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AD NUMBER

AD595287

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FROM:
Controlling DoD Organization: Picatinny
Arsenal, Dover, NJ.

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ARRADCOM ltr dtd 13 Feb 1980; ARRADCOM ltr
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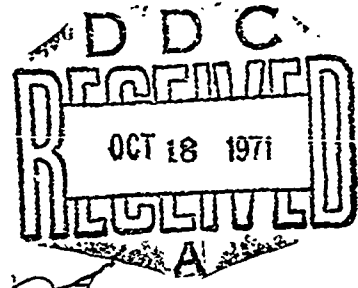
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PICATINNY ARSENAL TECHNICAL DIVISION



TECHNICAL REPORT

STABILITY OF ROCKET PROPELLANTS

SUBJECT: Effect of Metals on Double-Base Propellants

PROJECT NO.	TU2-4C	REPORT NO.	1
PREPARED BY:	J.E. Abel A.S. Ribnick E. McAbee	DATE	28 July 1951
P. A. SERIAL NO.	1822	COPY NO.	50

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6 STABILITY OF ROCKET PROPELLANTS
Effect of Metals on Double-Base Propellants [u] 8

16 Ord - performance
Project No. TU2-4C

9 Report No. 1,

Picatinny Arsenal Technical Report No. 1822

11 28 Jul 51

12 43 p.

14 FA-TR-1822
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Agency Performing Work: Picatinny Arsenal, Dover, New Jersey

Agency Authorizing Work: ORDTU

Project No.: TU2-4C

DOA Priority Designation: 2A

Project Title: Stability of Rocket Propellants -
Effect of Metals on Double-Base Propellants

OBJECT

To determine the effect of metals and plastics on the stability and physical characteristics of double-base propellant powders.

SUMMARY

Tests have been made to determine the degree of reactivity between the M2, M7, M13 and T7 Propellants and aluminum, magnesium, stainless steel, tin-plated steel, zinc-plated steel and phenol formaldehyde varnish-coated sheet steel. Two sets of test conditions were employed. First, ground mixtures of propellant and metal or phenol formaldehyde varnish were stored for six months at 50°C and ambient humidity. Second, grains of each propellant were stored in contact with each of the surfaces mentioned for six months at 32°C and 90% Relative Humidity.

Both 120°C Heat Test and 90°C Vacuum Stability Test results indicate that no decomposition occurred during storage of the ground mixtures.

Microscopic examination of the propellant grains indicates the following: (1) the propellants, in order of decreasing compatibility, are: M7, M13, M2 and T7, and (2) the contact surfaces in order of decreasing compatibility are: stainless steel, phenol formaldehyde varnish, aluminum, tin, zinc and magnesium.

The standard JAN compression test did not show any significant difference for grains of any one propellant stored with any of the contact surfaces.

CONCLUSIONS

The degree of reactivity between propellant grains and contact surfaces was determined by microscopic examination.

On this basis, aluminum, stainless steel and this particular phenol formaldehyde coating are less reactive than tin, magnesium and zinc.

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RECOMMENDATIONS

It is recommended that authorization be given for the use of aluminum or phenol formaldehyde varnish-coated steel as liners for containers for the storage of propellants.

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(Project No. TU2-4C)

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INTRODUCTION:

1. The Department of the Air Force has reported instances of physical deterioration of double-base propellants in contact with their storage containers (Ref A). Observations of reduction in tensile strength, decrease in stability and non-uniformity of the contact metal surfaces have been reported. The British have reported deterioration and embrittlement of double-base powder stored in zinc-coated containers (Ref B). Information was, therefore, desired on the type of metal or metal coating which would be most effective for use as containers or liners for containers for the storage of double-base propellant powders.

2. At the request of the Office, Chief of Ordnance (Ref C), all previous pertinent research was reviewed and an investigative program prepared which was designed to provide additional and more complete information on this subject. This research program comprised an investigation to study the effect produced on the M2, M7, M13 and T7 propellants when stored in contact with aluminum, magnesium, stainless steel, tin-plated steel, zinc-plated steel and phenol formaldehyde varnish-coated sheet steel under accelerated conditions of temperature and humidity.

3. The investigation reported herein was divided into two principal parts, as follows:

a. Cylindrical grains of each propellant powder were stored in contact with each metal and plated or coated metal at 32°C (90°F) and 90% Relative Humidity. Control samples on glass under these conditions and also at desiccated humidity were studied for comparison.

b. Ground mixtures of each of the four propellant powders with each of the five metals and the phenol formaldehyde varnish, as well as controls consisting of individual samples of each propellant, metal and varnish, were stored at 50°C and prevailing humidity.

4. This report gives the detailed results of stability and physical property tests made at the end of both three and six months' storage under the above conditions. Work on this project has been concluded and no further report is to be issued.

RESULTS:

5. The results of both the 120°C Heat Test and the 90°C Vacuum Stability Test indicated that no significant reaction occurred between ground, intimate mixtures of any of the propellants with any of the metals or the varnish during storage for six months at 50°C and ambient humidity. Initial test values and those obtained at the end of three and six months' storage are given in Table II.

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RESULTS: (contd)

6. Microscopic examination of the propellants and metals after storage for three months at 32°C and 90% Relative Humidity indicated the following:

a. The propellants, in order of decreasing compatibility are: M7, M13, M2 and T7.

b. The contact surfaces, in order of decreasing compatibility are: stainless steel, phenol formaldehyde varnish, aluminum, tin, zinc and magnesium.

The same relative order of propellants and contact surfaces were noted at the end of six months' storage at 32°C and 90% Relative Humidity. However, the adverse effects were all generally accentuated. The results of the microscopic examinations made of the propellant grains and contact surfaces stored under this condition are given in Tables III, IV, VI and VII.

7. Microscopic examination of the propellants and contact surfaces after three and six months' storage at 32°C and desiccation indicated very little reaction to occur, except the case of T7 propellant stored on zinc. This latter combination did appear to undergo some reaction. The results of all the microscopic examinations made for this storage condition are given in Tables V and VIII.

8. Photographs representative of the changes noted by microscopic examination are included, Figures 1, 2, 3, 4 and 5.

9. Standard JAN compression tests on samples stored at (a) 32°C and (b) 32°C and 90% Relative Humidity (Tables IX - XII and Figures 6 - 13 incl) showed the following:

a. No one contact surface showed a particularly deleterious effect on any propellant. Surface effect differences noted in microscopic examinations were not generally reflected in compression test values. One exception to this was the case of the T7 propellant. In this case, the values for the work to produce failure were somewhat lower for those grains which had been stored with magnesium, tin and zinc (Figure 13).

b. Neither desiccated nor 90% Relative Humidity storage with any of the different contact surfaces had any apparent or uniform effect on the compressive properties of the M2 propellant.

DISCUSSION OF RESULTS:

10. As compared with previous investigations (Ref D) of this nature, the study reported herein had several different features. First, the use

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DISCUSSION OF RESULTS: (contd)

of dynamic test conditions for the storage of the propellant grains. This was accomplished by employing a Tenney Temperature-Humidity Test Chamber to maintain the desired conditions of temperature and humidity within one per cent, with uniformity of chamber conditions assured by continuous air circulation. Previous studies have been conducted principally under static chamber conditions which have not proven uniform. Secondly, mixtures of ground propellant and ground metal were made on the basis of equal areas of surface contact as calculated from the respective particle sizes. Previous studies have been made principally on an equal weight basis which did not result in valid comparisons in cases where the densities and particle sizes of propellant and metal differed significantly.

11. Mixtures of ground propellant and metal were used in this investigation to establish, by the use of elevated temperature storage, whether any reaction would occur. Examination of the data given in Table II would indicate that under these storage conditions, no change took place. Further, these tests showed no decomposition that could be correlated with the results of visual and microscopic examination of the propellant grains.

12. The detailed microscopic examination of the propellant grains are given in Tables III through VIII and need little explanation. It should be noted that under the conditions of high humidity, corrosion of both propellant and metal was very evident even after only three months. Continued storage for an additional three months only served to accentuate the corrosion process. The T7 propellant was the most affected which may be due to its nitroguanidine content. Undoubtedly, under prolonged storage at these conditions, this propellant would have eventually deteriorated to the point of complete physical breakdown. This might ultimately happen to other propellants also, but in the case of the T7, the process would be more rapid. While the surface effects were not reflected by changes in the compressive properties, it is considered likely that this corrosion process would adversely effect the physical properties of the propellant, should the conditions of high temperature and humidity prevail for prolonged periods of time.

13. The physical property data, in a sense, were somewhat disappointing in that no correlation was found to exist between the surface effects noted by microscopic examination and the compressive properties of the grains. Only in one case, that of the T7 propellant, was there any evidence of a possible correlation (see Figure 13). Values for "work to produce failure" plotted against storage conditions gives some slight evidence of the deleterious effect of zinc, magnesium and tin, in that the values for this property are somewhat lower for the grains of T7 propellant stored in contact with these three metals. The values at 1% compression for all propellants are not graphically illustrated since the largest experimental

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DISCUSSION OF RESULTS: (contd)

error would occur within the early stages of the compression. A study of the data obtained gives no complete correlation regarding the effect of storage materials on the compressive properties. Likewise, no rule can be made regarding the effect of desiccated and 90% Relative Humidity storage on the physical properties of the grains. However, in the cases of stress at 5% compression of the M7 and M13 and stress at rupture of the T7 propellants, there is a decided increase in stress after storage at 90% Relative Humidity. This would seem to indicate some effect of the high humidity on these propellants. This raising of stress is contrary to the results usually obtained, as water normally acts as a plasticizer and as such increases the deformation and lowers the strength of the materials. While visual examination of the grains revealed variable degrees of corrosion at the surface of the propellants, this had not penetrated deeply enough to have any appreciable effect on the compressive properties. It is probable that the compressive test will not indicate the effects of surface corrosion, but would be more indicative of the functioning of the grain as a unit.

14. Work similar to that reported herein has also been done at the Naval Powder Factory (Ref D). Part of this research embraced a study of the effect produced on the physical properties of propellant grains stored in contact with various metal surfaces. Specifically, it involved a study of grains of 3"/50 cal "NH" and Cordite N propellants stored for six months on steel, brass, zinc-coated steel, zinc-coated steel-chromate treated steel and steel coated with phenolic lacquer at three different conditions; namely, (a) 92°F and ambient humidity, (b) 150°F desiccated and (c) 150°F and 100% Relative Humidity. The last two conditions were much more severe than those used in the present study and any degradation would be more accentuated by these conditions than those used in this report. The grains of "N" and "NH" were severely affected, particularly under the conditions of high temperature and humidity and stored in contact with zinc and brass. The NPF used the side impact test for brittleness to establish effects on physical properties (Ref F). This is in contrast to the compressive test used in this program. The conclusion reached in the NPF report was that, of the contact surfaces tested, a phenol lacquered steel had the least effect on the propellants.

15. In view of all the above, it would seem advisable to use in practice those metals or protective coatings which show the least effect on propellants. From the observations made herein, stainless steel, aluminum and phenol formaldehyde varnish-coated steel are indicated to be less reactive than zinc, magnesium and tin. On the basis of both studies, it is recommended that consideration be given to the use of the three best materials as liners or protective coatings for containers where such are to be used for the storage of propellants for prolonged periods of time,

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DISCUSSION OF RESULTS: (contd)

possibly under extreme climatic conditions. Stainless steel is now being employed as liner for propellant containers for small arms propellants.

EXPERIMENTAL PROCEDURE:

16. The propellant powders used (see Table I) in the mixtures were ground in a hand grinder to pass through a 12 mesh sieve. Magnesium, aluminum, zinc and tin were atomized to approximately the same size, 168 microns, 145 microns, 124 microns and 171 microns, respectively, as determined by the air permeability method (Ref E). The stainless steel was obtained in 75 micron size. The phenol formaldehyde varnish was prepared by painting this material on polyethylene sheets and scraping it off. A final drying of the varnish was made in vacuum. The mixtures of ground propellant and metal were made on an equal surface area basis according to the calculations of Gooden and Smith (Ref E).

17. The mixtures of ground propellant and metal, subjected to 50°C and ambient humidity, were stored in loosely cork-stoppered glass bottles in electrically heated, thermostated ovens, Model 1250, manufactured by the Precision Scientific Company.

18. The ground mixtures were subjected to 120°C Heat Tests and 90°C Vacuum Stability Tests in accordance with the procedures described in Picatinny Arsenal Technical Report No. 1401, Revision 1.

19. The storage of the propellant grains was made in a temperature-humidity test chamber, Model 36TR, manufactured by the Tenney Engineering Company, Incorporated, Newark, New Jersey. The grains subjected to 32°C and 90% Relative Humidity were placed end-wise on 6" x 6" squares of metal varnish-coated metal and glass (control) in the test chamber. The grains and test surfaces subjected to 32°C and desiccated humidity were placed in glass desiccators using "Desicchlora" as the drying agent and the desiccators were placed in the same test chamber.

20. The following contact surfaces were used in this investigation:

- a. Aluminum: 16 gauge, #2, half-hard
- b. Magnesium: 0.156", U.S. Army Specification 57-157, Class 18, annealed
- c. Stainless steel: 1/6", #5012, Type 18-8
- d. Tin-plated steel: 0.0125 = 30 gauge, Type 2, Grade 2
- e. Zinc-plated steel: 16 gauge, Federal Specification QQ-L-696
- f. Phenol Formaldehyde Varnish, "Bakelite" XV 1657, 12½ gallon tung oil, phenolformaldehyde, Navy specification NAVORD No. 1433, Type A. This varnish was coated on:
Sheet steel: 1/6", Federal Specification QQS-11A

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EXPERIMENTAL PROCEDURE: (contd)

21. The method of compression testing employed was that given in Ref G. The samples were tested under standard conditions ($77^{\circ}\text{F} \pm 2^{\circ}\text{F}$ and 50% Relative Humidity \pm 2% Relative Humidity) following temperature conditioning. Compression testing was done on an Instron Tester with an adjustable speed control so that the rate of crosshead travel could be varied among specimens to give the desired 0.100 inch per minute per inch of specimen height. A sub-press and compressometer in conjunction with a Baldwin stress-strain recorder were used to assure axial loading and accurate measurement of the amount of compression (Photograph M-38451). The outside diameters and heights were measured by micrometer. However, the perforations were so small that the only satisfactory method of measurement was to insert wires of known diameters and assume this diameter to be equal to the diameter of the perforation. Due to excessive amounts of corrosion found in some of the perforations, it was felt that a microscopic determination of the diameters would be extremely difficult. The above method was, therefore, used.

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No 34585 (11 July 1947)
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Base Propellants."
- E. "Measuring Average Particle Diameter of Powders," by Gooden and
Smith; Analytical Edition, Industrial and Engineering Chemistry,
Volume 12, pages 479-482, 15 August 1940.
- F. OSRD Report NC 5592.
- G. JAN Panel on Physical Properties of Solid Propellants - Method for
Determining the Compressive Properties of Solid Rocket Propellants -
Approved 24 January 1950.

INCLOSURES:

Tables I - XII incl
Figures 1 - 13 incl
Photograph M-38451

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TABLE I

COMPOSITION AND GRAIN DIMENSIONS OF PROPELLANTS USED

<u>Type</u>	<u>M2</u>	<u>M7</u>	<u>M13</u>	<u>T7</u>
Lot Number	RAD-9713	RAD-51045	SUN-18577	DP-6285
Nitrocellulose, %	76.26	54.29	57.04	20.78
Nitroglycerine / Dinitrotoluene, %	20.52	35.32	40.23	17.28
Potassium perchlorate, %	-	7.98	-	-
Barium Nitrate, %	1.54	-	-	-
Potassium Nitrate, %	0.82	-	-	-
Potassium Sulfate, %	-	-	1.61	-
Graphite, %	0.26	-	-	-
Carbon Black, %	-	1.31	-	-
Diphenylamine, %	0.60	-	0.19	-
Ethyl Centralite, %	-	1.10	0.93	5.42
Nitroguanidine, %	-	-	-	54.93
Cryolite, %	-	-	-	0.25
Total Volatiles	1.85	0.39	0.88	0.17
Height of Grain, in	3/16	3/8	7/8	5/16
Diameter of Grain, in	3/16	3/8	7/8	5/16
Tolerance, in (as measured)	± 0.005	± 0.007	± 0.009	± 0.004

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TABLE II

THERMAL STABILITY DATA OF MIXTURES OF GROUND PROPELLANT AND METAL

Pro- pellant	Metal	120° C Heat Test									90° C Vac Stab cc gas/40 hrs		
		Initial Values			3 months			6 months			0	3	
		SP min	RF min	EXPL min	SP min	RF min	EXPL min	SP min	RF min	EXPL min	mos	mos	mos
T7	Tin	95	300/	300/	120	300/	300/	80	300/	300/	0.62	0.55	0.45
M13	"	70	300/	300/	100	240	300/	90	250	300/	0.73	1.03	0.90
M7	"	100	300/	300/	110	300/	300/	80	275	300/	0.86	0.62	0.54
M2	"	95	300/	300/	90	250	300/	100	260	300/	0.16	0.40	1.32
T7	Zinc	95	250	300/	150	285	300/	105	280	300/	0.64	0.81	0.66
M13	"	60	200	300/	105	275	300/	85	200	300/	0.49	1.00	0.85
M7	"	85	210	300/	105	280	300/	95	275	300/	0.57	0.51	0.66
M2	"	100	300/	300/	110	285	300/	85	290	300/	0.55	0.69	0.45
T7	Aluminum	70	140	300/	95	240	300/	80	180	300/	1.09	0.93	0.96
M13	"	65	210	300/	60	150	300/	65	125	300/	1.04	1.19	1.23
M7	"	70	220	300/	80	210	300/	75	150	300/	1.14	0.61	0.80
M2	"	85	220	300/	65	150	300/	70	105	300/	0.78	1.23	1.77
T7	Magnesium	100	300/	300/	90	175	300/	85	250	300/	1.38	1.28	1.19
M13	"	55	120	300/	55	125	300/	70	200	300/	1.41	1.45	1.41
M7	"	65	180	300/	95	250	300/	80	175	300/	1.27	1.31	1.14
M2	"	90	110	300/	100	210	300/	70	250	300/	1.14	1.58	1.89
T7	Bakelite	65	150	300/	65	140	300/	70	100	300/	3.32	1.08	1.27
M13	"	50	150	300/	60	130	300/	60	80	300/	3.24	1.43	1.39
M7	"	70	180	300/	65	130	300/	65	110	300/	2.71	1.03	1.19
M2	"	65	180	300/	65	145	300/	75	155	300/	3.02	1.25	1.46
T7	Stainless Steel	75	300/	300/	120	300/	300/	100	290	300/	0.69	0.64	0.56
M13	"	50	210	300/	65	210	300/	70	110	300/	0.88	0.76	0.87
M7	"	90	300/	300/	90	210	300/	100	175	300/	0.86	0.52	0.60
M2	"	80	300/	300/	95	250	300/	95	250	300/	0.58	0.91	1.05
T7	-	40	90	300/	55	105	300/	60	100	300/	2.95	3.01	3.20
M13	-	40	65	300/	55	90	300/	55	60	300/	2.99	3.87	3.95
M7	-	40	80	300/	55	90	300/	55	65	300/	2.60	2.27	2.62
M2	-	45	85	300/	50	90	300/	50	55	300/	2.67	3.79	4.06
-	Tin	-	-	-	-	-	-	-	-	-	0.22	0.15	-
-	Zinc	-	-	-	-	-	-	-	-	-	0.31	0.57	-
-	Aluminum	-	-	-	-	-	-	-	-	-	0.34	0.17	-
-	Magnesium	-	-	-	-	-	-	-	-	-	0.24	0.20	-
-	Bakelite	-	-	-	-	-	-	-	-	-	3.80	0.60	-
-	Stainless Steel	-	-	-	-	-	-	-	-	-	0.17	0.18	-

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EVALUATION OF PROPELLANT GRAINS BY MICROSCOPIC INSPECTION AFTER THREE MONTHS' STORAGE

TABLE III

Metal	Storage Temperature	Relative Humidity	Propellant						
			M2	M7	M3	T7			
Zinc	32°C	90%	B _{1,3}	A	D ₁	B ₁	E ₁	E ₄	E ₄
Zinc	32°C	Desiccated	A	B	C	A	A	A	B
Stainless Steel	32°C	90%	C ₃	A	B	A	B	E ₁	C
Stainless Steel	32°C	Desiccated	A	A	A	C	B	A	A
Tin	32°C	90%	D ₃	B	B	C	C	E ₅	E
Tin	32°C	Desiccated	A	A	A	A	A	A	E
Magnesium	32°C	90%	D _{1,3}	A	D	A	A	A	E
Magnesium	32°C	Desiccated	A	E ₁	E	D _{1,2}	E ₁	E _{5,6}	E ₁
Aluminum	32°C	90%	D _{3,7}	A	A	A	A	A	A
Aluminum	32°C	Desiccated	A	C	B	A	B	D _{1,3}	D
Bakelite	32°C	90%	D ₃	A	A	A	A	A	A
Bakelite	32°C	Desiccated	A	U	A	A	A	E ₅	D _{7,8}
Glass	32°C	90%	D _{1,3,7}	A	A	B ₂	A	A	A
Glass	32°C	Desiccated	A	A	A	A	A	D _{1,3}	A

Rating Code

- A = Unchanged from original appearance
- B = Staining, incipient corrosion
- C = Slight corrosion
- D = Medium corrosion, pitting, some decomposition
- E = Severe corrosion, cracking of grain

Notes

1. Heavy crystal formation on surface
2. Liquid exudate
3. Perforations filled with yellow crystalline deposit
4. Deposit of amorphous yellow-brown substance
5. Base of grain is dark, red-brown, soft, exfoliated
6. Radial cracking of grain
7. Numerous filaments on surface
8. Numerous long needle-like crystals
9. White crystals in the form of clusters

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TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLANT
GRAINS STORED FOR THREE MONTHS AT 32°C AND 90% RELATIVE HUMIDITY

TABLE IV

	Propellant Surface *				
	A	B	C	D	E
A	M7 - Bakelite M13 - Bakelite	M7 - Glass M13 - Glass		M2 - Glass T7 - Glass	
B	M7 - S. Steel M7 - Aluminum M13 - S. Steel M13 - Aluminum	M7 - Tin	M2 - S. Steel		
C			M13 - Tin	M2 - Aluminum M2 - Bakelite	T7 - S. Steel
D	M7 - Zinc	M2 - Zinc	M7 - Magnesium	M2 - Tin T7 - Aluminum	T7 - Bakelite
E		M13 - Zinc		M2 - Magnesium M13 - Magnesium	T7 - Zinc T7 - Tin T7 - Magnesium

Metal Surface *

* Same Ratings Used as Given in Table III

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TABLE V

TABULAR EVALUATION BY MICROSCOPIC EXAMINATION OF PROPELLANT
GRAINS STORED FOR THREE MONTHS AT 32°C UNDER DESICCATION

		Propellant Surfaces *				
		A	B	C	D	E
Metal Surfaces *	All Others					
	M13 - S. Steel T7 - Zinc					
			M7 - Zinc			

* Same Ratings Used as Given in Table III

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EVALUATION OF PROPELLANT GRAINS BY MICROSCOPIC INSPECTION AFTER SIX MONTHS STORAGE

TABLE VI

Metal	Storage Temperature	relative Humidity	Propellant											
			M2			M7			M3			F7		
			Propellant- contact surface	metal interface	Propellant- exterior	Propellant contact surface	metal interface	Propellant exterior	Propellant contact surface	metal interface	Propellant exterior	Propellant contact surface	metal interface	Propellant exterior
Zinc	32°C	90%	C	D	C	B	D	E	C	E	D	E	E	C
Zinc	32°C	Desiccated	A	A	A	B	C	C	A	A	B	A	B	C
Stainless Steel	32°C	90%	D	B	A	B	B	C	C	C	B	E	E	A
Stainless Steel	32°C	Desiccated	A	A	A	A	A	C	A	C	B	A	C	A
Tin	32°C	Desiccated	D	D	E	D	D	A	C	E	D	E	A	A
Tin	32°C	90%	A	A	A	A	A	E	A	A	A	A	A	E
Magnesium	32°C	Desiccated	A	E	D	A	D	A	D	A	D	A	E	A
Magnesium	32°C	90%	A	A	A	A	B	C	A	B	B	A	E	A
Aluminum	32°C	Desiccated	D	D	C	B	C	C	B	B	B	A	D	D
Aluminum	32°C	90%	A	A	A	A	A	C	A	A	A	A	A	A
Bakelite	32°C	Desiccated	D	D	D	A	B	A	B	A	A	E	A	D
Bakelite	32°C	90%	A	A	A	A	A	A	A	A	A	A	A	A
Glass	32°C	Desiccated	D	A	A	A	A	A	A	A	A	A	A	A
Glass	32°C	90%	A	A	A	A	A	A	A	A	A	A	A	A

Rating Code:
 A - Unchanged from original appearance
 B = Staining, incipient corrosion
 C = Slight corrosion
 D = Medium corrosion, pitting, some decomposition
 E = Severe corrosion; cracking of grain

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TABLE VII
 TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLANT GRAINS
 STORED FOR SIX MONTHS AT 32°C AND 90% RELATIVE HUMIDITY

		Propellant Surfaces *				
		A	B	C	D	E
A			M7 - S. Steel M7 - Bakelite M13 - Aluminum M13 - Bakelite	M7 - Glass M13 - Glass	M2 - Glass	T7 - Glass
B			M7 - Aluminum M7 - Zinc	M2 - Tin M2 - Aluminum M2 - Bakelite M7 - Tin M7 - Magnesium	M2 - S. Steel	T7 - Aluminum T7 - Bakelite
C			M13 - Zinc M13 - Tin	M13 - S. Steel	M13 - Magnesium	T7 - S. Steel
D						
E						

* Same Ratings Used as Given in Table VI

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TABLE VIII
TABULAR EVALUATION BY MICROSCOPIC INSPECTION OF PROPELLANT GRAINS
STORED FOR SIX MONTHS AT 32°C UNDER DESICCATION

Metal Surface* (Interface)		Propellant Surface *				
	A	B	C	D	E	
A	ALL others					
B	M7 Magnesium M13-S. Steel M13 - Magnesium M7-Zinc					
C	M7-Aluminum	M7-Zinc				
D						
E						

* Same Ratings Used as Given in Table VI

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TABLE IX
 COMPRESSIVE PROPERTIES OF M-2 PROPELLANT
 At 92°C

Storage Material	Storage Period mos	Desicc- 90% RH cated	Stress in psi at				Rupture	Work ft lbs/in ³ to Produce 50% Comp
			1% Comp	5% Comp	50% Comp	50% Comp		
Control Average Range	0	0	3640 (5) 4130-2790	6540 (5) 6730-6410	17100 (5) 17400-16800		376 (5) 385-358	
	3	3	2750 (7) 4020-1540	6420 (7) 6760-5660	17100 (7) 18300-16500		385 (7) 398-370	
			2210 (7) 4330-1000	6550 (7) 7030-5670	17000 (7) 18600-15400		372 (7) 396-349	
Zinc Average Range	6	6	2070 (7) 3620-1130	5840 (7) 6160-5540	16600 (7) 20100-15300		350 (7) 390-327	
			2250 (7) 2770-1900	7540 (7) 8130-6970	17900 (7) 446-388		412 (7) 446-388	
Stainless Steel Average Range	3	3	3120 (7) 4290-2220	6760 (7) 7790-5880	16100 (7) 17500-14700		366 (7) 387-347	
			3090 (7) 3920-2000	7390 (7) 7940-6760	18000 (7) 19600-16500		408 (7) 435-404	
			1450 (7) 2560-1090	5870 (7) 6160-5540	16100 (7) 17100-15300		348 (7) 363-339	
Tin Average Range	6	6	2560 (7) 2770-1900	7030 (7) 8130-6970	17900 (7) 19700-16800		412 446-388	
			2970 (7) 4330-1780	6950 (7) 7840-5940	17000 (7) 17300-15800		382 (7) 415-368	
Tin Average Range	3	3	1950 3270-1540	6740 7320-6230	16700 17600-16100		378 413-354	
			1700 (7) 2380-1180	6000 (7) 6420-5020	16400 (7) 18100-15300		350 (7) 373-318	
Tin Average Range	6	6	2350 (7) 4290-1250	6320 (7) 6940-5710	16100 (7) 17300-14800		356 (7) 386-329	

(Figures in parenthesis are the number of observations)

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TABLE IX (cont'd)

Storage Material	Storage Period, mos	Desic-90% RH cated	Stress in psi at			Rupture	Work ft lbs/in ³ to Produce 50% Comp
			1% Comp	5% Comp	50% Comp		
<u>Aluminum</u> Average Range Average Range Average Range Average Range	3		2520 (7) 3930-1160 2270 (7)	6760 (7) 7230-5480 6780 (7)	17400 (7) 19700-16200 17300 (7)	376 (7) 407-345 385 (7)	
	6		3800-1580 2980 (7) 3830-1220	7170-6400 5970 (7) 6600-5210	18600-16200 15900 (7) 17600-14100	404-366 351 (7) 390-327	
	3	6	2780 (7) 4420-1470	6510 (7) 6840-6030	16500 (7) 18200-15400	365 (7) 381-345	
	3		2800 (7) 3760-2030 2320 (7)	6970 (7) 7210-6670 6680 (7)	17800 (7) 18700-16900 16800 (7)	396 (7) 409-376 376 (7)	
	6		3960-1570 1870 (7) 2490-1110	7460-6090 6280 (7) 6600-5830	19900-15400 16500 (7) 17200-16000	398-352 361 (7) 375-342	
	3	6	2840 (7) 4410-1600	6530 (7) 6960-5850	16500 (7) 18200-15100	369 (7) 393-350	
<u>Magnesium</u> Average Range Average Range Average Range Average Range	3		3800 (7) 2980-4110 1880 (7)	6620 (7) 6870-6480 6640 (7)	17000 (7) 17900-15900 17100 (7)	378 (7) 366-394 386 (7)	
	6		2440-1110 1750 (7) 2030-1390	7310-5330 5740 (7) 6080-5460	18300-16200 16100 (7) 17600-15000	412-358 341 (7) 355-330	
	3	6	2680 (7) 4550-1170	6610 (7) 6960-5850	16800 (7) 18500-15200	374 (7) 390-354	
	3		3800 (7) 2980-4110 1880 (7)	6620 (7) 6870-6480 6640 (7)	17000 (7) 17900-15900 17100 (7)	378 (7) 366-394 386 (7)	
	6		2440-1110 1750 (7) 2030-1390	7310-5330 5740 (7) 6080-5460	18300-16200 16100 (7) 17600-15000	412-358 341 (7) 355-330	
	3	6	2680 (7) 4550-1170	6610 (7) 6960-5850	16800 (7) 18500-15200	374 (7) 390-354	
<u>Varnish</u> Average Range Average Range Average Range Average Range	3		3800 (7) 2980-4110 1880 (7)	6620 (7) 6870-6480 6640 (7)	17000 (7) 17900-15900 17100 (7)	378 (7) 366-394 386 (7)	
	6		2440-1110 1750 (7) 2030-1390	7310-5330 5740 (7) 6080-5460	18300-16200 16100 (7) 17600-15000	412-358 341 (7) 355-330	
	3	6	2680 (7) 4550-1170	6610 (7) 6960-5850	16800 (7) 18500-15200	374 (7) 390-354	
	3		3800 (7) 2980-4110 1880 (7)	6620 (7) 6870-6480 6640 (7)	17000 (7) 17900-15900 17100 (7)	378 (7) 366-394 386 (7)	
	6		2440-1110 1750 (7) 2030-1390	7310-5330 5740 (7) 6080-5460	18300-16200 16100 (7) 17600-15000	412-358 341 (7) 355-330	
	3	6	2680 (7) 4550-1170	6610 (7) 6960-5850	16800 (7) 18500-15200	374 (7) 390-354	

(Figures in parenthesis are the number of observations)

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TABLE IX (contd)

Storage Material	Storage Period, mos	Desic- cated	Stress in psi at			Rupture	Work ft lbs/in ³ to produce 50% Comp
			1% Comp	5% Comp	50% Comp		
Class Average Range	3		2940 (7) 5180-1370	6580 (7) 6990-5980	17200 (7) 18100-16000	377 (7) 399-351	
	6		2580 (7) 4050-1500	6830 (7) 7650-5700	17800 (7) 19000-16000	391 (7) 435-336	
Average Range	3	3	3430 (7) 4270-3200	6370 (7) 6730-6180	17200 (7) 17900-16300	370 (7) 393-358	
	6	6	2700 (7) 4580-1370	6750 (7) 7250-6040	17600 (7) 20200-15700	389 (7) 444-350	

(Figures in parenthesis are the number of observations)

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TABLE X
 COMPRESSIVE PROPERTIES OF M-7 PROPELLANT
 AT 32°C

Storage Material	Storage Period, mos	Stress in psi at				Compression at		Work ft lbs/in ³ to Produce	
		Desiccated	1% Comp	5% Comp	50% Comp	Rupture	Rupture, %	50% Comp	Rupture
Control	Average	0	1020	1630	6040			123	
	Range	0	1170-926	1680-1580	6470-5530			127-119	
	Average Range	3	1280 (7) 1410-1030	2170 (7) 2250-2120	6580 (1) 6580-6580	6380 (6) 6570-6230	48.4 (6) 49.8-47.7	145 (1) 145-145	138 (6) 144-132
Zinc	Average	6	1060 (7)	2740 (7)	7380 (1)	7520 (6)	49.3 (6)	171 (1)	171 (6)
	Range	3	1400-914	2810-2670	7380-7380	7830-7170	49.8-48.0	171-171	178-164
	Average Range	6	1040 (7) 1320-428	1610 (7) 1650-1560	6110 (6) 6300-5570	6040 (1) 6040-6040	49.5 (1) 49.5-49.5	124 (6) 130-118	118 (1) 118-118
Stainless Steel	Average	6	960 (7)	1760 (7)	6550 (7)	6920-6390		131 (7)	
	Range	3	1280-505	1840-1660			137-126		
	Average Range	3	1290 (7) 1710-1190	2280 (7) 2380-2170	6590 (1) 6590-6590	6500 (6) 6960-5890	47.8 (6) 48.1-47.2	152 (1) 152-152	141 (6) 151-135
Tin	Average	6	1170 (7)	2950 (7)	8240 (1)	7360 (5)	47.6 (5)	180 (2)	173 (5)
	Range	3	1700-694	3020-2860	8240-8240	7940-6670	49.4-45.9	180-179	180-166
	Average Range	6	1090 (7) 1390-692	1640 (7) 1730-1550	6170 (3) 6480-5790	6160 (4) 6410-5960	48.9 (4) 49.5-48.6	128 (3) 131-125	121 (4) 126-116
Tin	Average	3	1230 (7)	1720 (7)	6650 (7)			133 (7)	
	Range	6	1530-660	1820-1630	6950-6390			137-128	
	Average Range	3	1450 (7) 1950-1150	2370 (7) 2460-2260	7580 (3) 7580-7220	6560 (7) 6950-6020	47.7 (7) 48.3-46.8	174 (3) 174-170	143 (7) 146-139
Tin	Average	6	1110 (7)	2820 (7)	7770-7220	7240 (4)	48.2 (4)	178-170	167 (4)
	Range	3	1510-738	2850-2790	7770-7220	7560-6550	49.5-47.0	178-170	173-160
	Average Range	6	1260 (7) 1490-1100	1690 (7) 1940-1600	6520 (5) 6800-5890	6520 (2) 6660-6370	49.2 (2) 49.6-48.7	135 (4) 144-128	131 (2) 134-127
Tin	Average	6	1030 (7)	1710 (7)	6290 (7)			125 (7)	
	Range	3	1340-569	1860-1620	6760-5690			133-118	
	Average Range	3	1450 (7) 1950-1150	2370 (7) 2460-2260	7580 (3) 7580-7220	6560 (7) 6950-6020	47.7 (7) 48.3-46.8	174 (3) 174-170	143 (7) 146-139

(Figures in parenthesis are the number of observations)

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TABLE X (contd)

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Rupture	Compression at Rupture, %	Work ft lbs/in ³ to Produce	Rupture
			1% Comp	5% Comp	50% Comp				
<u>Aluminum</u>	3	6	Average	1160 (7)	2320 (7)	6360 (7)	47.7 (7)	125 (6)	140 (7)
			Range	1420-1040	2410-2220	6730-5590	49.0-46.0		150-128
			Average	1150 (7)	2780 (7)	7370 (7)	48.5 (7)		164 (7)
	6	3	Range	1620-762	2910-2680	7600-7210	49.5-47.4	131-118	168-162
			Average	978 (7)	1590 (7)	6000 (1)	48.2 (1)		117 (1)
			Range	1200-747	1700-1510	6240-5620	48.2-48.2		117-117
6	6	Average	1050 (7)	1730 (7)	6520 (7)	131 (7)	134-121	143 (7)	
		Range	1240-807	1800-1700	6810-574	136-126			
		Average	1450 (7)	2400 (7)	6710 (7)	46.8 (7)			
<u>Magnesium</u>	3	6	Range	1680-1330	2440-2370	6900-6530	47.7-45.3	180 (4)	146-141
			Average	1100 (7)	2880 (7)	7740 (3)	48.7 (3)		173 (3)
			Range	1600-656	2940-2780	7940-7600	49.7-47.4		174-173
	6	3	Average	1030 (7)	1640 (7)	6140 (7)	48.8 (7)	126 (7)	125 (3)
			Range	1220-639	1660-1600	6630-5540			
			Average	1180 (7)	1700 (7)	6360 (7)			
6	6	Range	1450-426	1810-1610	6690-5920	48.8-47.5	134-121	147 (2)	
		Average	1280 (7)	2280 (7)	6310 (7)	129 (4)			
		Range	1680-1030	2340-2240	6780-5770				
<u>Vanilish</u>	3	6	Average	1520 (7)	2780 (7)		7310 (7)	48.3 (7)	134-122
			Range	1720-1410	2830-2740	7620-7190	49.1-47.5	147 (2)	
			Average	866 (7)	1650 (7)	6003 (4)	48.7 (3)	125 (3)	
	6	3	Range	1110-554	1720-1610	6110-5600	49.1-48.1	153-141	155-138
			Average	1350 (7)	2110 (7)	6960 (5)	48.2 (2)		
			Range	2150-822	2270-1940	7230-6810	48.8-47.5		

(Figures in parenthesis are the number of observations)

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TABLE X (contd)

Storage Material	Storage Period, mos	Stress in psi at					Rupture	Compression at Rupture, %	Work ft lbs/in ³ to Produce Rupture	Rupture
		Desiccated	1% Comp	5% Comp	50% Comp	50% Comp				
Glass	Average	3	1170 (7)	2250 (7)	7390 (1)	6280 (7)	47.2 (7)		137 (7)	
	Range	3	1440-1040	2300-2210	7390-7390	6510-5770	48.8-44.9		148-129	
Average	6	1460 (7)	2640 (7)	7390 (6)	7330 (6)	46.9 (6)	169 (1)	162 (6)		
	Range	3	1740-1130	2760-2530	7390-7390	7420-7060	49.7-46.7	169-169	169-147	
Average	3	1040 (7)	1560 (7)	5970 (6)	5880 (1)	48.8 (1)	124 (6)	115 (1)		
	Range	3	1220-753	1660-1450	6380-5630	5880-5880	48.8-48.8	127-121	115-115	
Average	6	724 (7)	6970 (7)	6970 (7)	136 (7)	138-129				
	Range	6	914-381	1860-1680	7410-6160					

(Figures in parenthesis are the number of observations)

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TABLE XI
 COMPRESSIVE PROPERTIES OF M-13 PROPELLANT
 AT 32°C

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Rupture	Rupture, %	Work to Produce Rupture	
			1% Comp	5% Comp	50% Comp				
Control	0	0	804 (5)	1250 (5)	3700 (2)	3610 (3)	47.7 (3)	87.2 (2)	78.9 (3)
			948-725	1290-1160	3810-3590	3700-3530	48.4-46.9	89.5-85.0	82.0-76.4
			Average Range						
Zinc	3	3	843 (6)	1140 (6)	4530 (3)	3530 (6)	47.8 (6)	113 (3)	87.2 (6)
			978-613	1620-1310	4710-4370	3820-3250	48.7-46.8	117-110	92.7-78.8
			Average Range						
Steelless Steel	3	6	788 (7)	1500 (7)	3610 (1)	3730 (6)	47.9 (6)	91.9 (1)	93.5 (6)
			1010-582	1720-1340	3610-3610	4300-3470	49.4-46.3	91.9-91.9	102-86.4
			Average Range						
Steel	6	6	804 (6)	1830 (6)	4510 (2)	4220 (4)	48.4 (4)	113 (2)	103 (4)
			905-640	1900-1730	4610-4410	4360-4060	48.9-47.8	113-112	104-101
			Average Range						
T14	3	3	810 (7)	1120 (7)	3370 (2)	3520 (5)	49.6 (5)	75.9 (2)	79.3 (5)
			969-685	1220-1030	3400-3330	3540-3220	49.9-48.7	76.0-75.8	85.3-73.9
			Average Range						
T14	6	6	702 (7)	1030 (7)	3540 (6)	3760 (1)	49.6 (1)	73.9 (6)	73.6 (1)
			784-661	1120-924	3710-3230	3760-3760	49.6-49.6	77.4-69.2	73.6-73.6
			Average Range						
T14	3	3	775 (7)	1460 (7)	3820 (2)	3590 (5)	45.6 (5)	97.1 (2)	85.9 (5)
			1050-548	1590-1210	3880-3750	4010-3410	48.2-36.3	99.7-94.4	96.4-76.0
			Average Range						
T14	6	6	945 (6)	1770 (6)	4320 (4)	4290 (2)	47.7 (2)	109 (4)	99.5 (2)
			1020-737	1830-1710	4440-4190	4580-4000	48.1-47.2	113-107	102-969
			Average Range						
T14	3	3	643 (7)	1110 (7)	3500 (4)	3570 (3)	49.9 (3)	80.7 (4)	80.2 (3)
			721-583	1240-946	3790-3140	3780-3460	49.9 (3)	87.9-72.0	87.4-72.2
			Average Range						
T14	6	6	656 (6)	1050 (6)	3720 (6)		50.1-49.8	72.8 (6)	
			855-589	1160-949	4510-3310			84.3-60.2	
			Average Range						

(Figures in parenthesis are the number of observations)

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TABLE XI (contd)

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Rupture	Rupture, %	Compression at	
			1% Comp	5% Comp	50% Comp			To Produce	To Produce
Aluminum	Average	3	705 (7)	1410 (7)	3640 (5)	3520 (2)	48.2 (2)	91.1 (5)	84.4 (2)
	Range		820-508	1470-1320	3850-3290	3710-3320	48.3-48.1	96.3-82.0	85.8-83.0
	Average	6	717 (7)	1640 (7)	4280 (6)	4320 (1)	49.5 (1)	97.7 (6)	101 (1)
	Range		982-526	1780-1560	4970-3950	3220-4320	49.5-49.5	104-81.8	101-101
	Average	3	749 (7)	1110 (7)	3550 (5)	3560 (20)	49.7 (2)	78.9 (5)	79.1 (2)
	Range		870-676	1220-1070	4160-3260	3810-3310	49.9-49.5	91.6-73.4	81.2-76.9
Average	6	573 (7)	917 (7)	3250 (7)			67.4 (7)		
Range		680-537	1040-812	3730-2880			75.6-59.3		
Magnesium	Average	3	980 (7)	1470 (7)	3660 (2)	3610 (5)	47.8 (5)	92.7 (2)	88.1 (5)
	Range		1050-868	1550-1450	3710-3600	3860-3350	49.3-45.7	97.6-87.7	103-78.5
	Average	6	885 (6)	1790 (6)	4270 (2)	4250 (4)	48.8 (4)	107.5 (2)	105 (4)
	Range		1040-699	1870-1710	4310-4220	4500-4220	49.3-48.5	109-106	106-104
	Average	3	747 (7)	1110 (7)	3410 (4)	3420 (3)	49.0 (3)	78.4 (4)	76.4 (3)
	Range		819-662	1240-946	3670-3150	3620-3270	49.3-48.8	84.5-70.9	81.0-73.9
Average	6	645 (7)	990 (7)	3440 (7)			72.9 (7)		
Range		708-580	1030-929	3860-3000			77.4-66.7		
Varnish	Average	3	814 (7)	1280 (7)	3400 (1)	3590 (6)	47.6 (6)	83.1 (1)	78.2 (6)
	Range		1020-652	1350-1140	3400-3400	4670-3130	48.3-46.7	83.1-83.1	83.9-71.1
	Average	6	815 (7)	1640 (7)	3740 (2)	4170 (5)	48.2 (5)	92.1 (2)	98.4
	Range		1060-596	1840-1460	3850-3630	4580-3710	48.7-47.5	96.0-88.2	104-89.8
	Average	3	790 (7)	1050 (7)	3350 (5)	3630 (2)	48.8 (2)	74.7 (5)	77.6 (2)
	Range		856-726	1130-966	3510-3180	3810-3450	48.8-48.7	77.6-71.1	79.8-75.3
Average	6	607 (7)	1010 (7)	3430 (7)			72.8 (7)		
Range		700-469	1090-950	3740-3100			76.6-66.3		

(Figures in parenthesis are the number of observations)

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TABLE XI (contd)

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Compression at		Work ft lbs/in ³ To Produce	
			1% Comp	5% Comp	50% Comp	Rupture, %	Rupture, %	50% Comp	Rupture
Glass	Average	3	751 (7)	1310 (7)	3610 (3)	3450 (4)	48.8 (4)	87.0 (3)	80.5 (4)
	Range	6	1000-557	1416-1150	3760-3470	3700-3190	49.5-48.3	87.8-86.2	91.4-73.7
Average	6	3	849 (7)	1670 (7)	3710 (1)	3810 (6)	47.7 (5)	98.9 (1)	93.9 (6)
			1070-666	1750-1610	3710-3710	4160-3660	49.3-45.1	98.9-98.9	96.6-91.8
Average	6	3	714 (7)	1140 (7)	3830 (7)			81.7 (7)	
			817-662	1230-1040	3980-3570			85.8-77.6	
Average	6	6	777 (7)	1280 (7)	4260 (7)			89.9 (7)	
			998-692	1370-1150	4560-4070			94.4-82.6	

(Figures in parenthesis are the number of observations)

TABLE XII
 COMPRESSIVE PROPERTIES OF T-7 PROPELLANT
 AT 32°C

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Rupture	Compression at Rupture, %	Work ft lbs/in ³ To Produce Rupture	
			1% Comp	5% Comp	50% Comp				
Control Average Range	0	0	2720 (5) 3130-1930	4780 (5) 5510-4410		4890 (5) 5630-4530	6.04 (5) 6.28-5.31	19.0 (5) 22.6-16.9	
	Zinc Average Range	3		2110 (7) 3040-1830	5880 (2) 6270-5490		5970 (7) 6300-5510	4.81 (7) 5.20-4.60	15.8 (7) 18.4-14.5
		6		1930 (7) 2550-1390		6980 (7) 7300-6680	4.34 (7) 4.87-3.85	16.0 (7) 18.9-13.9	
		3	3	1570 (7) 1860-1250	4520 (7) 4870-4090	4700 (7) 5110-4330	6.13 (7) 6.41-5.55	17.0 (7) 19.8-15.6	
	Stainless Steel Average Range	6	6	1800 (7) 2440-1250	4570 (7) 5180-4300	4820 (7) 5280-4530	6.55 (7) 7.61-5.80	19.2 (7) 22.1-16.9	
		Tin Average Range	3		2160 (7) 3300-1360	5910 (3) 6290-5340	6000 (7) 6400-5530	5.00 (7) 5.33-4.75	16.6 (7) 20.0-16.0
6				3160 (7) 4090-2280	7080 (3) 7340-6690	7230 (7) 7560-6720	4.64 (7) 5.41-3.82	19.6 (7) 23.0-15.5	
3	3		1710 (7) 2440-1180	4470 (7) 5060-4030	4630 (7) 5150-4360	6.02 (7) 6.49-5.74	16.3 (7) 17.0-15.1		
Tin Average Range	6	6	1450 (7) 1810-1190	4440 (7) 4650-4320	4730 (7) 4900-4550	6.59 (7) 7.11-5.87	18.2 (7) 21.5-14.9		
	Tin Average Range	3		2720 (7) 3230-2190	6120 (3) 6310-5920	5990 (7) 6310-5680	4.76 (7) 5.36-4.18	17.0 (7) 19.6-13.9	
		6		3060 (7) 4480-2150		7280 (7) 7840-6490	3.98 (7) 4.48-3.04	15.9 (7) 20.4-12.5	
3		3	1640 (7) 2100-1260	4480 (7) 4710-4270	4720 (7) 5100-4360	6.25 (7) 6.92-5.75	16.9 (7) 18.6-14.6		
Tin Average Range	6	6	1680 (7) 2730-1020	4570 (7) 4950-4290	4790 (7) 5010-4430	6.22 7.78-5.01	18.2 (7) 21.7-16.4		

(Figures in parenthesis are the number of observations)

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TABLE XII (contd)

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Compression at		50% Comp	Rupture
			1% Comp	5% Comp	50% Comp	Rupture, %	Work fl. lbs/in ³		
Aluminum	Average	3	3540 (7)	6480 (2)		6530 (7)	4.65 (7)	18.7 (7)	
	Range	6	4180-2730	6550-6400		6850-6290	5.18-3.99	20.7-16.3	
	Average		3650 (7)			8340 (7)	3.99 (7)	18.9 (7)	
	Range		4240-2650			8640-7580	4.32-3.86	22.9-16.4	
	Average	3	1720 (7)	4060 (7)		4390 (7)	6.68	17.2 (7)	
	Range	6	2040-1500	4390-3920		4630-4280	7.56-6.00	19.0-14.2	
Magnesium	Average		1420 (7)			4820 (7)	6.48	17.7 (7)	
	Range		2260-916	5280-4140		5490-4470	7.62-5.50	20.4-15.4	
	Average	3	2020 (7)	5740 (4)		5950 (7)	5.22 (7)	17.8 (7)	
	Range	6	2860-1510	6390-5150		6480-5470	7.03-4.41	23.1-14.4	
	Average		2830 (7)			7540 (7)	4.05 (7)	16.2 (7)	
	Range		4290-1770			8410-6570	4.38-3.83	18.1-13.5	
Zinc	Average	3	1900 (7)	4650 (7)		4820 (7)	6.13 (7)	17.3 (7)	
	Range	6	2450-1330	5010-4190		5080-4410	6.64-5.58	18.4-16.6	
	Average		1590 (7)	4810 (7)		5090 (7)	6.47 (7)	19.0 (7)	
	Range		2450-1050	5490-4390		5620-4720	6.99-6.09	22.1-16.2	
	Average	3	3280 (7)	6530 (2)		6530 (7)	4.69 (7)	18.7 (7)	
	Range	6	4460-1970	6610-6450		6770-6410	5.11-4.15	20.8-16.7	
Zinc	Average		4100 (7)			7860 (7)	3.97 (7)	18.5 (7)	
	Range		5070-1880			8210-7120	4.34-3.68	21.0-15.4	
	Average	3	1970 (7)	4560 (7)		4790 (7)	6.35 (7)	18.6 (7)	
	Range	6	2710-1320	5080-4250		5260-4550	6.86-5.93	19.3-17.7	
	Average		1670 (7)	5020 (7)		5290 (7)	6.33 (7)	19.0 (7)	
	Range		3230-740	5400-4660		5560-4910	6.96-5.41	20.3-16.7	

(Figures in parenthesis are the number of observations)

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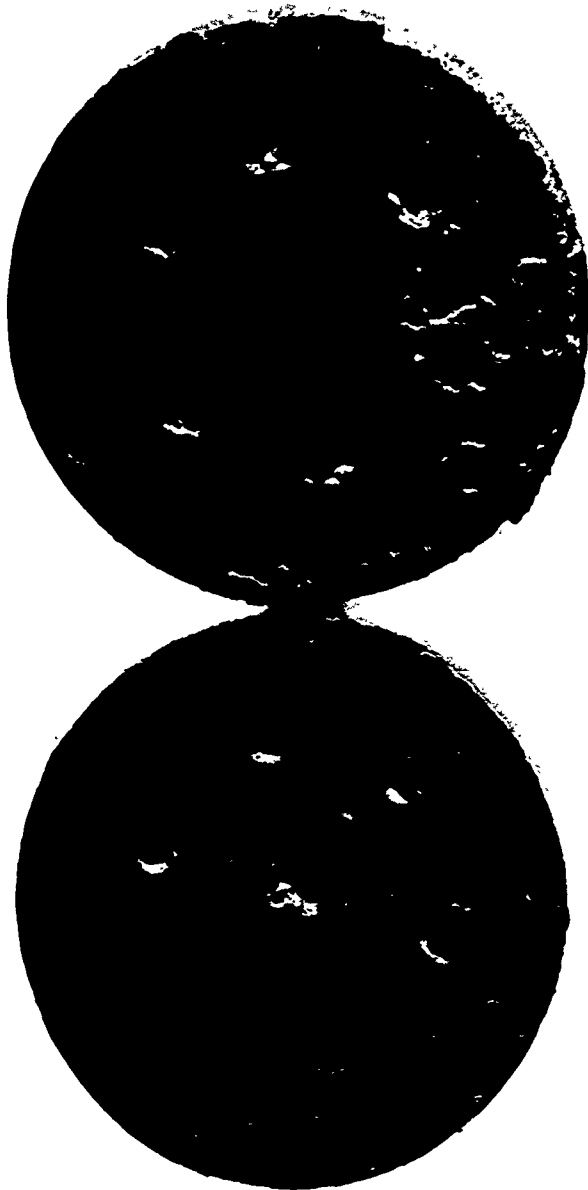
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TABLE XII (contd)

Storage Material	Storage Period, mos	Desiccated	Stress in psi at			Rupture	Compression at Rupture, %	Work ft lbs/in ³	
			1% Comp	5% Comp	50% Comp			To Produce	Rupture
Glass	Average Range	3	2590 (7)	6190 (7)		6250 (7)	6.06 (7)	5.34 (7)	19.7 (7)
	Average Range	6	3100-1420 3600 (7)	6390-5890		6420-5890 7690 (7)	6.51-5.48 5.86 (7)	6.11-4.98	22.5-17.8 20.3 (7)
Glass	Average Range	3	4190-2770 2560 (7)	4720 (7)		8020-7330 4880 (7)	6.51-5.48 5.86 (7)		24.9-16.8 18.8 (7)
	Average Range	6	2990-2090 2930 (7)	5250-4530 5170 (7)		5310-4670 5250 (7)	5.86 (7)		21.1-16.0 19.1 (7)
Average Range			3410-2550	5750-4800		5780-4890	6.54-5.34		21.8-17.7

(Figures in parenthesis are the number of observations)

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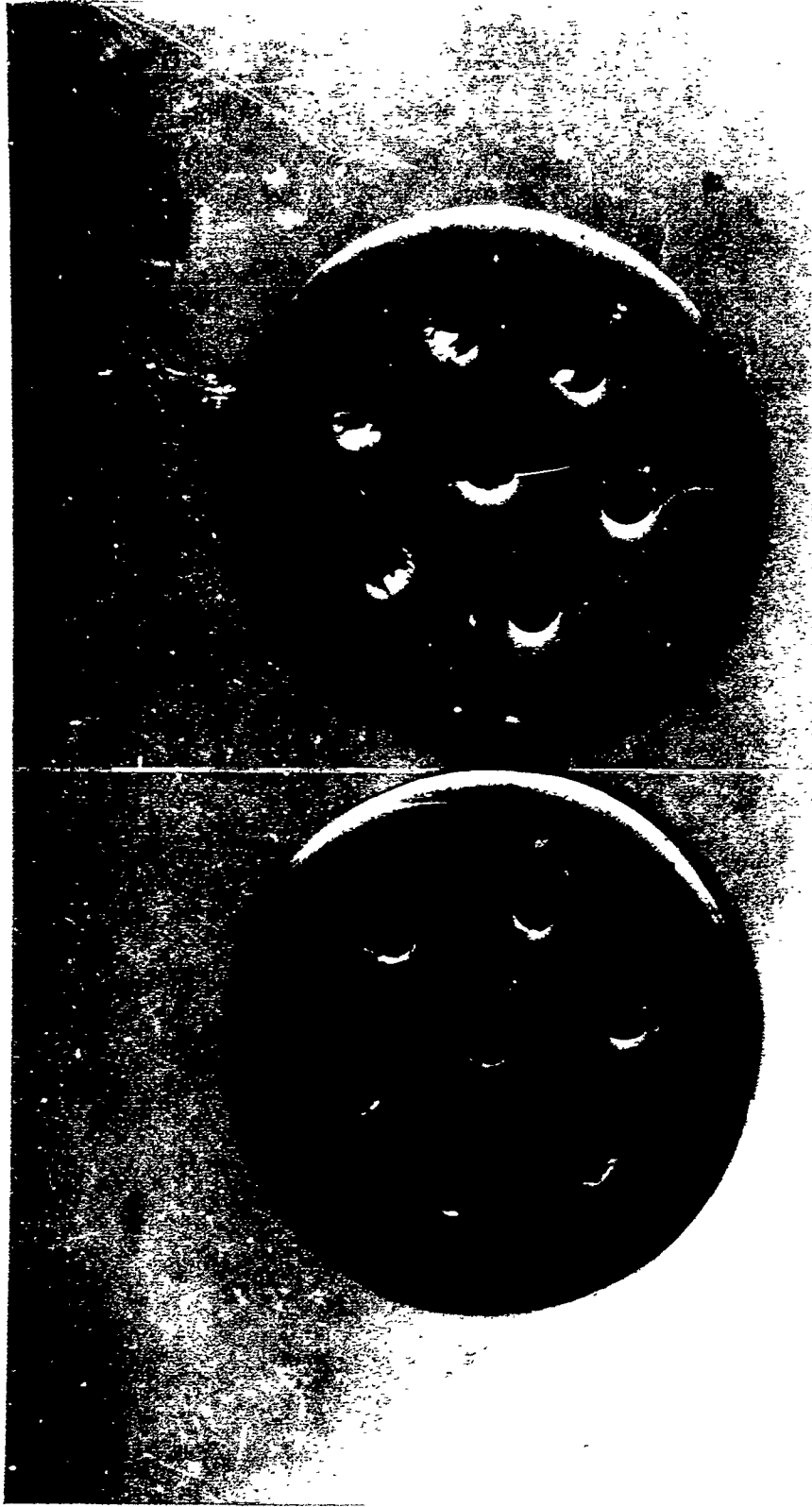
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PICATINNY ARSENAL

ORDNANCE CORPS

Fig. 1

Grains of T7 Propellant Stored In Contact With Magnesium For Six Months
At 32°C And 90% Relative Humidity.



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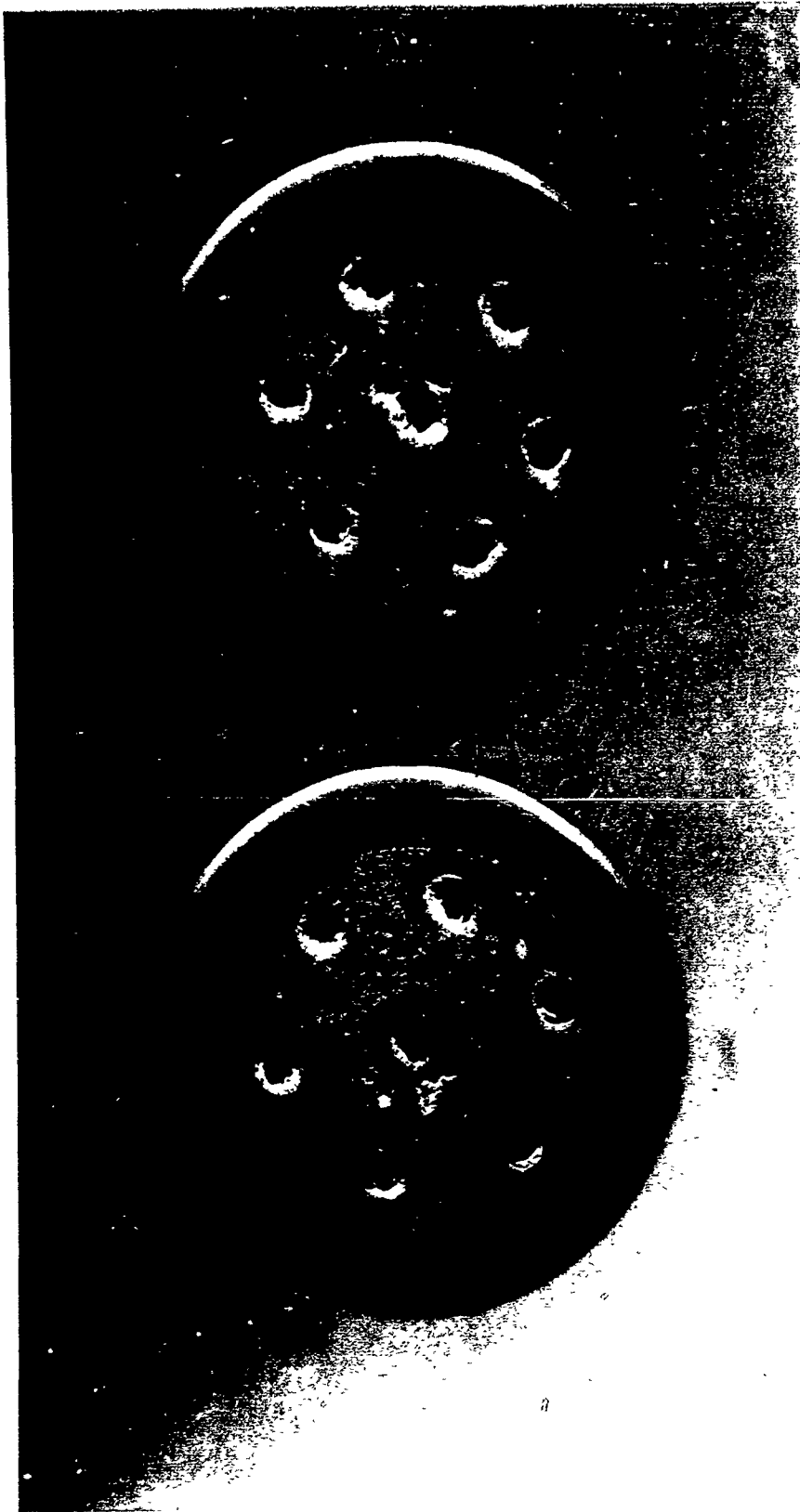
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Fig. 2

Grains of T7 Propellant Stored In Contact With Phenol Formaldehyde -
Coated Steel For Six Months At 32°C and 90% Relative Humidity.

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PLATTINUM ARSENAL

Fig. 3

Grains of T7 Propellant Stored in Contact With Stainless Steel For Six Months At 32°C And 90% Relative Humidity:

ORDRANCE CORPS



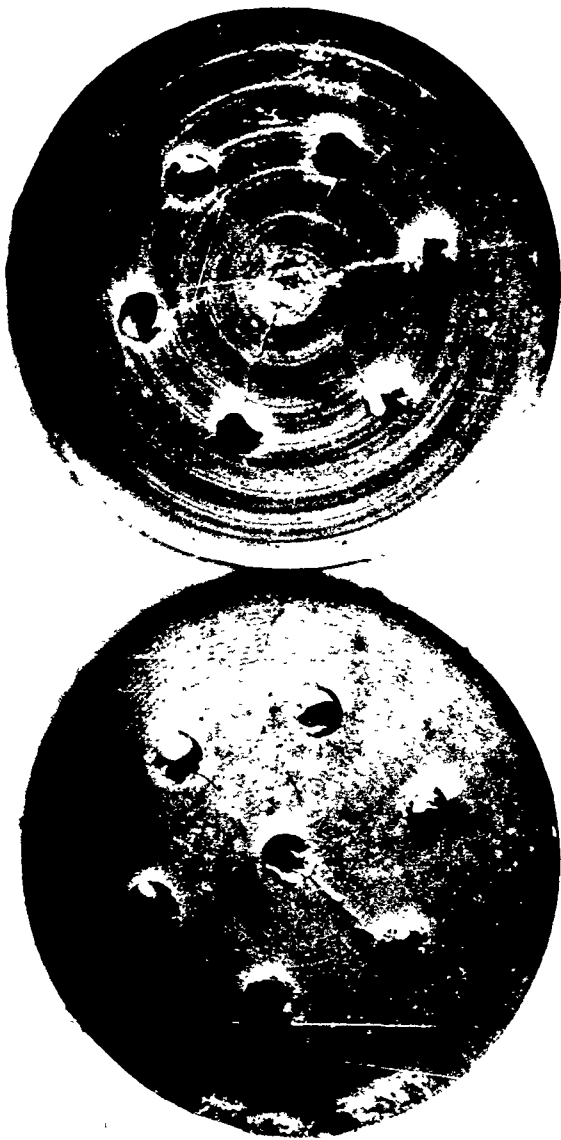
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Fig. 4
Grains of T7 Propellant Stored in Contact With 2 inc Plated Steel
For Six Months at 32°C and 90% Relative Humidity.



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Fig. 5

Grains of T7 Propellant Stored In Contact With Aluminum For Six Months
at 32°C And 90% Relative Humidity.

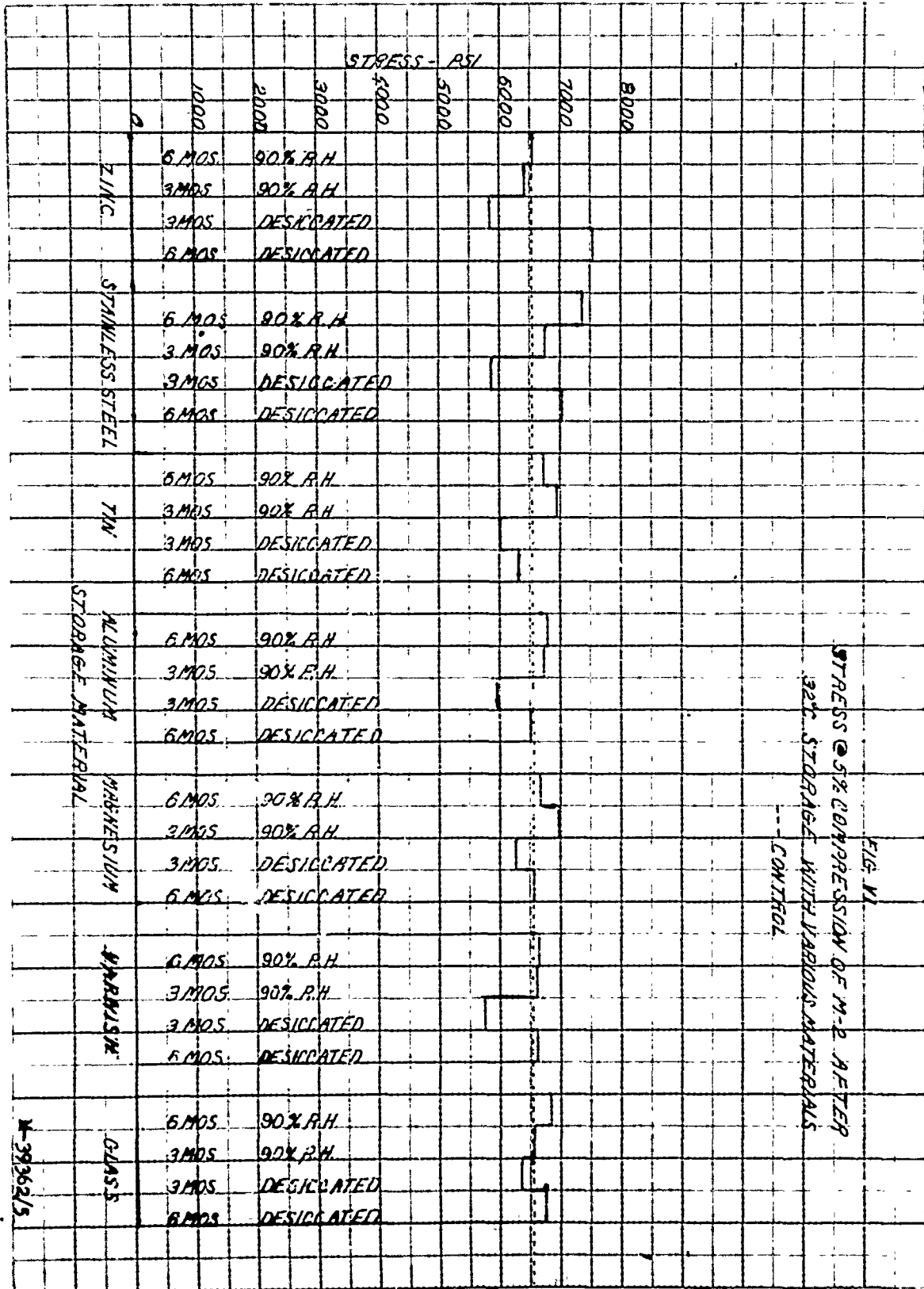


FIG. 11
 STRESS @ 5% COMPRESSSION OF M.P. AFTER
 32W. STORAGE WITH VARIOUS MATERIALS
 CONTROL

M-39862/5

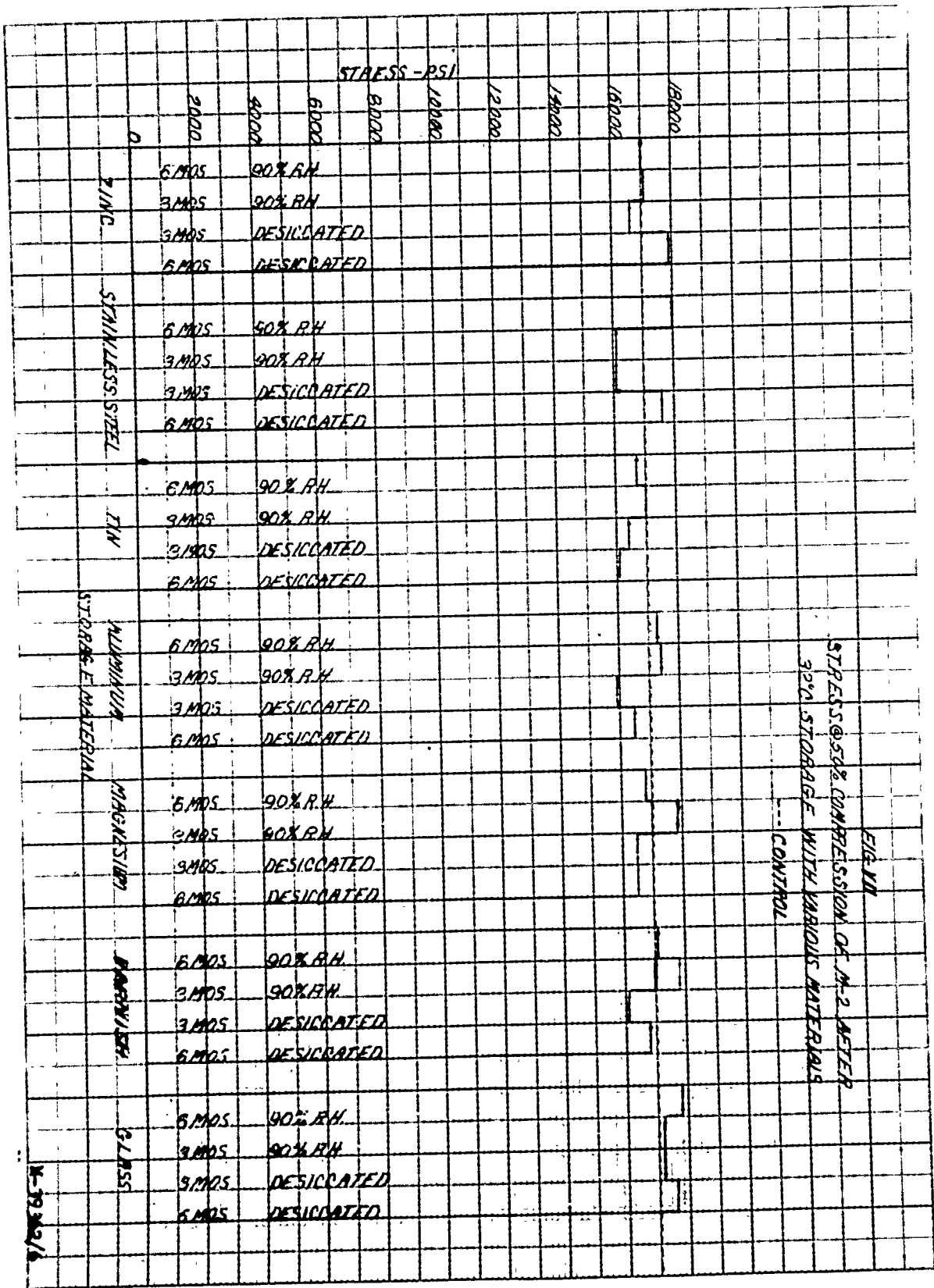
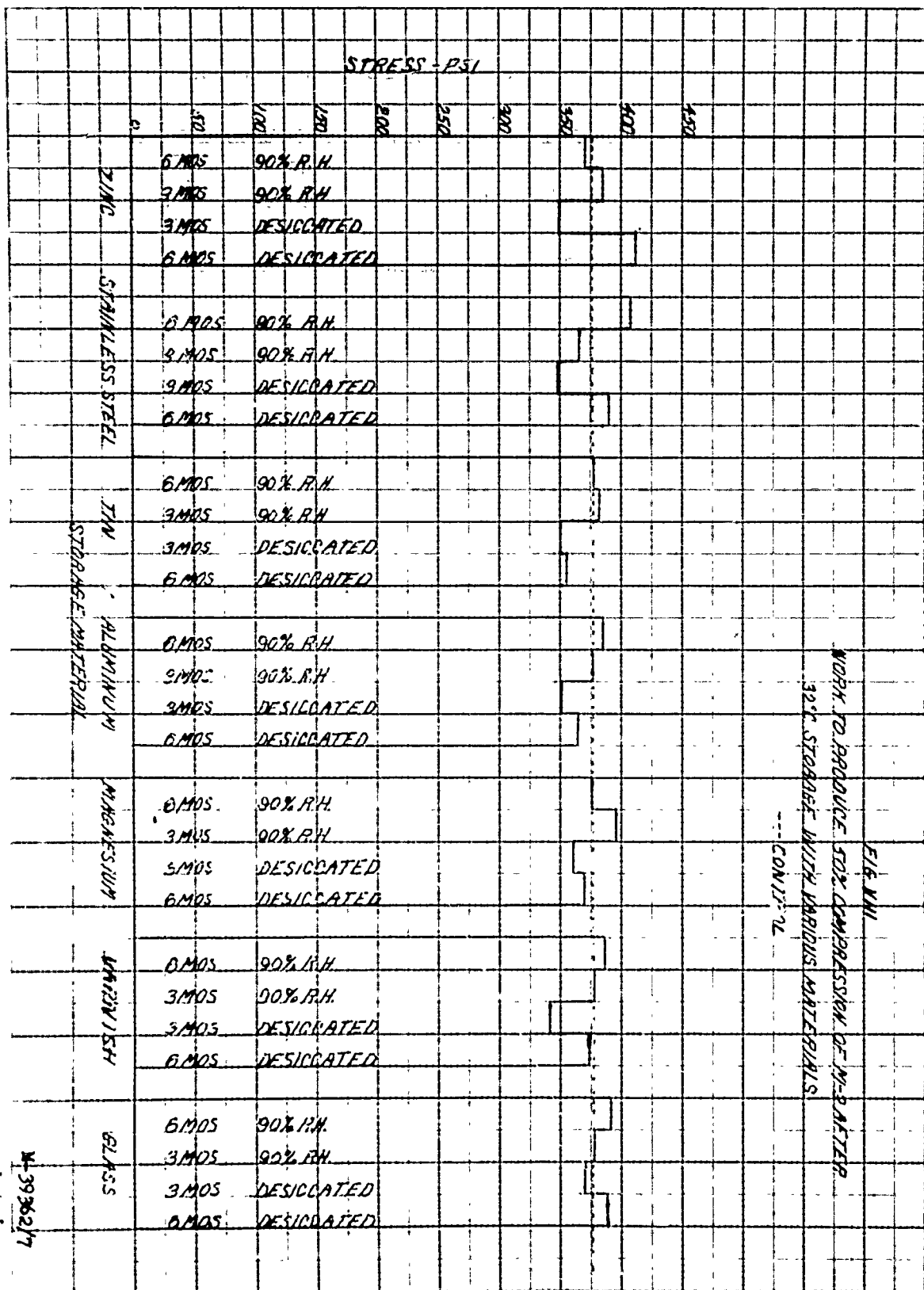


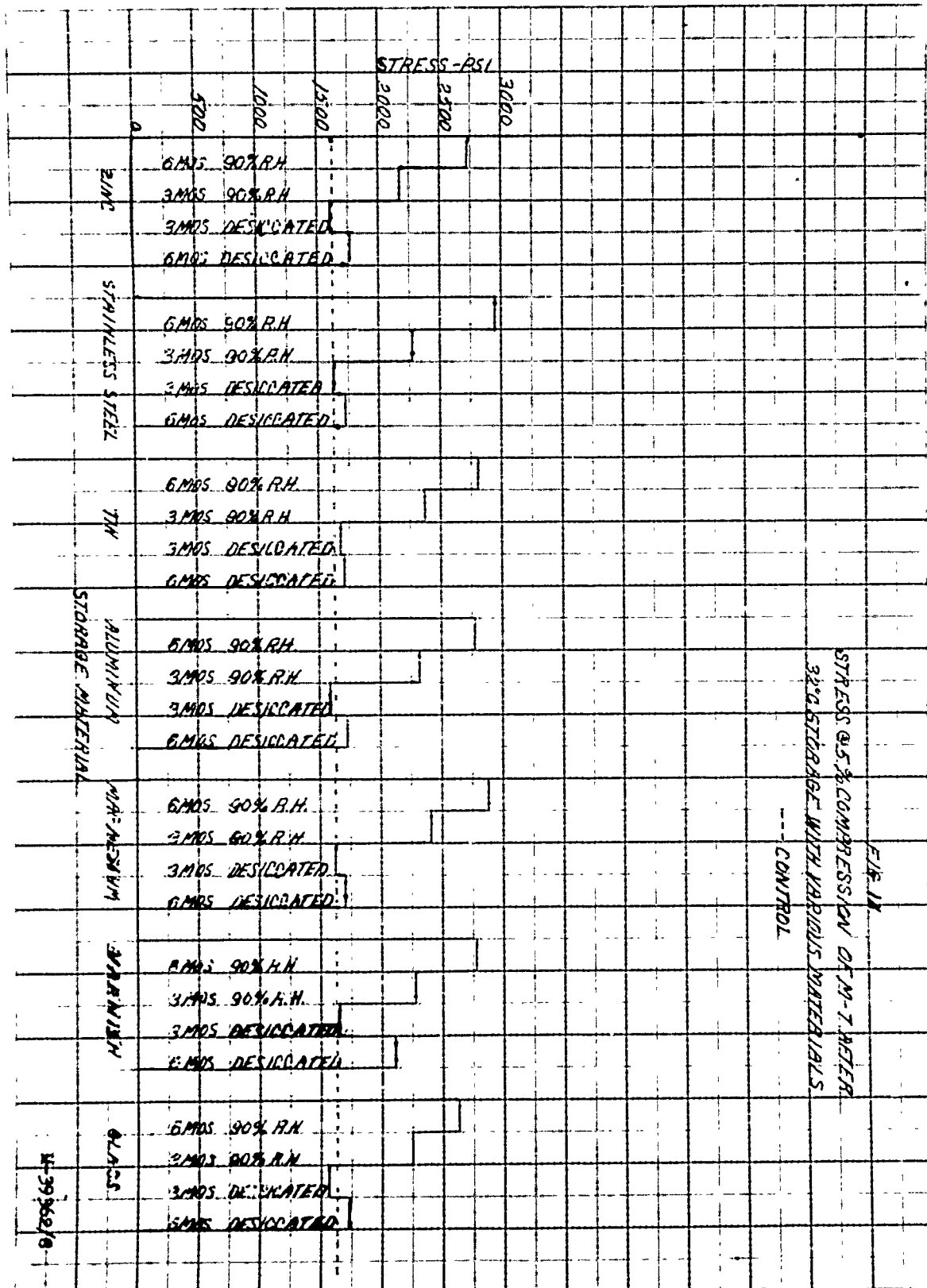
FIG. VII
STRESS @ 50% COMPRESSION OF M-2 AFTER
32% STORAGE WITH VARIOUS MATERIALS
CONTROL

W-7030/6



WORK TO PRODUCE 50% COMPRESSION OF M-3 AFTER
 32% STORAGE WITH VARIOUS MATERIALS
 --- CONT'G ---
 FIG. VII

M-398627



STRESS @ 5% COMPRESSION Q/T M-T. AFTER
32% STORAGE WITH VARIOUS WATER/ALS
--- CONTROL

14-39962/0

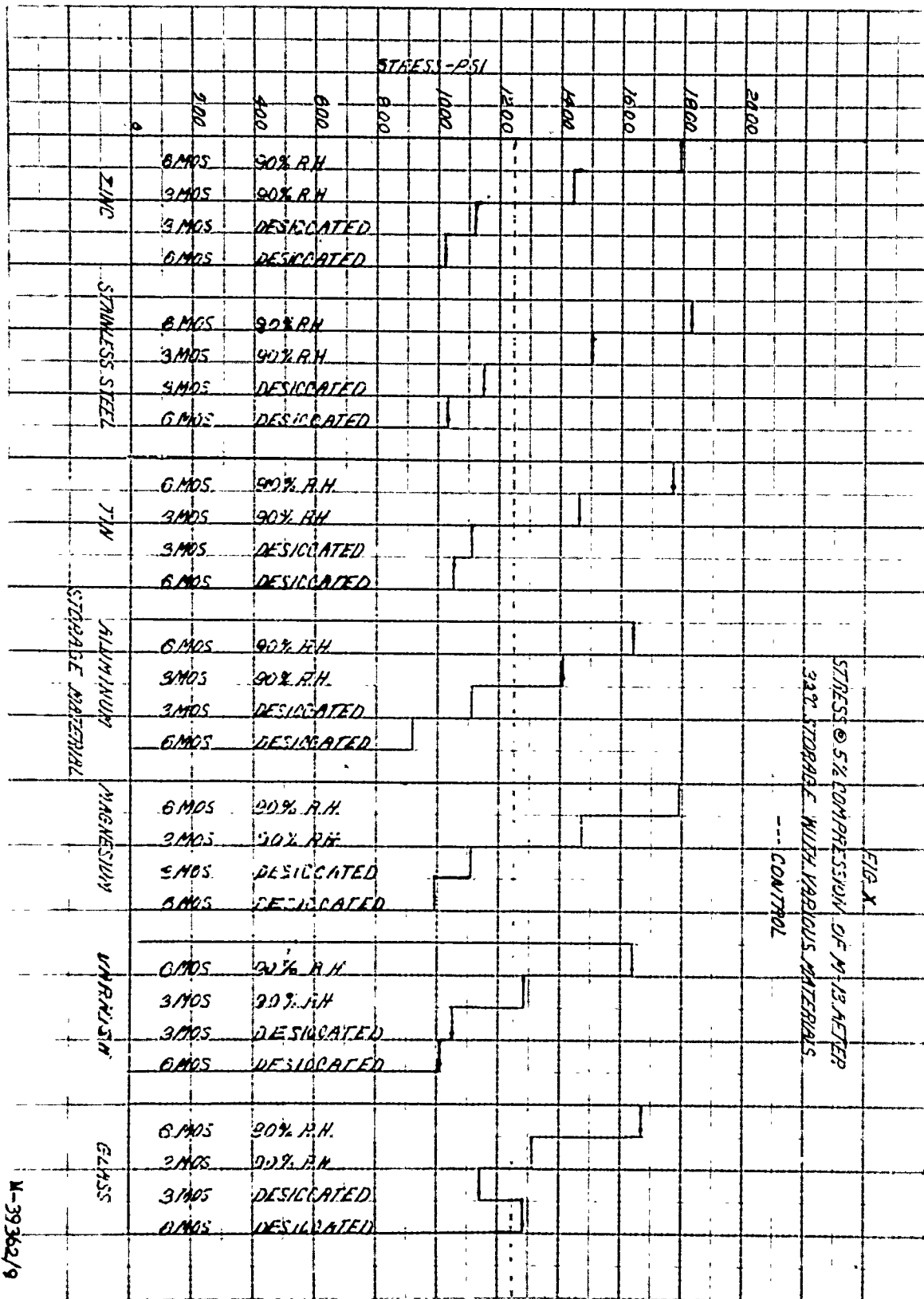


FIG. X
 STRESS @ 5% COMPRESSION, GIP M-13 METER
 32% STORAGE WITH VARIOUS MATERIALS
 --- CONTROL

M-39362/9

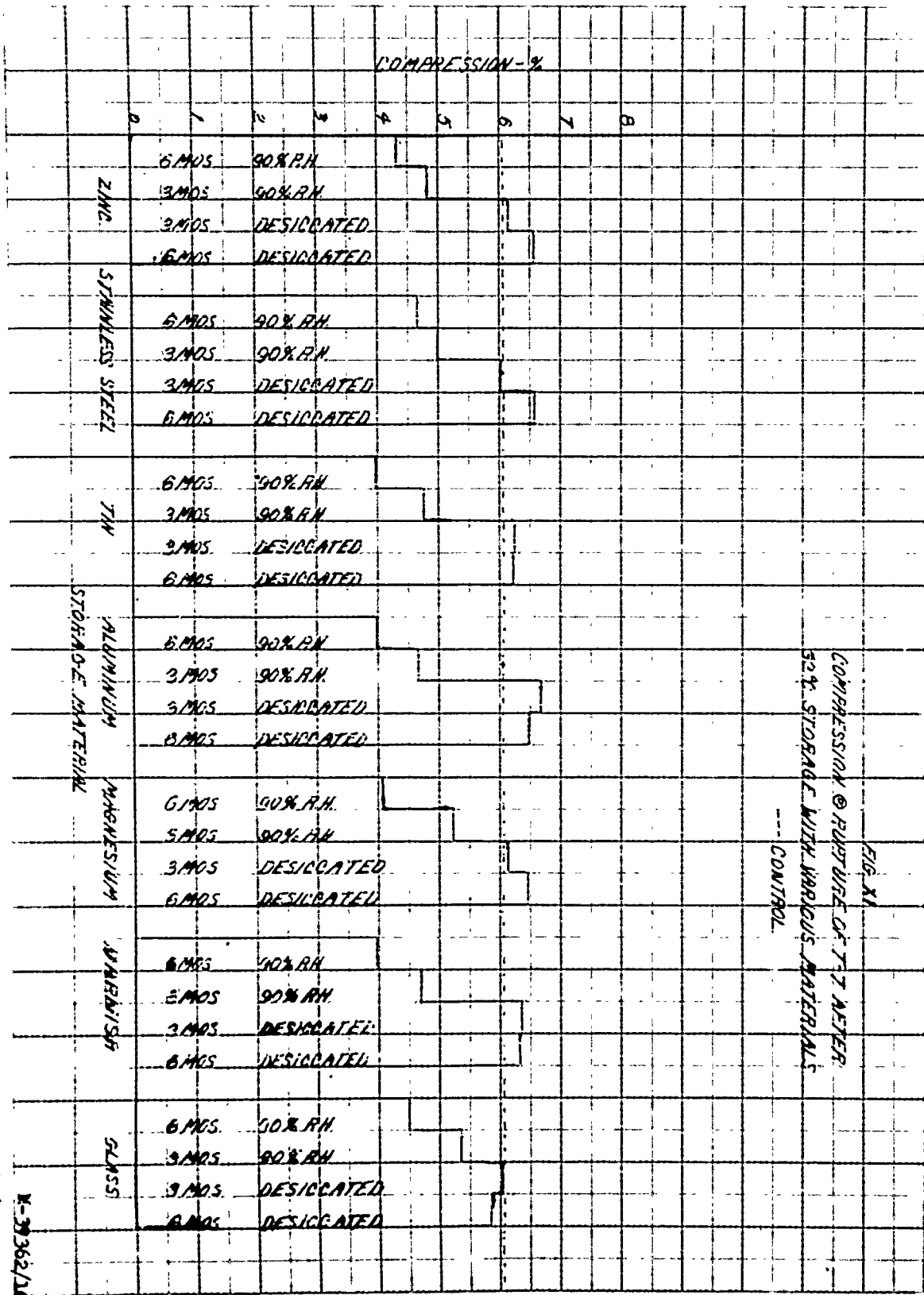


FIG. XI
 COMPRESSION @ RHYTHM OF 7.7 METERS
 52% STORAGE WITH VARIOUS MATERIALS
 --- CONTROL

X-39362/10

		STRESS - PSI									
		0	1000	2000	3000	4000	5000	6000	7000	8000	9000
ZINC	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
STAINLESS STEEL	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
TIN	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
ALUMINUM	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
MANGANESE	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
WARRIASH	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							
GLASS	6 MDS			90% R.H.							
	3 MDS			90% R.H.							
	3 MDS			DESICCATED							
	6 MDS			DESICCATED							

F/6-XV
 STRESS @ RUPTURE OF T-T METERS
 3% STORAGE WITH VARIOUS MATERIALS
 CONTROL

W-99362/11

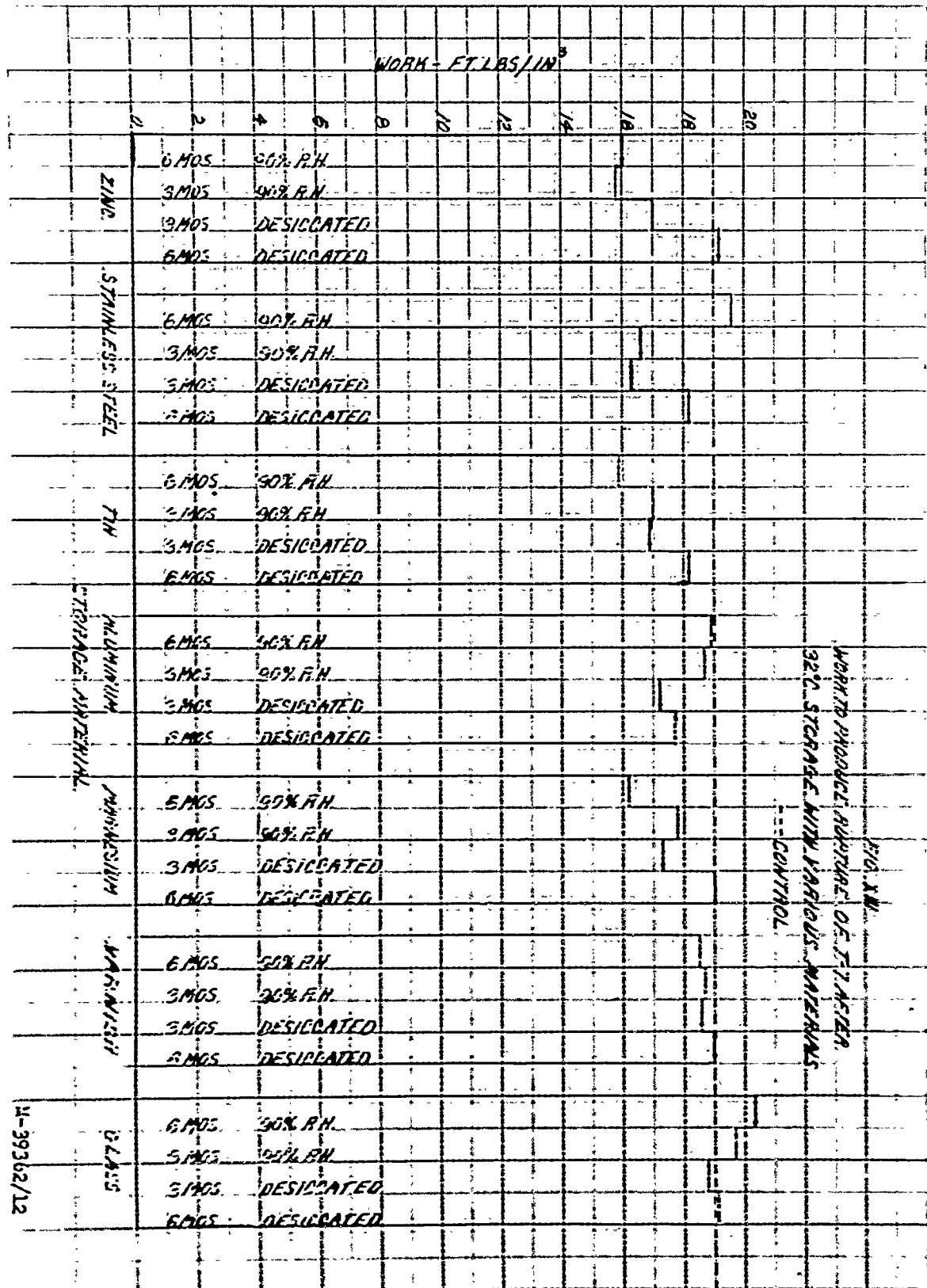
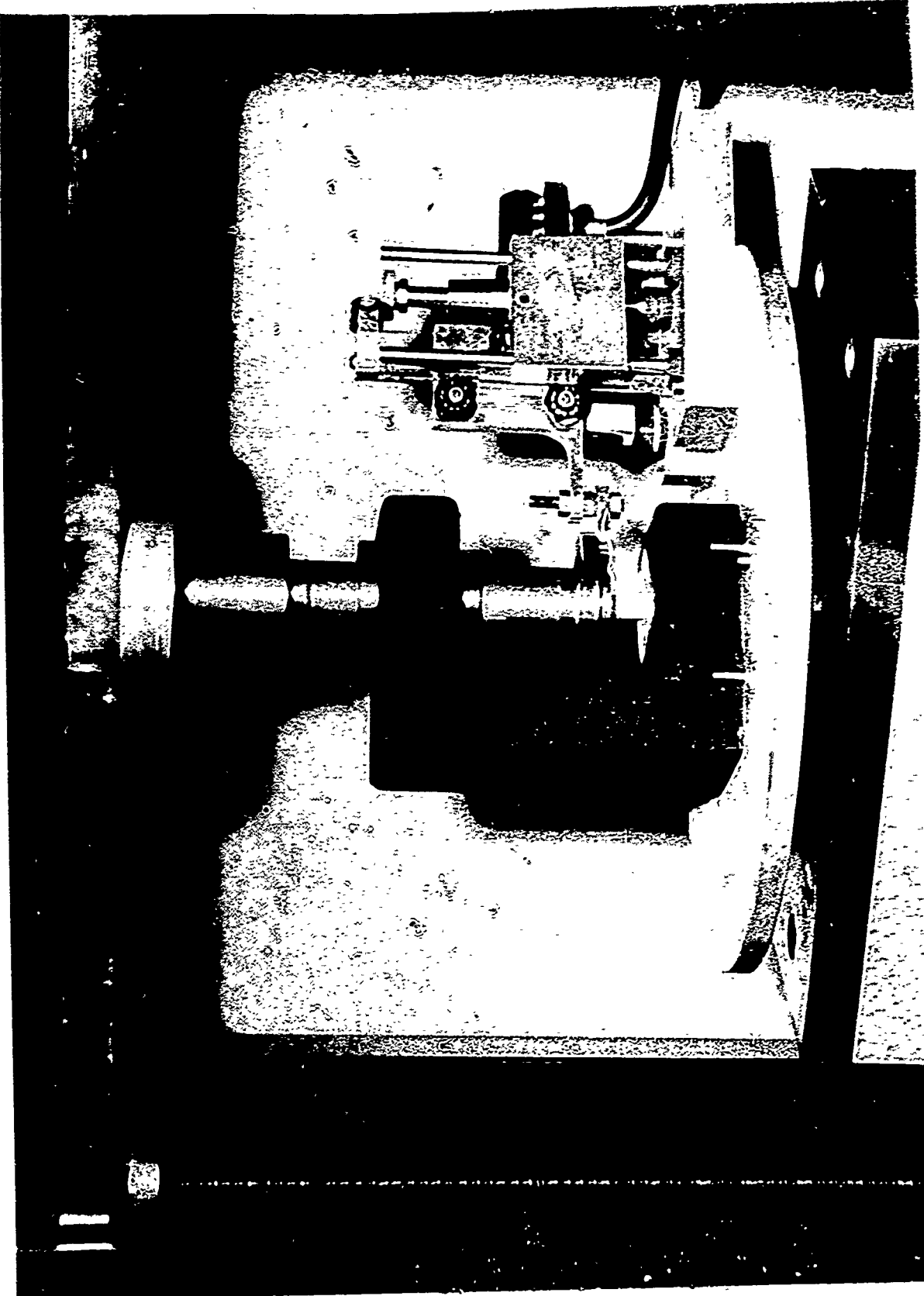


FIG. XW
 WORK TO PRODUCE SURFACE OF FLATENED
 32% STORAGE WITH VARIOUS MATERIALS
 CONTROL

11-39362/12



M-38451

January 1951

PICATINNY ARSENAL

Sub-Press and Compressor Mounting on Compression Table

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