge and a coupling unit. A circuit diagram of this equipment is shown in Figure 2.5.

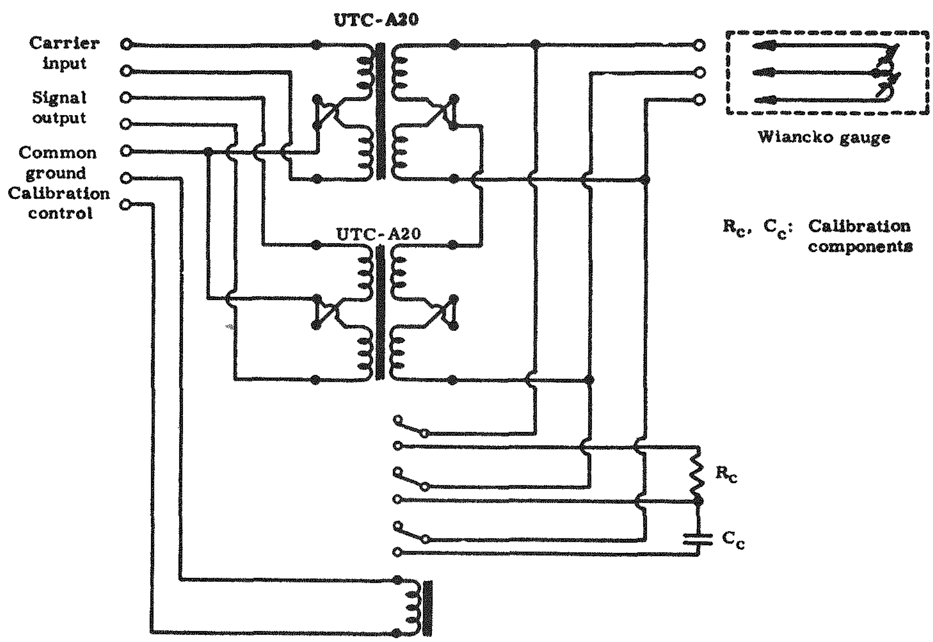

Fig. 2.5 Coupling Unit

Because of the unusually long lines used with the Consolidated equipment and the necessity of employing a carrier generator having very low output impedance, a 3000-cps 30-watt amplifier was used to deliver at least a 6-volt carrier to the gauge.

A simulated pressure was obtained for calibration purposes by means of a relay in the coupling unit. The relay inserted fixed electrical components into the bridge circuit and caused an unbalance equal to that which would result from a known applied pressure. The calibration pressures were based upon pressures predicted by Stanford Research Institute.

Following the original calibration in the instrument trailer, the coupling unit was installed in the probe and the calibration checked by applying pressure using a hand pump.

The decision to replace the telemetering system by the wire system for the underground shot required further modification of the measuring system. Four carrier lines supplied four gauges directly from the carrier amplifier. A second amplifier at 8000 feet from ground zero supplied the remaining eight gauges, each of which had a separate carrier line.

In addition, a single tube amplifier was placed in each signal return line at a distance of approximately 4000 feet from ground zero.

It was found that the Consolidated equipment did not provide a sufficient degree of adjustment to bring the outgoing and return carrier into phase. To overcome this difficulty a phase control was inserted in the grid input of the signal line amplifier. This adjustment, with that on the Consolidated equipment, gave the necessary degree of control.

A linearity check of the entire system from gauge to galvanometer was made less than twelve hours before each shot.

2.5.2 Radio Telemeter System

Simplicity and availability of equipment were the primary considerations which resulted in the choice of an AM-FM radio telemeter system. The Wiancko gauge was used in the usual four-arm inductance bridge. To indicate pressure polarity, provision was made for operation with some unbalance of the bridge circuit.

The bridge was excited by a 10-kc subcarrier oscillator. The magnitude of the bridge unbalance current corresponding to zero pressure was adjusted to about one-third the anticipated maximum unbalance current. The amplitude-modulated unbalance signal was applied to a reactance tube modulator, which modulated the frequency of a transmitter in the 70-90 mc-per-sec band.

The transmitter consisted of a Raytheon CK-5702 reactance tube, a CK-5702, 20-mc oscillator-doubler, and a CK-5702 40-mc buffer-doubler driving an RCA 5763 80-mc final amplifier. The r-f power output was approximately three watts. A quarter-wave vertical shunt-fed antenna was used.

The receiving antennas consisted of 3-element vertical Yagi arrays. The receivers were Navy Sonobouy RBF-3's whose audio amplifiers were modified to provide approximately 10 watts of a-f power. The 10-kc signal was fed to a full-wave bridge comprised of 1N39 germanium diodes. The demodulated signal was fed to the recorder through a 1,500 cps low-pass filter.

The Wiancko gauges used in the radio link were calibrated th through the entire radio telemeter system. Linearity of the system was within ± 1 per cent. Calibration signals were obtained by means of relays which shunted the bridge arms by suitable reactances which were chosen to simulate the maximum expected pressure.

The subcarrier oscillator, transmitter, calibration box, and battery power pack were located in the pipe probe. Power was applied to the electronic system by relays actuated by the -15-minute control, and the calibration relays were actuated by the -1-sec control signal. These control signals supplied by Edgerton, Germeshausen, and Grier were transmitted from the recording trailer to the pipe probes by means of a 5-mile length of W-11-B cable.

2.5.3 Recorder

All Wiancko gauge data were recorded using one Consolidated Engineering Corporation type 5-114P3 recording oscillograph. The 28-volt power supply for the oscillograph consisted of a bank of five 6-volt heavy-duty lead-acid storage batteries. Recording was initiated by the -1-sec control signal supplied by Edgerton, Germeshausen, and Grier.

Consolidated Engineering Corporation type 7-223 galvanometers were used to record the output of the wire-link system. These galvanometers have a flat (± 5 per cent) frequency response from 0 to 500 cps. The output of the radio telemetering system was recorded by Consolidated Engineering Corporation type 7-226 galvanometers having a flat (± 4 per cent) frequency response from 0 to 3000 cps and were 80 per cent critically damped.

To realize the higher frequency response inherent in the radio-telemeter system a recording speed of 75 in./sec was chosen. The recording medium was Kodak Linagraph Ortho film.

2.5.4 Critique of Data-Transmission Systems

The information-transmission system employing copper-steel field wire (W-110-B) proved reliable and practical although somewhat limited in frequency response. The cross-talk problem from a total of as many as 26 pairs buried in the same trench was insignificant. The use of field wire, which was procured from the military services, had the advantages of availability, economy, and mechanical strength. Splices and terminations were of the Stakon type. Therefore any lineman's crew could lay the 5-mile lengths of wire, and field terminations could be rapidly and efficiently made in adverse weather conditions without special equipment or techniques. Traffic, the blast wave, dust-control sprinkling, and weather proved to be no serious hazard to the wire since the most vulnerable portions were buried 1 to 3 feet below the surface. Further investigation of methods for transmitting high-frequency carrier signals on field wire will probably result in considerable improvement of the 500-cps resolution limit.

Frequency-modulated telemetering, despite the mediocre showing in this project, deserves some consideration. The system employed required on control line to each transmitter for turn-on and calibration. Even when using this system, but especially when using an all r-f setup (turn-on and calibration using a one-tube receiver), minimum preparation would be required to instrument a test. End instrument-transmitter packages could be placed in the test area as late as one day prior to the test, used, recovered, and stored for the next test.

However, it is doubtful that any atomic test will take place without last-minute unforeseeable radio interference that would seriously impair the reliability of a r-f system. Unless considerable attention is given to the problem of radio interference, the full advantage of a radio-telemetered system with respect to mobility and economy of time, expense, and personnel can not be realized.

SECTION 3

RESULTS AND CONCLUSIONS

3.1 DATA OBTAINED

Pressure-time-distance data for surface and underground shots are presented in Tables 3.1 and 3.2. Peak overpressure, time of arrival, and positive phase duration are plotted against distance from ground zero in Figures 3.2, 3.3 and 3.4. Pressure-time waveforms for the surface and underground shots are summarized in Figures 3.5 and 3.6.

Tables 3.3 and 3.4 contain indenter diameter data for the surface and underground shots. It is not necessary to rationalize indent-diameter with overpressure by determining the force constant for rapid rise time phenomena. The tabulation of diameters is sufficient to indicate that the measured phenomenon (regardless of its components) shows a marked symmetry. From analysis of the variants it is apparent that the symmetry of the measured phenomenon is greater than the precision of the measuring system.

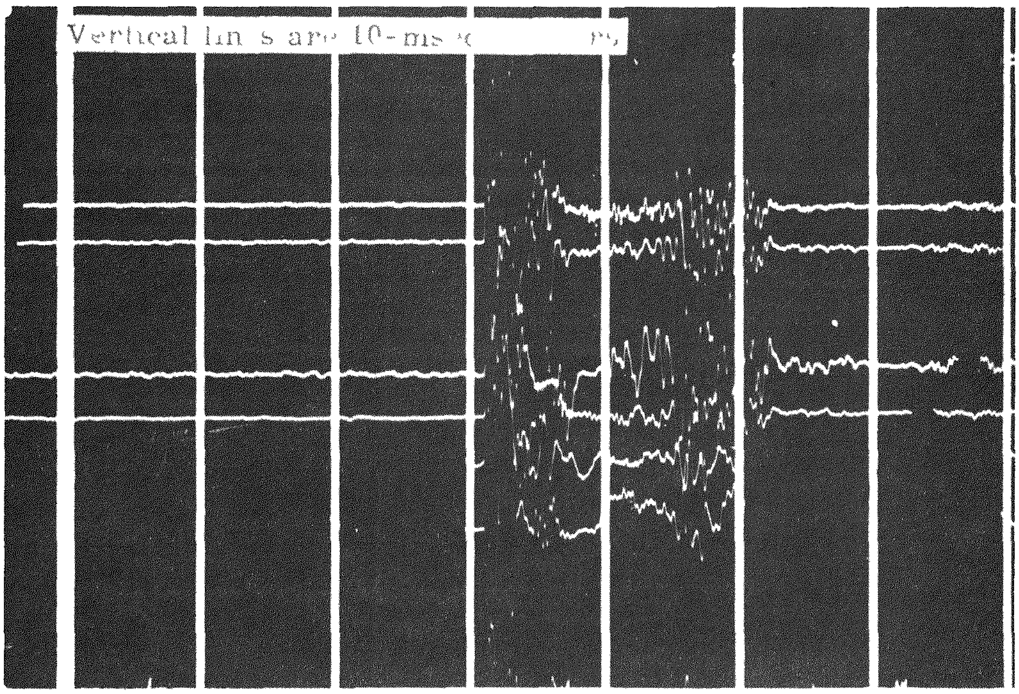

Fig. 3.1 Zero-Time Noise Burst

PROJECT 1.4

TABLE 3.1

Pressure-Time-Distance Data, Surface Shot

Distance (ft)	$\lambda^{\dagger}$	Peak Overpressure (psi)	Time of Arrival (msec)	Positive Phase Duration (msec)
680	5.4	17.76	203	197
680(tel)		17.85	202	224
920(tel)	7.3	10.80	354	222
1250	9.95	7.02	593	303
1250(tel)		7.53	593.4	322.6
1700	13.5	4.07	947	381.5
1700(tel)		4.02	946	345.7
2300	18.2	2.44	1446	410.0
2300(tel)		2.64	1446	390.0
4200(int)	33.3	0.83		502.0

$\dagger$ = λ based on a charge weight of 2 x 10^6 lbs TNT
Tel = telemeter link
Int = interferometer

TABLE 3.2

Pressure-Time-Distance Data, Underground Shot

Distance (ft)	$\lambda^{\dagger}$	Peak Overpressure (psi)	Time of Arrival (msec)	Positive Phase Duration (msec)
314	2.5	32.39	122.5	100.2
498		13.57	228.2	170.8
500	3.96	14.39	229.0	160.0
680	5.4	9.90	348.7	206.8
680		10.09	348.0	201.0
920	7.3	7.30	520.5	238.5
920		7.07	521.5	287.5
1250	9.95	4.95	775.0	274.0
1250		5.20	774.5	254.5
1700	13.5	3.04	1134.5	314.5
1700(tel)		3.47	1134.0	335.0
2300	18.2	2.14	1636.3	363.0
3100	24.6	1.70	2322.0	387.0

$\dagger$ = λ based on a charge weight of 2 x 10^6 lbs TNT
Tel = telemeter link

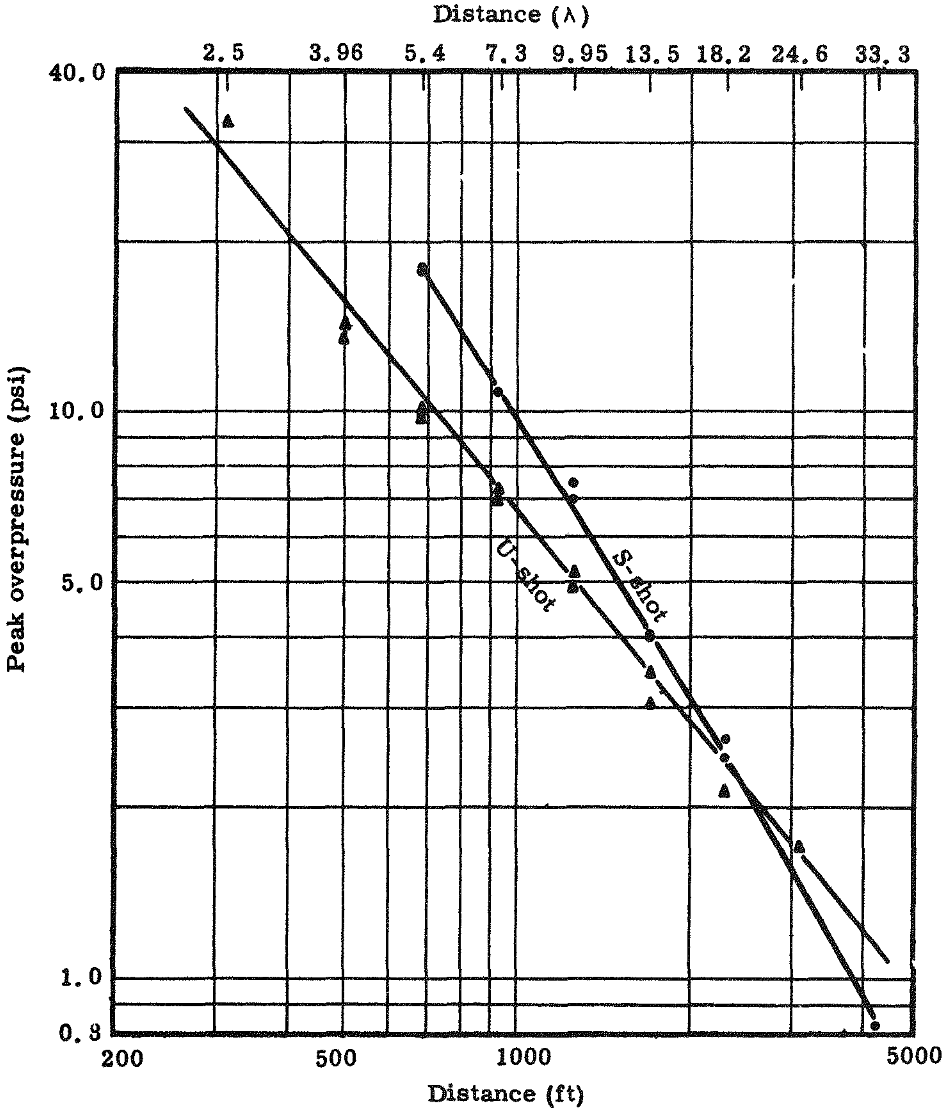

Fig. 3.2 Peak Overpressure vs Distance (Lines connecting data points are arbitrary.)

Ground acceleration may have introduced a systematic error into all readings of indenter gauges. However, a K-factor (force constant) of 50 psi/mm^2 can be derived from surface shot indenter data and the 1,700-ft peak air pressure, as measured by the Wiancko system. This same K-factor applied to the underground data resulted in agreement between indenter and Wiancko data at 1,250 feet, where ground accelerations were higher.

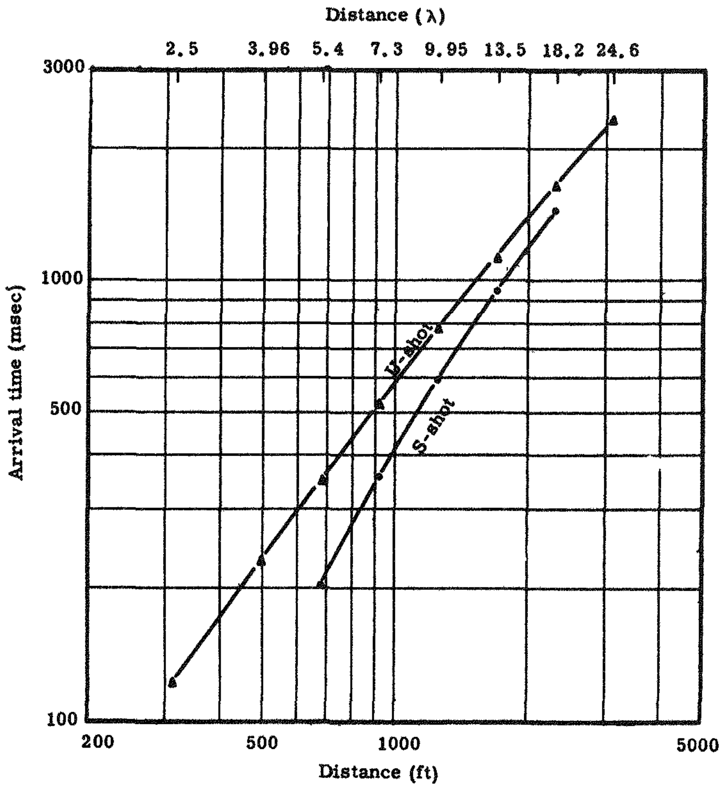

Fig. 3.3 Time of Arrival vs Distance

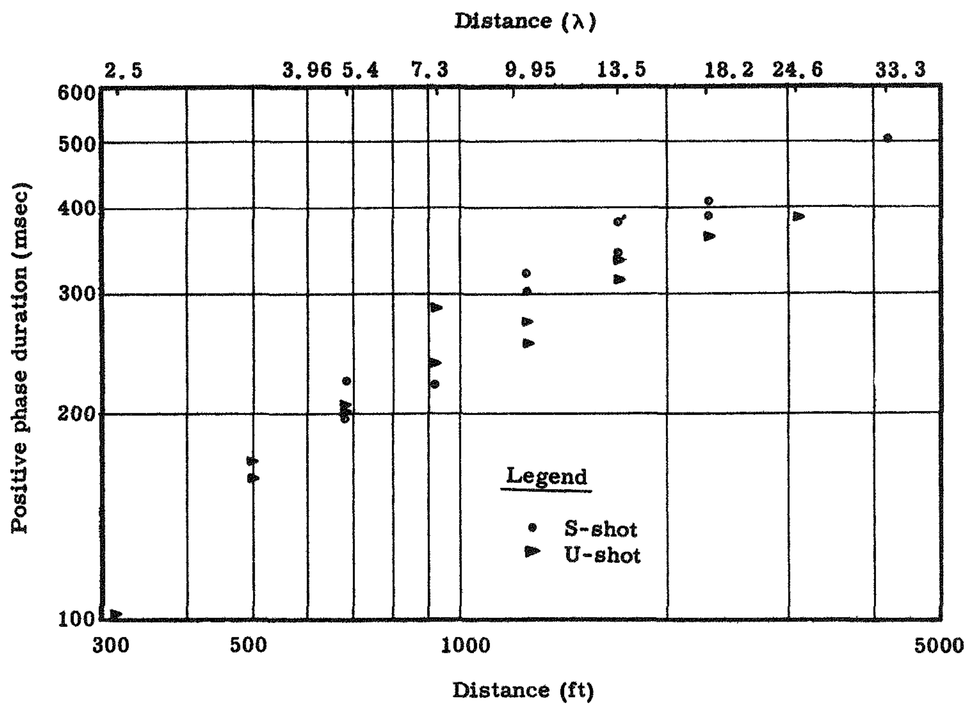

Fig. 3.4 Positive Phase Duration vs Distance

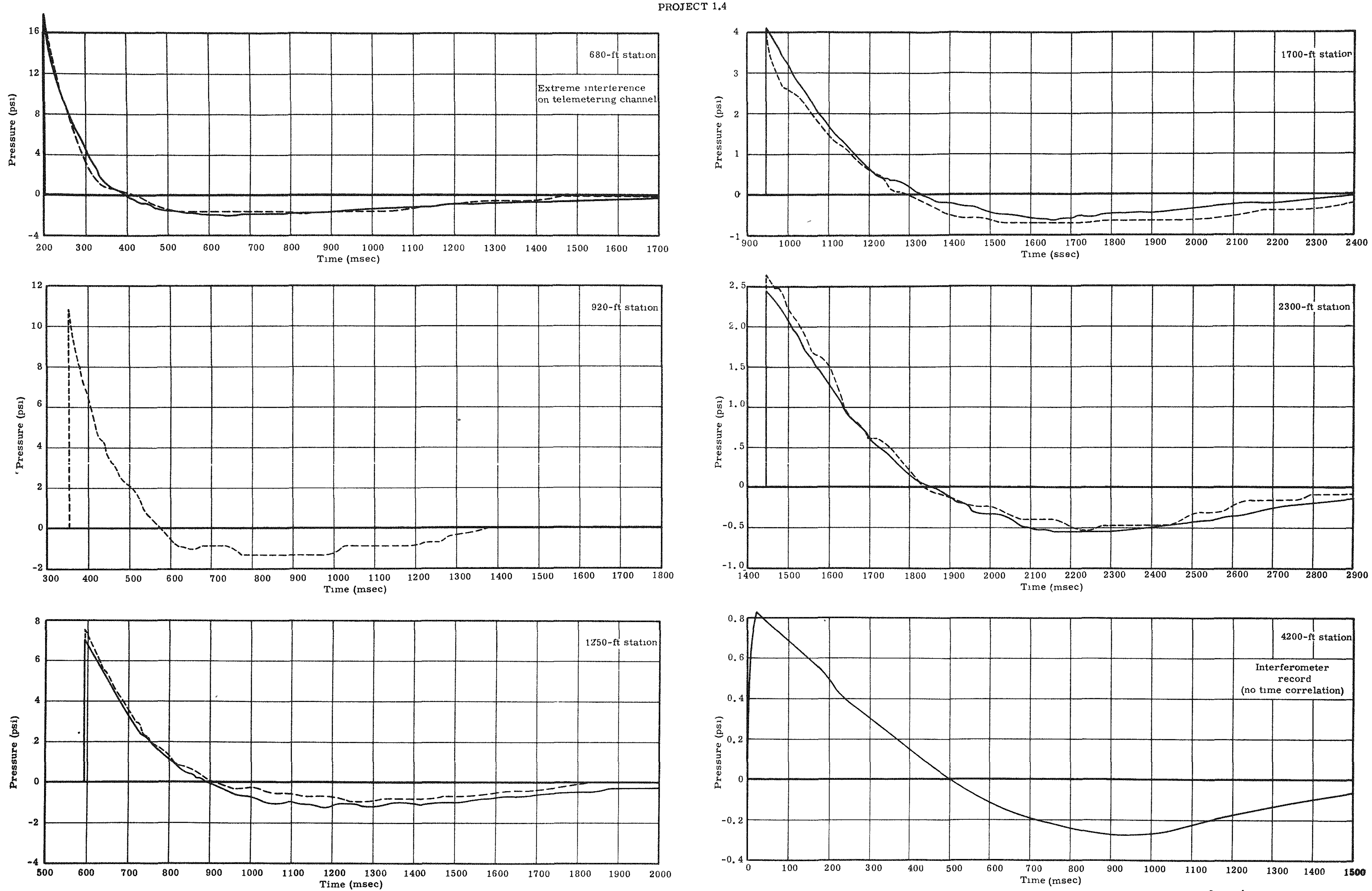

Fig. 3.5 Surface Shot Pressure-Time Curves

Legend
Wire link channel———
Telemetered channel - - - -

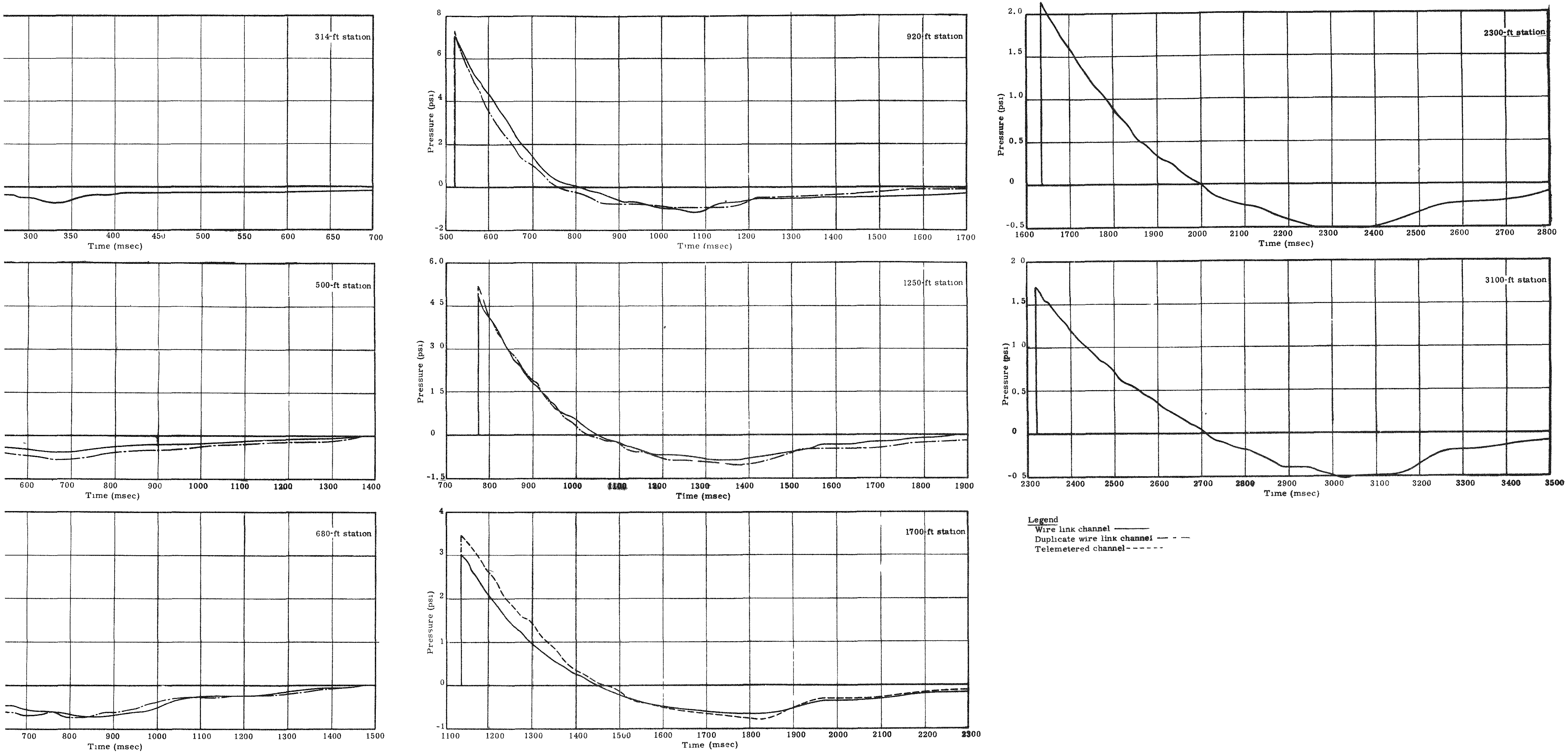

Fig. 3.6 Underground Shot Pressure-Time Curves

TABLE 3.3

Indenter Gauge Data, Surface Shot

Station	Gauge No.	Diameter (mm)	Diameter^2	Pressure (psi)
1	1 2 3 4	.255 .256 .306 .271	.0650 .0655 .0936 .0734	3.25 3.28 4.68 3.67 3.72 (ave)
2	1 2 3 4	.280 .290 .237 .274	.0784 .0841 .0562 .0751	3.92 4.21 2.81 3.76 3.68 (ave)
3	1 2 3 4	.263 .273 .296 .298	.0691 .0745 .0876 .0888	3.46 3.73 4.38 4.44 4.00 (ave)
4	1 2 3 4	.304 .288 .268 .302	.0924 .0829 .0718 .0912	4.62 4.15 3.59 4.56 4.23 (ave)
5	1 2 3 4	.292 .284 .297 .299	.0853 .0807 .0882 .0894	4.27 4.04 4.41 4.47 4.30 (ave)

TABLE 3.4

Indenter Gauge Data, Underground Shot

Station	Gauge No.	Diameter (mm)	Diameter^2	Pressure (psi)
1	1 2 3 4	.336 .307 .339 .337	.113 .094 .115 .114	5.65 4.70 5.75 5.70 5.45 (ave)
2	1 2 3 4	.340 .341 .342 .346	.116 .116 .117 .120	5.80 5.80 5.85 6.00 5.86 (ave)
3	1 2 3 4	.337 .340 .353 .343	.114 .116 .125 .118	5.70 5.80 6.25 5.90 5.91 (ave)
4	1 2 3 4	.332 .334 .339 .332	.110 .112 .115 .110	5.50 5.60 5.75 5.50 5.59 (ave)

The data gathered are useful for correlating blast strengths with observed damage to structures of Program Three, for distinguishing air-induced ground shocks from true ground phenomena (air-to ground coupling, and as source material for any application study.

3.2 CONCLUSIONS

It is apparent from the pressure-time curves for both underground and surface shots that the shape of the shock wave conforms generally to the classic form as described in The Effects of Atomic Weapons.* The system (including data reduction) permitted time resolution to 0.5 msec. Within this limitation the pressure discontinuity at the shock front appears instantaneous in most instances. +

Pressure-distance data were within 10 per cent of anticipated values, based on Stanford Research Institute extrapolations from scaled TNT blasts at DUGWAY and early JANGLE tests.** Extrapolation of air shock data from surface and underground TNT tests appears valid for surface and underground atomic blasts.

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* The Effects of Atomic Weapons, Section 3.11, Los Alamos Scientific Laboratory, U. S. Government Printing Office, 1950.

+ For a discussion rise-time phenomena from other atomic blasts see Murphey, B. F., Operation BUSTER - Some Measurements of Overpressure-Time vs Distance for Airburst Bombs, Sandia Corporation report No. SC-2142 (tr) (to be published).

** Doll, E. B. Interim Report - Part II HE tests - Operation JANGLE, Stanford Research Institute, October 1951, Figs. 5 and 6.

APPENDIX A

PERSONNEL PARTICIPATING IN PROJECT 1.4

From Sandia Corporation, Albuquerque, N. M.

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J. C. Hughes
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From 1st Tactical Support Squadron, Sandia Base, Albuquerque, N. M.

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PROJECT 1.4

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