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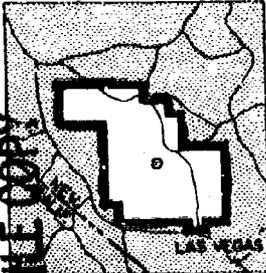
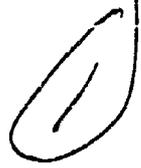
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OPERATION

PLUMB BOB



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Project 41.1c

EFFECTS ON MATERIALS EXPOSED
TO A NUCLEAR DETONATION

[U]

Issuance Date: March 26, 1965

SANDIA LABORATORY ✓
ALBUQUERQUE, NEW MEXICO

DDC CONTROL
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EFFECTS OF MATERIALS EXPOSED TO A NUCLEAR DETONATION

(8)
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By

(10)

W. K. Dolen,
R. M. Jefferson
M. M. Karnowsky.

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ABSTRACT

In September 1957, the Fizeau Shot of Operation Plumbbob conducted in Nevada provided an 11-kiloton nuclear burst which was used for a variety of noninstrumented tests upon a broad range of materials related to weapon construction. The objectives of ~~this portion of the tests~~ were: (1) correlation of structural changes on materials with respect to fireball location and/or heating rates; (2) observation of the effects on various materials, of thermal and nuclear radiation delivered at high rates, both singly and in combination.

For studying the thermal environment inside the fireball, eleven different materials (200 samples) were inserted in two 4-ton steel billets suspended near air zero. Vaporization, melting, and structural changes were determined on the recovered samples. These data, subsequently analyzed and combined with data from other parts of the experiment, led to the determination of fireball temperatures. These temperature determinations agree quite well with theoretical and instrumented temperatures observed on shots of this size.

Additional data for the fireball studies were derived from samples placed in couplings located at 20-foot intervals along the height of the Peace Pipe. This pipe was a vertical shaft directly beneath air zero. Samples along the Peace Pipe were designed for energy input studies. Metallic examination of these samples, and similar samples later exposed in a solar furnace, lent additional reliability to the results of the fireball studies.

The determination of the effects of high dose rates of thermal and nuclear radiation on weapon materials was accomplished by exposing an array of various samples (primarily tensile samples) at different distances from air zero. The samples were partially protected from the blast effects by placing them in deep pits on a line of sight to air zero. The only observed effect upon the metallic tensile specimens was corrosion. At the distances exposed, tensile values were unchanged by exposure. Other samples (coatings and organic materials) exhibited definite thermal and nuclear radiation degradation.

Exposure of materials and components to nuclear radiation alone was accomplished by housing these items and dosimetry devices in small aluminum spheres. In many cases there were no observed effects upon the samples. Those samples showing the greatest observed changes were the electronic components.

Results of this event and its experiments indicate several things. There was a high degree of sample survival, bearing out the general acceptability of sample mounting methods. The fireball studies resulted in the determination of environments independent of measuring systems but closely agreeing with other observed data. Studies conducted outside the fireball showed at best only threshold damage levels.

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PREFACE

During Operation Plumbbob, Sandia Laboratory conducted several projects designed to provide information related to the vulnerability of nuclear weapons exposed to nuclear explosions. These projects were consolidated in Program 41 of Operation Plumbbob which was sponsored by the Weapons Effects Department (now designated as the Nuclear Burst Physics Department). C. D. Broyles of that department served as scientific advisor in this program and provided the technical coordination of the several projects. A. D. Thornbrough of the Full-Scale Test Department served as Program Director.

Program 41 consisted of the following projects, some of which have been reported as indicated below:

- Project 41.1a Fireball Studies (WT-1517)
- Project 41.1b Vulnerability of Weapons Components
- Project 41.1c Effects on Materials Exposed to a Nuclear Detonation (WT-1519)
- Project 41.2 Vulnerability of Nuclear Weapons to Nuclear Countermeasures (SC-4946(WD))
- Project 41.3 Effect of Altitudes on Neutron Measurements (WT-1521)

Experimentation and results encompassed by Project 41.1c are covered in this report.

Appreciation is expressed here to personnel of Sandia Laboratory who provided technical support for this project: R. U. Acton, C. F. Bild, J. L. Colp, D. M. Ellett, R. E. Fisher, K. C. Humpherys, D. R. Johnson, K. E. Mead, H. E. Montgomery, G. Rainhart, J. C. Russell, J. A. Sisler, A. W. Snyder, and R. R. Sowell.

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Chapter 1

INTRODUCTION

1.1 OBJECTIVES

The primary purpose of the project in the Fizeau event was to obtain, independent of instrumentation, information on effects sustained by a variety of materials in the fireball at various distances from the point of detonation. In conjunction with this effort, an attempt was made to determine effects on materials subjected to high heating rates. These first two objectives constitute studies in the fireball proper. The third effort was to determine effects of combined thermal and nuclear radiation on selected materials, and the last was to study permanent effects of nuclear radiation from a weapon burst and dependence of these effects upon dose rate in various materials.

1.2 MILITARY SIGNIFICANCE

Weapons systems which subject materials and components to environments of temperatures which are at the extremes of their operational limits are now in existence. Future systems undoubtedly will require compatibility with environments of both high thermal and nuclear radiation. Since Sandia Laboratory is cognizant of these environments, it must expend considerable effort in testing and evaluation of metal, ceramic, and organic materials to determine their compatibility with these future weapons systems.

1.3 BACKGROUND AND THEORY

Several agencies have studied thermal effects of nuclear detonations on materials. Earliest investigations associated with Trinity were concerned with ignition temperatures at various distances from the fireball. The first concrete investigation of thermal effects on materials was conducted during Operation Greenhouse¹ by the Naval Materials Laboratory (NML), the Naval Radiological Defense Laboratory (NRDL), and the National Bureau of Standards (NBS). Objectives of their investigations were twofold: The first concerned characteristics of thermal radiation associated with nuclear detonation; the second exposed correlation between field and laboratory exposures, environments, and effects on various materials.

During Operation Buster,² in addition to studies of spectral and intensity-time characteristics of thermal radiation and effects of target geometry on the degree of thermal damage, NML performed the same types of investigations conducted during Operation Greenhouse. This program was continued and supplemented by NML in Operation Upshot-Knothole.³

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In Operation Teapot,⁴ Wright Air Development Center (WADC) exposed materials samples within the fireball proper. This was the first time that the fireball was utilized as an environment, and the project was primarily concerned with studies of the lethality of a fireball to basic missile structures, with determinations of the amount of metal loss from selected materials.

Investigation instituted on Teapot⁴ by WADC was continued on Redwing,⁶ which confirmed original work and expanded it with the addition of new materials and shapes, including the use of instrumented spheres. The latter contained tape recorders to record time histories of acceleration, depths of melting of surface material, and specimen temperatures near the surface. To obtain data on time rate of material removal of metals by high-temperature radiant energy, Sandia Laboratory, in its Totem Pole experiment in the Kickapoo shot of Redwing,⁶ placed melt-study plugs on a large pipe which extended into the fireball.

In the Fizeau shot of Plumbbob, Project 41.1c has attempted to expand previous and current fireball lethality studies and determine effects produced on selected materials by thermal and/or nuclear radiation.

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Chapter 2

PROCEDURES

2.1 PREDICTED ENVIRONMENTS

The predicted environments for the materials exposed are listed in Table 2.1.¹

2.2 SELECTION OF MATERIALS

2.2.1 Materials Within Fireball Proper

Materials placed inside the fireball for the study of thermal effects were selected on the basis of three types of reactions of a solid to a heat source: vaporization, melting, and internal structure changes such as recrystallization and transformation. The program was designed to utilize each of these responses in a suitable set of samples in order that the effects attained could be studied.

a. Vaporization. Since parameters for material survival in regions close to the point of burst are unknown, a variety of materials was chosen to insure test results. Use of a group of materials differing widely in specific heat, thermal conductivity, density, and melting point permits several different approaches to an understanding of fireball lethality. Amounts of vaporized material thus might be used to confirm heat input to a variety of materials.

b. Melting. Melt-study specimens were made from powders by compacting. Materials were selected to give as wide a range of melting temperatures as possible. Unsintered powder compacts were chosen so that melting of individual small grains of powder at the surface of the compact could be observed.

c. Internal Changes. Three materials having known physical property changes due to internal reactions caused by heating were chosen for this part of the study. Naval brass was selected for its conversion of quenched, retained beta to alpha at approximately 900°F. Fully hardened 0.89 carbon steel was selected for tempering effects between 200° and 1300°F. Cold-rolled, full-hard molybdenum was selected for its sharp recrystallization temperature at 2100°F. For survival purposes, these three materials were presented in two geometries, described later. Mounted with these was a group of six materials exposed primarily for survival and effects studies. These materials were wood, graphite, 6061-T6 aluminum, and organic compounds of DC-301 silicone, diallyl phthalate, and epoxy.

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TABLE 2.1 -- PREDICTED ENVIRONMENT FOR FIZEAU SHOT*

Distance from air zero	Total (neutrons/cm ²)			Total gamma roentgens	Peak gamma roentgens (sec ⁻¹)	Thermal energy (cal/cm ²)	Peak gas temp (°K)
	>200 ev	>1.5 Mev	>3 Mev				
<u>Billet specimens</u>							
30 to 100 ft	3 x 10 ¹⁷ to 3 x 10 ¹⁶	5 x 10 ¹⁶ to 5 x 10 ¹⁵	3 x 10 ¹⁶ to 2 x 10 ¹⁵	10 ⁷ to 6 x 10 ⁶	10 ¹⁴ to 2 x 10 ¹³	10 ⁶ to 10 ⁵	3.5 x 10 ⁵ to 1.5 x 10 ⁵
<u>Peace Pipe specimens</u>							
215 to 495 ft	10 ¹⁶ to 2 x 10 ¹⁵	2 x 10 ¹⁵ to 5 x 10 ¹⁴	6 x 10 ¹⁴ to 10 ¹⁴	2 x 10 ⁶ to 5 x 10 ⁵	3 x 10 ¹² to 4 x 10 ¹¹	10 ⁴ to 10 ³	4.5 x 10 ⁴ to 10 ⁴
<u>Pit specimens</u>							
700 to 2800 ft	10 ¹⁵ to 3 x 10 ¹²	3 x 10 ¹⁴ to 8 x 10 ¹¹	6 x 10 ¹³ to 2 x 10 ¹¹	3 x 10 ⁵ to 2 x 10 ³	2 x 10 ¹¹ to 10 ⁹	100 to 30	

*Data taken from Ref. 1. These predicted data are intended for comparative purposes only, since they are free-field values and, because of attenuation, may not be directly applicable to specific material samples.

†Maximum neutron-flux rate at these distances is of the order of 10⁶ sec⁻¹ times the total flux.

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Inasmuch as the space in the base of the top billet was made available at such a late date, samples to be exposed in this nuclear radiation environment were: (1) previously untested material with probable high radiation resistance, (2) materials being tested elsewhere in the experiment to be used in the study of permanent dose rate effects, and (3) materials of interest in pure physics experiments. Availability of material was, of course, a factor in determining choice. Space was a problem and dictated, to some extent, the choice of samples, but was not considered a primary factor.

2.2.2 Pit Specimens

Pit specimens consisted of metals, plastics, ceramics, coatings, and components.

a. Metals. Metals chosen for exposure in the pits covered a wide range of transformation temperatures, as well as mechanical and heat-treated conditions. These materials have well-known physical and mechanical properties and, in general, are now in use or are contemplated for use in Sandia Laboratory weapon applications. It is not known what the properties of the materials chosen will be after subjection to the high heating rates and total nuclear dose expected. More specifically, the metals were chosen because of individual or group application as follows:

- (1) titanium alloys: high strength-to-weight ratio, relatively high temperature of transformation, commercial availability, and military use.
- (2) stainless steels: proved use as strength members, relatively high-temperature applications, missile and weapon materials, effects study on heat-treated and precipitation-hardening materials.
- (3) aluminum alloys: weapon applications for case materials and strength members, airframe structure applications, and general commercial usage.
- (4) copper base alloys: component applications and widespread commercial use, especially in electronic apparatus.
- (5) steels: eutectoid and alloy transformation study and general commercial use.
- (6) magnesium alloys: weapon, missile, and airframe application.
- (7) nickel and cobalt alloys: high-temperature strength and corrosion-resistant alloys.
- (8) zinc-die-casting alloy: study of effects on soldered joints for experimental procedure in joining aluminum alloys.

b. Thermosetting Molding Materials. The three thermosetting molding compounds which were selected were a glass-fiber-filled diallyl phthalate (dap), a Dacron-fiber-filled diallyl phthalate, and a glass-fiber-filled silicone. The glass-filled dap was selected

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because of its many applications in present weapon programs, where it is used as an insulator as well as a structural member. The Dacron-filled dap is used in several weapon programs, but only where a low "Z" material is necessary. With the trend toward materials resistant to ever-increasing temperatures, the glass-fiber filled silicone compound was selected with a view toward future applications. A polyester-glass premix compound was also included, since it is being used for potting shells which become permanent parts of an electronic package.

c. Laminates. Although the present trend in structural plastics is toward the epoxy and polyester resin laminates, several phenolic resin laminates were included because of their stability at high temperatures. The phenolics were laminated with asbestos and glass cloth. The asbestos laminate was impregnated with a high-temperature resin. The epoxy and polyester glass laminates are representative of standard radome and structural materials while epoxy lead-glass cloth laminate was selected for investigative purposes.

d. Polymers. Because of considerable data available on radiation degradation of Teflon, this polymer was included as a measuring stick for evaluation of the other organic materials. High-density polyethylene of the Ziegler type was chosen in preference to common polyethylene, primarily because of its higher rigidity. Several applications using this new polymer are under development.

e. Casting Resins. Formulations tested consist, for the most part, of materials already in widespread use or with anticipated broad usage. All base resins were epoxies. Only two investigative approaches were attempted. In one, a silica-filled formulation was compared with mica, since more silica (Neo-Novacite) than mica can be incorporated into an equal volume of epoxy resin. Inorganic fillers are more radiation-resistant than organic resin; hence, a more highly filled formulation should be more resistant to radiation damage. In the other investigation, 7-percent metallic boron was added to an unfilled resin to determine the effect of the high-neutron-capture cross section of boron as a stabilizer for epoxy resin while exposed to radiation.

f. Foams. Rigid polyurethane foams of 4 lb/ft³, 30 lb/ft³, and 60 lb/ft³ densities were exposed. Foams in the 30 lb/ft³ to 60 lb/ft³ density range are being used in present applications. Foams in the 4 lb/ft³ density range will be used in future applications. Flexible polyurethane foams were used for shock, vibration, and insulation applications at points where dosage was recorded. Visual inspection of foams at these locations is expected to give some qualitative information on degradation.

g. Elastomers. Seven rubber compounds exposed represent the most common base polymers used in rubber formulations. No attempt was made under this program to formulate for radiation resistance. Several formulations tested are currently being used in our weapon components. It is hoped that a comparison of radiation resistances of various base polymers can be made and that conclusions can be drawn relative to performance of materials used in nuclear weapons.

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h. Adhesives. Four adhesives tested were representative of those used in present weapon programs. These were a 100-percent solid-liquid epoxy resin, a polysulfide adhesive sealer, a silica-filled epoxy, and a silicone rubber sealer. Two experimental adhesives, one with a graphite filler and one with a heavy metal filler, were tested to determine the effect of radiation on adhesives with various fillers. Exposure was also made of two structural adhesives for investigative purposes.

i. Coatings. Coatings chosen for exposure are among conventional systems used for weapons, handling tools, test equipment, and packaging. Other coatings selected are of the high-reflectivity, or heat-resistant, variety.

All coatings selected have proved themselves under one or more normal environments and are, for the most part, in use at this time. These coatings, essentially paints, were chosen to facilitate study of effects of thermal and nuclear radiation on finish and adhesion to base materials.

Three base materials--aluminum, magnesium, and steel--were used for comparison studies of coatings. Magnesium panels with two surface treatments were exposed for comparative purposes.

j. Radiation Effects Materials. Radiation effects materials located in the pits were actually intended for exposure at the same location as the remainder of radiation effects samples, but physical size of samples prevented their being placed in spheres. Reasons for choice of these materials are the same as for the remainder of radiation effects specimens indicated below. Dosimeters placed in the pits were selected to obtain correlation between exposures (neutron and gamma) on the surface and in the pits.

2.2.3 Sphere Specimens

Samples chosen for exposure in spheres are divided into six general categories: components, plastics, elastomers, hydraulics, dielectrics, and metals. Basically, there were four reasons for the choice of these materials. Each falls into one or more of the following groups:

- a. Presently used weapon materials and components of suspected radiation susceptibility.
- b. Materials for which data are available for radiation damage at contemplated exposure, but at lower rates.
- c. Materials of possible future weapon use, but of unknown radiation susceptibility.
- d. Materials of known radiation vulnerability.

Dosimeters, both neutron and gamma, were placed at each sphere position and inside two of the pits.

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2.3 SPECIMEN CONFIGURATION

Material specimens selected for Fizeau were designed in specific configurations required for the test. Conventional sample configurations were used for tensile, impact, adhesive, and paint panels wherever possible. Other shapes were used where Sandia has routinely adopted a special configuration or where space limitations required modifications. Special studies, such as vaporization and internal structure changes, demanded samples of particular design.

2.3.1 Vaporization Specimens

Vaporization specimens were designed to present a flat surface to the thermal environment. The specimens had a 3/4-inch-square cross section for 1-1/4 inches. The cross section was then tapered down to a 1/2-inch threaded section. The specimens were screwed into a holder in such a manner that only the 3/4-square-inch face was exposed to the fireball. The samples were weighed prior to insertion so that the amount of metal loss by vaporization could be determined after the shot (Figure 2.1).

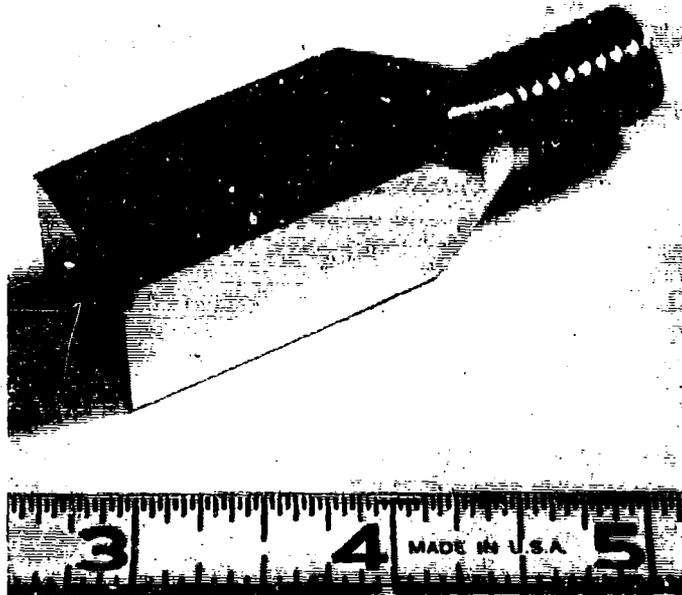


Fig. 2.1 -- Vaporization specimen.

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2.3.2 Compact Specimens

For ease in pressing, right circular cylinders were chosen for powder-melt study specimens. Samples were 1/2-inch in diameter and were pressed into a 1/2-inch-diameter stud with a 6-32 thread projecting for mounting purposes (Figure 2.2).



Fig. 2.2 -- Compact specimen assembly.

2.3.3 Wedge Specimens

Wedge specimens were designed to eliminate mass effects in establishing changes in internal structure. Samples were 1-inch-diameter rods machined on one end to a triangular pyramid having one edge parallel to the longitudinal axis and, consequently, terminating in a sharp point. The specimen was oriented so that the perpendicular bisector of the triangular cross section was parallel to the Peace Pipe. This arrangement presents to the temperature front a steadily increasing cross section in which structure changes can be seen metallographically (Figure 2.3).

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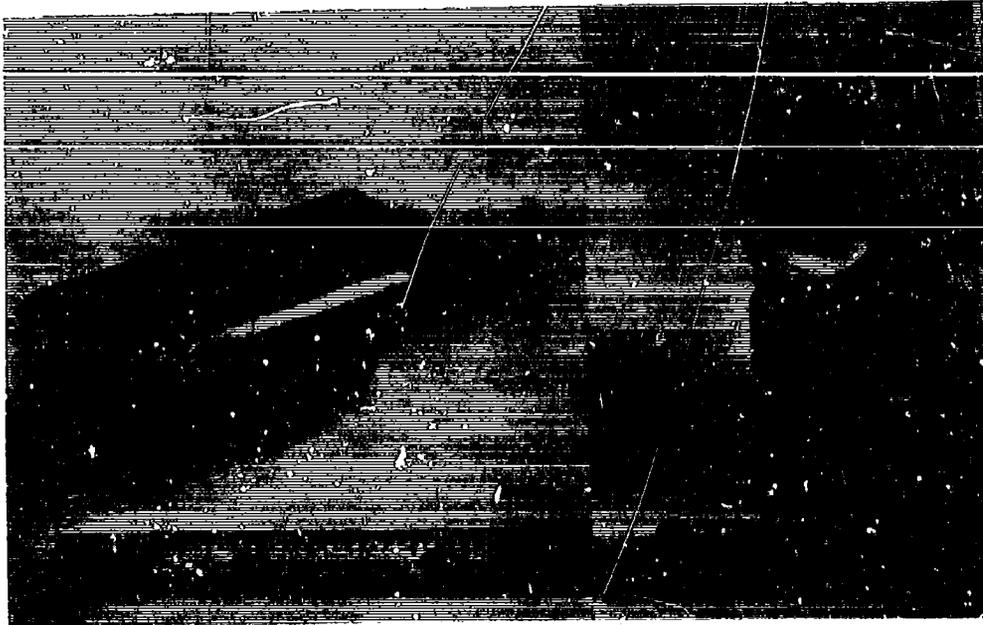


Fig. 2.3 -- Two views of wedge specimen.

2.3.4 Rod Specimens

Rod specimens of the same material as the wedge specimens, designed principally for maximum survival, were mounted beside the wedge specimens and, although the wedges protruded from the holder, the rods were mounted flush. These were 1-1/4 inches long and either hexagonal or round, depending upon availability of shape. One end was turned to a 1/4-20 thread for mounting purposes (Figure 2.4).

2.3.5 Pit Specimens

Most pit samples exposed in Fizeau were standard ASTM (American Society for Testing Materials) tensile bars. Metal specimens were 8 inches long; plastic laminates, foams, casting resins, and Teflon were 8-1/2 inches long. Molded tensile specimens were in accordance with ASTM D 651-48, and the impact bars as exposed were double length as described in ASTM D 256-54T, thus giving two specimens per mounted sample (Figure 2.5). Coating panels were 3-by-6-inch rectangles, a size considered standard for the Sandia Materials Laboratory for normal environmental testing. Their thickness ranged from 0.035 to 0.064 inch, depending on the base material--aluminum, magnesium, or steel. Exceptions to standard-size tensile bars are as follows:

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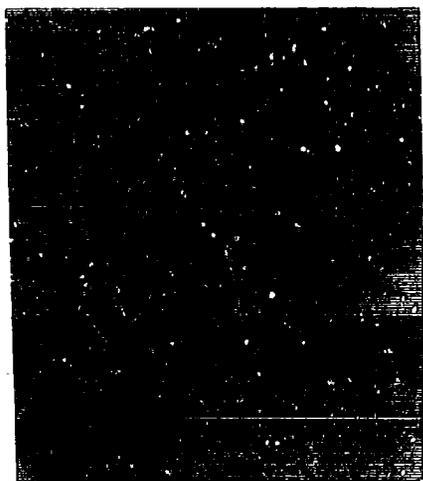


Fig. 2.4 -- Rod specimen, 1-1/2 by 1/4-inch hexagon.

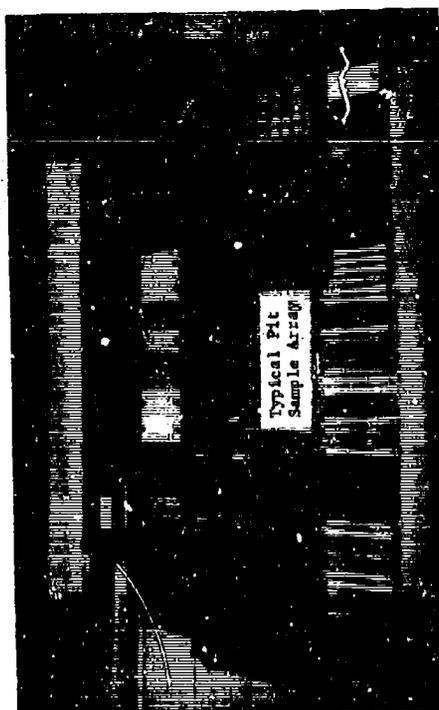
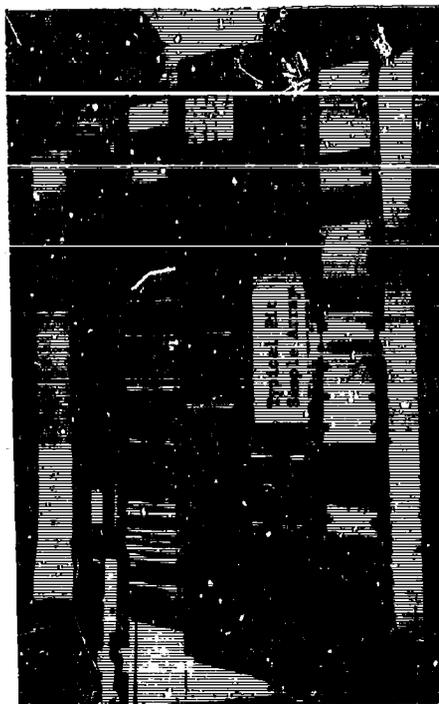


Fig. 2.5 -- The two pit specimen arrays.

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- a. Thickness was reduced to 1/16 inch on one titanium alloy, one uranium alloy, and one stainless steel. All other measurements were standard.
- b. Aluminum bars soldered with zinc die-casting alloy, as well as bars of the zinc die-casting alloy itself, were 5 inches rather than 8 inches in length. All other measurements were standard.
- c. High-density polyethylene tensile bars were injection-molded by the supplier and were 7 inches long by 1/8 inch thick.
- d. Adhesive specimens for both shear and tension tests were designed to have 1 square inch of bonded area.

2.3.6 Sphere Specimens

Configurations of specimens placed in spheres were determined by space available inside (Figure 2.6).



Fig. 2.6 -- Typical sphere specimens.

a. Components. Since components must be tested in whatever configuration they happen to exist, the only limitation in this case was the 6-inch inside diameter of the sphere.

b. Plastics. Because of limited space, a miniature specimen was designed which combined tensile and impact specimens. The former has a 1-inch gage length of 0.180-inch diameter. The clamping ends

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are 0.250 inch square; on one of these was mounted a miniature Izod impact specimen 1-1/2 inches long. Specimens of laminates, casting resins, and foam were machined, and thermosetting compounds were molded to this configuration.

c. Elastomers. Standard ASTM tensile specimens were cut with die "C," as dimensioned in Specification D 412-51T.

d. Hydraulics. Hydraulic samples were contained in 3-inch steel cylinders with 1-inch outside diameters. A filler tube on one end was sealed by driving a taper pin and welding across the top of the tube and pin. These holders contained a 10-cc sample of the fluids under test.

e. Dielectrics. Two sizes of 0.125-inch-thick dielectric sample discs were used in the spheres: a 2.00-inch disc for normal voltage and a 4.00-inch disc for high voltage. In order to determine physical characteristics of these irradiated materials, tensile, compression, flexural, and impact samples were included. Because of their size, tensile specimens were placed in the bottom of Pits B, E, and H in AN cans, and other samples were placed in spheres. Both tensile and notch impact bars are of standard ASTM dimensions.

f. Metals. Metal tensile bars were standard ASTM except for length, which was reduced to 5 inches to allow them to be placed inside the spheres.

2.4 SPECIMEN MOUNTING

The method of mounting specimens was considered carefully because of the obvious importance of recovering samples. In every case, three aspects of sample mounting were considered:

- a. Resistance to blast and temperature effects on mounting panels.
- b. Structural capacity to maintain identity on a large number of small samples.
- c. A facility for expeditious removal of samples from attachment.

2.4.1 Billet-Mounted Specimens

It was determined that a simple method for attachment of the billet specimens for vaporization studies described in Paragraph 2.3.1 (in the light of the three objectives listed above) would be to thread them into a massive steel billet (Figures 2.7 and 2.8), use of which permits a secure method of attachment, resists (by virtue of mass) blast and thermal effects in the fireball itself, and permits an arrangement for simple recovery of individual samples. Standard mill-size billets, 12 inches in diameter, 20 feet long, and of Type 1020 steel, were selected. To offer less resistance to the shock front, the top 12-inch section was machined to a right circular cone. Two billets were mounted at the center of the north side of the tower, with centers 40 and 90 feet from air zero. Each billet had 101 sample positions. Holes were 1.32 inches in diameter and were spiraled

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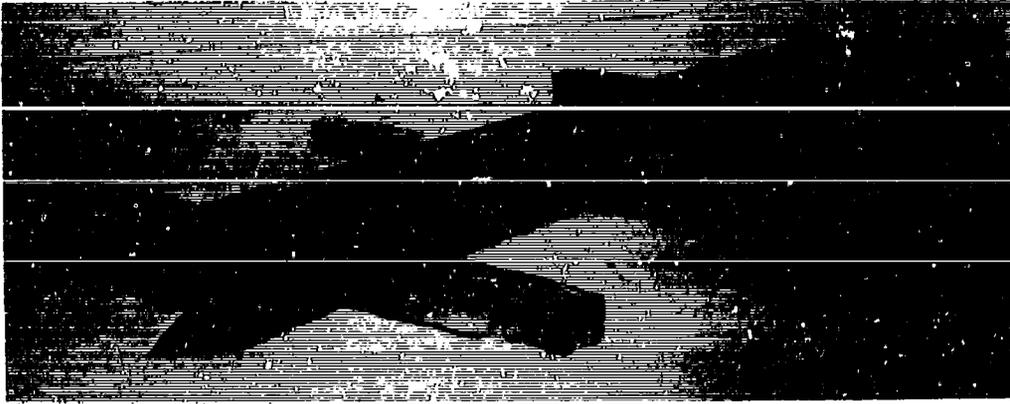


Fig. 2.7 -- Billet specimen mounting detail.



Fig. 2.8 -- Tower mounting of billets.

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about the periphery of the billets 90 degrees apart, with 2-inch vertical displacement per sample. After every set of four holes, a rotation of 15 degrees was made to begin the next set of four. At the bottom of each of the billets, a cavity, 6 inches in diameter, 12 inches deep, and suitably capped, was machined to contain a component package or a tape recorder.

In all cases, specimens were insulated from the billet by modeling clay. Tests conducted during the Boltzmann event had indicated that the clay was undamaged, easily removed, and prevented the accumulation of particles--melted or otherwise--in the areas needed for socket wrench insertion.

2.4.2 Peace Pipe

The Peace Pipe extended up the center of the 500-foot tower from the concrete bunker to a point 175 feet below the cab. The pipe itself was made of 2-inch-wall mild-steel pipe in 20-foot lengths. (An alloy steel was used in the top 40 feet.) The 20-foot lengths were joined by couplings large enough to accommodate welding of the pipe and allow for six access holes, three of which were available to Project 41.1c. These holes were fitted with 6-inch-diameter plugs, which were attached to the coupling by three 1/4-20 Allen-head screws. Two of the plugs contained the wedge specimens (Para. 2.3.3) and the rod specimens (Para. 2.3.4), and the third contained the compact specimens (Para. 2.3.2). The wedge specimens were attached to the plug by bolts from the back side, although wrench flats were incorporated on the sides of the wedges to provide an additional method of removal from the front of the plug. The rod specimens were flush-mounted and were threaded into the plug, permitting removal by socket wrench from the front. All wedge and rod samples were insulated from the plug by modeling clay. The compact plugs were attached to the pipe by the same type of bolting arrangement used for the wedge plugs (Figure 2.9).

2.4.3 Pit Specimens

Samples placed in pits were bolted to 9-inch-wide plates of aluminum. Five plates, with lengths of 46, 60, 60, 66, and 66 inches, were used in each pit. Duplication of lengths permitted alternation of plates to obtain more nearly uniform sample exposure. Since the elastomer samples were exposed as sheets from which tensile specimens would be cut after exposure, the sample mounting was different from the individual samples. The sheets were rimmed with 2-inch strips of aluminum bolted to the 9-inch plates. Adhesive samples were attached to plates which, in turn, were bolted to the 9-inch plates (Figure 2.5).

The pits themselves were chosen as a result of Boltzmann experimentation. Prior to Boltzmann, a considerable amount of attention was directed to sand blasting and missile damage effects on gages and other devices recovered from the path of the shock wave. At distance beyond inception of the precursor, with a reasonably fine type of soil, a sufficiently large amount of damage would be sustained by tensile specimens to invalidate data. Consideration of means of protecting samples from this type of damage led to trial in the Boltzmann shot of two major means of mitigation:

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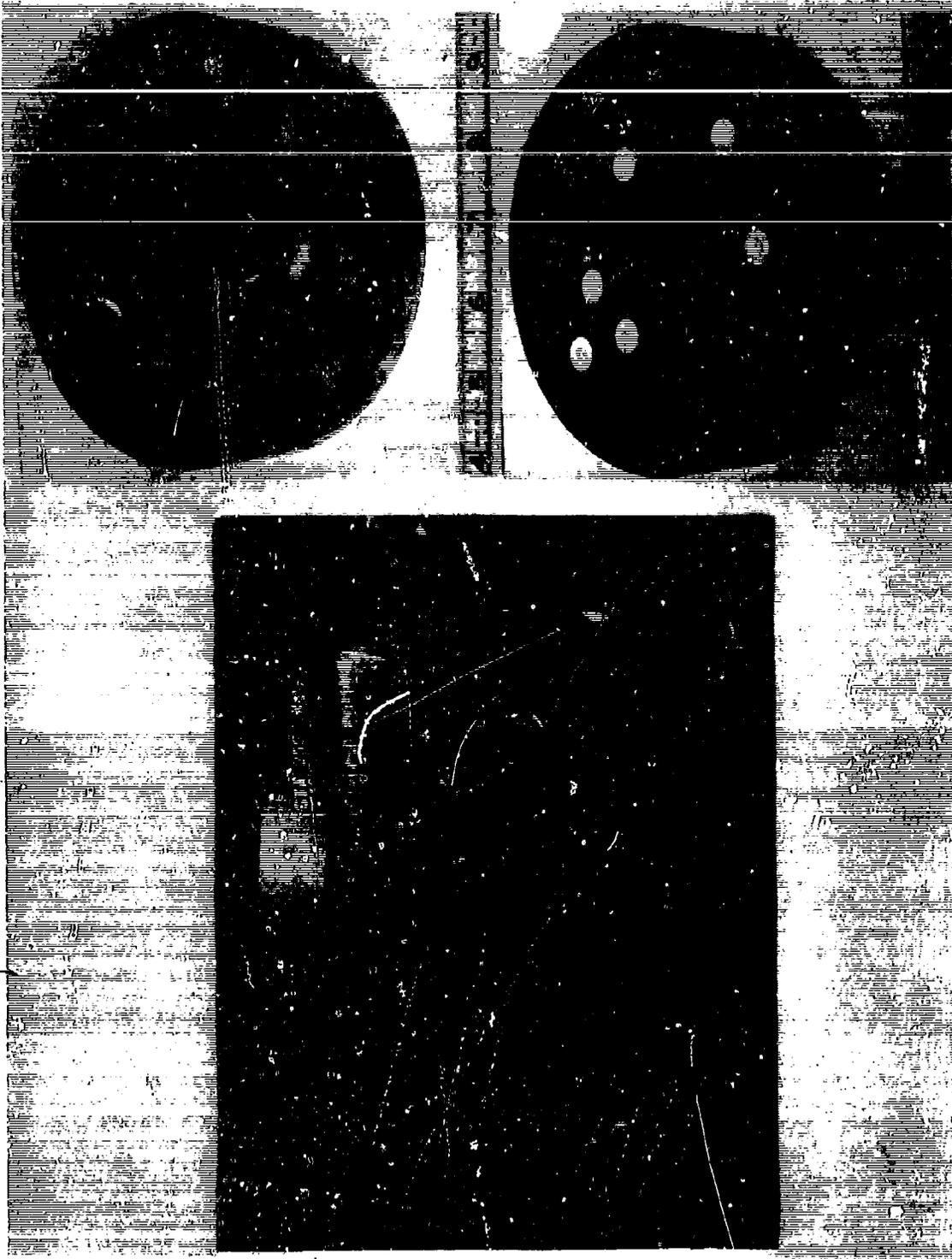


Fig. 2.9 -- Peace Pipe coupling showing wedge and compact plugs.

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(1) the use of mirrors, or the reflected pit method, and (2) the use of a 6-foot-diameter circular pit, known as a direct pit, having an axis parallel to the line of sight to the cab. Theoretically, successful operation of the mirrors would guarantee virtual freedom from blast damage at the expense of attenuated neutron and thermal flux. At the possible risk of some blast damage, the direct pits offered line-of-sight exposure to neutron flux and to all available thermal effects.

It was determined that a sufficient length of culvert should provide dead-air space to decelerate particles to a point where damage would be slight. To test feasibility of these methods, two pits were used in the Boltzmann shot. A 4-by-6-foot first surface mirror (an assembly of 2-by-3-foot mirrors) was erected. This was intended to reflect approximately 80 percent of the heat onto the specimens which were mounted on the end plate of a 6-foot-diameter culvert embedded in the ground at an angle of 23 degrees. This had a reflected slant range, normal to the base of the pit, of 1175 feet from air zero. The direct pit also was made of 6-foot culvert stock and was embedded in the soil at a 23-degree angle at 1175-foot slant range. This arrangement constituted a line of sight to the cab. A series of samples attached to the end plates of each of the pits was intended to be responsive to blast damage. Thirty-five aluminum sheets (as segments of a hexagon) and painted specimens were used to evaluate, by virtue of their soft surfaces, extent of blast damage. Evaluation of these panels after the Boltzmann shot indicated too great an attenuation by the mirror system; it was therefore eliminated from further consideration. The direct-pit samples indicated that only a slight gamma attenuation was experienced. It was hoped that evident small blast damage could be reduced by increasing to 3 to 1 the ratio of the shortest element of length of the pit to the diameter.

As a result of these considerations, the direct-pit system was adopted for Fizeau (Figures 2.10 and 2.11). Because the 6-foot diameter was available as culvert stock, the size of the end plate limited the number of samples. To obtain a reasonable number of samples of each system, three pits were used at each distance. Positions for the pits were chosen to present a wide range of thermal and nuclear exposure. The following table indicates the slant range, the ground range, and the angles of inclination of each of the pits used:

<u>Pit Letter Designation</u>	<u>Slant Range (ft)</u>	<u>Ground Range (ft)</u>	<u>Angle of Inclination</u>
A, B, & C	707	500	45°
D, E, & F	1000	707	30°
G, H, & I	1410	1000	20° 42'
J, K, & L	2000	1414	14° 30'
M, N, & O	2820	2000	10° 2'

These distances are 500 times integral powers ($\sqrt{2}$), so that the dosages can be halved at each successively farther station by the normal inverse square law. (Attenuation by air, dust, and debris is ignored.)

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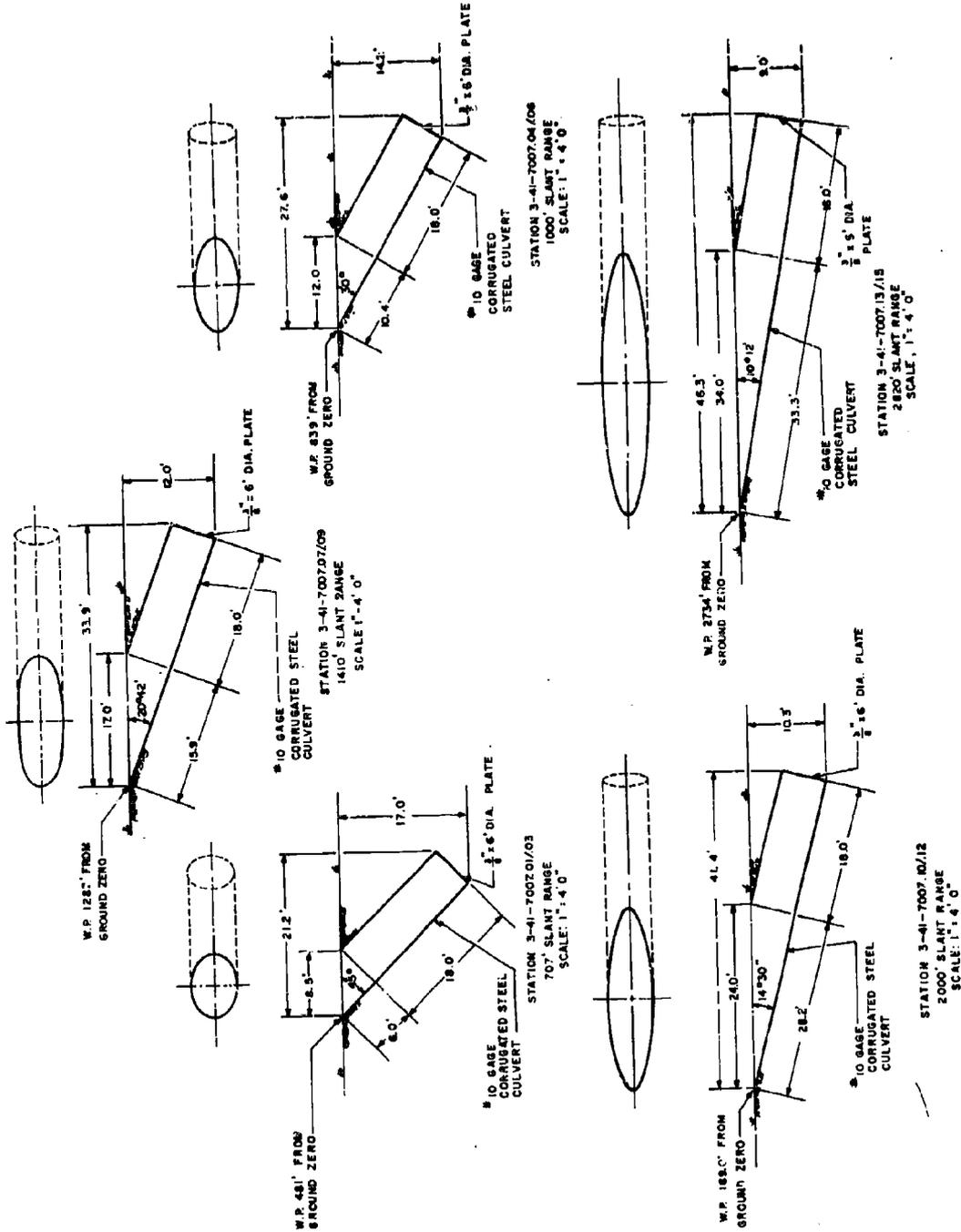


Fig. 2.10 -- Pit configurations.

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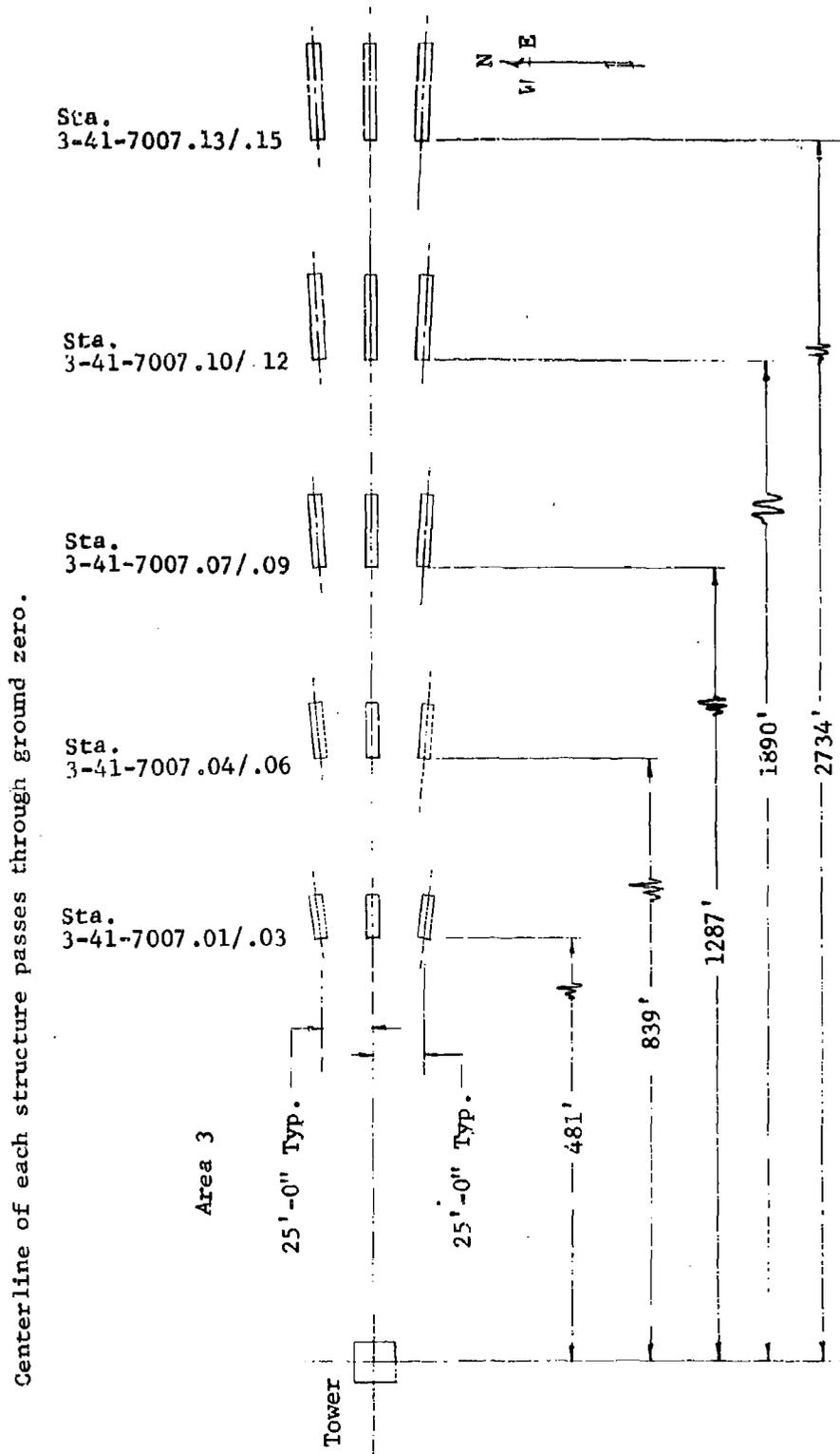


Fig. 2.11 -- Pit station layout.

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Complete sets of neutron detectors, as well as gamma dosimeters, were available for the stations. These were staked to the ground outside the pits. The neutron environment was measured with threshold neutron detectors which included three fission-type foils of plutonium, neptunium, and uranium. Gold foils were used to determine thermal neutron flux (neutrons with energies less than 0.4 ev). Both cadmium-covered and bare gold foils were used for measurements. Each of the other four detectors measured total neutron flux above a specific threshold energy characteristic of each foil. Thus, plutonium measured the total flux of neutrons above 1000 ev; neptunium, the flux above 0.75 mev; uranium, the flux above 1.5 mev; and sulfur, the total flux of neutrons with energies greater than 3.0 mev. Since the material was not available, it was not possible to have a neptunium foil in each neutron detector station.

Gamma dosimetry was accomplished with Borate glass (Corning 9762) dosimeters and chemical dosimeters. The glass turns blue in a gamma field, intensity of color being proportional to gamma dose received.

Chemical dosimeters, tetrachloroethylene overlaid with a water solution of indicator dye, were contained in glass ampoules 6 mm in diameter and 4 cm high. Lithium metal, placed around the dosimeters to reduce thermal neutron flux, minimized dosimeter neutron response. When gamma irradiation occurs, hydrochloric acid is formed, changing the color of the indicator dye, thus giving a dose measurement.

To make correlations of any attenuation which might have occurred because the samples were in the pits, duplicate sets of dosimeters were installed in Pits B and N. Since the number of neutron detectors was limited, only the two additional detectors in Pits B and N were used.

2.4.4 Spheres

The system employed to mount or contain samples for radiation exposure was designed to isolate samples from other environments present (blast and thermal) by placing test items in a container sufficiently thick to withstand expected overpressure, thus eliminating thermal and primary blast effects.

The problem of shock or mobilities was partially alleviated by tying the containers in place. A 356-T6 aluminum-alloy hemisphere with a 6-inch inside diameter and a 3/4-inch wall thickness was developed. The equatorial plane of each hemisphere consisted of a flange which allowed two hemispheres to be clamped together to form a sphere. The clamping action was provided by a 9-inch AN locking ring and bolt. To hold the sphere in place, a No. 5 eye-bolt was threaded into one of two bosses located on the polar caps (Figure 2.12). Calculation of maximum shock loading as a function of distance from ground zero produced a maximum load of 8500 g's during transient time of the shock around the sphere (diffraction phase) at 500 feet from ground zero. The best of various materials considered for sample packing appeared to be flexible polyurethane foam with a density of from 4 to 6 pounds per cubic foot.

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Fig. 2.12 -- Aluminum-alloy sphere.

The Boltzmann shot provided a preshot evaluation of our methodology. In this test, the placement of five spheres set out at two locations provided two important pieces of information. The first pertained to sphere confinement. At 500 feet, a sphere placed in a shallow depression so that one third of the sphere protruded above the ground would stay in place even though unrestrained in any other way. The second was a method of fastening the sphere to the cable. In Boltzmann, a cable clip was used to fasten the eyebolt directly to the cable. This method failed, but it pointed out the advantage of using a loop on both ends of the cable.

In preparation for Fizeau, all samples were packed in the spheres in sliced flexible foam. The samples were placed and the sphere closed, thus compressing the foam around the samples (Figure 2.13). The spheres were then laid out and staked in place at the same slant ranges as the pits indicated in Para. 2.4.3 (see Figure 2.11).

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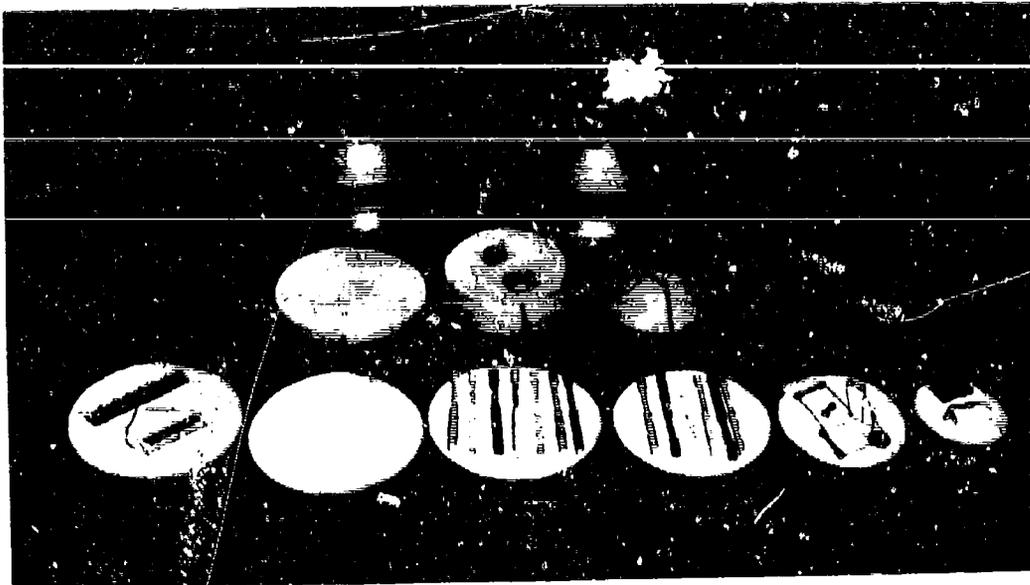


Fig. 2.13 -- Typical sphere packing arrangement.

Spheres at Stations 1 and 2 were each on an individual cable and individually staked in place. Those at Stations 3, 4, and 5 were staked out six to a cable.

Including dosimetry spheres in Pits B and N, 66 spheres were used in the event.

REFERENCES

1. C. D. Broyles and others, Weapon Effect Curves for a 10-kt Atomic Explosion, Sandia Corporation TM 115-57-51, Albuquerque, N. Mex., April 15, 1957.

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Chapter 3

RESULTS

A large number of samples survived in all exposed positions. Evaluation of specimens is reported in the sections which follow.

3.1 MOUNTING METHODOLOGY

The mounting methodology employed in Project 41.1c participation in the Fizeau event included the use of billets, plugs, and spheres. While such usage was not original with this project, it differed from previous experiments in application. The use of corrugated pipe placed in the ground with proper alignments to air zero and containing test specimens is believed to be original here. Use of a flexible foam (polyurethane) for shock protection and of modeling clay for shock protection and thermal insulation are also believed to be original with this project.

3.1.1 Billets

Both billets remained intact and survived fireball environment remarkably well. Because of thermal radiation effects evidenced, positioning of the billets on the tower with respect to air zero was evident upon examination of the surfaces of the recovered billets.

The top billet, center-located 40 feet from air zero, suffered the greatest amount of surface melting and incurred an approximate 15-degree bend in the blast direction 4 feet from the top of the billet. This billet was recovered 525 feet north of ground zero after the shot and was aligned with the top end south and the base north (Figure 3.1). It appeared to have been in an almost horizontal plane as it struck the ground, having rotated from its position on the tower at least 270 degrees in the vertical plane. The billet skidded into the ground, base end forward, burying itself to a depth of 18 inches on the base end and to ground level on the top end. The base plug was missing, blown off by the initial shock, which broke the bolts holding it in place. The base cavity was partially caved in and the radiation effects samples it contained were lost. The top of this billet suffered impact and melt damage as evidenced in Figure 3.2.

The bottom billet, center-located at 90 feet from air zero, was recovered 300 feet north of ground zero after the shot (Figure 3.3). On it there was a lesser degree of surface melting than on the top billet. It was driven into the ground at approximately a 75-degree angle, with the top end buried 12 feet. Judging from the angle at which it was resting, the billet had rotated at least 180 degrees in a vertical plane from its mounting platform on the tower.

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Fig. 3.1 -- The top billet, showing 15-degree angle and site of recovery.



Fig. 3.2 -- A close-up of the top of the top billet, showing impact and melt damage. Note cavities where specimens were threaded.

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Fig. 3.3 -- Bottom billet in recovered position.

3.1.2 Peace Pipe Plugs

Few of the plugs were lost. The plugs themselves were designed to be removed readily from the couplings. However, the curvature of the couplings, plus accumulation of erosion products, condensed vapor, droplets, and other debris at the intersection of the flat face of the plugs hindered their removal. A design feature had been incorporated to allow samples to be removed from the front of the plugs in case plug removal proved impossible.

3.1.3 Pits

Pits nearest to Station 1 at ground zero (A, B, and C) were half full of sand. A large portion of the total expected thermal and neutron flux was received by the samples before the corrugated iron was crushed inward by the shock wave (Figure 3.4). Failure of the culvert walls permitted dry sand to flow in and cover the specimens. At Station 2, the same kind of damage, but lesser in extent, was noted. Two of the three pits showed caved-in walls, and some sand removal was necessary before samples could be removed. At Stations 3, 4, and 5, virtually no sand was blown in and no cave-ins occurred (Figure 3.5). Dosimeters placed in Pits B and N (first and last center pits) were correlated with sphere dosimeters at ground level and indicated the degree of nuclear radiation attenuation.

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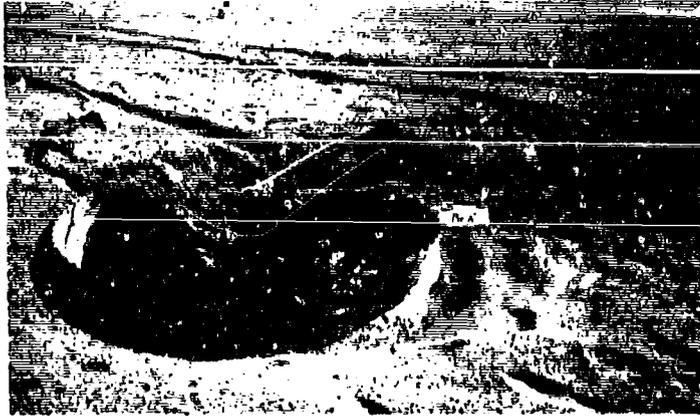


Fig. 3.4 -- Damage incurred at Pit A, slant range 707 feet. A tower guy cable is seen.

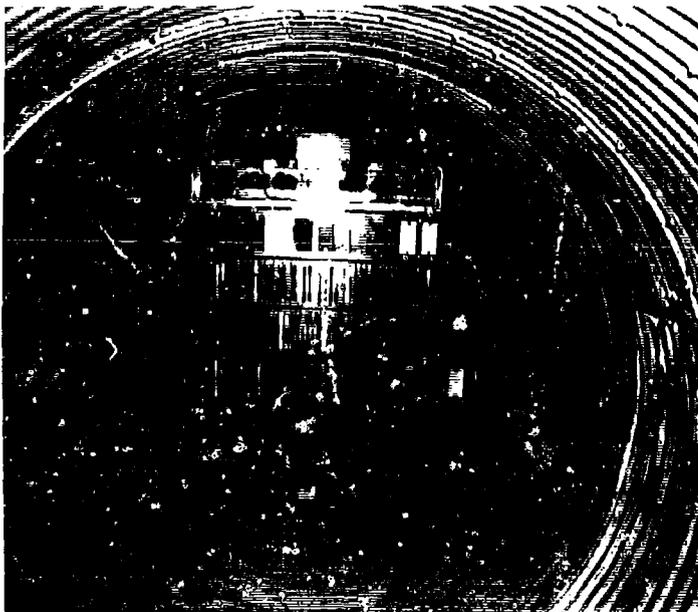


Fig. 3.5 -- A view of a Station 5 pit, showing no debris or collapse. Some thermal damage is evident on the top two panels, on some of the elastomers, and on coating specimens.

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3.1.4 Spheres and AN Cans

All 64 spheres used were recovered; of these, 44 were attached to their cables, 12 were intact (although detached from their cables), and 8 were broken open. Some samples from the spheres which had broken open were found. Table 3.1 indicates the condition in which each of the spheres was found. (Sphere No. 7 in each case was a dosimetry sphere.) See Figure 3.6 for typical sphere damage.



Fig. 3.6 -- Typical sphere damage.

AN cans located in Pits B, E, and H were recovered and, although they exhibited marked overpressure damage, samples of oil and plastic were removed intact with the exception of one plastic specimen from Pit E and plastic specimens in Pit B.

3.2 DOSIMETRY

Neutron and gamma doses as measured were nearly equal to those expected for the exposure conditions. Because of relatively high residual activity in the immediate vicinity of ground zero, it was not possible to recover all dosimeters in time for conventional analysis.

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TABLE 3.1 -- CONDITION OF SPHERES

Slant Range (ft)	707	1000	1410	2000	2820
Station	1	2	3	4	5
<u>Sphere</u>					
1	Open	Loose	In place	In place	In place
2	Open	Loose	In place	In place	In place
3	Open	In place	In place	In place	In place
4	Loose	In place	In place	In place	In place
5	Loose	Loose	In place	In place	In place
6	Loose	In place	In place	In place	Omitted
7	In place	In place	Loose	In place	In place
8	Open	In place	Loose	In place	In place
9	In place	In place	Open	In place	In place
10	In place	In place	Loose	In place	In place
11	In place	In place	Open	In place	In place
12	In place	In place	Open	In place	In place
13	In place	In place	Open	In place	In place
14	Loose				
15	In place				
16	In place				
17	In place				
18	Open				
19	In place				
20	Loose				
21	Loose				
<u>TOTALS</u>					
Open	5	0	3	0	0
Loose	6	3	3	0	0
In place	10	10	6	12	6

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Fission foils not recovered within 2 weeks of the shot were analyzed radiochemically.

All conventional counting analyses were made with facilities of ORNL, Plumbbob Project 39.5. Radiochemical analyses were performed by Los Alamos Scientific Laboratory. Glass and hydrocarbon dosimeters were analyzed at Sandia Corporation. Gamma and neutron dosimetry measurements are contained in Table 3.2.

3.3 SPECIMENS

Recovery of specimens proceeded as rapidly as radioactivity levels permitted entrance of recovery teams.

3.3.1 Billet-Plug Specimens

The billet plugs were used to determine the percentage of weight lost from the original plugs because of melt and blast. Fifteen specimens from Billet #1 were removed but were inadvertently lost prior to analysis; therefore, this study is based entirely on 45 specimens recovered from Billet #2. Several recovered specimens from Billet #2, of wood, graphite, molybdenum and W-Cu-Ni alloy survived but are not considered in this study.

Since, in some cases, metal from the cab and tower had been deposited on the billet plugs, the following method of determining

1. The exposed samples were weighed in air to the nearest tenth of a gram.
2. The samples were weighed in distilled water.
3. From these weighings and/or displacements, the volumes of the recovered billet plugs were calculated.
4. Using the volumes calculated in Step 3 and the densities of the parent metals, the total mass of remaining parent metals was calculated for each billet plug. It is well to note that none of the billet plugs of stainless steel or SAE 4130 showed any deposited metal.

The losses from five metals are shown in Table 3.3.

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TABLE 3.2 -- FIZEAU DOSIMETRY RESULTS

Station and Slant Sample Range Numbers (feet)	Foil Neutron Measurements (neutrons/cm ²)							Glass Gamma Measurements (R)	Hydrocarbon Gamma Measurements (R)
	<0.4 eV NVT	>3 KeV NVT	>0.75 MeV NVT	>1.5 MeV NVT	>2.5 MeV NVT				
<u>Pit stations</u>									
1-surface 707	*	6.2 x 10 ¹⁴	1.1 x 10 ¹⁴	1.1 x 10 ¹⁴	1.1 x 10 ¹⁴	3.9 x 10 ¹³	1.1 x 10 ⁶	8.8 x 10 ⁵	
1-in pit 707	*	*	*	*	*	2.35 x 10 ¹³	1.2 x 10 ⁵	2.9 x 10 ⁵	
2-surface 1000	*	1.9 x 10 ¹⁴	†	4.13 x 10 ¹³	4.13 x 10 ¹³	1.7 x 10 ¹³	4 x 10 ⁵	4.1 x 10 ⁵	
3-surface 1410	5.1 x 10 ¹³	7.8 x 10 ¹³	†	1.22 x 10 ¹³	1.22 x 10 ¹³	4.45 x 10 ¹²	9 x 10 ⁴	1.7 x 10 ⁵	
4-surface 2000	6.2 x 10 ¹²	1.6 x 10 ¹⁴	†	2.78 x 10 ¹²	2.78 x 10 ¹²	1.44 x 10 ¹²	2.7 x 10 ⁴	4.3 x 10 ⁴	
5-surface 2820	1.08 x 10 ¹²	3.2 x 10 ¹²	†	4.5 x 10 ¹¹	4.5 x 10 ¹¹	1.51 x 10 ¹¹	10 ⁴	4.7 x 10 ²	
5-in pit 2820	6.4 x 10 ¹⁰	1.6 x 10 ¹¹	*	9.3 x 10 ¹⁰	9.3 x 10 ¹⁰	5.25 x 10 ¹⁰	<10 ⁴	893	
<u>Peace Pipe stations</u>									
1 215	*	1.9 x 10 ¹⁵	2.0 x 10 ¹⁴	9.7 x 10 ¹³	9.7 x 10 ¹³	1.6 x 10 ¹³	1.4 x 10 ⁶	1.6 x 10 ⁶	
2 315	*	*	4.3 x 10 ¹⁴	6.8 x 10 ¹³	6.8 x 10 ¹³	1.27 x 10 ¹³	1.3 x 10 ⁶	1.4 x 10 ⁶	
3 415	*	*	2.3 x 10 ¹⁴	1.3 x 10 ¹³	1.3 x 10 ¹³	6.47 x 10 ¹²	8 x 10 ⁵	1.3 x 10 ⁶	
4 495	*	*	1.4 x 10 ¹⁴	2.1 x 10 ¹³	2.1 x 10 ¹³	3.1 x 10 ¹²	*	*	

* No data
† Neptunium foils not available for these stations

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TABLE 3.3 -- AVERAGE LOSS OF WEIGHT AND VOLUMES FROM BILLET SPECIMENS

	Percent Loss (weight)	Loss (in. ³ /in. ² of exposed surface)
Aluminum (6061)	16.6	0.31
Titanium (6Al-4V)	15.7	0.28
Stainless steel (17-4)	12.6	0.21
Steel (SAE 4130)	7.4	0.13
Silver	5.8	0.11

In addition to the loss in weight, the equivalent decrease in length in inches along a uniform cross section three-fourths of an inch square was determined. (This value appears in Table 3.3 as loss in cubic inches per square inch of exposed surface.)

Preliminary investigations were aimed at correlation of losses with respect to distance from air zero. No patterns developed in attempting correlations between either (1) the slant distance from the point of detonation to the individual samples or (2) the shielding afforded by the billet due to sample position. The fireball should be thought of as a single environment and that envelopment defines the environment.

The next aspects considered were the relationships of percent weight loss versus physical characteristics: i.e., thermal conductivity, specific heat, density, and combination of these. Figures 3.7, 3.8, 3.9, 3.10, and 3.11 show these relationships.

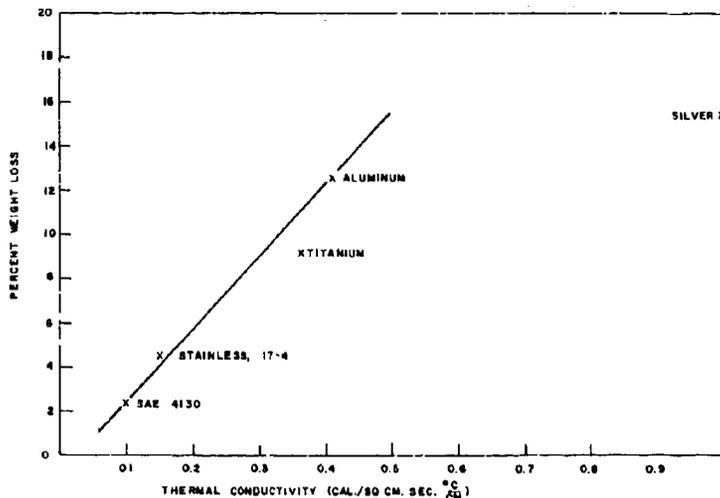


Fig. 3.7 -- Weight loss versus thermal conductivity.

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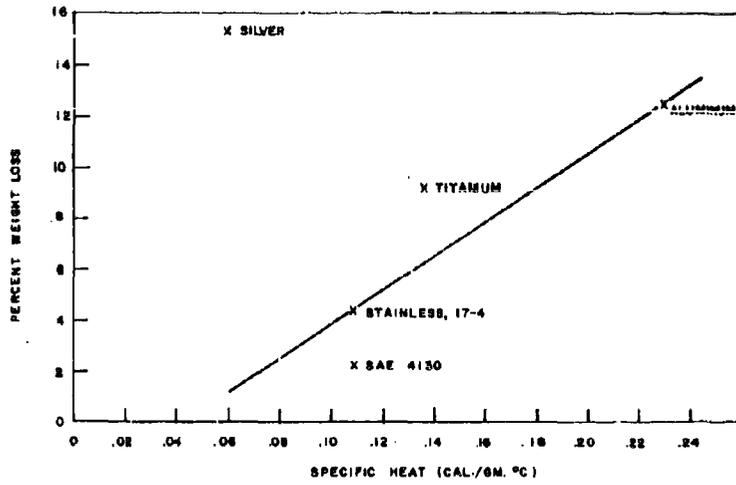


Fig. 3.8 -- Weight loss versus specific heat.

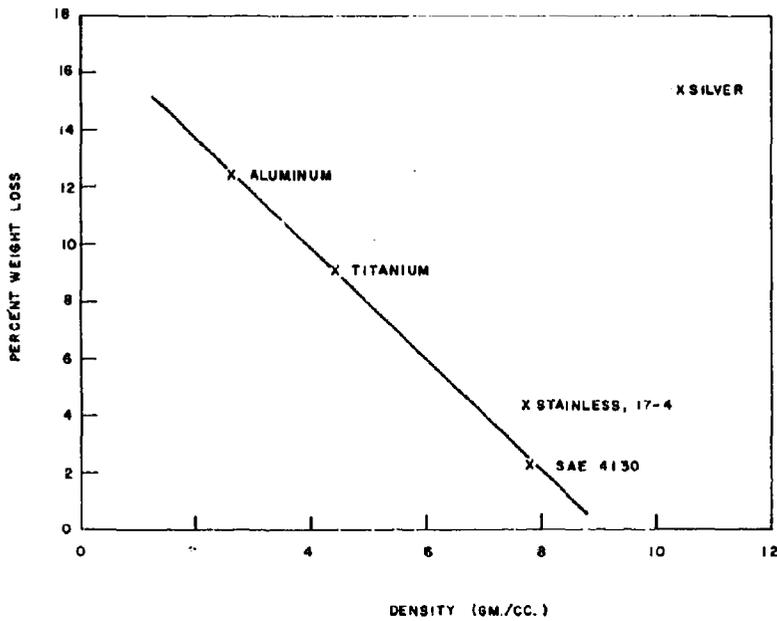


Fig. 3.9 -- Weight loss versus density.

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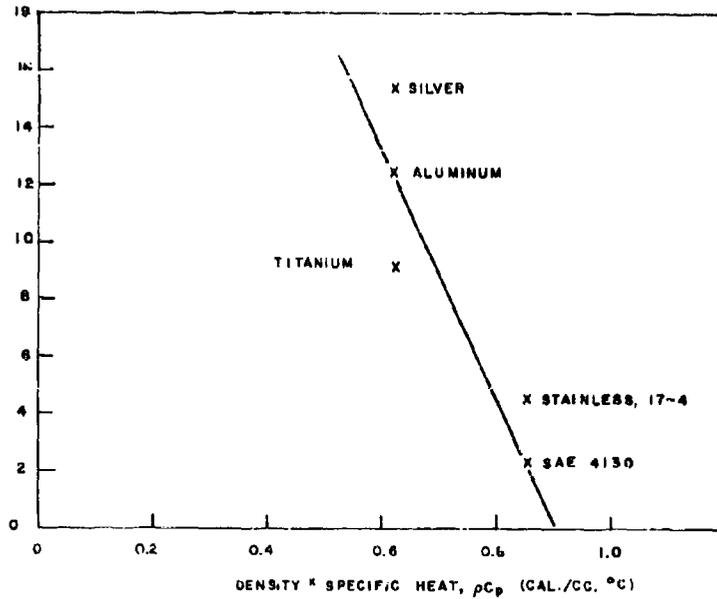


Fig. 10 -- Weight loss versus density times specific heat.

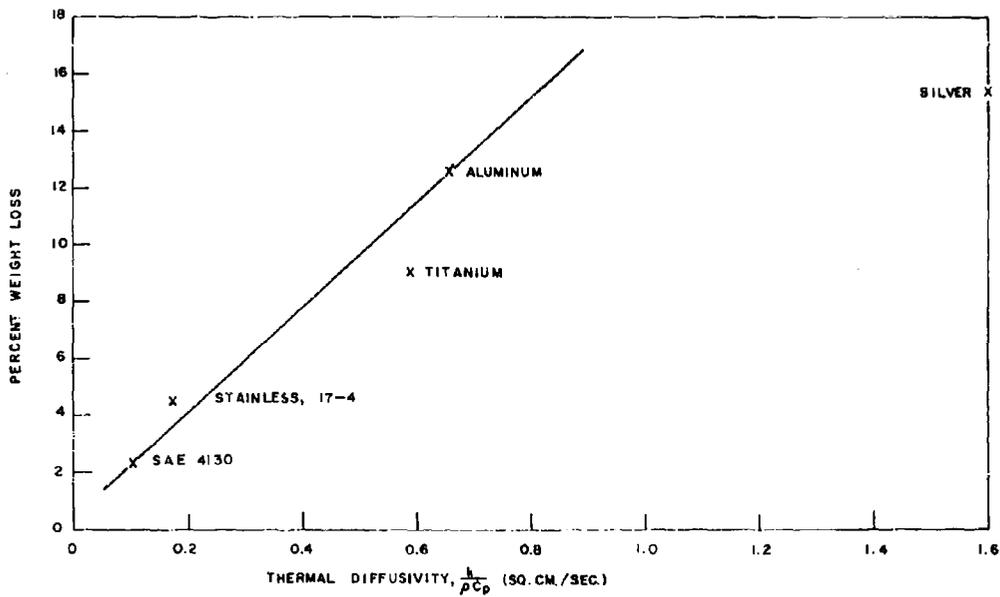


Fig. 11 -- Weight loss versus thermal diffusivity.

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The percentage of loss of each individual specimen was used in determining all considerations with respect to distances and locations. In considering the specimen's relation to physical properties, the arithmetic average of the weight losses for all the samples of any metal was used.

Wright Air Development Center's experiments in blast-melt studies are documented in WADC report WT-1134.¹ WADC used a different experimental method from Sandia's in their melt studies. WADC used 10-inch spheres mounted on TV towers at five intervals, 80 through 398 feet from air zero. The loss from the spheres was determined by two methods: careful measurement of the diameters, and weighing the recovered spheres. These values are recorded as a decrease in radius, and only the information from the 80- and 160-foot stations was used in preparing this report. In order to secure the same frame of reference for comparison of the two melt studies, the sphere surface-melt was calculated as though it were a flat surface-melt. The logarithmic mean area of the premelt and postmelt spheres was used for this calculation. The formula was taken from W. H. McAdams.²

$$A_m = \frac{A_2 - A_1}{\ln(A_2/A_1)} \quad (3.1)$$

where

- A_m = logarithmic mean area
- A_2 = area of premelt sphere
- A_1 = area of postmelt sphere.

The following tables show the results of the two tests:

TABLE 3.4 -- SPHERE MELT (WADC)¹

Distance from Air Zero (ft)	Decrease in Radius in Inches		Loss in Cubic Inches per Square Inch	
	Steel	Aluminum	Steel	Aluminum
80	0.40	1.20	0.39	1.18
160	0.31	0.98	0.30	0.98

TABLE 3.5 -- PLUG MELT (SANDIA)*

Distance from Air Zero (ft)	Loss in Cubic Inches per Square Inch	
	Steel	Aluminum
90 (Av)	0.13	0.31

*The yield in the WADC test was twice that of the Fizeau event.

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3.3.2 Peace Pipe Specimens

Specimens on the Peace Pipe consisted of wedges, rods, and compacts. A satisfactory degree of recovery was experienced with all specimens, i.e., wedges - 70%, rods - 90%, and compacts - 70%. For purposes of presenting results obtained from the specimens, the compacts and the organic rod specimens will be treated separately from the wedge and metallic rod specimens.

a. Compacts. Compacts were prepared from ceramic and metallic powders. There were 15 compacts, each mounted in a 6-inch-diameter plug. The plugs were equally spaced in couplings along the Peace Pipe at distances from 215 to 495 feet from air zero. The compact plug from Station 4, located 275 feet from air zero, was not recovered.

The compacts were examined visually with the aid of low-power (10 X) magnification and given a scratch test to determine if fusion or sintering of the pressed powders had occurred. The compacts that showed fusion were, in general, fused completely. The major exception consisted of the four magnesium oxide compacts; this group appeared to be fused on the surface only, and it appears that the surface might have spalled off as succeeding layers became fused. Two other exceptions were the iron and nickel compacts from Station 15; these two showed only a thin fused layer.

Table 3.6 lists results determined from the study of the compacts. Because of the difficulty of compacting and the resultant friability of many of the powders, both metallic and ceramic, high percentages (50%) of compacts were lost. Most losses were on the following: TaC, B₄C, and Mn - 100%; ThO₂ - 92%; W - 90%; HfC and SiC - 50%.

An analysis of the obtained data showed the following:

1. Hafnium carbide (m.p. 7520°F) fused at Station 1.
2. Zirconium carbide (m.p. 6404°F) fused at all stations used.
3. Titanium carbide (m.p. 5684 ± 194°F), thorium dioxide (m.p. 5522°F), silicon carbide (m.p. 4712°F), zirconium dioxide (m.p. 4892°F), beryllium oxide (m.p. 4586 ± 86°F), aluminum oxide (m.p. 4122°F), silicon dioxide (m.p. 3110°F), and titanium dioxide (m.p. 3182°F) did not show evidence of fusion at any station.
4. Magnesium oxide (m.p. 5072°F) fused at Stations 1, 3, 7, and 9, and did not fuse at Stations 5, 10, 14, and 15.
5. All the metallics fused at all stations, with the exception of titanium (m.p. 3137°F), which did not fuse at Stations 1, 9, 13, and 15, but did fuse at Stations 7 and 10.

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TABLE 3.6 -- RESULTS SHOWN BY STUDY OF THE COMPACTS

Material	Melting Point (°F)	Station Number														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
HfC	7520	F	*			*	F	*	F					*	F	*
TaC	7016	*	2-F			*	F	*							F	
ZrC	6404	F				*	*									
W	6100	*				*	*									
TiC	5684 ± 194	NF	2-NF													
ThC ₂	5522	*		2-NF												
MgO	5072	F	*	F												
ZrO ₂	4892	*		*												
Mo	4768		F													
SiC	4712		2-NF													
BeO	4586 ± 86	*		*												
B ₂ C	4442		*													
Al ₂ O ₃	4122	NF		NF												
TiO ₂	3182	*		*												
T ₂	3137	NF														
SiO ₂	3110		NF													
Cr	2939															
Fe	2795		F													
Ni	2651		*													
Mn	2300															
Cu	1981	F	F													
Ag	1760															
Mg	1204		F													
Zn	788															
Pb	621															
Sn	450	F														
In	311		F			*										
	* = Missing	6	6	7	15	7	3	4	2	2	3	3	2	1	2	2
	F = Fused	6	6	4		7	8	5	9	8	7	8	7	9	10	10
	NF = Not Fused	3	3	4		1	4	5	4	5	5	4	6	5	3	3

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6. No attempt has been made in this study to differentiate between the possible mechanisms for sintering and fusion or to correlate time-temperature histories of the various compacts.

b. Rods (organic). There was one each of the following four organic-material rods at each Peace Pipe station:

1. Wood (maple)
2. Epoxy (Shell 828)
3. Diallyl Phthalate (glass-filled)
4. Silicone (DC-301, glass-filled)

Sixty specimens were exposed, and 45 were recovered and identified. Longitudinal sections of the rod specimens were mounted in epoxy, lapped, polished, and macroscopically examined.

The following results were noted:

1. The cast epoxy experienced the most severe erosion of all the organic rod specimens. This material also was the most uniformly eroded, with all specimens showing slight curvature, by erosion, of the edges on the exposed surface.
2. The diallyl phthalate, glass-filled, experienced less erosion than the epoxy and more erosion than the silicone. In this material the glass fibers were bunched, which permitted the low-melting resin to soften, melt, and vanish, leaving the bunched fibers exposed.
3. The silicone, DC-301, glass-filled, was the least eroded of the plastic materials.
4. The wood specimens were charred and burned, some showing a concave surface and others an irregular convex. The actual survival of the wood specimens in the fireball environment seems significant.
5. Radiation damage was very minor compared to the thermal damage to the four organic-material specimens exposed. It is felt that essentially all damage to these specimens can be attributed to heat or possibly to blast.

c. Wedge and Rod Specimens (metallic). The wedge and rod specimens consisted of two each of the following materials at each Peace Pipe station.

1. Brass
2. Molybdenum
3. Steel

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The usual metallographic procedures were followed: Bakelite or epoxy mounts were made. The samples were lapped, hand polished and/or electrolytically polished, and etched to provide the best available specimens for metallographic analysis.

Photomicrographs at 50 X magnification were made of those specimens which showed phase transformation or recrystallization. The photomicrographs for each area were mounted to form a "mosaic" which delineated the complete section through which a phase change or recrystallization and grain growth had taken place.

The purpose of the mosaics was to provide a record of the transformation and to provide a reasonably accurate method for measuring the amount of change. One such mosaic is shown in Figure 3.12 or Rod Sample 2-2, a brass rod sample located at Station 2. and of the second series.

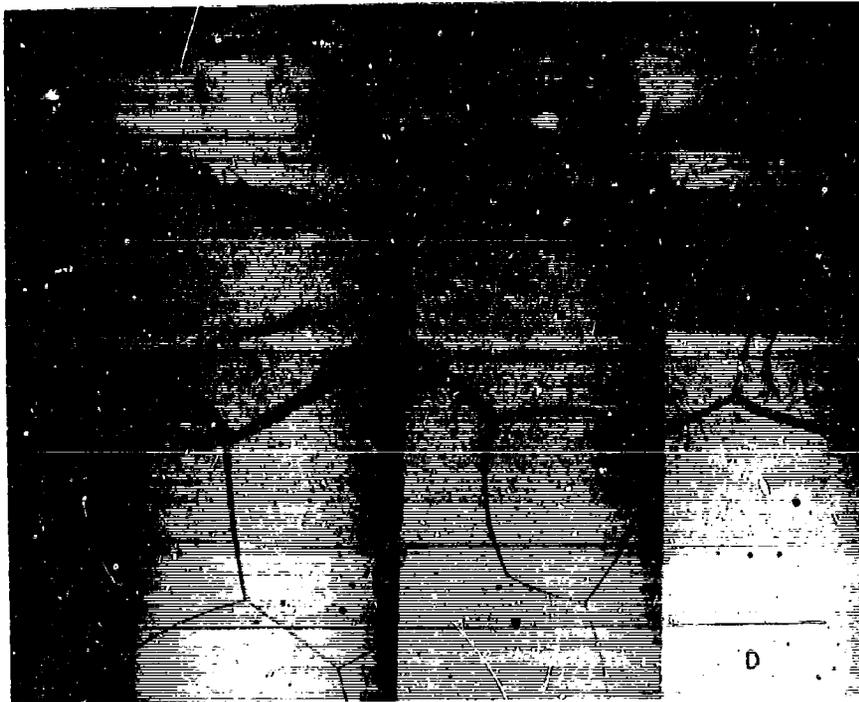


Fig. 3.12 -- Typical brass transformation specimen.

An examination of the three systems of rod specimens indicated (1) that the time-temperature relationship of the environment did not permit the molybdenum to transform; (2) that the steels were unsuitable; but (3) that the brass samples furnished a series which showed progressive transformation.

A photograph of a mosaic shows a typical sample with transformation. Reference to Figure 3.12 indicates the following zones of a typical transformed brass, Sample 2-2:

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1. Alpha plus beta brass at the exposed face. (Area A)
2. An island of beta brass in a dumbbell configuration. (Area B)
3. The mottling of intersecting needles of alpha in beta brass. (Area C)
4. The unchanged beta brass. (Area D)

The phase diagram for the copper zinc alloy of the composition range of concern is given in Figure 3.13.

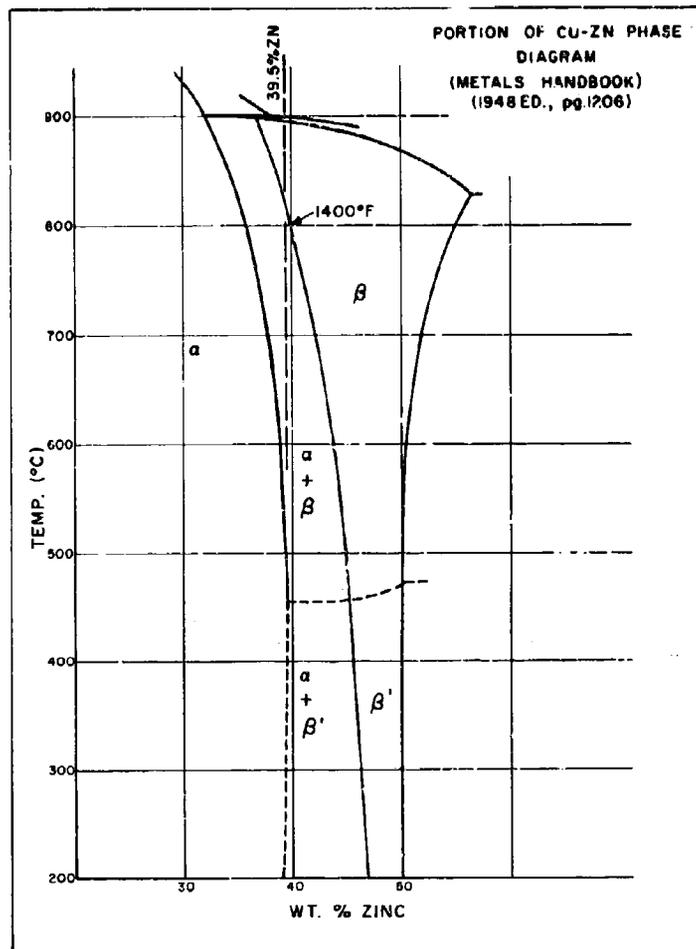


Fig. 3.13 -- Portion of Cu-Zn phase diagram.

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A graph of the volume of transformation of these brasses plotted against the distances from air zero is shown in Figure 3.14. Note that in both cases, Samples 1-1 and 1-2 show no transformation. It is believed that these two specimens can be safely ignored. An explanation of the probable cause of the lack of transformation in these two samples was the melting and flow of a large amount of lead from a gamma shielded neutron counter located directly above Station 1. Figure 3.15 indicates the extent to which the coupling was covered with lead.

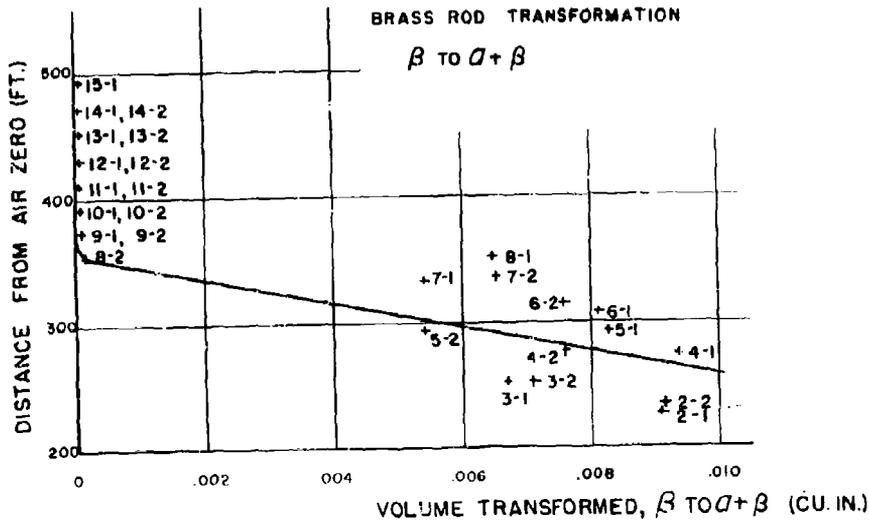


Fig. 3.14 -- Brass-rod transformation.

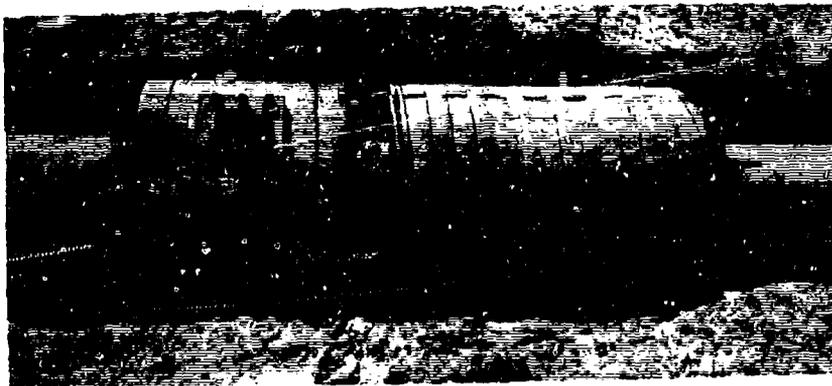


Fig. 3.15 -- Coupling #1, showing lead shield

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To obtain exposure times for the specimens, four sets of films of the growth of the fireball were examined. Tracings were made of the outline of the growing sphere and, after correlations with the time scale, exposure times were plotted versus distance from air zero. A typical plot is shown in Figure 3.16. The general agreement, in consideration of the difficulties of reading film in the fashion required, seems good.

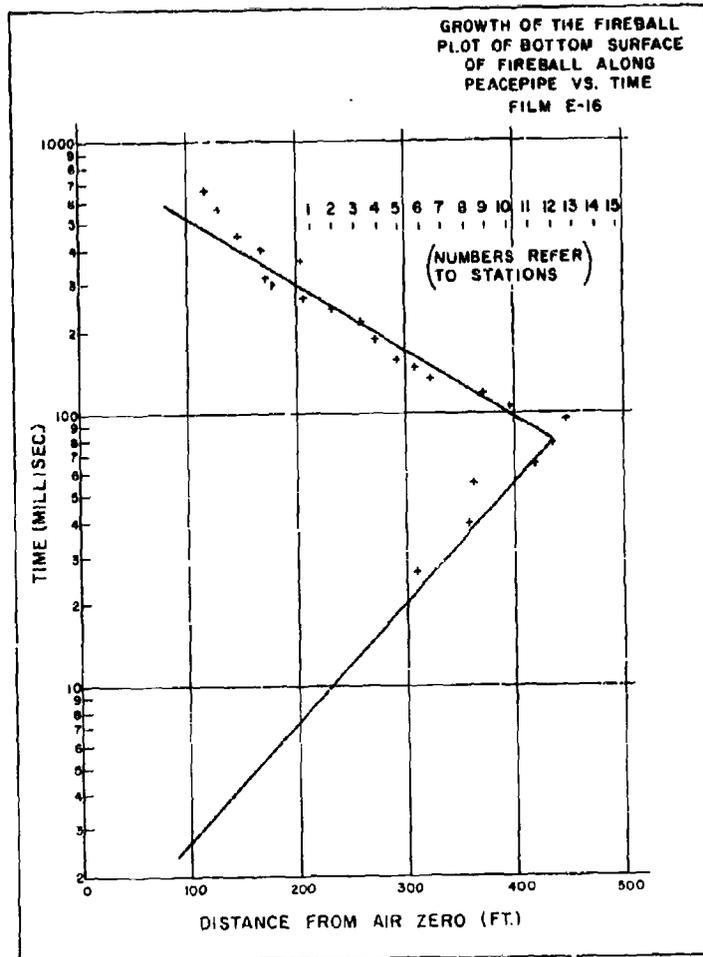


Fig. 3.16 -- Growth of the fireball.

A plot of the average exposure time for each station is given in Figure 3.17.

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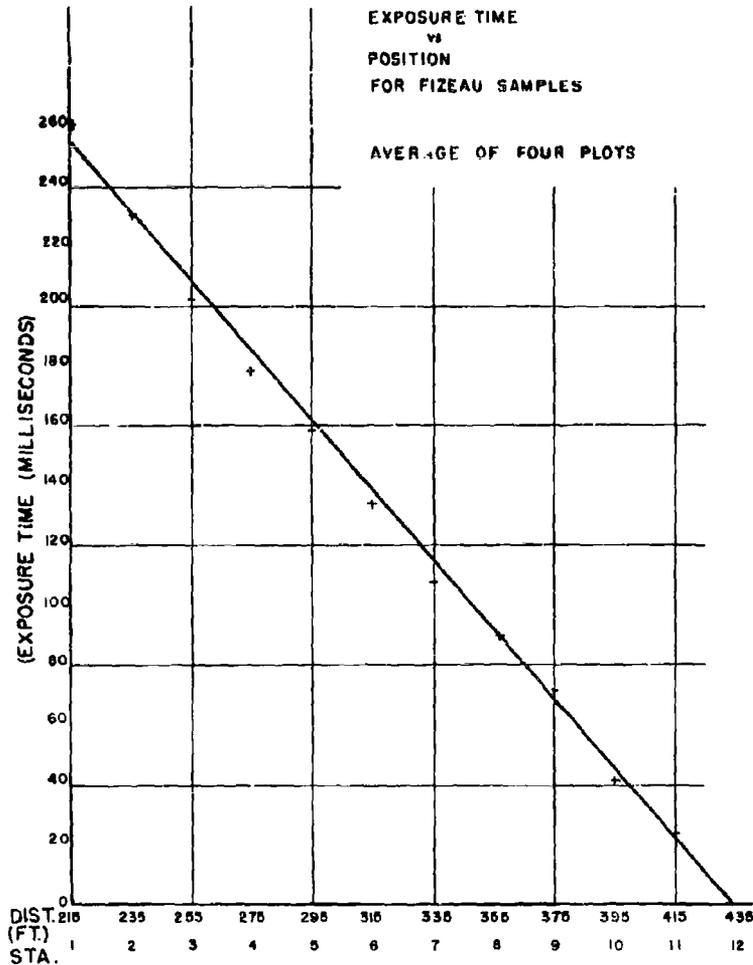


Fig. 3.17 -- Exposure time versus position for Fizeau samples.

d. Billet Specimens

1. Temperature determinations by the heat transfer method. Heat transfer methods were used to determine the temperature of the environment outside of the samples. The heat transfer method gives an equivalent environment, as a steady state, for the duration of the exposure. Equations and calculations will be shown for typical samples followed by a tabulation of the results.

A temperature profile can be plotted through a sample that has experienced a high heating rate. Equation 3.2² derived for heating a relatively thick body for a relatively short time is used.

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$$Y = \frac{2}{\sqrt{\pi}} \int_0^z e^{-z^2} dz \quad (3.2)$$

where:

$$Y = \frac{t_a - t}{t_a - t_b}$$

$$z = \frac{x}{2\sqrt{\alpha\theta}}$$

t_a = temperature of surroundings, °F

t = temperature at point x , °F

t_b = uniform base temperature, °F

x = distance from exposed surface, ft

α = thermal diffusivity, ft²/hr

θ = time, hr.

Values of Y versus z are plotted in the same reference with this equation. The temperature profile can be plotted using this equation and curve. The energy absorbed by a sample can then be found by integrating between the ambient temperature and the plotted temperature profile, which is a summation of $V\rho c_p \Delta T$. Using this absorbed energy in the general heat-transmission equation (Equation 3.3), the temperature of the surrounding environment T_1 can be calculated.

$$E = A h_c (T_1 - T_2) + A\alpha T_1^4 - A\sigma\epsilon T_2^4 \quad (3.3)$$

where:

E = energy transmitted, BTU/hr

A = area of exposed surface, ft²

h_c = forced convection transfer coefficient, $\frac{\text{BTU}}{\text{ft}^2 \text{hr}^\circ \text{R}}$

T_1 = temperature of environment, °R

T_2 = temperature of sample, °R

σ = Stefan-Boltzmann constant, 0.1713×10^{-8} BTU/ft²hr°R⁴

α = absorption coefficient

ϵ = emissivity coefficient.

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The forced convection transfer coefficient was determined from the dimensionless groups in the following equation for turbulent flow parallel to a flat plate.

$$\frac{h_c}{\rho v c_p} \left(\frac{\mu c_p}{k} \right)^{2/3} = \frac{0.0296}{\left(\frac{l v}{\mu} \right)^{0.2}} \quad (3.4)$$

where:

h_c = forced convection heat transfer coefficient, BTU/ft²hr°R

ρ = density, lb/ft³

v = velocity, ft/sec

c_p = specific heat, BTU/lb °R

μ = viscosity, lb sec/ft²°R

k = thermal conductivity, BTU/hr ft² $\frac{°R}{ft}$

l = length of surface, ft.

The absorption coefficient, α , was determined in the solar furnace. This coefficient is the ratio of absorbed energy to incident energy, with the absorbed energy being calculated after exposure, and the incident energy in the solar furnace being known.

The emissivity coefficient was taken from the literature.²

After the samples were sectioned and polished, several values could be determined by metallographic inspection. The temperature between the beta zone near the exposed surface and the alpha plus beta zone behind it is given as 1400°F in the phase diagram (see Figure 3.13). By plotting a temperature profile through the sample as outlined above, the temperature at the rear end of the transformation was calculated to be 675°F. This temperature was verified by a series of soaked and quenched samples. It was also possible to retain the beta zone by quenching a sample at 350°F from a soak at 1575°F. Calculations show that the samples in the Fizeau event could have been cooled to 300°F in 8 seconds following the exposure, by conduction of the heat to the large steel heat sink in which the samples were mounted.

To verify this method of calculation, a series of brass samples was exposed in the solar furnace and a sample calculation was then made on a typical sample. The sample chosen was exposed in the solar furnace for 1.70 seconds on May 9, 1958, at 3:30 P.M., with a clear sky. The temperature profile was plotted for this sample as shown in Figure 3.18. The energy absorbed by the sample was then found by integrating between the ambient temperature of the sample and the temperature profile plotted after the exposure of the sample. This energy is the summation of $\rho v c_p \Delta T$. The calculation gave 0.203 BTU for the sample. The energy absorbed was then used to determine the absorption coefficient for this brass sample.

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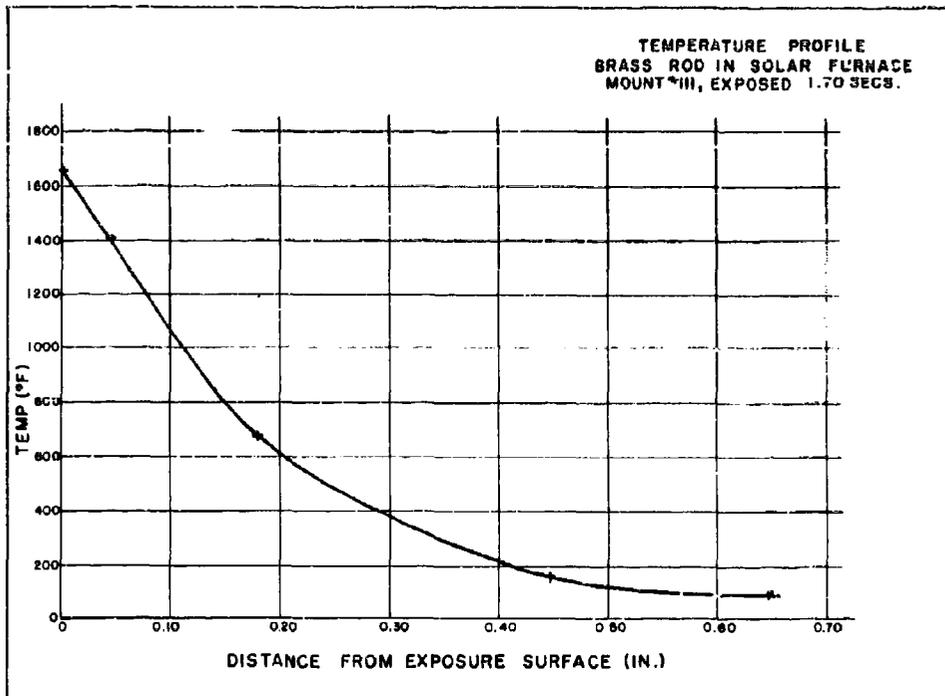


Fig. 3.18 -- Temperature profile.

The incident energy of the sun on the surface of the earth is given as 1.94 calories per cm^2/min .⁴ This energy falls on the 5-foot mirror in the solar furnace and is reflected to focus on an approximately 1/4-inch circle. The circle is smaller than the exposed face of the sample so that the total energy falling on the mirror is incident on the exposed face of the sample. Following is the calculation of the absorption coefficient:

$$\alpha = \frac{\text{energy absorbed}}{\text{energy incident}}$$

$$= \frac{0.203 \text{ BTU}}{\frac{1.94}{60} \times 13,272 \frac{\text{BTU}}{\text{hr ft}^2} \times (2.5)^2 \pi \text{ ft}^2 \frac{1.70 \text{ sec}}{3600 \text{ sec/hr}} \times 30\% \text{ eff}}$$

$$\alpha = 0.169 \text{ effective absorption coefficient.} \quad (3.5)$$

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Using this absorption coefficient and the energy absorbed by the sample, the general heat transmission equation (Equation 3.3) can be solved for T_1 , the temperature in the solar furnace.

For no flow

$$h_c = 0, \quad \text{and}$$

$$\epsilon = 0.3$$

with T_2 taken as an average from temperature profile.²

$$\frac{0.203 \times 3600}{1.7} \frac{\text{BTU}}{\text{hr}} = \frac{0.0542}{144} \text{ft}^2 \times \frac{0.1713 \text{ BTU}}{\text{hr ft}^2 \text{ } ^\circ\text{R}^n} \times 10^{-9} \times 0.169 \times T_1$$
$$- \frac{0.562 \text{ ft}^2}{144} \times 0.1713 \times 10^{-9} \frac{\text{BTU}}{\text{hr ft}^2 \text{ } ^\circ\text{R}^4} \times 0.3(1000)^4$$

$$T_1 = 7800^\circ\text{R}, \text{ temperature of focal spot in solar furnace. (3.6)}$$

Arthur D. Little, Incorporated, of Cambridge, Massachusetts, manufactures solar furnaces of the type and size used for this exposure. Their specifications cite 3500°C as the maximum temperature attainable in a solar furnace of this type, which is 6792°R . The temperature quoted from Arthur D. Little was determined at sea level, which could differ from the temperature at the local altitude. It is felt that agreement is sufficient to warrant this type of calculation.

The two sets of brass-rod samples from Fizeau and the set of aluminum-rod samples were analyzed in the same manner as the sample from the solar furnace as shown above. Since there was heat transfer by forced convection in addition to the radiant energy transfer in the Fizeau event, the heat transfer coefficient for forced convection had to be evaluated before the temperature determination could be made on these samples. This heat transfer coefficient was evaluated, using average turbulent flow along a flat plate.

This equation uses dimensionless groups which hold for all ranges of turbulence. The values obtained for the forced convection heat transfer coefficient, h_c , and the temperatures obtained for the environment surrounding the samples in the Fizeau event are tabulated in Table 3.7.

The absorption coefficients (α) used in these calculations were determined in the solar furnace, and are tabulated in Table 3.7.

Because of the nature of the samples, the temperatures obtained are for a steady state environment. The samples exposed in the Fizeau event would have shown the same effects if they had been exposed to an environment of the calculated temperature and velocity of flow, as a steady state, for the same duration of exposure. The

TABLE 3.7 -- CALCULATION OF TEMPERATURE AT EACH SAMPLE POSITION

Sample No.	Material	Type of Sample	Distance from AZ (ft)	$\text{BTU hr}^{-1} \text{ft}^{-2} \text{R}^{-1}$ *	α †	Temperature ($^{\circ}\text{R}$)
191	Aluminum	Billet plug	97	85.0	0.048	12,500
3-1	Aluminum	Flush rod	255	82.0	0.049	16,900
4-1	Aluminum	Flush rod	275	81.25	0.049	16,250
5-1	Aluminum	Flush rod	295	80.6	0.049	17,400
6-1	Aluminum	Flush rod	315	80.0	0.049	16,000
7-1	Aluminum	Flush rod	335	79.3	0.049	14,500
8-1	Aluminum	Flush rod	335	78.6	0.049	14,450
2-1	Brass	Flush rod	235	82.5	0.169	15,525
3-1	Brass	Flush rod	255	82.0	0.169	14,700
4-1	Brass	Flush rod	275	81.25	0.169	15,800
5-1	Brass	Flush rod	295	80.6	0.169	15,900
6-1	Brass	Flush rod	315	80.0	0.169	16,850
7-1	Brass	Flush rod	335	79.3	0.169	14,700
8-1	Brass	Flush rod	355	78.7	0.169	14,600
2-2	Brass	Flush rod	235	82.5	0.169	15,100
3-2	Brass	Flush rod	255	82.0	0.169	14,625
4-2	Brass	Flush rod	275	81.25	0.169	15,000
5-2	Brass	Flush rod	295	80.6	0.169	14,700
6-2	Brass	Flush rod	315	80.0	0.169	15,850
7-2	Brass	Flush rod	335	79.3	0.169	15,100

* Equivalent to about 500 ft/sec velocity of normal density air.

† Absorption coefficient calculated from solar furnace data.

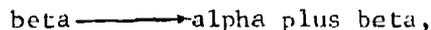
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transient environment in the Fizeau event cannot be calculated directly from the exposed samples by this method. It may be possible to derive the transient environment by mathematical means from these results.

The configuration of the wedge specimens prevented the use of the equations to plot a temperature profile. The temperature profile was approximated and plotted for Specimen #5, located 295 feet from air zero, of the molybdenum wedges. Several points were determined by metallographic examination, and a typical curve was drawn. The variation of volume presented by the configuration would not permit direct integration of energy content, so the centroid of the volume of recrystallization was used in the summation of $V\rho c_p \Delta T$. The forced convection heat transfer coefficient, h_c , was calculated, using the dimensionless equation and graph in McAdams.² This coefficient, was determined to be $346 \text{ BTU hr}^{-1} \text{ ft}^{-2} \text{ }^\circ\text{R}^{-1}$. The absorption coefficient, a , was determined from a solar furnace sample to be 0.274. The general heat transmission equation was used to determine the temperature of the environment to which this specimen was exposed, resulting in a temperature of $17,550^\circ\text{R}$.

2. Temperature determinations by the reaction-rate method. A second approach to the calculation of the temperature was made with the reaction-rate method. A precedent for this method is found in the work of B. L. Averbach and Morris Cohen.⁶

Based on the premise that the reaction in the brass is



and that the product beta differs from the reactant beta by analysis, a typical first-order or unimolecular reaction is under discussion.

The velocity of a first-order reaction can be given by

$$-\frac{dc}{dt} = kC \quad (3.7)$$

where:

$-\frac{dc}{dt}$ = change in concentration of beta brass with time

C = original concentration of beta brass

k = reaction-rate constant, a function of temperature.

By rearrangement,

$$k = -\frac{1}{C} \left(\frac{dc}{dt} \right) \quad (3.8)$$

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if

$$a = C_{\text{reactant at time} = 0}$$

$$x = C_{\text{product at time} = t}$$

$$a-x = C \text{ of reactants at time} = t.$$

Upon integration and elimination of the negative sign,

$$kt = \frac{\ln a}{a-x}.$$

If logs are taken of both sides, then

$$\log k + \log t = \log \ln \frac{a}{a-x}. \quad (3.9)$$

A plot of $\log t$ versus $\log \ln \frac{a}{a-x}$ should give a straight line from which the value of k can be determined for any one temperature.

Arrhenius developed an empirical relationship which described the temperature dependence of k :

$$\ln k = \ln A - \frac{Qk}{RT}. \quad (3.10)$$

This equation is also linear when $\frac{1}{T}$ is plotted versus $\ln k$. By determining k for a number of known temperature heating media, the k for the Fizeau event might be bracketed. From the value of k the temperature can be found.

It was then proposed to determine k for several heating media such as the solar furnace, the oxyacetylene torch, and the plasma jet, in the hope that it might be possible to establish the line in Equation 3.10 from which the temperature might be determined for the Fizeau event.

The procedure was to make timed exposures of a series of properly heat-treated brasses to the torch and solar furnace environments and, after metallographic preparation, measure the transformations from the exposed faces. Plots of the transformations for the two series of samples from Fizeau, the torch, and the solar furnace are given in Figures 3.19, 3.20, 3.21, and 3.22, along with the calculated k values.

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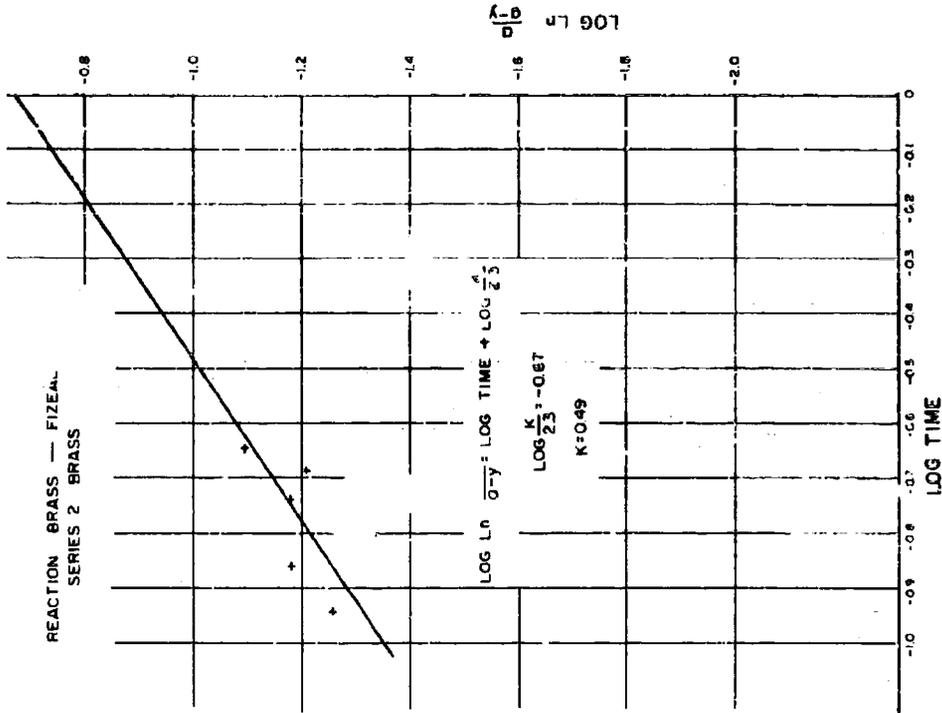


Fig. 3.20 -- Reaction rate--Fizeau, Series 2 brass.

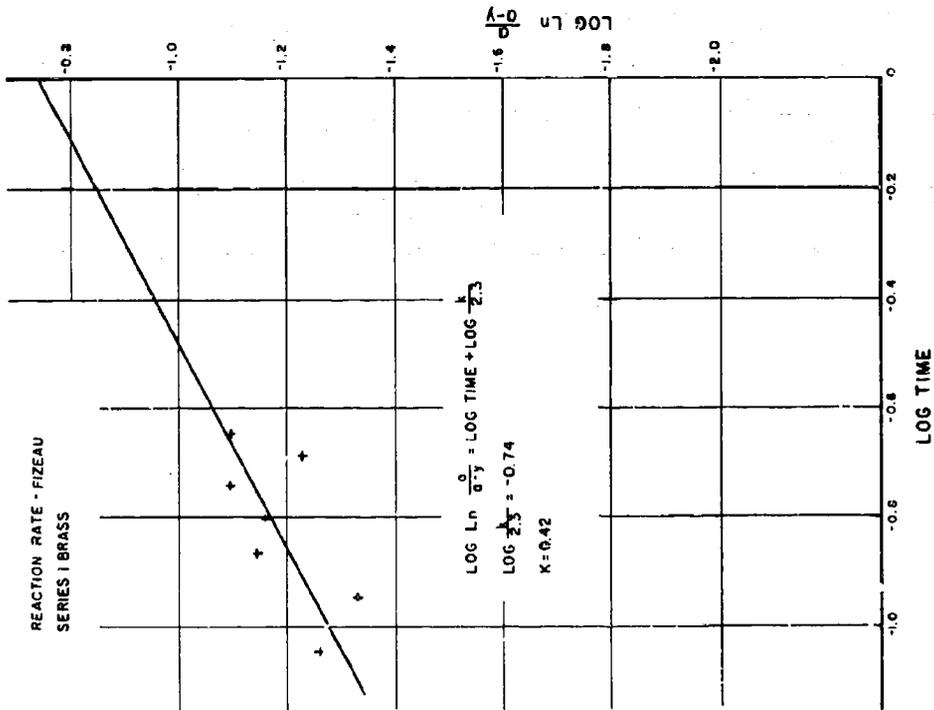


Fig. 3.19 -- Reaction rate--Fizeau, Series 1 brass.

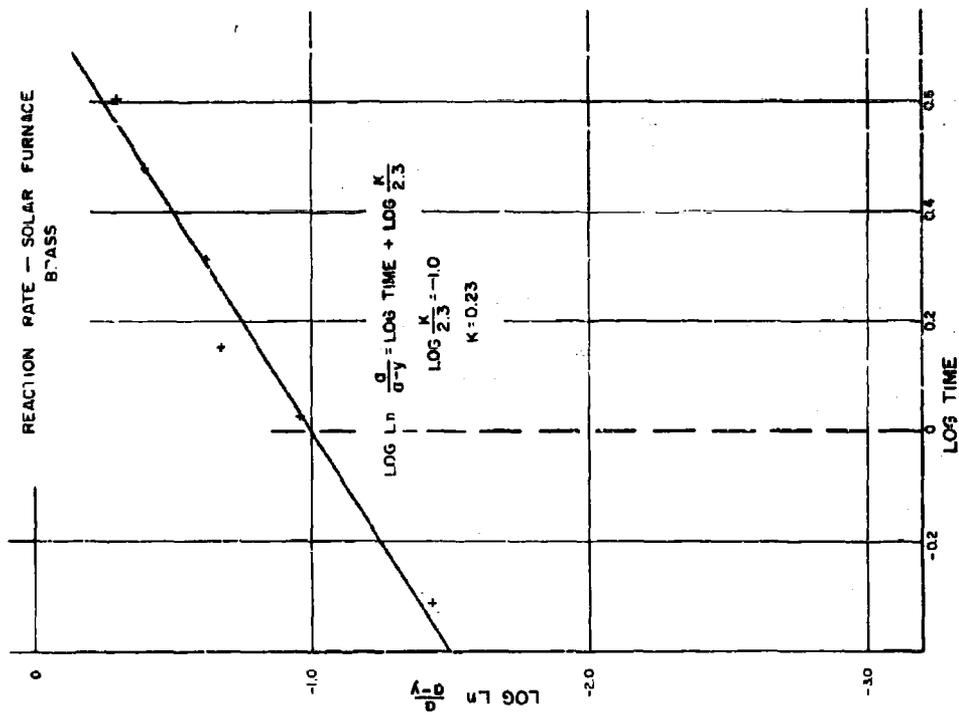


Fig. 3.22 -- Reaction rate, solar-furnace brass.

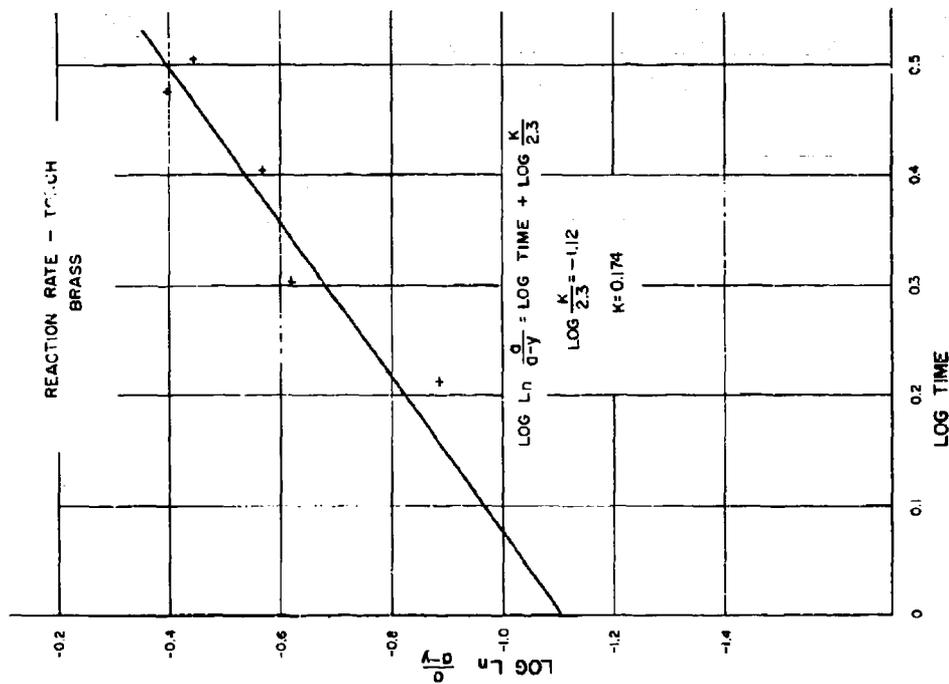
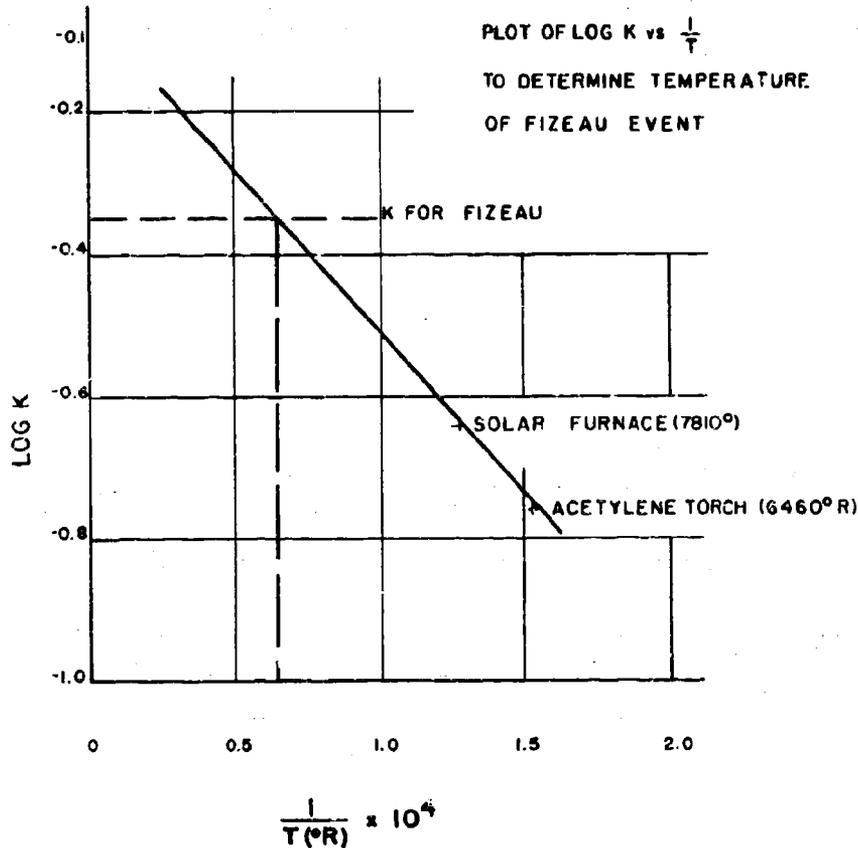


Fig. 3.21 -- Reaction rate, torch brass.

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At the same time, some practical temperature values for the media were assumed. These temperatures were 6460°R for the acetylene torch, and 7800°R for the solar furnace. These temperatures represent the best information which is available, and no claim is made for any better validity than this information. Calorimetry is indicated, should the values be desired with greater certainty.

With the qualifications noted, a plot of $\log K$ versus $\frac{1}{T}$ on the basis of Arrhenius' equation is given. From this plot a temperature for the flush-mounted specimen is suggested to be near 15,000°R (Figure 3.23).



FIZEAU TEMPERATURE = 15,400°R

Fig. 3.23 -- Plot of $\log K$ versus $\frac{1}{T}$ to determine "effective constant" heating temperature of Fizeau event.

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Reaction rate equations were attempted on the molybdenum wedges, and the same type of distribution was found. Figure 3.24 is a plot of the volume of transformed molybdenum. Figure 3.25 represents a mosaic produced from a molybdenum wedge.

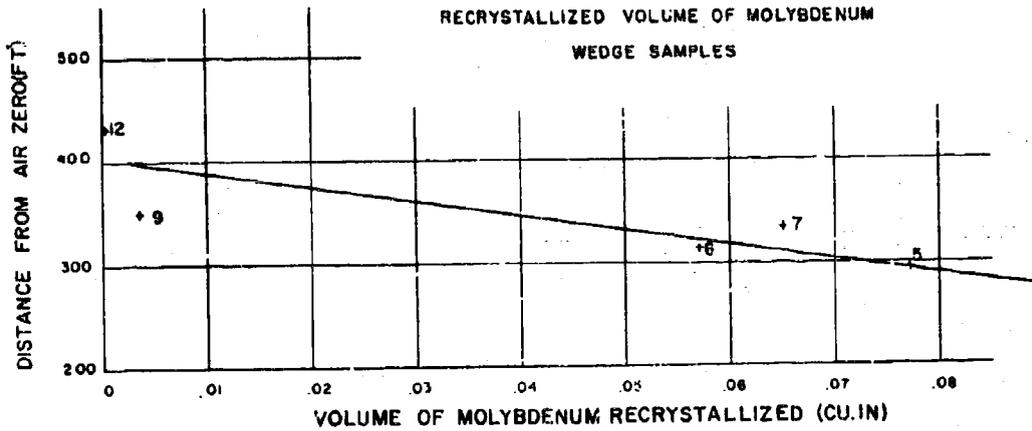


Fig. 3.24 -- Recrystallized volume of molybdenum wedge samples.

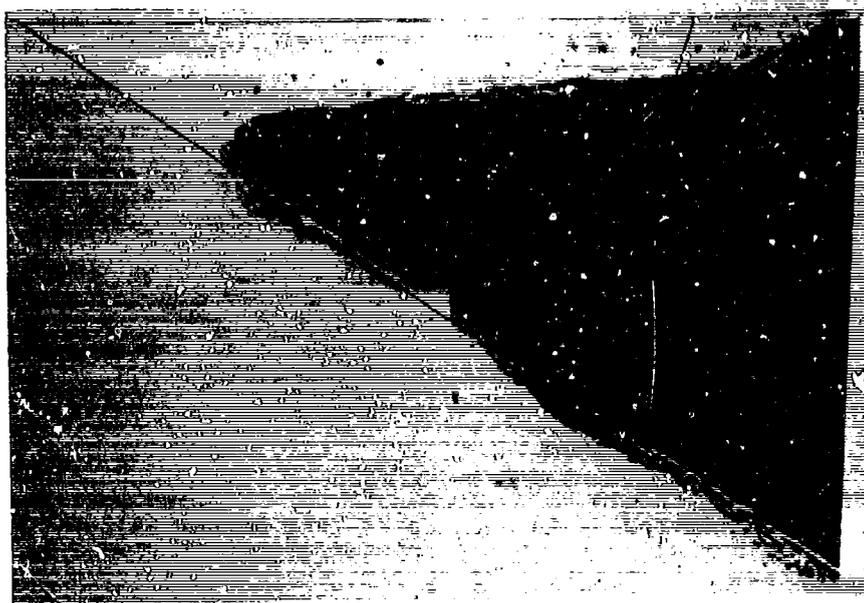


Fig. 3.25 -- Mosaic of molybdenum wedge Specimen 7-1 after exposure. Outline of original configuration and extent of recrystallization are indicated.

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Results were obtained which would not correlate with solar furnace and the acetylene-torch samples. It is conjectured that such a correlation could exist for the flush-mounted specimens, where the heat transfer mode was almost entirely radiation, but fails for the wedges, which protrude into the stream because of the different contributions by radiation and convection.

It is conceivable that the plasma jet exposure would likely offer correlation with the Fizeau event molybdenum wedge samples but would not with the flush-mounted brass samples unless the specimens were so placed as to receive only radiation.

Of some concern was the evident disparity between temperatures calculated from the samples and those calculated from the adiabatic expansion of the fireball. Such calculated temperatures were part of the information obtained from IBM Problem.⁶

An interesting comparison can be made, using the values found in the IBM calculations. Curves are given which show the calculated temperatures of the inside of the fireball at stated times. A temperature history of any point could be drawn from these calculations. From such a plot, an average temperature could be determined.

Such a plot was made for the 235-foot-location, Station 2, and the average temperature appeared to be about 6000°K or 10,800°R. Stations farther from air zero indicated lower temperatures. The temperatures from the history are lower than those by the calculated transformation of samples indicate. Note that the linear (in time) averages of the temperature are calculated, not the temperature averaged according to Equation 3.2. A comparison which was the best calculated variation of temperature and velocity with time might give better agreement.

3.3.3 Pit Specimens

The results of the tests of the pit specimens are presented under the appropriate headings.

a. Metal Tensile. No metal tensile specimens were lost although corrosion was a problem with a number of specimens. The one set of pit specimens recovered from Station 1 showed extreme corrosion of the Sandia magnesium-thorium alloy cast bars and some corrosion of the commercial magnesium-thorium alloy (HK 31). The steel bars showed some oxidation, as did the copper alloy bars. (Blast damage at Station 1 was slight.)

Of two sets of pit specimens removed from Station 2, corrosion of the Sandia alloy seemed to vary between pits from "none" to "pronounced." In both cases, the copper alloys showed evidence of thermal radiation by oxidation which varied from "little if any" to "minor." Blast damage at this station was slight.

Specimens at Station 3 showed little corrosion but more blast damage than did those at any other station. Specimens from Stations 4 and 5 showed little blast damage and no oxidation.

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Tensile strength, yield, percentage elongation, and hardness were determined on all specimens except those excessively corroded and those whose hardness was too high to be gripped by the jaws available. These values, along with the control specimen values, are presented in Appendix B.

b. Coating Panels. The relatively soft surfaces of coating panel specimens are good yardsticks of blast damage; some of the panels were inflammable and thus provided proof of thermal radiation received. These effects were noted visually. Five percent of the paint panels exposed were lost. Panels recovered at Station 1 showed little blast damage, less than any other pit. Two blue panels at this station had a radioactivity level of 25 mr 6 weeks after the detonation. At Station 2, extensive blast damage occurred, with six panels torn from the mounting panels. Thermal damage observed was less than noted at farther stations.

Panels at Station 3 suffered the greatest damage, both thermal and abrasive. Panels with two blue-paint systems flashed, a larger number than at any other station. Panels which flashed had systems of Amercoat 1133 vinyl strip and the same coating over zinc chromate primer with lacquer topcoat.

Panels at Station 4 showed slight abrasion, and the zinc chromate lacquer-Amercoat 1133 paint flashed. At Station 5, panels showed little abrasion or damage; three Amercoat 8633 panels flashed in all three pits.

Adhesion, flexibility, and other tests were performed; because of the low level of radiation, the results are generalized in the chapter on conclusions.

c. Elastomers. All elastomer test samples from Stations 3, 4, and 5 were recovered. Black smudges on the mounting fixtures indicate one thermal degradation; this discoloration was, as might be expected, exhibited only by black samples. White silicone and red hypalon samples showed some discoloration. Slight surface abrasion from blast was evident on all samples; the modulus appeared to have increased in the exposed areas of some samples. Most samples appeared to be in good condition, with the exception of those at Station 2, which showed severe missile damage.

Physical tests were performed on the three samples of each material from each radio position. The results indicate a wide scatter and are generalized in Chapter 4.

d. Molded Thermosetting Compounds. The glass-fiber-filled diallyl-phthalate specimens from Stations 3, 4, and 5 had small, irregularly spaced blisters on the exposed surfaces. The exposed surfaces of specimens from Stations 2 and 3 showed erosion from blast damage which was not evident on specimens from Stations 1, 4, and 5. Station 1 specimens showed no blast and little thermal damage. Surfaces of Dacron-fiber-filled diallyl phthalate showed some charring, which gave the exposed fiber a satin-like appearance. The blast effect on Station 3 specimens obliterated this appearance. Negligible charring and no blistering were observed on the DC-301 glass-fiber-filled silicone specimens at the last three stations.

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Blast effects at Stations 2 and 3 were sufficient to remove the resin skin, leaving the glass fibers exposed. As a result of blast erosion, polyester preform specimens from Stations 4 and 5 showed slight erratic surface blistering; this was not evident on specimens from Stations 2 and 3.

e. Foams. Specimens of the 30 to 60 lb/cu ft polyurethane forms showed little degradation, with the exception of slight blast erosion on specimens from Stations 2 and 3. The 4 lb/cu ft foam specimens located at Station 4 showed a higher degree of charring than did those at Station 5. Since highly eroded Station 3 specimens did not show the charring observed at the latter locations, it was assumed that the blast at this location removed the hot, molten surface resulting from the thermal radiation. There were no 4 lb/cu ft specimens recovered from Stations 1 and 2.

f. Polymers. Polyethylene specimens from Station 3 showed some surface charring, but specimens at Stations 4 and 5 showed no visible degradation. High distortion of Station 2 specimens was due to missile damage at the time the specimens were softened by the thermal radiation. Teflon specimens from Station 3 were stiffer than those from Station 5 when they were subjected to a cursory flexing test. Also, Station 3 specimens were charred on the exposed surfaces. Specimens from Station 2 showed missile damage, but specimens from Station 1 showed little, if any.

g. Casting Resins and Laminates. Casting resins and laminates showed no visible degradation except for slight blast erosion on Station 3 specimens. As with other organic materials, Station 2 specimens suffered the greatest amount of missile damage, which, coupled to the negative-pressure phase, fractured a number of the more brittle casting-resin specimens and one of the laminates.

h. Adhesives. Adhesive test specimens showed no damage except for the carbonization of the polysulfide resin used to mount the specimens and some carbonizing of the rubber which was part of the test specimen.

The mechanical properties measured were compression shear on adhesives and sealants and tensile-strength values of hydropol bonded specimens. These data are given in Appendix C.

3.3.4 Sphere Specimens

Of 1966 specimens contained in spheres, 94 percent (1824) were recovered. None of the recovered specimens showed any evidence of blast or thermal effects. The obtained results on the particular materials tested are presented in the following paragraphs.

a. Electrical Cable. No evidence of meaningful damage to any exposed cables was observed.

b. Rubber Products. There was no evidence of damage to the silicone rubber products. There was, however, marked degradation of the exposed nylon pressure tubing which would make it unusable for application in a radiation environment of the levels experienced.

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c. Vacuum Tubes. The results indicated that, while some changes were noted in the characteristics of the tubes exposed, these changes established no trend in any case and should not preclude using these tubes in a radiation environment of this intensity.

d. Transistors. A Sandia Corporation internal memorandum⁸ covering all the work done on the Fizeau semiconductor specimens has been published.

In all cases, there was an increase in the forward resistance, reverse-current leakage, and breakdown voltage. While the increase in breakdown voltage is not detrimental, the increase in the other two characteristics means a decrease in efficiency of diodes, making them unusable in circuits where their capabilities are fully utilized before irradiation. One interesting result of the test was the fact that the same type of unit, made by two different methods, shows different results (diffused units show less change in characteristics than alloy units).

e. Capacitors. Analysis of the capacitor data indicated that there was essentially no permanent change in capacitance of any of the units exposed although the dissipation factor did increase in all cases. The change in this dissipation factor was greatest in the mica-dipped types. The dielectric constant of the units also changed markedly with the greatest change in the mylar.

f. Plastomer Tensile Specimens. In all cases the tensile strength and elongation decreased after combined exposures of 2×10^{14} nvt and 4×10^5 gamma. Two of the four types exposed showed an increase in tensile properties at intermediate exposure levels. This phenomenon is attributed to the peroxide cure of these whereas the others were sulfur-cured. Generally speaking, these samples showed less damage at these rates than similar samples receiving the same total dose at a lower rate, although the results might be somewhat questionable in light of the delay between exposure and testing which would permit some healing, and consequent masking, of the true degradation immediately following exposure.

g. Semiconductor Materials. Two Sandia Corporation internal memoranda^{9,10} have been issued covering this phase of the test. These reports state that, on N-type germanium, the rate of application of nuclear radiation has no effect (assuming that annealing did not mask the results), but that P-type germanium has a possible rate correlation. Results also indicated that (within experimental error) changes in characteristics of semiconducting devices are wholly attributable to the changes in the bulk properties of the semiconducting materials.

h. Organic Fluids. The results indicated that, while there were some detectable changes in viscosity and that even though some gas evolved from the specimens, in no case were the samples damaged to a point that would make them unacceptable for normal use.

i. Paint Finishes. There was no measurable difference between the finishes on the exposed coupons and those on the control coupons.

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j. Adhesives. The shear strength of the specimens exposed at Station 2 (slant range 1000 ft) was approximately 25 percent lower than at more distant stations, and the shear strength at these more distant stations showed no significance.

k. Sealants. The physical properties of all the specimens exposed were not significantly affected, with the exception of Silastic 6127, which showed a progressive increase in hardness with increasing proximity to air zero.

l. Elastomeric Materials. The exposed specimens of Teflon showed significant degradation, greatest in the position closest to air zero and decreasing with increasing distance from air zero. The specimens of unvulcanized Neoprene stock were cured, whereas the specimens of unvulcanized natural and nitrile rubber were not cured. The exposed specimens of natural rubber showed a doubling of the modulus at 300-percent elongation. The modulus at 500-percent elongation was slightly increased; the tensile strength was greatly increased; and the ultimate elongation, which usually decreases with increasing tensile strength was actually slightly increased, indicating a higher degree of crosslinking of molecules.

m. Reinforced Plastic Laminates. There was no significant change in the physical properties of any of the exposed specimens.

n. Greases. There was no significant change in the physical characteristics of the exposed specimens.

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Chapter 4

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

4.1.1 Mounting

The billets functioned as intended, were easily located, and retained a large number of specimens. Survival of Peace Pipe plugs was gratifying. Clay used both in billets and in Peace Pipe plugs for thermal insulation and shock protection functioned well in all applications.

The spheres were effective, as was the foam used to protect samples embedded in it. Failure of cables to hold some of the spheres is related in part to differences in soil conditions between areas for the Boltzmann and Fizeau shots. The Boltzmann area, where the methodology evaluation was performed, had a more nearly stabilized soil than the Fizeau area had, and adequate allowance was not made for the difference. Loss of spheres at Station 1 may have been caused by fouling of tower guy cables which fell across all three pits and some of the spheres.

Use of pits for sample containment at this stage seems to have been a valid method. Pit cave-ins were partially caused by lack of mechanical strength in assembling riveted segments, since these were only tack-welded. The end-plate attachment was also tack-welded and suffered the same mechanical failure.

4.1.2 Specimens

a. Peace Pipe Specimens. The following conclusions are presented:

1. It is believed that the technique of observing metallurgical changes in materials is a novel and useful method for gaining information about high-temperature excursions.
2. From the metallographic data, heat transfer methods could be used to determine the average temperature of the samples' environment over the exposure time. Validity for proceeding along this line was furnished when a similar calculation produced a solar furnace temperature in good agreement with expected values.
3. An independent method, the reaction-rate method based on the physical chemistry of a unimolecular decomposition, could be used to determine an equivalent constant temperature of the environment.

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4. The temperatures so obtained were in the region of 15,000°R. These calculations appear reasonably valid for the flush-mounted specimens where the heat transfer was nearly 100 percent radiant.
5. Better validity of the data could be established by recourse to additional exposure of the wedge specimens in the plasma jet where an additional temperature point with combinations of convective and radiant heat transfer could be incorporated. The heat transfer method seemed more useful because of the light it shed upon the relative contributions by radiant and convective heating. The flush-mounted specimens offer somewhat more confidence than the wedge specimens because of the essential simplicity of the sample and the heat transfer made.

The uniformity of the cross section and the single exposed face permitted the application of well-known equations to the heat calculations. The radiant heating of this specimen accounted for approximately 93 percent of the heat transferred.

The wedges absorbed heat from all directions and had a changing cross section which made a temperature profile nearly impossible to calculate. The wedges indicated that approximately 50 percent of the heat transfer was by convection; the convection coefficient for temperatures and velocities of this range are not known with a great deal of certainty.

The reaction-rate method seemed to offer a valid solution where the heating methods were similar. If heat transfer systems similar to those of Fizeau had been available, the correlation would have been better.

6. The technique of using a billet and a variety of metal-plug inserts proved to be a valuable method for obtaining information about metal losses close to air zero.
7. Values representing the losses for the metals selected for this study were obtained. The close correlation of the arithmetic mean and the median indicated a symmetrical distribution of the values. There is an implication of statistical validity.
8. The evidence secured from the billet-plug studies shows that, in spite of helical placement of the plugs, it must be considered that all plugs saw the same environment.
9. In relating percentage of weight loss to physical properties, it was found that the loss is proportional to thermal conductivity and specific heat and is inversely proportional to density. Silver is an exception to this statement but is not an exception when the metal loss is plotted against heat content.

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10. Little can be said about the comparison of WADC's and Sandia's melt studies. With only two volumes for each of two materials, complicated by their having been exposed to two different yields, it is impractical to establish scaling curves for lethality.
11. Because of the high percentage of loss of specimens, the compact-plug study did not function as well as originally intended. It is now known, however, that the transition from a compacted powder to a homogeneous mass can be readily detected.

b. Pit Specimens

The general conclusion reached by a study of the results of the pit specimens is that the effects seen are more accurately related to blast and thermal damage than to radiation. This statement applies to the coating panels, elastomers, molded thermosealing compounds, foams, polymers, and casting resins.

The conventional panel systems commonly used on the weapons suffered no apparent damage related to thermal or blast damage.

The statements may be categorized as follows:

1. This test indicated almost all the materials chosen can successfully withstand the nuclear radiation environments experienced in this test.
2. Every metal specimen withstood entire environment nuclear radiation as well as blast and thermal effects.
3. Beyond Station 2 most effects noted are ascribed to thermal radiation rather than nuclear radiation.

c. Sphere Specimens. The conclusions are:

1. Little to no damage due to nuclear radiation was experienced by electrical cables, paint finishes, reinforced plastics, or greases.
2. Slight nuclear radiation damage at the "close in" stations was experienced by the rubber products, vacuum tubes, organic fluids, adhesives, sealants, and elastomer tensile specimens.
3. Transistors, semiconducting materials, capacitors, and elastomeric materials suffered some radiation damage at all stations.

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4.2 RECOMMENDATIONS

The following recommendations for future tests of this nature are proposed in two phases:

a. Mechanical Features

1. Billet cavities and base caps should be redesigned for greater shock resistance.
2. The plug design should be changed for easier removal from the Peace Pipe coupling.
3. Pits should be strengthened by continuous welding around the segments and end plate to help prevent cave-ins.
4. Individual tie-downs should be used on each sphere.

b. Selection and Placement of Specimens

1. For a study of radiation damage, either a closer position or a higher-yield device should be used for the field-type specimens.
2. The selection of specimens would reflect the information accumulated since the Fizeau event.

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APPENDIX A

SPECIMEN EXPOSURES IN FIZEAU EVENT

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APPENDIX A

A.1 SUMMARY OF SPECIMEN EXPOSURES

A complete list of the specimens exposed in the Fizeau event is tabulated in the following sections.

A.1.1 Billet Specimens

Billet specimens were numbered from 1 to 101 for the top billet and from 102 to 202 for the second billet.

a. First Billet

- | | |
|--|--------------------------------|
| 1. Graphite AGX | 36. Graphite AGX |
| 2. Graphite CCN | 37. Molybdenum |
| 3. Molybdenum (full hard) | 38. 17-4PH stainless steel |
| 4. Mallory 1000 tungsten
copper nickel alloy
(as sintered) | 39. 4130 alloy steel |
| 5. 17-4PH stainless steel | 40. 6Al-4V titanium alloy |
| 6. 4130 alloy steel | 41. 6061-T6 aluminum alloy |
| 7. 6Al-4V titanium alloy
(annealed) | 42. Graphite AGX |
| 8. Mallory 821 titanium
alloy (annealed) | 43. Molybdenum |
| 9. Silver (as cast) | 44. 17-4PH stainless steel |
| 10. 6061-T6 aluminum alloy | 45. 4130 alloy steel |
| 11. Wood, maple | 46. 6Al-4V titanium alloy |
| 12. Graphite AGX | 47. 6061-T6 aluminum alloy |
| 13. Molybdenum | 48. Graphite AGX |
| 14. 17-4PH stainless steel | 49. Molybdenum |
| 15. 4130 alloy steel | 50. 17-4PH stainless steel |
| 16. 6Al-4V titanium alloy | 51. 4130 alloy steel |
| 17. 6061-T6 aluminum alloy | 52. 6Al-4V titanium alloy |
| 18. Graphite AGX | 53. 6061-T6 aluminum alloy |
| 19. Molybdenum | 54. Graphite CCN |
| 20. 17-4PH stainless steel | 55. Silver |
| 21. 4130 alloy steel | 56. Wood, maple |
| 22. 6Al-4V titanium alloy | 57. Mallory 821 titanium |
| 23. 6061-T6 aluminum alloy | 58. Mallory 1000 |
| 24. Graphite AGX | 59. Graphite AGX |
| 25. Molybdenum | 60. Molybdenum |
| 26. 17-4PH stainless steel | 61. 17-4PH stainless steel |
| 27. 4130 alloy steel | 62. 4130 alloy steel |
| 28. 6Al-4V titanium alloy | 63. 6Al-4V titanium alloy |
| 29. 6061-T6 aluminum alloy | 64. 6061-T6 aluminum alloy |
| 30. Graphite AGX | 65. Graphite CCN |
| 31. Molybdenum | 66. Silver |
| 32. 17-4PH stainless steel | 67. Wood, maple |
| 33. 4130 alloy steel | 68. Mallory 821 titanium alloy |
| 34. 6Al-4V titanium alloy | 69. Mallory 1000 |
| 35. 6061-T6 aluminum alloy | 70. Graphite AGX |
| | 71. Molybdenum |
| | 72. 17-4PH stainless steel |
| | 73. 4130 alloy steel |
| | 74. 6Al-4V titanium alloy |

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- | | | | |
|-----|------------------------|------|----------------------------|
| 75. | 6061-T6 aluminum alloy | 89. | Molybdenum |
| 76. | Graphite AGX | 90. | 17-4PH stainless steel |
| 77. | Silver | 91. | 4130 alloy steel |
| 78. | Wood, maple | 92. | 6Al-4V titanium alloy |
| 79. | Graphite AGX | 93. | 6061-T6 aluminum alloy |
| 80. | Molybdenum | 94. | Graphite CCN |
| 81. | 17-4PH stainless steel | 95. | Silver |
| 82. | 4130 alloy steel | 96. | Wood, maple |
| 83. | 6Al-4V titanium alloy | 97. | Graphite AGX |
| 84. | 6061-T6 aluminum alloy | 98. | Molybdenum |
| 85. | Graphite CCN | 99. | Mallory 1000 |
| 86. | Silver | 100. | Mallory 821 titanium alloy |
| 87. | Wood, maple | 101. | 17-4PH stainless steel |
| 88. | Graphite AGX | | |

b. Second Billet

- | | | | |
|------|------------------------|------|------------------------|
| 102. | Mallory 1000 | 144. | 17-4PH stainless steel |
| 103. | Graphite AGX | 145. | 4130 alloy steel |
| 104. | Graphite CCN | 146. | 6Al-4V titanium alloy |
| 105. | 17-4PH stainless steel | 147. | 6061-T6 aluminum alloy |
| 106. | 4130 alloy steel | 148. | Wood |
| 107. | 6Al-4V titanium alloy | 149. | Silver |
| 108. | 6061-T6 aluminum alloy | 150. | Molybdenum |
| 109. | Molybdenum | 151. | Molybdenum |
| 110. | Wood, maple | 152. | Graphite AGX |
| 111. | Silver | 153. | Graphite CCN |
| 112. | Graphite AGX | 154. | 17-4PH stainless steel |
| 113. | Graphite CCN | 155. | 4130 alloy steel |
| 114. | 17-4PH stainless steel | 156. | 6Al-4V titanium alloy |
| 115. | 4130 alloy steel | 157. | 6061-T6 aluminum alloy |
| 116. | 6Al-4V titanium alloy | 158. | Molybdenum |
| 117. | 6061-T6 aluminum alloy | 159. | Molybdenum |
| 118. | Molybdenum | 160. | Molybdenum |
| 119. | 4130 alloy steel | 161. | Graphite AGX |
| 120. | Molybdenum | 162. | Graphite CCN |
| 121. | 6Al-4V titanium alloy | 163. | 17-4PH stainless steel |
| 122. | Graphite AGX | 164. | 4130 alloy steel |
| 123. | Graphite CCN | 165. | Graphite AGX |
| 124. | 17-4PH stainless steel | 166. | 17-4PH stainless steel |
| 125. | 4130 alloy steel | 167. | 4130 alloy steel |
| 126. | 6Al-4V titanium alloy | 168. | 6Al-4V titanium alloy |
| 127. | 6061-T6 aluminum | 169. | 6061-T6 aluminum alloy |
| 128. | Wood, maple | 170. | Wood |
| 129. | Silver | 171. | Silver |
| 130. | Molybdenum | 172. | Graphite AGX |
| 131. | 6Al-4V titanium alloy | 173. | 17-4PH stainless steel |
| 132. | Graphite AGX | 174. | 4130 alloy steel |
| 133. | Graphite CCN | 175. | 6Al-4V titanium alloy |
| 134. | 17-4PH stainless steel | 176. | 6061-T6 aluminum alloy |
| 135. | 4130 alloy steel | 177. | Wood |
| 136. | 6Al-4V titanium alloy | 178. | Silver |
| 137. | 6061-T6 aluminum alloy | 179. | 6061-T6 aluminum alloy |
| 138. | Molybdenum | 180. | Graphite AGX |
| 139. | Molybdenum | 181. | 17-4PH stainless steel |
| 140. | Molybdenum | 182. | 4130 alloy steel |
| 141. | Molybdenum | 183. | 6Al-4V titanium alloy |
| 142. | Graphite AGX | 184. | 6061-T6 aluminum alloy |
| 143. | Graphite CCN | 185. | Wood |

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186.	Silver	195.	17-4PH stainless steel
187.	Graphite AGX	196.	4130 alloy
188.	17-4PH stainless steel	197.	6Al-4V titanium alloy
189.	4130 alloy steel	198.	6061-T6 aluminum alloy
190.	6Al-4V titanium alloy	199.	Wood
191.	6061-T6 aluminum alloy	200.	4130 alloy steel
192.	Wood	201.	6Al-4V titanium alloy
193.	6061-T6 aluminum alloy	202.	17-4PH stainless steel
194.	Graphite AGX		

A.1.2 Top Billet Cavity Samples

The following radiation effects samples were placed in the top billet cavity:

Code B

<u>Sample No.</u>	<u>Base Polymer</u>	<u>Antirad</u>
1-GFA7	Natural rubber - carbon black compound, sulfur-cured.	none
81-GTA6	Natural rubber - carbon black compound, sulfur-cured.	5 parts naphthyl-amine radiation damage inhibitor
1-GFA8	GR-S - carbon black compound, sulfur-cured.	none
81-GTA7	GR-S - carbon black compound, sulfur-cured.	5 parts naphthyl-amine damage inhibitor
1-GFA9	Neoprene GN - carbon black compound, conventional curing agents.	none
81-GTA8	Neoprene GN - carbon black compound, conventional curing agents.	5 parts naphthyl-amine damage inhibitor
1-GFA10	Hycar 1002 - carbon black compound, sulfur-cured.	none
81-GTA9	Hycar 1002 - carbon black compound, sulfur-cured.	5 parts naphthyl-amine damage inhibitor

Each numbered compound above was made up into the following seven samples:

- 2 - 1/8-inch Dumbbells
- 3 - Scott Dumbbells
- 2 - Hysteresis Pellets

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Code C

<u>No.</u>	<u>Nomenclature</u>	<u>Material</u>
SA4	Organic	n-Butylbenzene
SA5	Organic	Biphenyl
SA6	Organic	Dibenzothiophene
SA7	Organic	p-Terphenyl
SA8	Organic	m-Terphenyl
SA9	Organic	Naphthalene
SA10	Organic	Monoisopropylbiphenyl
SA11	Organic	Biphenyl with 5 percent dibenzothiophene

Code M

<u>No.</u>	<u>Nomenclature</u>	<u>Material</u>
3	Plastic	Supramica 500 ceramoplastic

Code S-1451

<u>Manufacturer</u>	<u>No. of Samples</u>	<u>Nomenclature</u>	<u>Description</u>
General Electric 14-6124	1	1N537 Si diode	
	1	1N538 Si diode	High conductance
	1	1N539 Si diode	Alloy junction
	1	1N540 Si diode	
	2	1N93 Ge diode	Alloy junction
	1	2N43 Ge transistor	Low gain
	1	2N44 Ge transistor	Medium gain
	1	2N45 Ge transistor	High gain
	1	4JD4A4 Si transistor	High frequency
	1	4JD4A4 Si transistor	High frequency
Transitron 14-6125	2	SG211 Si diode	Fast recovery alloy junction
	2	1N483A Si diode	High conductance alloy junction
	1	TL-21 Si rectifier	Large area 200 ma
	1	1N248 Si rectifier	Large area 10 a
	1	1N251 Si diode	High frequency
Hughes Products 14-6126	2	1N458 Si diode	High conductance alloy junction
	2	1N628 Si diode	Fast recovery alloy junction
Texas Instruments 14-6127	1	1N588 Si rectifier	High voltage grown junction
	1	1N589 Si rectifier	High voltage grown junction
	1	T1951 Si transistor	Grown junction, high gain
	1	T1953 Si transistor	Grown junction, low gain

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National Semi-conductor 14-6128	1	1N200	Si diode	N10v
	1	1N210	Si diode	N70v alloy junction type
	1	1N218	Si diode	N200v
	1	1N222	Si diode	N500v
Pacific Semi-conductor 14-6129	2	SD-5101	Si diode	Fast recovery, diffused
	2	PS-564	Si diode	High conductance, diffused
Raytheon 14-6130	1	CK-840	Si diode	50v high conductance, diffused
	1	CK-841	Si diode	200v high conductance, diffused
	1	CK-843	Si diode	400v high conductance, diffused
	1	CK-845	Si diode	600v high conductance, diffused

Code S-1473

No.	Nomenclature	Material
T-1	Spring, captive	"Dynavar" (Hamilton Watch Co.)
T-2	Spring, captive	"Dynavar" (Hamilton Watch Co.)
T-3 No. 1	Spring, captive ring	"Dynavar" (Hamilton Watch Co.)
T-4	Spring, captive ring	"Dynavar" (Hamilton Watch Co.)
T-5	Spring, relaxed	"Dynavar" (Hamilton Watch Co.)
T-6	Spring, relaxed	"Dynavar" (Hamilton Watch Co.)
1	Spring, coiled tension, 1 inch long	High carbon steel
2	Spring, coiled tension, 1 inch long	High carbon steel
3	Spring, coiled tension, 1/8 inch long	High carbon steel
4	Spring, coiled tension, 1/8 inch long	High carbon steel
5	Spring, coiled conical, 1-3/4 inch long	High carbon steel
6	Spring, coiled conical, 1-3/4 inch long	High carbon steel
7	Spring, negator, rolled helical	301/302 stainless steel
8	Spring, negator, rolled helical	301/302 stainless steel
9*	Spring, torsion w/arm	Ni Span C
10*	Spring, torsion w/arm	Ni Span C
11*	Spring, coiled leaf and bell gear	"Elgiloy" (Elgin Watch Co.)
12*	Spring, coiled leaf and bell gear	"Elgiloy"

* These items were not numbered.

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Code S-5133

<u>No.</u>	<u>Manufacturer</u>	<u>Composition</u>	<u>Type Samples</u>
Cymel 404T	American Cyanamid	Melamine formaldehyde	No. 1
Cymac 201	American Cyanamid	Methylstyrene acrylonitrile	No. 2
Cymac 400	American Cyanamid	Methylstyrene	No. 2
AF-77	Monsanto	Polystyrene	No. 2
HT-88B	Monsanto	Polystyrene	No. 2
LXC	Monsanto	Polystyrene	No. 2
S1	Shell	Epon 828 curing agent CL	No. 3
S2	Shell	Epon 828 curing agent Z	No. 3
S3	Shell	Epon 828 curing agent BF ₃ -400	No. 3
S4	Shell	Epon 828 curing agent HET anhyd.	No. 3
S5	Shell	Epon 828 curing agent diaminophenylsulfate	No. 3

Sample Types

- No. 1 - Compression and hardness
- No. 2 - Compression, hardness, impact, and tensile
- No. 3 - Compression, impact, and tensile

A.1.3 Peace Pipe Samples

Specimens mounted on the Peace Pipe included wedges, rods, and compacts. Compacts, with positions at which they were placed are tabulated below. Station numbers are defined by distance in feet from air zero.

<u>Station No.</u>	<u>Plug No.</u>	<u>Compacts (one, unless specified)</u>
215	1	HfC, TaC, ZrC, W, TiC, ThO ₂ , BeO, MgO, Al ₂ O ₃ , ZrO ₂ , Ti, TiO ₂ , Cu, Mg, Sn
235	2	HfC, 2-TiC, 2-ZrC, 2SiC, Mo, B ₄ C, MgO, SiO ₂ , Fe, Mn, Ag, In
255	3	2-W, 2-TiC, 2-ThO ₂ , ZrO ₂ , BeO, Al ₂ O ₃ , MgO, SiO ₂ , Fe, Cu, Mg, In
275	4	TaC, ZrC, W, TiC, ThO ₂ , SiC, Mo, B ₄ C, MgO, Ti, Cr, Ni, Cu, Ag, In
295	5	TaC, ZrC, W, TiC, ThO ₂ , MgO, ZrO ₂ , BeO, Al ₂ O ₃ , SiO ₂ , TiO ₂ , Fe, Mn, Mg, Pb
315	6	TaC, W, TiC, ThO ₂ , SiC, Mo, B ₄ C, Al ₂ O ₃ , Cr, Fe, Ni, Cu, Ag, Zn, In
335	7	ZrC, W, TiC, ThO ₂ , MgO, ZrO ₂ , BeO, Al ₂ O ₃ , Ti, Cr, Fe, Mn, Mg, Pb, Sn

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355	8	TaC, W, TiC, ThO ₂ , SiC, Mo, B ₄ C, Al ₂ O ₃ , SiO ₂ , TiO ₂ , Fe, Cu, Ag, Zn, Sn
375	9	ZrC, W, ThO ₂ , MgO, ZrO ₂ , BeO, Al ₂ O ₃ , Ti, Cr, Fe, Ni, Ag, Mg, Pb, In
395	10	W, TiC, ThO ₂ , MgO, ZrO ₂ , BeO, Al ₂ O ₃ , Ti, Cr, Fe, Cu, Ag, Zn, Pb, In
415	11	TaC, ZrC, ThO ₂ , SiC, Mo, BeO, Al ₂ O ₃ , SiO ₂ , TiO ₂ , Fe, Mn, Ag, Mg, Zn, Sn
435	12	ZrC, ThO ₃ , SiC, Mo, B ₄ C, Al ₂ O ₃ , SiO ₂ , TiO ₂ , Fe, Mn, Ag, Mg, Zn, Pb, Sn
455	13	TaC, TiC, MgO, ZrO ₂ , BeO, Al ₂ O ₃ , Ti, Cr, Fe, Cu, Ag, Mg, Zn, Pb, In
475	14	ZrC, ThO ₂ , MgO, Mo, Al ₂ O ₃ , SiO ₂ , TiO ₂ , Fe, Mn, Ag, Mg, Zn, Pb, Sn, In
495	15	TaC, ThO ₂ , MgO, Mo, Al ₂ O ₃ , Ti, Cr, Fe, Ni, Ag, Mg, Zn, Pb, Sn, In

A.1.4 Wedge Specimens

As has been noted elsewhere, two wedge plugs were placed at each station. Each plug holds three wedge specimens, one each of the following:

1. Cold-rolled molybdenum.
2. Naval brass, ASTM B21-54 Alloy A, quenched to retain the beta phase.
3. 1095 steel (0.87 carbon), quenched to RC 65 (martensitic).

Since there are two plugs with identical materials, duplicates for checking or survival are provided.

A.1.5 Rod Specimens

There were positions for six flush-mounted rods in each of the plugs for internal structure change studies. In each case the brass, molybdenum, and steel samples occupied three of the six positions. The remaining three positions were alternately occupied by graphite, 6061-T6 aluminum and wood (maple) or cast epoxy, diallyl phthalate molding compound, and DC-301 silicone compound.

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A.1.6 Pit Specimens

As has been described, there were 15 pits, 3 each at the 5 positions, 707-, 1000-, 1410-, 2000-, and 2820-foot slant ranges from air zero. The sample types used on the end panels of each of the pits are as follows:

1. Metal tensiles
2. Plastic tensile bars and impact test specimens
3. Adhesive panels
4. Elastomers
5. Paint panels
6. Pit spheres

A.1.7 Metal Tensile Specimens

Three each of the following systems were placed in each pit:

1. CP titanium
2. 8 percent manganese - titanium alloy, annealed
3. 6 aluminum - 4 vanadium, titanium alloy, annealed
4. 6 aluminum - 4 vanadium, titanium alloy, heat-treated
5. 416 stainless steel, heat-treated
6. 440C stainless steel, heat-treated
7. 17-7PH stainless steel, annealed
8. 17-7PH stainless steel, heat-treated
9. 17-4PH stainless steel, annealed
10. 17-4PH stainless steel, heat-treated
11. 347 stainless steel, cold-rolled
12. 302 stainless steel, cold-rolled
13. Al-Mag 35 aluminum casting alloy
14. 356-T6 aluminum casting alloy
15. 7075-T6 aluminum alloy, wrought
16. 2024-T6 aluminum alloy
17. 6061-T4 aluminum alloy
18. 6061-T6 aluminum alloy
19. HK31-T6 magnesium alloy
20. AZ91C-HTA magnesium alloy
21. 4340 steel, heat-treated
22. 4140 steel, heat-treated
23. 1018 steel, cold-rolled
24. 117 steel, cold-rolled
25. 1095 steel, hot-rolled
26. Inconel, nickel alloy, annealed
27. Inconel X, nickel cobalt alloy, age-hardened
28. Haynes-Stellite No. 25, nickel cobalt alloy, annealed
29. Beryllium copper, 1/2 hard
30. Beryllium copper, 1/2 H.T.
31. Phosphor-bronze, spring-temper
32. 65-35 brass, 1/2 hard
33. CP copper, cold-rolled
34. 202 stainless steel, cold-rolled
35. Magnesium-thorium alloy, as cast (Sandia)
36. Aluminum-uranium-thorium alloy, as cast (ORNL)
37. Mallory 821 titanium alloy (aluminum-tantalum-columbium)
38. Zamak soldered aluminum bars, 6061-T6 bars, three each in Pits E and H

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A.1.8 Plastic Tensiles, Elastomers, and Impact Specimens

Three specimens of the following systems were mounted on each of the end panels of the pits.

a. Laminates

1. Epoxy-glass laminate
Shell 828 resin, Shell CL hardener, 181 cloth
2. Epoxy-lead glass cloth laminate
Shell 828 resin, Shell D hardener, Archer cloth
3. Polyester-glass laminate
Selection 5016 resin, benzoyl peroxide catalyst,
181 cloth
4. Phenolic-glass laminate
per ASTM D-709-52T
5. Phenolic-asbestos laminate
Trevano F-120 resin

b. Potting Compounds

6. 50 parts mica
50 parts Shell 828 resin
6 parts DEA hardener
7. 60 parts Neo-Novacite
40 parts Shell 828 resin
5 parts DEA hardener
8. 50 parts mica
50 parts Shell 828 resin
25 parts Thiokol flexibilizer
3 parts N-HEP hardener
9. 100 parts Shell 828 resin
12 parts DEA hardener
10. CRP #235 as supplied by Minnesota Mining and
Manufacturing Company
11. 100 parts Shell 828 resin
12 parts triethylene tetramine hardener
12. 100 parts Shell 828 resin
27 parts adipic-anhydride hardener
13. 100 parts Shell 828 resin
90 parts methylnadic-anhydride hardener
14. 50 parts Shell 828 resin
6 parts DEA hardener
50 parts commercial boron filler

c. Elastomers - (see Table A.1 for compound formulations)

15. Silastic 50
16. Neoprene, compound #858-45II, 60 durometer
17. Neoprene, compound #858-27, 40-60 durometer
18. Natural rubber, compound #858-113, 55-60 durometer,
sulfur cure
19. Natural rubber, compound #130417, peroxide cure
20. Natural rubber, compound #858-119 VI
21. Hypalon, compound #858-49, 80 durometer

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TABLE A.1 -- ELASTOMER FORMULATIONS

	Formula Number (%)					
	858-45 II	858-27	858-113	130417	858-119 VI	858-49
Neoprene W	100					
Neoprene WRT		100				
Natural Rubber			100	15	100	
SBR-1500				85		
Hypalon						100
Magnesium Oxide	4	2				20
Neozone D	1.5	2	1.5		1	
Snowflake White	80					90
Kosmos 40	10					
TP-90B	5					
Heliozone	3					
Zinc Oxide	10	5	5		3	
NA-22	1	0.35				
Thermax		50				
Stearic Acid		0.5	1		1.5	
Diocetyl Sebacate		20	10		15	
Kosmos 60			75			
Altax			1			
Methyl Zimate			0.1			
Sulfur			3			
Kralac A-EP				25		
Philblack 0				1.5		
Aminox				1		
Dicumyl Peroxide				2		
Methyl Tuads					3	
Tetron A					0.75	1.5
Spheron 9					25	
Sterling FT					55	
Staybelite Resin						5
Polyethylene AC 6						2

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d. Foams

22. Isocyanate, rigid, 4 lb/cu ft density as supplied by ALPCO, Stafoam #104
23. Isocyanate, rigid, 30 lb/cu ft density as supplied by ALPCO, Stafoam #730
24. Isocyanate, rigid, 60 lb/cu ft density as supplied by ALPCO, Stafoam #760

e. Plastic Molding Compounds

25. Diallyl phthalate, long-glass-fiber-filled, as supplied by Mesa Plastics Company, #52-20-20
26. Diallyl phthalate, Dacron fiber-filled, as supplied by Mesa Plastics Company, #50-51
27. Silicone, long-glass-fiber-filled, as supplied by Dow Corning, #301
28. Impact bar of #25
29. Impact bar of #26
30. Impact bar of #27
31. Polyethylene, high-density type as supplied by Phillips Petroleum Company, Marlex 50
32. Teflon
33. Polyester, long-glass-fiber premix compound, as supplied by Plumb Chemical Corporation, #1000

A.1.9 Adhesive Panels

Each of the 15 pits had one adhesive panel bolted to one of the aluminum plates. Each panel had a selection of adhesives from the eight systems listed below:

1. Armstrong C4 - Activator D - 100/25 epoxy
2. Armstrong C4 - Activator D - Graphite 100/25/66 epoxy
3. Armstrong C4 - Activator D - Heavy metal - 100/25/50 epoxy
4. Prod. Res PRC 1221 - Catalyst 10/1 polysulfide
5. Armstrong A-2 - Activator E - 100/6 epoxy
6. Dow-Corning RTV 5302/5303 - A4014 primer 50/50 silicone
7. Bloomingdale FM 47 vinyl phenolic
8. Chrysler cycleweld C 3525 rubber phenolic

A.1.10 Paint Panels

Three hundred and twenty paint panels were exposed from 21 different systems of coatings. This list of systems is as follows:

1. Zinc-chromate primer on a steel plate JAN-L-73 topcoat (alkyd lacquer)
2. Zinc-chromate primer on magnesium panel JAN-L-73 topcoat (alkyd lacquer)
3. Zinc-chromate primer on aluminum panel JAN-L-73 topcoat (alkyd lacquer)
4. Zinc-chromate primer (MIL-P-68893) alkyd on aluminum
5. Enamel (TT-E-485C) (alkyd) on aluminum
6. Epo-Lux 100 red on aluminum (epoxy)
7. Epo-Lux 100 white on aluminum (epoxy)
8. Cal-a-Lac grey on aluminum (epoxy)

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9. Amercoat 86-33 system vinyl on aluminum
10. Dow 17 on magnesium conversion coating
11. Plasite (phenolic modified epoxy) on aluminum
12. Amercoat 1133 over aluminum (vinyl strip)
13. Zinc-chromate primer JAN-L-73 lacquer topcoat
Amercoat 1133 strip (alkyd lacquer vinyl strip)
on aluminum
14. Phenoline 300 primer and phenoline 300 primer and
phenoline 300 topcoat (polyurethane) on aluminum
15. Eagle-Picher, hi-temp aluminum pigmented (silicone)
on aluminum
16. Heat-Rim, hi-temp aluminum pigmented (silicone) on
aluminum
17. Maas and Waldstein varnish, MIL-V-173A (Tuf on 747)
phenolic on aluminum
18. Dow-Corning varnish No. 993 (silicone) on aluminum
19. Equipment enamel, grey (MIL-E-15090) alkyd melamine
formaldehyde
20. Iridite 15 on magnesium, conversion coating
21. Convair Paint system
M.1 - C-8514 RM
M.1 - P-7962 SW
White acrylic enamel - Fuller on anodized clad 7075T6

A.1.11 Sphere Specimens

A large number of specimens, not only of materials but also connectors, transistors, and capacitors were included in the sphere. Since the space was limited, the material samples were, as a rule, miniature specimens.

A tabulation of the contents of each sphere is presented here, using the nomenclature described previously. The array of spheres has been listed and the identification of the spheres was made, with the letter "F" designating the Fizeau event, a number from 1 to 5 designating the station (and, therefore, the radial distance from ground zero), and another number from 1 to 22 designating the individual sphere.

A list of the sphere contents follows. Exact plastic formulations may be cross referenced with Paragraph A.1.7.

F-1-1

<u>No.</u>	<u>Description</u>
2	Rigid 60-pound foam (isocyanate) miniature tensile impact bar
1	Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
1	Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
1	Epoxy-glass laminate miniature tensile impact bar
1	Phenolic-glass laminate miniature tensile impact bar
1	Epoxy-lead glass laminate miniature tensile impact bar
1	Polyester-glass laminate miniature tensile impact bar
1	60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
1	Mica 50-828, 6 DEA miniature tensile impact bar

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- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417 peroxide-cure standard ASTM elastomer tensile specimen
- 1 HF77 polystyrene compression, hardness, and impact specimen
- 1 LXC polystyrene compression, hardness, and impact specimen
- 1 HT88B polystyrene compression, hardness, and impact specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 1 Epon 828, curing agent Z compression, impact specimen
- 1 Epon 828, curing agent diaminophenylsulphate compression, impact specimen

F-1-2

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-50-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50, standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 HF77 polystyrene compression, hardness, and impact specimen

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- 1 LXC polystyrene compression, hardness, and impact specimen
- 1 HT88B polystyrene compression, hardness, and impact specimen
- 1 Epon 828 curing agent Z, compression impact specimen
- 1 Epon 828 curing agent diaminophenylsulphate, compression impact specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch

F-1-3

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Cymac-201 methylstyrene acrylonitrile compression, hardness, and impact specimen
- 1 Cymac-400 methylstyrene compression, hardness, and impact specimen
- 1 HF77 polystyrene compression, hardness, and impact specimen
- 1 Epon 828 curing agent CL impact specimen
- 1 Epon 828 curing agent HET anhyd. impact and tensile specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Neoprene 828-27 D 40, standard ASTM tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM tensile specimen

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F-1-4

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 HF77 polystyrene compression, hardness, and impact specimen
- 1 Cymac-400 methylstyrene compression, hardness, and impact specimen
- 1 Cymac-201 methylstyrene acrylonitrile compression, hardness, and impact specimen
- 1 Epon 828 curing agent CL impact specimen
- 1 Epon 828 curing agent HET anhyd. impact specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40 standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen

F-1-5

- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 HT88B polystyrene, compression, hardness, and impact specimen
- 1 Epon 828 curing agent CL compression, hardness, and impact specimen
- 1 Epon 828 curing agent BF₃-400 impact specimen
- 1 LXC polystyrene compression, hardness, and impact specimen
- 1 Cymel 404T melamine formaldehyde compression and hardness specimen
- 1 HF77 polystyrene standard dielectric sample (2-inch disc)
- 1 HT88B polystyrene standard dielectric sample (2-inch disc)
- 1 Cymac 400 methylstyrene standard dielectric sample (2-inch disc)
- 1 LXC polystyrene standard dielectric sample (2-inch disc)
- 1 Cymac 201 methylstyrene acrylonitrile standard dielectric sample (2-inch disc)

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- 1 Cross-point switch
- 1 71N137B silicon alloy diode
- 1 1N468 silicon alloy diode
- 1 Germanium metal sample
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Zinc chromate primer on three SC aluminum panels
(3 x 1-1/4-inch panels)
- 1 Zinc chromate primer and white enamel on three
SO MIL-P-10687 aluminum panels (3 x 1-1/4-inch panel)

F-1-6

- 1 Epon 828 curing agent Z, compression, and impact specimen
- 1 Epon 828 curing agent BF₃-400 impact specimen
- 1 Epon 828 curing agent HET anhyd. compression and impact
specimen
- 1 Cymel 404T melamine formaldehyde compression and hardness
specimen
- 1 LXC polystyrene compression, hardness, and impact
specimen
- 1 HT88B polystyrene compression, hardness, and impact
specimen
- 1 Cymac 400 methylstyrene standard dielectric sample
(2-inch)
- 1 HF77 polystyrene standard dielectric sample (2-inch)
- 1 Cymac 201 methylstyrene acrylonitrile standard dielectric
sample (2-inch)
- 1 HT88B polystyrene standard dielectric sample (2-inch)
- 1 LXC polystyrene standard dielectric sample (2-inch)
- 3 GA 52998 silicon power diode (diffused type)
- 1 Easley cube (germanium cube)
- 3 2N66 germanium alloy (medium power) transistors
- 3 Art WAHL evacuated transistors
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300 v DC

F-1-7

- 5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
- 2 Borate-glass total-energy dosimeters (C&D)
- 1 Uranium foil
- 1 Neptunium foil
- 1 Plutonium foil
- 1 Sulfur pellet
- 2 Gold foils

F-1-8

- 1 HT88B polystyrene compression, hardness, and impact
specimen
- 1 HF77 polystyrene compression, hardness, and impact
specimen
- 1 LXC polystyrene compression, hardness, and impact
specimen
- 1 Sprague #118P4740652 capacitor, 47, 600-v DC
- 1 Solar ceramic disc capacitor, 0.01-mfd
- 1 Sprague ceramic monolithic capacitor, 0.1-mfd

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1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
3 CA 53282 silicon-diffused diode
3 S181G germanium alloy point contact computer-type diode
3 1-mfd tantalum capacitor
3 A 584E lacquer capacitor
3 1-mfd low dielectric constant ceramic capacitor
3 0.01-mfd high dielectric constant ceramic capacitor
1 Polymethyl methacrylate viscosity sample (UVA II)
1 Polymethyl methacrylate viscosity sample (#55)
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance alloy
junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N428 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery alloy
junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction
1 Texas Instruments TI951 Silicon transistor grown junction,
high gain
1 Texas Instruments TI953 Silicon transistor grown junction,
low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

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F-1-9

- 1 HF77 polystyrene compression, hardness, and impact specimen
- 1 LXC polystyrene compression, hardness, and impact specimen
- 1 HT88B polystyrene compression, hardness, and impact specimen
- 3 2042 silicon-diffused base transistors
- 4 2030 diffused silicon computer diode
- 3 Specially prepared tubulations
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 3 1N205 silicon alloy diodes
- 3 1N222 silicon alloy diodes
- 3 GA 52934 silicon-diffused diodes
- 3 T19G germanium alloy diodes (computer diodes)
- 1 HiQ capacitor, 1000-mmfd, 6-kv (ceramic disc type)
- 1 Solar ceramic disc capacitor, 0.01-mfd
- 1 El Menco (Arco) mica capacitor, 15,000-mfd, 1000 WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mfd, 1000 WV, 1 percent
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v DC
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample
- 1 Sprague ceramic monolithic capacitor, 0.1-mfd
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v

SECRET

1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v, high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v, high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v, high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v, high conductance,
diffused

F-1-10

3 3N22 germanium tetrode transistor
3 GA 53270 germanium alloy transistor (low power)
3 GA 53233 germanium diffused-base transistor
3 2N337 Texas Instrument transistor
2 3N25 Texas Instrument transistor
3 WAHL oxygen-filled transistor
1 SA 235-23 capacitor, 47-mfd, 600-v DC
2 Gudeman oil-filled capacitor, 0.47-mfd, 600-v DC,
10 percent
1 El Menco (Arco) mica capacitor, 2000-mmfd, 1600-WV,
1 percent
1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV,
1 percent
1 HiQ ceramic disc capacitor, 1000-mmfd, 6-kv
1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
1 MC-818 (Ser. #MH55837E7) with silicone foam rubber boot
potted in Epon 828 with mica filler
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 19540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance alloy
junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery alloy
junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction

SECRET

SECRET

- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-1-11

- 10 MA 40 microwave diodes (MA 408 type)
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v DC, 10 percent
- 1 Sprague ceramic disc capacitor, 0.01 mfd, 1-kv
- 1 Good-all capacitor, type 6200 WHT, 0.22 mfd, 300-v DC
- 1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV, 1 percent
- 1 EC-801 sealant in aluminum tube
- 1 RTV sealant in aluminum tube
- 1 PR 1422 sealant in aluminum tube
- 1 DC 6127 sealant in aluminum tube
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction

SECRET

1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction
1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

F-1-12

1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV,
1 percent
1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV,
1 percent
1 Sprague ceramic disc capacitor, 0.01-mfd, 1-kv
1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v,
10 percent
1 C₁₄₋₁₈ diphenyl ether fluid sample
1 Skydrol hydraulic oil in aluminum cylinder
1 Synjet-15 oil in aluminum cylinder
1 DC 6127 sealant in aluminum tube
1 EC-801 sealant in aluminum tube
1 PR-1422 sealant in aluminum tube
1 RTV sealant in aluminum tube
1 Zamak tensile bar
1 Aluminum tensile bar with Zamak solder joint in gage area
2 Caro SA336 connector attached to SA-337 connector
1 Sprague #196P104910S2 capacitor, 0.1-mfd, 1000-v DC

F-1-13

1 Neoprene rubber in aluminum tube
1 Nitrile rubber in aluminum tube
1 n-Butylbenzene fluid sample
1 Orthosilicate hydraulic oil in aluminum cylinder
1 MPD-2067 hydraulic oil in aluminum cylinder
1 MIL-G-5278 grease in aluminum cylinder
4 Styrene miniature tensile impact bar
3 Rag-filled phenolic miniature tensile impact bar
1 Zamak tensile bar
1 Aluminum tensile bar with Zamak solder joint in gage area

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- 2 Caro SA-336 connector attached to SA-337 connector
- 1 Polypenco "Nylaflo" pressure tubing, 3/4 inch H
- 1 Boot, silicone foam rubber, for thermal unit

F-1-14

- 2 GE 6442 vacuum tube ceramic triode, high temperature
- 1 Fluorolube FS-5 in aluminum cylinder
- 1 MIL-O-5606 hydraulic oil in aluminum cylinder
- 1 Fluorolube LG-160
- 1 JP-4 jet fuel liquid sample
- 1 Neoprene rubber uncured in aluminum tube
- 1 Natural rubber in aluminum tube
- 1 Zamak tensile bar
- 1 Aluminum tensile bar with Zamak solder joint in gage area
- 1 Coaxial cable (black insulation), polyfoam (Dwg. 134994)
7-inch-long polyethylene insulation

F-1-15

- 2 GE Z5112 voltage tunable magnetron, high temperature
- 1 Turbo oil No. 15 in aluminum cylinder
- 1 DC-55 grease (MIL-G-4343) in aluminum cylinder
- 1 Biphenyl liquid sample
- 1 Natural rubber uncured in aluminum tube
- 1 Nitrile rubber in aluminum tube
- 1 Teflon sheet in aluminum tube

F-1-16

- 1 In56P-type semiconducting material
- 2 HF77 polystyrene standard dielectric sample (4 inch)
- 2 HT88B polystyrene standard dielectric sample (4 inch)
- 2 LXC polystyrene standard dielectric sample (4 inch)
- 1 IRC resistor, 60-megohm, 1 percent
- 1 Spirameg resistor, type 700E, 60-megohm, 5 percent
- 1 Coaxial cable, LASL type G, brown, 12-inch-long
polyethylene insulation
- 1 Wire, 12-inch-long MIL-W-16878B, type E-20 with Teflon
insulation, white
- 1 Wire, 12-inch-long MIL-W-16878B, type E-20 with Teflon
insulation, blue
- 1 Wire, 12-inch-long MIL-W-16878B, type E-20 with Teflon
insulation, yellow
- 1 Wire, 12-inch-long MIL-W-16878B, type E-20 with Teflon
insulation, orange
- 1 Wire, 12-inch-long MIL-W-16878B, type B, C, or D with
polyvinyl chloride insulation, white with red stripe
- 4 1N353 transistor silicon diodes

F-1-17

- 6 SA-413 thermal fuse
- 5 Bussman fuse GLK-3 (sealed)
- 1 Cannon connector KO2-16-10PU(C13), SA-393-7 with nylon
cap and melamine insert
- 1 Buggie connector #4962 (SA-589)

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1 Bendix connector PCC 7A-16-26P rubber insert
1 Sylvania SA-625 cold cathode trigger tube, Ser. 7FF-191R
1 QF-888A Raytheon cold cathode gas rectifier, low-pressure,
double-ended, subminiature tube, Ser. #53 exp.
1 CK-1042/6659 Raytheon cold cathode gas rectifier, high-
pressure, single-ended, subminiature tube, Ser. #148
1 CK-6174 Raytheon cold cathode gas rectifier, low-pressure,
double-ended, miniature tube with startor electrode,
Ser. #148
1 QM 648 Raytheon cold cathode gas rectifier, low-pressure,
double-ended, ruggedized, miniature tube, Ser. #23
1 CK 1046/6763 Raytheon cold cathode gas rectifier, high-
pressure, double-ended, ruggedized, miniature tube,
Ser. #14
1 Bendix XSA-379 cold cathode trigger tube, experimental
design #1080
1 6RS6GH 77THB1 selenium rectifier
1 6RS6GH 40THB1 selenium rectifier
1 6RS6GH 65THB1 selenium rectifier
1 Raytheon CK 1036 cold cathode gas rectifier, low-pressure,
single-ended, subminiature tube, Ser. #47

F-1-18

1 Bendix capacitor #10-113350 (SA-409)
1 Deutsch connector #8700-78
1 Cannon connector 22247 glass and rubber, high-voltage
1 Raytheon CK 1036 cold cathode gas rectifier, low-pressure,
single-ended, subminiature tube, Ser. #6
1 Raytheon CK 1042/6659 cold cathode gas rectifier, high-
pressure, single-ended, subminiature tube, Ser. #145
1 Raytheon QF-888A cold cathode gas rectifier, low-pressure,
double-ended, subminiature tube, Ser. #24 exp.
1 Raytheon CK 1046/6763 cold cathode, high-pressure, double-
ended ruggedized, miniature tube, Ser. #1
1 Raytheon QM-648 cold cathode gas rectifier, low-pressure,
double-ended, ruggedized, miniature tube, Ser. #20 exp.
1 Raytheon CK 6174 cold cathode gas rectifier, low-pressure,
double-ended, miniature tube with starter electrode,
Ser. #81
1 Bendix XSA-466 cold cathode trigger tube, experimental
1 Bendix pigmy connector 02 (SA-403-9)
1 Cannon connector DB-25P, nylon (SA-638)
1 Sylvania XSA-625 cold cathode trigger tube, Ser. #17R
1 Bendix pigmy glass-seal connector, SA-408-1
1 6RS6GH 77THB1 selenium rectifier
1 6RS6GH 65THB1 selenium rectifier
1 6RS6GH 40THB1 selenium rectifier
6 SA-413 thermal fuse
5 Bussman fuse GLK-3, sealed

F-1-19

6 SA-413 thermal fuse
5 Bussman fuse GLK-3, sealed
1 CK-1036 Raytheon cold cathode gas rectifier, low-pressure,
single-ended, subminiature tube, Ser. #7

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- 1 CK 1042/6659 Raytheon cold cathode gas rectifier, high-pressure, single-ended, subminiature tube, Ser. #146
- 1 QF-888A Raytheon cold cathode gas rectifier, low-pressure, double-ended, subminiature tube, Ser. #48
- 1 CK-6174 Raytheon cold cathode gas rectifier, low-pressure, double-ended, miniature tube with starter electrode, Ser. #82
- 1 CK 1046/6763 Raytheon cold cathode gas rectifier, high-pressure, double-ended, ruggedized miniature tube, Ser. #2
- 1 Sylvania (SA-625) cold cathode trigger tube, Ser. 7FC 81R
- 1 Bendix XSA-379 cold cathode trigger tube, experimental design, Ser. 7E042-2
- 1 Pulse break-away connector diallyl phthalate insert, XSA-378
- 1 Switching connector, rubber insert, XSA-438, DCO 14200-42
- 1 Miniature rectangular "D" amphenol connector, melamine insert, SA-455-13

F-1-20

- 6 SA-413 thermal fuse
- 5 Bussman fuses GLK-3, sealed
- 1 Raytheon CK 1042/6659 cold cathode gas rectifier, low-pressure, single-ended, subminiature tube, Ser. #147
- 1 Raytheon QF-888A cold cathode gas rectifier, low-pressure, double-ended, subminiature tube, Ser. #56
- 1 Raytheon CK-1036 cold cathode gas rectifier, low-pressure, single-ended, subminiature tube, Ser. #9
- 1 Raytheon QM-648 cold cathode gas rectifier, low-pressure, double-ended, ruggedized, miniature tube, Ser. #22 (experimental)
- 1 Raytheon CK 1046/6763 cold cathode, high-pressure, double-ended, ruggedized, miniature tube, Ser. #3
- 1 Raytheon CK-6174 cold cathode gas rectifier, low-pressure, double-ended, miniature tube with starter electrode, Ser. #83
- 1 H. H. Buggie connector #3922
- 1 SA-455-13 Cannon connector, rectangular "D" miniature, melamine insert
- 1 SA-482 connector pulse break-away, diallyl phthalate insert
- 1 SA-229-15 Bendix AN 3057-12B connector, rubber insert, radioplane

F-1-21

- 1 Cannon connector 22087 glass seal - 1 high-voltage contact, 20 low-voltage contacts
- 1 SA-587 Bendix connector No. 10-130585, 2 high-voltage, 3 low-voltage, Hoagland high voltage
- 1 SA-346-2 connector, glass seal (AJ-B6)
- 1 Cannon connector K02-19-20-SN, special diallyl phthalate insert
- 1 SA-361-6 Bendix XSA-361-6, rubber insert
- 1 Cable junction Thiokol
- 1 CF-1338 cable assembly, Bendix 10-125280-1 Plastisol

SECRET

F-1-B

5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
2 Borate-glass total-energy dosimeters (J and K)
1 Uranium foil
1 Plutonium foil
1 Sulfur pellet
1 Gold foil

F-2-1

2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
1 Epoxy-glass laminate miniature tensile impact bar
1 Phenolic-glass laminate miniature tensile impact bar
1 Epoxy-lead glass laminate miniature tensile impact bar
1 Polyester-glass laminate miniature tensile impact bar
1 60 Neo-Novacite, 40-825, 5 DEA miniature tensile impact bar
1 Mica 50-828, 6 DEA miniature tensile impact bar
1 100-828, 12 DEA miniature tensile impact bar
1 50-828, 6 DEA commercial boron miniature tensile impact bar
1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
1 Silastic 50 standard ASTM elastomer tensile specimen
1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
1 Epon 828 curing agent Z, impact specimen
1 Epon 828 curing agent diaminophenylsulfate, impact specimen
1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
1 LXC polystyrene, compression, hardness, and impact specimen
1 HT88B polystyrene, compression, hardness, and impact specimen
1 HF77 polystyrene, compression, hardness, and impact specimen

F-2-2

2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar

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- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 848-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 3 Styrene miniature tensile impact bar
- 3 Rag-filled phenolic miniature tensile impact bar

F-2-3

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber, 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch

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- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall),
1 x 1 x 1/8 inch
- 1 Epon 828 curing agent CL impact specimen
- 1 Epon 828 curing agent BF₃-400, compression, impact specimen
- 1 Cymac 201, methylstyrene = acrylonitrile, compression,
hardness, and impact specimen
- 1 Cymac 400 methylstyrene, compression, hardness, and
impact specimen
- 1 HF77 polystyrene, flexural specimen

F-2-4

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact
bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled
miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled
miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact
bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact
bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile
specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting
standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM
elastomer tensile specimen
- 1 Conolan 506 phenolic resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall),
1 x 1 x 1/8 inch
- 1 Natural rubber in aluminum tube

F-2-5

- 1 50 828, 6 DEA commercial boron miniature tensile impact
bar
- 1 Epon 828 curing agent BF₃-400, compression, and impact
specimen
- 1 HT88B polystyrene, flexural specimen
- 1 LXC polystyrene flexural specimen
- 1 Cymel 404T melamine formaldehyde compression, hardness,
and impact specimen
- 1 HF77 polystyrene, flexural specimen
- 1 HT88B polystyrene standard dielectric sample (2-inch)

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- 1 LXC polystyrene standard dielectric sample (2-inch)
- 1 Cymac 400 methylstyrene standard dielectric sample (2-inch)
- 1 Cymac 201 methylstyrene acrylonitrile standard dielectric sample (2-inch)
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2-inch
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Zinc chromate primer on 1-1/4 x 3-inch 350 aluminum
- 1 Zinc chromate primer and white enamel on 1-1/4 x 3-inch 350 aluminum
- 1 Teflon sheet in aluminum tube
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample

F-2-6

- 1 LXC polystyrene, flexural specimen
- 1 HT88B polystyrene, flexural specimen
- 1 HF77 polystyrene standard dielectric sample (2-inch)
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Stainless steel bonded to Teflon 1 x 5-1/2-inch
- 1 Nitrile rubber in aluminum tube
- 1 Polymethyl methacrylate viscosity sample (UVA II)
- 1 Polymethyl methacrylate viscosity sample (#55)
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused

SECRET

- 1 LXC polystyrene standard dielectric sample (2-inch)
- 1 Cymac 400 methylstyrene standard dielectric sample (2-inch)
- 1 Cymac 201 methylstyrene acrylonitrile standard dielectric sample (2-inch)
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2-inch
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Zinc chromate primer on 1-1/4 x 3-inch 350 aluminum
- 1 Zinc chromate primer and white enamel on 1-1/4 x 3-inch 350 aluminum
- 1 Teflon sheet in aluminum tube
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample

F-2-6

- 1 LXC polystyrene, flexural specimen
- 1 HT88E polystyrene, flexural specimen
- 1 HF77 polystyrene standard dielectric sample (2-inch)
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Stainless steel bonded to Teflon 1 x 5-1/2-inch
- 1 Nitrile rubber in aluminum tube
- 1 Polymethyl methacrylate viscosity sample (UVA II)
- 1 Polymethyl methacrylate viscosity sample (#55)
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused

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- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-2-7

- 5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
- 1 Borate-glass total-energy dosimeters (U)
- 1 Uranium foil
- 1 Plutonium foil
- 1 Sulfur pellet
- 2 Gold foils

F-2-8

- 1 Sprague oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 Solar ceramic disc capacitor, 0.01-mfd
- 1 Sprague ceramic monolithic capacitor, 0.1-mfd
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
- 1 Neoprene rubber in aluminum tube
- 1 Zamak tensile bar
- 1 Aluminum tensile bar soldered with Zamak
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain

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- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-2-9

- 1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV, 1 percent
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 Hi-Q ceramic disc capacitor, 1000-mmfd, 6-kv
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 Biphenyl fluid sample
- 1 Sprague ceramic disc capacitor, 0.01-mfd, 1-kv
- 1 RTV sealant (silastic) in aluminum tube
- 1 Dow-Corning 6127 sealant in aluminum tube
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Zamak tensile bar
- 1 Aluminum tensile bar soldered with Zamak
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction

SECRET

SECRET

- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-2-10

- 1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV, 1 percent
- 2 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 RTV silastic sealant in aluminum tube
- 1 Dow-Corning 6127 sealant in aluminum tube
- 1 n-Butylbenzene fluid sample
- 1 MPD-2067 hydraulic oil in aluminum cylinder
- 1 MIL-O-5606 hydraulic oil in aluminum cylinder
- 1 Turbo oil No. 15 in aluminum cylinder
- 1 Semiconductor package (#9)

F-2-11

- 1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV, 1 percent
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 C14-16 diphenyl ether fluid sample
- 1 EC 801 sealant in aluminum tube
- 1 PR 1422 sealant in aluminum tube
- 1 Synjet-15 oil in aluminum cylinder
- 1 MIL-G-3278 grease in aluminum cylinder
- 1 Fluorolube FS-5 in aluminum cylinder
- 1 Zamak tensile bar
- 1 Aluminum tensile bar soldered with Zamak
- 2 Caro SA-336 attached to SA-337 (connectors)
- 4 Transistron 1N353 silicon diodes
- 1 Texas Instruments 2N389 silicon power transistor
- 1 Minneapolis-Honeywell H-6 germanium power transistor

SECRET

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1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance
alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery
alloy junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction
1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast recovery,
diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

F-2-12

1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
1 EC 801 sealant in aluminum tube
1 PR 1422 sealant in aluminum tube
1 JP-4 jet fuel sample
1 DC-55 grease (MIL-G-4343) in aluminum cylinder
1 Skydrol hydraulic oil in aluminum cylinder
1 Fluorolube LG-160 in aluminum cylinder
1 Orthosilicate hydraulic oil in aluminum cylinder
2 Caro SA-336 attached to SA-337 (connectors)
1 6RS6GH 77THB1 selenium rectifier

SECRET

1 6RS6GH 65THB1 selenium rectifier
1 6RS6GH 40THB1 selenium rectifier

F-2-13

2 HF77 polystyrene standard dielectric sample (4-inch)
2 HT88B polystyrene standard dielectric sample (4-inch)
2 LXC polystyrene standard dielectric sample (4-inch)
1 6RS6GH 77THB1 selenium rectifier
1 6RS6GH 65THB1 selenium rectifier
1 6RS6GH 40THB1 selenium rectifier

F-3-1

2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
1 Epoxy-glass laminate miniature tensile impact bar
1 Phenolic-glass laminate miniature tensile impact bar
1 Epoxy-lead glass laminate miniature tensile impact bar
1 Polyester-glass laminate miniature tensile impact bar
1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
1 Mica 50-828, 6 DEA miniature tensile impact bar
1 100-828, 12 DEA miniature tensile impact bar
1 50-828, 6 DEA commercial boron miniature tensile impact bar
1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
1 Silastic 50 standard ASTM elastomer tensile specimen
1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
1 Epon 828/CL epoxy-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch

F-3-2

2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
1 Epoxy-glass laminate miniature tensile impact bar
1 Phenolic-glass laminate miniature tensile impact bar
1 Epoxy-lead-glass laminate miniature tensile impact bar

SECRET

SECRET

- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113, D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch

F-3-3

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Molded Supramica 560 ceramoplastic miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch

SECRET

F-3-4

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 1 Natural rubber in aluminum tube

F-3-5

- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
- 1 Teflon sheet in aluminum tube
- 2 Cross-point switches
- 3 1N137B silicon alloy diodes
- 3 1N468 silicon alloy diodes
- 1 Germanium metal sample
- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Zinc chromate primer on 1-1/4 x 3-inch 3SO aluminum
- 1 Zinc chromate primer and white enamel on 1-1/4 x 3-inch 3SO aluminum
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample

F-3-6

- 1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
- 1 Easley wafer cube (germanium)
- 3 GA52998 silicon power diodes (diffused type)
- 3 2N66 germanium alloy (medium power)

SECRET

SECRET

3 WAHL evacuated transistors
1 Nitrile rubber in aluminum tube
1 Polymethyl methacrylate (UVA II) viscosity sample
1 Polymethyl methacrylate (#55) viscosity sample
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy junction
2. Transistron 1N483A Silicon diode - high conductance alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-3-7.

5 Hydrocarbon dye (Sigoloff type) gamma dosimeter
1 Borate-glass total-energy dosimeter ("V")
1 Uranium foil
1 Plutonium foil
1 Sulfur pellet
2 Gold foils

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F-3-8

1 Neoprene rubber in aluminum tube
1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
1 Sprague ceramic monolithic capacitor, 0.1-mfd
1 Solar ceramic disc capacitor, 0.01-mfd
1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
3 GA53282 silicon-diffused diode
3 S181G germanium alloy point-contact computer-type diode
3 1-mfd dry tantalum capacitor
3 A584E lacquer film capacitor
3 0.1-mfd low dielectric constant ceramic capacitor
3 0.01-mfd high dielectric constant ceramic capacitor
1 Sprague oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
1 GE 1N541 Germanium diode - alloy junction
1 GE 1N542 Germanium transistor - low gain
1 GE 1N543 Germanium transistor - medium gain
1 GE 1N544 Silicon transistor - high frequency
1 GE 1N545 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance alloy
junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery
alloy junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction
1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

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F-3-9

1 RTV sealant in aluminum tube
1 Dow-Corning 6127 sealant in aluminum tube
1 0.01-mfd high dielectric constant ceramic capacitor
1 Sprague ceramic disc capacitor, 0.01-mfd, 1-kv
2 Gudemán oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
1 Good-all capacitor, type 6200 WHT, 0.22-mfd, 300-v DC
1 El Menco (Arco) mica capacitor, 15,000-mfd, 1000-WV,
1 percent
1 El Menco (Arco) mica capacitor, 2000-mfd, 1000-WV,
1 percent
3 1N205 silicon alloy diode
3 1N222 silicon alloy diode
3 GA52934 silicon-diffused diode
3 T19G germanium alloy computer diode (point contact)
3 2042 silicon diffused-base transistors
4 2030 silicon diffused-computer diode
3 Specially prepared tubulations
2 Caro SA-336 attached to SA-337 (connectors)
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance
alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery
alloy junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction
1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused

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- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-3-10

- 1 RTV silastic sealant in aluminum tube
- 1 Dow-Corning 6127 sealant in aluminum tube
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 Good-all capacitor, type 6200-WHT, 0.22-mfd, 300-v DC
- 1 El Menco (Arco) mica capacitor, 15,000-mfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mfd, 1000-WV, 1 percent
- 3 3N22 germanium tetrode
- 3 GA53270 germanium alloy (low power) transistor
- 3 GA53233 germanium diffused-base transistor
- 3 2N337 Texas Instruments transistor
- 2 3N25 Texas Instruments transistor
- 3 WAHL evacuated transistor
- 10 MA40 microwave diodes
- 2 Caro SA-306 attached to SA-337 (connectors)
- 1 6RS6GH 77THB1 selenium rectifier
- 1 6RS6GH 65THB1 selenium rectifier
- 1 6RS6GH 40THB1 selenium rectifier
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v

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- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-3-11

- 1 Biphenyl fluid sample
- 1 MPD-2067 hydraulic oil in aluminum cylinder
- 1 MIL-O-5606 hydraulic oil in aluminum cylinder
- 1 Turbo oil No. 15 in aluminum cylinder
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v DC, 10 percent
- 1 Good-all capacitor, type 6200 WHT, 0.22 mfd, 300-v DC
- 1 El Menco (Arco) mica capacitor, 15,000-mmfd, 1000-WV, 1 percent
- 1 El Menco (Arco) mica capacitor, 2000-mmfd, 1000-WV, 1 percent
- 1 EC 801 sealant in aluminum tube
- 1 PR 1422 sealant in aluminum tube
- 1 Synjet-15 oil in aluminum cylinder
- 1 MIL-G-3278 grease in aluminum cylinder
- 1 n-Butylbenzene fluid sample
- 4 1N353 transistor silicon diodes
- 1 2N389 Texas Instruments silicon power transistor
- 1 H-6 Minneapolis-Honeywell germanium power transistor

F-3-12

- 1 Fluorolube FS-5 in aluminum cylinder
- 1 DC-55 grease (MIL-G-4343) in aluminum cylinder
- 1 Skydrol hydraulic oil in aluminum cylinder
- 1 Fluorolube LG-160 in aluminum cylinder
- 1 Orthosilicate hydraulic oil in aluminum cylinder
- 1 Gudeman oil-filled capacitor, 0.47-mfd, 600-v, 10 percent
- 1 EC 801 sealant in aluminum tube
- 1 PR 1422 sealant in aluminum tube
- 1 C₁₄₋₁₆ diphenyl-ether fluid sample
- 1 JP-4 jet fuel sample
- 1 6RS6GH 77THB1 selenium rectifier
- 1 6RS6GH 65THB1 selenium rectifier
- 1 6RS6GH 40THB1 selenium rectifier

SECRET

F-4-1

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40 standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch

F-4-2

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40 standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch

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- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall),
1 x 1 x 1/8 inch

F-4-3

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen
- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Enolan 506 phenolic-resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate,
1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall),
1 x 1 x 1/8 inch

F-4-4

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica, 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Silastic 50 standard ASTM elastomer tensile specimen

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- 1 Neoprene 858-27 D 40, standard ASTM elastomer tensile specimen
- 1 Natural rubber 858-113 D 55-60, sulfur-cure conducting standard ASTM elastomer tensile specimen
- 1 Natural rubber 130417, peroxide-cure standard ASTM elastomer tensile specimen
- 1 Conolan 506 phenolic-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL epoxy-resin 181 glass-fiber laminate, 1 x 1 x 1/8 inch
- 1 Epon 828/CL and glass rovings (motor case wall), 1 x 1 x 1/8 inch
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample

F-4-5

- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 2 Cross-point switches
- 3 1N137B silicon alloy diodes
- 3 1N468 silicon alloy diodes
- 1 Germanium metal sample #7
- 1 Zinc chromate primer on 3SO 3 x 1-1/4-inch aluminum panels
- 1 Zinc chromate primer and white enamel (MIL-P-10687) on 3SO 3 x 1-1/4-inch aluminum panels
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2-inch adhesive sample
- 1 Teflon sheet in aluminum tube
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI931 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain

SECRET

SECRET

- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-4-6

- 3 52998 silicon power diodes
- 1 Easley wafer cube (germanium cube)
- 1 Nitrile rubber in aluminum tube
- 1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
- 3 2N66 medium power transistors
- 3 WHAL evacuated transistors
- 1 Natural rubber in aluminum tube
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N268 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type

SECRET

1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

F-4-7

5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
1 Borate-glass total-energy dosimeter (W)
1 Uranium foil
1 Plutonium foil
1 Sulfur pellet
2 Gold foils

F-4-8

1 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
1 Neoprene rubber in aluminum tube
3 GA53282 silicon diffused diodes
3 S181G germanium computer-type diodes
3 1-mfd dry tantalum capacitors
3 A584E lacquer film capacitors
3 0.1-mfd low dielectric constant ceramic capacitors
3 0.01-mfd high dielectric constant ceramic capacitors
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance
alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery
alloy junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction

SECRET

SECRET

1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance
diffused

F-4-9

3 1N205 silicon alloy diodes
3 1N222 silicon alloy diodes
3 GA52934 silicon -diffused diodes
3 T19G germanium alloy diodes (computer type)
3 2042 diffused base silicon transistors
4 2030 diffused silicon computer diodes
3 Specially prepared tubulations
1 RTV sealant in aluminum tube
1 EC 801 sealant in aluminum tube
1 DC 6127 sealant in aluminum tube
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance
alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction
2 Hughes Products 1N628 Silicon diode - fast recovery alloy
junction
1 Texas Instruments 1N588 Silicon rectifier - high voltage
grown junction
1 Texas Instruments 1N589 Silicon rectifier - high voltage
grown junction

SECRET

1 Texas Instruments TI951 Silicon transistor - grown
junction, high gain
1 Texas Instruments TI953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
1 National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

F-4-10

3 3N22 germanium tetrode transistors
3 GA53270 germanium alloy transistors
3 GA53233 germanium diffused-base transistors
3 2N337 Texas Instruments transistors
2 3N25 Texas Instruments transistors
3 WAHL oxygen-filled transistors
10 MA40 microwave diodes (MA408 type)
1 RTV sealant in aluminum tube
1 EC 801 sealant in aluminum tube
1 DC 6127 sealant in aluminum tube

F-4-11

1 PR 1422 sealant in aluminum tube
1 Biphenyl fluid sample
1 n-Butylbenzene fluid sample
1 MPD-2067 hydraulic oil in aluminum cylinder
1 MIL-O-5606 hydraulic oil in aluminum cylinder
1 Turbo oil No. 15 in aluminum cylinder
1 Synjet-15 oil in aluminum cylinder
1 MIL-G-3278 grease in aluminum cylinder

F-4-12

1 C₁₄₋₁₆ Diphenyl-ether fluid sample
1 JP-4 jet fuel fluid sample
1 PR 1422 sealant in aluminum tube
1 Fluorolube FS-5 in aluminum cylinder
1 DC-55 grease (MIL-G-4343) in aluminum cylinder
1 Skydrol hydraulic oil in aluminum cylinder
1 Fluorolube LG-160 in aluminum cylinder
1 Orthosilicate hydraulic oil in aluminum cylinder

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F-5-1

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PSS64 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused

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- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-5-2

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 Polymethyl methacrylate (UVA II) viscosity sample
- 1 Polymethyl methacrylate (#55) viscosity sample
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistors - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v

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- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-5-3

- 2 Rigid 60-pound foam (isocyanate) miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled miniature tensile impact bar
- 1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled miniature tensile impact bar
- 1 Epoxy-glass laminate miniature tensile impact bar
- 1 Phenolic-glass laminate miniature tensile impact bar
- 1 Epoxy-lead-glass laminate miniature tensile impact bar
- 1 Polyester-glass laminate miniature tensile impact bar
- 1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact bar
- 1 Mica 50-828, 6 DEA miniature tensile impact bar
- 1 100-828, 12 DEA miniature tensile impact bar
- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 1 GE 1N537 Silicon diode
- 1 GE 1N538 Silicon diode - high conductance
- 1 GE 1N539 Silicon diode - alloy junction
- 1 GE 1N540 Silicon diode
- 2 GE 1N93 Germanium diode - alloy junction
- 1 GE 2N43 Germanium transistor - low gain
- 1 GE 2N44 Germanium transistor - medium gain
- 2 GE 4JD4A4 Silicon transistor - high frequency
- 1 GE 2N45 Germanium transistor - high gain
- 2 Transistron SG211 Silicon diode - fast recovery alloy junction
- 2 Transistron 1N483A Silicon diode - high conductance alloy junction
- 1 Transistron TL-21 Silicon rectifier - large area 200 ma
- 1 Transistron 1N248 Silicon rectifier - large area 10 a
- 1 Transistron 1N251 Silicon diode - high frequency
- 2 Hughes Products 1N458 Silicon diode - high conductance alloy junction
- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain

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1 Texas Instruments T1953 Silicon transistor - grown
junction, low gain
1 National Semiconductor 1N200 Silicon diode N10v
1 National Semiconductor 1N210 Silicon diode N70v alloy
junction type
i National Semiconductor 1N218 Silicon diode N200v
1 National Semiconductor 1N222 Silicon diode N500v
2 Pacific Semiconductor SD5101 Silicon diode - fast
recovery, diffused
2 Pacific Semiconductor PS564 Silicon diode - high
conductance, diffused
1 Raytheon CK840 Silicon diode - 50-v high conductance,
diffused
1 Raytheon CK841 Silicon diode - 200-v high conductance,
diffused
1 Raytheon CK843 Silicon diode - 400-v high conductance,
diffused
1 Raytheon CK845 Silicon diode - 600-v high conductance,
diffused

F-5-4

2 Rigid 60-pound foam (isocyanate) miniature tensile impact
bar
1 Molded diallyl phthalate, Mesa 50-51, Dacron-filled
miniature tensile impact bar
1 Molded diallyl phthalate, Mesa 52-20-30, glass-filled
miniature tensile impact bar
1 Epoxy-glass laminate miniature tensile impact bar
i Phenolic-glass laminate miniature tensile impact bar
1 Epoxy-lead-glass laminate miniature tensile impact bar
1 Polyester-glass laminate miniature tensile impact bar
1 60 Neo-Novacite, 40-828, 5 DEA miniature tensile impact
bar
1 Mica 50-828, 6 DEA miniature tensile impact bar
1 100-828, 12 DEA miniature tensile impact bar
1 50-828, 6 DEA commercial boron miniature tensile impact
bar
1 Polymethyl methacrylate (UVA II) viscosity sample
1 Polymethyl methacrylate (#55) viscosity sample
1 GE 1N537 Silicon diode
1 GE 1N538 Silicon diode - high conductance
1 GE 1N539 Silicon diode - alloy junction
1 GE 1N540 Silicon diode
2 GE 1N93 Germanium diode - alloy junction
1 GE 2N43 Germanium transistor - low gain
1 GE 2N44 Germanium transistor - medium gain
2 GE 4JD4A4 Silicon transistor - high frequency
1 GE 2N45 Germanium transistor - high gain
2 Transistron SG211 Silicon diode - fast recovery alloy
junction
2 Transistron 1N483A Silicon diode - high conductance
alloy junction
1 Transistron TL-21 Silicon rectifier - large area 200 ma
1 Transistron 1N248 Silicon rectifier - large area 10 a
1 Transistron 1N251 Silicon diode - high frequency
2 Hughes Products 1N458 Silicon diode - high conductance
alloy junction

SECRET

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- 2 Hughes Products 1N628 Silicon diode - fast recovery alloy junction
- 1 Texas Instruments 1N588 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments 1N589 Silicon rectifier - high voltage grown junction
- 1 Texas Instruments TI951 Silicon transistor - grown junction, high gain
- 1 Texas Instruments TI953 Silicon transistor - grown junction, low gain
- 1 National Semiconductor 1N200 Silicon diode N10v
- 1 National Semiconductor 1N210 Silicon diode N70v alloy junction type
- 1 National Semiconductor 1N218 Silicon diode N200v
- 1 National Semiconductor 1N222 Silicon diode N500v
- 2 Pacific Semiconductor SD5101 Silicon diode - fast recovery, diffused
- 2 Pacific Semiconductor PS564 Silicon diode - high conductance, diffused
- 1 Raytheon CK840 Silicon diode - 50-v high conductance, diffused
- 1 Raytheon CK841 Silicon diode - 200-v high conductance, diffused
- 1 Raytheon CK843 Silicon diode - 400-v high conductance, diffused
- 1 Raytheon CK845 Silicon diode - 600-v high conductance, diffused

F-5-5

- 1 50-828, 6 DEA commercial boron miniature tensile impact bar
- 3 Stainless steel bonded to Teflon, 1 x 5-1/2 inch
- 1 Germanium metal sample
- 1 Biphenyl fluid sample
- 1 n-Butylbenzene fluid sample
- 1 C₁₄₋₁₆ Diphenyl-ether fluid sample
- 1 JP-4 jet fuel sample

F-5-7

- 5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
- 1 Borate-glass total-energy dosimeter ("X")
- 1 Uranium foil
- 1 Plutonium foil
- 1 Sulfur pellet
- 2 Gold foils

F-5-8

- 5 Hydrocarbon dye (Sigoloff type) gamma dosimeters
- 2 Borate-glass total-energy dosimeters ("X" and "Y")
- 1 Uranium foil
- 1 Neptunium foil
- 1 Plutonium foil
- 1 Sulfur pellet
- 2 Gold foils

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APPENDIX B

METAL TENSILE DATA

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TABLE B.1 -- AVERAGE TENSILE ULTIMATE, PSI

System	Station 1	Station 2	Station 3	Station 4	Station 5	Control
1	92,060	91,520	91,744	92,420	91,683	91,960
2	132,071	131,920	131,555	132,983	134,578	135,560
3	143,600	142,950	143,300	142,300	142,042	143,620
4	143,805	142,210	142,689	144,106	141,578	144,450
*5						
*6						
7	122,471	122,680	124,233	124,806	123,311	124,850
*8						
9	149,842	148,500	149,772	149,944	148,578	150,000
*10						
11	85,258	85,270	85,355	86,022	85,255	86,220
12	92,300	93,513	93,611	95,800	93,828	94,500
13	19,432	19,280	19,719	18,952	19,258	19,160
14	25,650	25,120	24,656	26,422	24,566	25,590
15	78,330	79,170	79,111	79,344	78,689	80,100
16	66,244	66,390	66,861	66,934	65,895	66,660
17	38,483	39,380	39,245	39,564	39,255	39,100
18	48,584	48,310	48,367	48,555	48,547	48,780
19	Corrosion	37,045	37,033	38,106	37,689	38,250
20	Corrosion	35,525	34,275	36,719	36,944	36,000
*21						
*22						
23	101,072	101,130	100,350	99,900	100,656	102,240
24	80,517	81,570	80,300	83,211	77,592	82,500
*25						
26	111,908	111,970	110,550	111,978	110,094	111,870
*27						
28	142,345	142,060	143,711	143,217	142,956	144,180
29	94,494	94,380	90,755	90,555	91,278	90,140
*30						
31	100,345	100,730	101,639	100,106	100,333	100,900
32	62,472	62,550	62,239	62,183	63,311	63,040
33	45,960	45,325	45,945	45,970	45,780	46,160
34	102,972	103,230	105,144	104,700	102,739	103,880
35			19,000	19,576		18,000
36	28,494	28,600	27,427	26,022	29,364	32,030
37						

*Tensile properties not available due to lack of proper equipment for pulling specimens.

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TABLE B.2 -- AVERAGE TENSILE YIELD, PSI

System	Station 1	Station 2	Station 3	Station 4	Station 5	Control
1	81,172	80,780	78,622	81,578	80,617	80,580
2	128,644	127,730	127,000	128,722	130,061	130,000
3	133,383	134,190	133,689	134,072	133,592	135,740
4	133,088	134,280	133,889	135,422	132,194	136,240
5						
6						
7	53,550	53,780	55,166	52,478	54,383	51,600
8						
9	146,138	148,430	148,600	148,489	146,028	145,370
10						
11	42,000	42,095	42,206	41,972	41,250	40,290
12	44,700	43,827	44,578	43,506	44,119	42,800
13	17,270	16,425	17,904	17,927	17,393	
14	18,798	19,655	18,903	21,605	18,408	20,770
15	71,939	73,190	72,433	72,872	71,939	73,880
16	45,972	48,545	49,478	59,222	44,964	47,760
17	23,700	24,980	25,289	25,028	24,867	25,260
18	43,928	44,210	44,664	44,734	44,106	44,120
19	Corrosion	25,310	26,767	26,336	25,300	25,580
20	Corrosion	23,860	24,172	28,200	26,067	25,000
21						
22						
23	101,072	101,130	100,350	99,900	100,656	102,240
24	75,980	78,840	75,711	79,606	70,942	80,460
25						
26	78,528	78,560	78,406	81,950	74,817	81,120
27						
28	79,133	77,880	80,055	79,425	76,875	78,660
29	89,300	90,640	87,567	87,672	87,456	85,640
30						
31	96,700	100,730	101,639	100,106	93,667	98,880
32	59,144	59,100	59,064	58,922	60,289	59,260
33	45,960	44,380	44,978	45,486	45,097	44,810
34	60,583	59,910	60,356	60,783	60,646	61,340
35						
36	24,589	28,000	20,637	23,529	24,906	24,320
37						

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TABLE B.3 -- AVERAGE PERCENT ELONGATION

System	Station 1	Station 2	Station 3	Station 4	Station 5	Control
1	21.8	22.3	22.2	22.3	22.3	22.0
2	12.4	12.8	12.8	13.4	13.5	11.8
3	8.9	9.3	9.3	9.5	9.3	9.1
4	9.3	9.0	9.1	9.0	9.1	9.5
5						
6						
7	35.1	36.0	36.3	34.3	35.1	34.6
8						
9	7.2	7.2	7.0	7.3	6.9	7.6
10						
11	44.2	44.7	45.8	45.3	45.9	45.1
12	54.5	56.6	56.9	55.9	56.8	58.1
13	0.7	0.8	0.5	0.9	0.9	0.7
14	2.0	2.1	1.9	2.3	2.2	2.1
15	6.9	8.3	9.1	8.7	8.8	9.2
16	16.5	15.4	15.3	15.6	15.9	16.1
17	19.2	19.6	19.2	18.8	19.4	19.4
18	10.6	10.0	9.9	10.4	10.6	10.5
19	Corrosion	11.1	12.5	13.6	14.2	14.7
20	Corrosion	4.7	3.2	5.5	4.7	3.8
21						
22						
23	5.2	6.9	5.1	5.6	5.1	5.3
24	9.6	8.8	9.6	9.0	9.3	8.8
25						
26	25.5	25.2	26.0	24.0	25.5	25.7
27						
28	55.9	57.1	56.6	56.0	57.8	56.0
29	9.4	9.0	9.3	9.1	9.2	9.8
30						
31	5.9	5.9	6.1	5.9	5.6	5.8
32	8.1	7.4	8.3	8.7	8.0	8.2
33	7.3	7.1	7.0	7.1	7.1	6.9
34	48.7	49.8	52.5	50.4	50.5	52.4
35			0.4	0.7		0.5
36	3.1	1.4	2.4	3.8	3.2	3.0
37						

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TABLE B.4 -- AVERAGE HARDNESS VALUES

System	Scale	Station 1	Station 2	Station 3	Station 4	Station 5	Total Average	Control	
1	R _C	21.6	21.0	22.3	21.4	22.2	21.7	20.1	
2	R _C	33.8	33.9	33.9	34.2	33.5	33.9	34.1	
3	R _C	33.5	33.1	33.4	33.7	33.6	33.5	33.5	
4	R _C	33.3	32.9	34.8	34.0	33.5	33.7	34.7	
5	R _C	41.3	41.0	42.5	42.8	43.4	42.2	41.7	
6	R _C	57.9	57.8	57.9	58.8	58.3	58.1	58.0	
7	R _H	84.2	83.5	84.7	84.3	84.5	84.2	83.3	
8	R _C	41.7	41.5	42.8	42.7	42.3	42.2	41.9	
9	R _C	31.8	31.6	31.7	32.6	33.1	32.2	31.9	
10	R _C	43.2	43.1	44.2	44.4	44.6	44.1	45.6	
11	R _B	77.5	78.0	79.3	79.2	78.9	78.6	77.5	
12	R _B	82.9	83.5	83.4	83.8	84.0	83.5	83.0	
13	R _F	71.6	71.5	70.7	73.0	72.3	71.8	75.5	
14	R _F	65.1	67.8	66.5	68.5	68.6	67.3	68.2	
15	R _B	86.6	86.6	88.8	89.3	88.6	88.0	89.7	
16	R _B	75.5	75.5	77.5	74.8	75.0	75.7	75.0	
17	R _F	76.3	75.9	77.2	77.1	76.8	76.7	77.1	
18	R _F	90.8	91.6	92.6	93.1	93.0	92.2	92.6	
19	R _F	Corrosion	62.3	61.7	61.6	64.3	62.5	65.0	
20	R _F	Corrosion	78.9	77.6	78.6	78.8	78.5	81.7	
21	R _C	40.6	40.9	42.0	41.0	42.1	41.3	40.7	
22	R _C	40.7	40.9	41.9	41.8	41.6	41.4	41.1	
23	R _C	13.9	14.6	15.0	15.4	16.6	15.1	14.6	
24	R _B	87.6	88.8	89.3	89.3	87.1	88.4	88.7	
25	R _C	40.4	40.3	41.9	41.8	42.1	41.3	41.4	
26	R _C	15.6	16.0	16.3	19.1	20.0	17.6	18.9	
27	R _C	34.1	34.0	34.6	35.0	35.4	34.0	34.3	
28	R _C	22.0	21.5	23.4	23.0	22.1	22.4	22.6	
29	R _C	16.6	18.1	18.5	17.2	17.3	17.5	16.6	
30	R _C	40.3	39.9	41.1	41.1	41.3	42.7	39.7	
31	R _C	15.9	16.5	17.1	16.9	17.7	16.8	16.1	
32	R _B	74.6	74.1	73.7	72.8	73.4	73.7	79.3	
33	R _B	50.8	50.3	50.6	50.0	50.6	50.5	49.9	
34	R _B	90.9	90.7	91.2	91.8	91.9	91.3	89.6	
35	R _F	Corrosion	89.2	89.6	89.7		89.5	86.9	
36	Too much initial variation in cast specimens								
37	R _C				33.0	33.4	33.2	35.5	

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APPENDIX C

TEST RESULTS OF ELASTOMER MATERIALS

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TABLE C.1 -- TEST RESULTS OF COMPRESSION SHEAR

Adhesive	Ratio	Type	Curing Conditions	Average Breaking Strength of Controls	Range	ps
C4/Act D	100/25	Epoxy	16 hr, 165°F	1892		13
C4/Act D/graphite	100/25/66	Epoxy	16 hr, 165°F	2460		29
C4/Act D/HM	100/25/50	Epoxy	16 hr, 165°F	2460		17
PRC1221/Acc	100/10	Polysulfide	16 hr, 165°F	400		4
A2/Act E	100/6	Epoxy	16 hr, 165°F	4560		39
RTV5302/5303 with A4C14 primer	50/50	Silicone	Room temperature for 71 weeks	149		1
Bloomington Corp. FM-47		Vinyl phenolic resin	16 hr, room temperature; 1 hr, 225°F; 1 hr, 275°F	6710	6100/7200	36
Cycleweld C-3525		Rubber phenolic	16 hr, room temperature; 1 hr, 275°F	1550	1380/1710	18

*The results for the controls are an average of five specimens. The results for the irradiate specimens are averages of six specimens.

NOTES

C4 - Armstrong Product
 Act D - Diethylene triam
 HM - Metal filler
 PRC1221 - Products Research
 A2 - Armstrong Produc
 Act E - Diethylaminoprop
 RTV5302/5303 - Dow Corning sili
 Cycleweld C-3525 - Chrysler Corpora

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COMPRESSION SHEAR SPECIMENS EXPOSED TO FIZEAU SHOT

Compression Shear Strength at Fizeau Site

Length Inches	Range	Number 1		Number 2		Number 3		Number 4		Number 5	
		psi	Range								
		1370	647/2250	1050	485/2270	1745	860/3220	1560	425/2900	1800	740/2770
		2950	2090/3800	3020	2005/3990	3600	2830/4170	3460	2310/4160	3670	2310/4210
		1783	650/3000	2160	1590/3000	2200	1080/3810	2430	1600/3240	2340	1820/2820
		460	410/505	560	450/820	410	380/505	450	425/490	495	450/525
		3980	3470/4880	3920	2505/4780	4620	3990/500	4190	3590/4860	3870	2890/4760
		119	105/132	126	113/141	130	112/1500	128	120/135	137	125/145
	6100/7200	3640	1620/5000	3820	1090/4610	4070	1150/4920	3840	800/4740	4370	3120/4940
	1380/1710	1870	1610/2130	1800	1650/2010	1970	1740/2310	1900	1610/2110	1970	1770/2340

ts for the irradiate

NOTES

- 4 - Armstrong Products Co. epoxy resin
- D - Diethylene triamine hardener
- M - Metal filler
- 1 - Products Research Co. polysulfide resin
- 2 - Armstrong Products Co. epoxy resin
- E - Diethylaminopropylamine
- 3 - Dow Corning silicone rubber sealer
- 5 - Chrysler Corporation rubber phenolic adhesive

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