NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE

No. 1136

BEARING STRENGTH OF SOME SAND-CAST MAGNESIUM ALLOYS

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INTRODUCTION

The tests described in this report were undertaken to determine the bearing strength characteristics of some magnesium-alloy sand castings and the relation between these and the more commonly determined tensile properties. Although bearing strengths are probably not a very important factor in the design of most magnesium-alloy castings, some few data relating to this property are needed for correlation with the information available on magnesium-alloy sheet (reference 1). Reference 2 indicates that the bearing strength of most magnesium alloys, both wrought and cast, may be taken as 1.6 times the tensile strength, provided the edge distance in the direction of stressing is not less than twice the diameter of the hole. Since this approximate rule was based on bearing tests of magnesium-alloy sheet only, some investigation of its applicability to sand castings is needed.

The three sand-cast magnesium alloys of principal interest from the standpoint of aircraft design are AM403, AM260, and AM265. Bearing ultimate strength values are given in reference 3 for AM265 only, and these correspond to stresses equal approximately to 1.4 times the tensile strength. No reference is made to bearing yield strengths or of the effect of edge distance upon bearing properties as in the case of the wrought and cast aluminum alloys.

The tests described in this report were undertaken to determine the bearing properties of these three cast magnesium alloys and to determine the relation between these and the tensile properties of this material. Data on compressive yield strengths and ultimate strengths in compression and shear are also included.

MATERIAL

The material for these tests was obtained in the form of 3/8- by $2\frac{1}{4}$- by 12-inch cast slabs and standard 1/2-inch-diameter cast tensile test bars. Table I gives the chemical composition of these samples and indicates the heat treatment procedures to which they were subjected. All the bearing test slabs were radiographed and found to be typically sound and free from flux and other inclusions.

SPECIMENS AND PROCEDURE

The bearing specimens were made by first squaring up the edges of the cast slabs and then machining the original 3/8-inch thickness down to 1/4 or 1/8 inch. Material was removed from both faces of the castings.

Figure 1 shows the manner in which the specimens were loaded in bearing on steel pins (heat-treated drill rod), inserted in close-fitting drilled and reamed holes near one end of the specimens. The 1/4-inch-thick specimens were loaded on a 1/2-inch-diameter pin; whereas the 1/8-inch-thick specimens were loaded on a 1/4-inch-diameter pin. Specimen widths were nominally $2\frac{3}{16}$ inches for both thicknesses. Edge distances, measured in the direction of stressing from the center of the pin hole to the edge of the specimen, ranged from 1 to 4 times the diameter for the 1/2-inch pin and 1.5 to 4 times the diameter for the 1/4-inch pin. All bearing tests were made in triplicate.

Hole deformations, from which bearing yield-strength values were determined, were obtained by measuring the relative movement of the pin and the castings on the under side of the pin by means of a filar micrometer microscope, reading directly to 0.01 millimeter and by estimation to 0.002 millimeter. The under side of the pin projecting from the specimen on the microscope side was flattened slightly to provide a shoulder in the plane of the casting on which one of the reference points for the microscope readings could be located. The edge of the hole provided the reference point on the casting.

Tensile tests were made in duplicate on the standard 1/2-inch-diameter cast-test bars submitted with each melt of bearing test slabs, as well as upon 1/4-inch - thick sheet-type specimens machined from the slabs. Compression and shear tests were made on 3/8-inch-diameter specimens machined from the 1/2-inch-diameter tension test bars.

RESULTS AND DISCUSSION

Table II summarizes the results of all the tension, compression, and shear tests. With the exception of the tensile yield strengths for alloy AM403 and one value of ultimate strength for this same alloy, the tensile properties obtained from the standard 1/2-inch-diameter test bars were well above the specified minimum given in tables 6-5 and 6-6 of ANC-5 (reference 3). The tensile yield and ultimate strengths obtained from the specimens machined from the bearing test slabs also exceeded specified minimum values (reference 4).

Table II shows ratios of the strengths obtained from the two types of tensile specimen used. Except in the case of one melt of alloy AM403, the average tensile ultimate strengths obtained from the cast slabs were less than obtained from the 1/2-inch-diameter test bars, the differences ranging from 2 to 14 percent. The average tensile yield strengths, on the other hand, were higher in four of the seven cases considered for the specimens machined from the slabs. The elongation values obtained from the slabs were, in general, lower than obtained from the 1/2-inch-diameter test bars although these differences were not out of line with those permitted by specifications (reference 4).

The tensile and compressive yield strengths, which are assumed to be equal for cast magnesium alloys, were in generally good agreement. Except in the case of alloy AM403, the differences did not exceed 10 percent. Both the compressive yield and the ultimate shear strengths were, with one exception (AM403), above the typical values for the alloys given in reference 2.

The ultimate compressive strengths given in table II were obtained in flat-end tests of 3/8-inch-diameter specimens having a slenderness ratio of 16 (length divided by radius of gyration). Values of this property are not generally specified because of the influence of specimen proportions upon strengths obtained. It should be pointed out, however, that the strengths given are appreciably above, in most cases, the "block" compressive stresses specified in tables 6-5 and 6-6 of ANC-5 for specimens having slenderness ratios of approximately 12.

Table III and figures 2 to 8 give the results of the bearing tests. Figure 9 shows typical bearing failures. Ratios of average bearing to tensile properties, the latter obtained from tensile specimens machined from the cast slabs, are summarized in table IV.

As in previous investigations of bearing strengths, the object in comparing bearing and tensile properties was to determine whether or not a satisfactory basis could be established for selecting allowable bearing values from specified design values in tension, thereby eliminating the need for routine bearing tests. The value of such a procedure depends upon the uniformity of these ratios for a wide range of alloys or products. All of the high strength aluminum alloys in the form of sheet (references 5 and 6), for example, have exhibited approximately the same ratios of bearing to tensile properties for any given edge distance. These ratios for sheet, however, are definitely not applicable to large extrusions of some of the same alloys, and for that reason it has been necessary to consider large extrusions as special cases. In previous tests of magnesium-alloy sheet (reference 1) some distinction was made between bearing to tensile ratios for different tempers but, in general, a single ratio could be given to cover adequately several alloys and tempers for a given edge distance.

Figure 10 indicates more clearly than table IV the trend of the ratios of bearing to tensile properties obtained in these tests of castings. The general shape of the diagrams shown is more representative of the behavior of wrought aluminum than wrought magnesium, although the spread between ratios of bearing ultimate to tensile ultimate strengths for the castings is greater than that observed for any of these other materials. Figure 10 also shows the ratios of bearing to tensile properties previously obtained for magnesium-alloy sheet. A number of interesting observations may be made:

1. The ratios of bearing yield to tensile yield strengths for all the castings, with the exception of alloy AM403, were approximately equal for any one edge distance from 1D to 2D and the variation between these limits was about linear. For edge distances greater than 2D the yield ratios tended to level off to a more constant value. In the case of the magnesium-alloy sheet, previously tested, the corresponding ratios remained fairly constant for edge distances ranging from 1.5D to 4D.

2. The ratios of bearing yield strength to tensile yield strength for the castings were appreciably higher than have been observed for sheet of either aluminum or magnesium tested at the same edge distances. The high ratios for alloy AM403 as compared to the other castings are not considered particularly significant because of the low tensile yield strength of this material. Corresponding ratios for the low yield strength aluminum alloys are also out of line with the values for the higher strength alloys.

3. The ratios of bearing ultimate strength to tensile ultimate strength for the castings show a much greater spread for any one edge distance than has been observed for either the wrought aluminum or magnesium alloys. It will be noted, however, that the mean of the values observed for the magnesium castings is not greatly different from that obtained for magnesium-alloy sheet.

4. Pin diameter seemed to have a significant effect upon both bearing yield and ultimate strengths. For an edge distance of 1.5D the bearing values observed for the 1/4-inch-diameter pin in a $2\frac{3}{16}$-inch-wide specimen were less than obtained for the 1/2-inch-diameter pin in a specimen of the same width. For edge distance of 2D or greater, however, the bearing values obtained for the 1/4-inch-diameter pin were higher.

Of the foregoing observations, the wide spread in ratios of bearing ultimate to tensile ultimate strength for castings having approximately the same tensile strengths and the high ratios of bearing yield to tensile yield strengths are of principal interest. Although an explanation of this behavior is not apparent, the results would seem to indicate that the expression of bearing strength characteristics in terms of tensile properties alone, while adequate for the purposes intended here, probably does not make proper allowance for all the factors involved in a bearing test.

It appears from figure 10 that a fairly representative set of ratios of bearing yield to tensile yield strength can be given for all the heat-treated casting alloys tested. No special consideration need be given to the high ratios obtained in the tests of alloy AM403, it is believed, in view of the low yield strength of this material. These proposed ratios are as follows:

Ratio	Edge Distance		
	1D	1.5D	2D or greater
Bearing yield / Tensile yield	1.5	2	2.5

It should be emphasized that the corresponding ratios for edge distances of 1.5D and 2D for high strength aluminum-alloy sheet are only 1.4 and 1.6, respectively; whereas ratios for magnesium-alloy sheet for edge distances of 1.5D or greater range from only 1.3 to 1.5. These differences are sufficiently great to warrant some consideration of their possible significance.

The 2-percent offset yield criterion which has been used in all recent bearing tests made at this Laboratory is, of course, an arbitrary one. An examination of a number of bearing stress-hole elongation curves for these castings, as well as for the magnesium- and aluminum-alloy sheet previously tested, has indicated, however, about the same yield characteristics. Ratios of the stresses at first yielding (proportional limit) to the so-called bearing yield values (2-percent set) range from about 0.55 to 0.65 for all these materials. The ratios for the castings, in fact, were about intermediate between those for the magnesium- and aluminum-alloy sheet tested. The method of selecting bearing yield strengths appears as applicable, therefore, to these castings as to these other materials.

The principal difference between the results of these tests of castings and previous tests of wrought alloys is that the ratios of bearing yield to bearing ultimate strength are appreciably higher for the castings. In other words, the margin of strength beyond the yield value for the castings is relatively small. With the exception of alloy AM403, the bearing yield values in table III range from 65 to 92 percent of the ultimate bearing values, with the corresponding average ratios varying from 85 percent for 1D to 73 percent for 4D. It is apparent from these data that ultimate bearing strengths rather than yield values will govern generally in the design of castings of this type for aircraft.

It is obviously not possible to select from figure 10 a set of ratios of bearing ultimate to tensile ultimate strengths that is as representative of the materials tested as was possible for yield strengths. For an edge distance of 1.5D, for example, the ultimate strength ratios range from 0.90 to 1.80; whereas in the tests of the magnesium-alloy sheet the corresponding ratios range from only 1.3 to 1.6. For an edge distance of 2D approximately the same relative behavior was observed for the castings. The highest ratios, it will be noted, were obtained for the weakest alloy, AM403. The ratios for alloy AM260 were consistently higher than for AM265, with the ratios for the T6 temper exceeding that for the T4 temper in both cases.

A comparison of the ratios of bearing ultimate to tensile ultimate strengths obtained in these tests with the value of 1.6 given in reference 2 for edge distances of 2D or greater shows only two ratios significantly below the published value. These exceptions are both for alloy AM265-T4. In view of the similarity of the tensile properties specified for this alloy and AM260-T4, the apparent weakness of AM265 in these tests might well be disregarded, it is believed, until more evidence of its variance with the published bearing to tensile ratio is obtained. It should be emphasized that the average of all the ultimate strength ratios given in table IV for the heat-treated castings is 1.63 for an edge distance of 2D.

For edge distances of 1.5D, the ratios of bearing to tensile ultimate strengths for the 1/4-inch-diameter pin tests were lower than observed for the 1/2-inch-diameter pin. The consideration to be given this result is questionable, however, in view of the fact that the relative position of the ratios for the tests at 2D was just reversed. For the present, at least, an average of the ratios given for the heat-treated castings at 1.5D should be reasonably satisfactory. The following ratios are proposed for the castings tested:

Ratio	Edge distance		
	1D	1.5D	2D or greater
$\frac{\text{Bearing ultimate}}{\text{Tensile ultimate}}$	0.8	1.2	1.6

These ratios are admittedly not as conservative from the standpoint of the test results, except for alloy AM403, as those proposed for yield strengths. In view of the relatively small range of tensile properties covered by the entire group of heat-treated castings tested, the use of an average set of ratios of bearing ultimate to tensile ultimate strengths such as proposed is believed justified.

Tests at a minimum edge distance of 1D rather than the customary 1.5D were included as a desirable feature of a preliminary investigation of the bearing properties of magnesium castings. Correspondingly small edge distances were included in the first bearing tests of wrought-aluminum alloys until a reasonable basis for estimating the effect of edge distance was established. In the design of castings it is doubtful if edge distances smaller than 2D in the direction of stressing will often be considered.

CONCLUSIONS

The following conclusions are believed to be warranted by the results of the tests of the sand-cast magnesium alloys described in this report. Three alloys, AM403, AM260, and AM265, the latter two in both the heat-treated (T4) and heat-treated and aged (T6) tempers, have been included:

1. The 3/8- by $2\frac{1}{4}$- by 12-inch especially cast bearing test slabs and the corresponding standard 1/2-inch-diameter cast tensile test bars exhibited tensile properties which, with several minor exceptions, met specified requirements for these alloys as given in references 3 and 4 and were satisfactory, therefore, for an investigation of bearing strengths.

2. The ratios of bearing yield to tensile yield strength obtained for all the castings were appreciably higher than obtained in previous tests of wrought-aluminum- or magnesium alloys. The following ratios are proposed for the castings tested, neglecting the high values observed for the unheat-treated alloy AM403.

Ratio	Edge distance		
	1D	1.5D	2D or greater
$\frac{\text{Bearing yield}}{\text{Tensile yield}}$	1.5	2	2.5

3. The ratios of bearing ultimate to tensile ultimate strength obtained for the castings show much more variation for materials having approximately the same tensile properties than has been observed in previous tests of either wrought aluminum or magnesium. The following average ratios are proposed, however, as being generally applicable to these materials neglecting, as before, the ratios for AM403:

Ratio	Edge distance		
	1D	1.5D	2D or greater
Bearing ultimate / Tensile ultimate	0.8	1.2	1.6

4. The ratios of bearing yield to bearing ultimate strengths obtained for the heat-treated castings were considerably higher than observed in previous bearing tests of wrought materials. Ultimate bearing values, therefore, will be of principal interest in the design of most magnesium-alloy castings.

Aluminum Research Laboratories,
Aluminum Company of America,
New Kensington, Pa., March 26, 1946.

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TABLE I

COMPOSITION AND HEAT TREATMENT OF MAGNESIUM-ALLOY SAND CASTINGS

Alloy	Melt number	Percent of alloying elements					Heat treatment	Aging treatment
		Al	Zn	Mn	Si	Cu		
AM260-T4	R27M	8.7	2.2	0.17	0.11	0.01	18 hr at 775° F	None
AM260-T6	R01M	8.8	2.1	.20	.11	.01	18 hr at 775° F	12 hr at 450° F
	R22M	8.8	2.0	.18	.11	.01	18 hr at 775° F	12 hr at 450° F
AM265-T4	H61B	6.7	3.1	.41	<.05	-	2 hr at 640° F + 12 hr at 730° F	None
AM265-T6	H61B (A)	6.7	3.1	.41	<.05	-	2 hr at 640° F + 12 hr at 730° F	12 hr at 450° F
AM403-C	403-01	<.01	<.01	1.62	.15	-	None	None
	403-02	<.01	<.01	1.55	.09	-	None	None

TABLE IV

RATIOS OF AVERAGE BEARING TO TENSILE PROPERTIES FOR MAGNESIUM-ALLOY SAND CASTINGS

Alloy	Melt number	Ratios for edge distances =							
		1 × pin diameter		1.5 × pin diameter		2 × pin diameter		4 × pin diameter	
		BS/TS	BYS/TYS	BS/TS	BYS/TYS	BS/TS	BYS/TYS	BS/TS	BYS/TYS
Bearing tests on 1/2-in.-diameter steel pin in 1/4-in.-thick by $2\frac{3}{16}$-in.-wide specimens									
AM260-T4	R27M	--	--	1.45	2.19	1.64	2.52	1.92	2.57
AM260-T6	R01M	--	--	1.42	2.13	1.75	2.58	2.05	2.79
	R22M	--	--	1.57	2.21	1.88	2.75	2.26	2.99
AM265-T4	H61B	0.77	1.58	1.07	2.15	1.30	2.62	1.66	2.89
AM265-T6	H61B (A)	.89	1.52	1.29	2.10	1.58	2.52	1.83	2.66
AM403-C	403-01	--	--	1.80	3.32	2.20	3.55	2.30	3.78
	403-02	--	--	--	--	--	--	2.15	3.56
Bearing tests on 1/4-in.-diameter steel pin in 1/8-in.-thick by $2\frac{3}{16}$-in.-wide specimens									
AM265-T4	H61B	--	--	0.90	2.09	1.49	2.67	1.90	3.35
AM265-T6	H61B (A)	--	--	.99	1.76	1.76	2.68	1.98	2.94

Ratios based on tensile properties obtained from bearing test slabs.

BS = bearing ultimate
BYS = bearing yield
TS = tensile ultimate
TYS = tensile yield

TABLE II.- TENSILE, COMPRESSIVE, AND SHEAR STRENGTHS OF MAGNESIUM-ALLOY SAND CASTINGS

M. T. Nos. 013045-A and 052145-C

Alloy	Melt and test number	Properties of 1/2-inch-diameter standard test bars								Tensile properties of bearing test slabs[4]			Ratios	
		Tension[1]			Compression[2]		Shear[3]	Ratios						
		Ultimate strength (psi) (1)	Yield strength[5] (psi) (2)	Elongation in 4D (percent) (3)	Ultimate strength (psi) (4)	Yield strength[5] (psi) (5)	Ultimate strength (psi) (6)	(2)/(5)	(6)/(1)	Ultimate strength (psi) (7)	Yield strength[5] (psi) (8)	Elongation in 2 in. (percent) (9)	(7)/(1)	(8)/(2)
AM260-T4	R27M-1	41,100	15,100	12.5	54,400	15,200	22,200			35,400	21,300	2.0		
	-2	41,300	13,800	11.5	52,300	15,000	22,400			37,800	18,700	3.5		
	Av.	41,200	14,450	12.0	53,350	15,100	22,300	0.96	0.54	36,600	20,000	2.8	0.89	1.38
AM260-T6	R01M-1	41,600	23,200	2.5	60,100	-------	25,300			37,100	22,000	1.5		
	-2	40,000	25,400	2.5	65,500	22,400	25,700			35,700	21.700	1.5		
	Av.	40,800	24,300	2.5	62,800	-------	25,500	1.09	.62	36,400	21,850	1.5	.89	.90
	R22M-1	40,100	24,000	3.0	63,900	21,700	25,100			30,500	21,200	1.0		
	-2	36,900	20,000	2.0	63,900	22,000	24,900			35,800	21,100	2.0		
	Av.	38,500	22,000	2.5	63,900	21,850	25,000	1.01	.65	33,150	21,150	1.5	.86	.96
AM265-T4	H61B-1	43,000	14,800	16.0	55,500	16,200	22,600			40,600	15,200	11.0		
	-2	43,100	15,000	15.5	53,700	14,900	22,400			39,100	14,800	10.0		
	Av.	43,050	14,950	15.8	54,600	15,550	22,500	.96	.52	39,850	15,000	10.5	.92	1.00
AM265-T6	H61B (A)-1	41,900	20,100	5.5	60,700	20,100	23,900			41,700	21,600	4.0		
	-2	40,500	21,100	4.5	60,700	21,600	23,600			38,800	20,300	4.0		
	Av.	41,200	20,600	5.0	60,700	20,850	23,750	.99	.58	40,250	20,950	4.0	.98	1.02
AM403-C	403-01-1	13,900	3,800	6.5	24,000	3,700	13,400			11,200	3,800	6.0		
	-2	11,500	3,000	5.5	25,400	3,900	13,800			11,100	3,300	6.0		
	Av.	12,700	3,400	6.0	24,700	3,800	13,600	.90	1.07	11,150	3,550	6.0	.88	1.04
	403-02-1	13,500	2,900	7.0	27,300	3,800	12,500			14,700	4,300	6.0		
	-2	13,900	2,600	7.0	25,600	4,000	12,900			15,500	4,300	6.0		
	Av.	13,700	2,750	7.0	26,450	3,900	12,700	.71	.93	15,100	4,300	6.0	1.10	1.59

[1]See fig. 1 of A.S.T.M. Tentative Specifications for Magnesium-Base Alloy Sand Castings (B80-44T), 1944 Book of A.S.T.M. Standards, pt. I, p. 1507.

[2]Tests of 3/8-in.-diam. × 1½-in. long specimens (L/r = 16) machined from standard tensile test bars.

[3]Tests of 3/8-in.-diam. × 3-in. long specimens machined from standard tensile test bars.

[4]Tests of 1/4-in.-thick sheet-type specimens machined from center of 3/8- × 2¼- × 12-in. cast slabs. See fig. 2 of Standard Methods of Tension Testing of Metallic Materials (E8-42), 1944 Book of A.S.T.M. Standards, pt. I.

[5]Stress corresponding to offset of 0.2 percent.

TABLE III.- BEARING STRENGTHS OF MAGNESIUM-ALLOY SAND CASTINGS

Alloy	Test number	Bearing strengths (psi) for edge distances = 1 × pin diameter: Ultimate	1 × pin diameter: Yield[1]	1 × pin diameter: Type of failure[2]	1.5 × pin diameter: Ultimate	1.5 × pin diameter: Yield	1.5 × pin diameter: Type of failure	2 × pin diameter: Ultimate	2 × pin diameter: Yield	2 × pin diameter: Type of failure	4 × pin diameter: Ultimate	4 × pin diameter: Yield	4 × pin diameter: Type of failure
Tests made on 1/2-in.-diameter steel pin in 1/4-in.-thick by $2\frac{3}{16}$-in.-wide specimens													
AM260-T4	1				53,200	44,800	T	60,000	50,800	T	71,400	54,000	B
	2				50,000	40,600	T	59,200	49,800	T	70,200	48,600	B
	3				55,900	46,000	T	61,200	51,000	T	69,800	52,000	B
	Av.				53,000	43,800		60,100	50,500		70,500	51,500	
AM260-T6	1				52,200	46,000	T	66,900	55,600	T	74,900	63,400	[3]T
	2				51,000	47,200	T	62,300	58,200	[3]T	74,000	61,200	T
	3				51,900	46,800	[3]T	60,900	57,000	T	75,000	60,800	T
	Av.				51,600	46,600		63,900	56,300		74,500	61,000	
AM265-T4	1	30,700	23,200	S	41,100	32,800	TS	49,400	38,600	TS	66,400	43,600	B
	2	29,800	23,200	TS	42,500	32,000	S	52,900	39,200	TS	67,400	44,400	B
	3	31,500	24,600	TS	43,800	32,200	TS	53,200	40,400	TS	64,800	42,000	B
	Av.	30,700	23,700		42,500	32,300		51,800	39,400		66,200	43,300	
AM265-T6	1	37,000	32,800	TS	51,100	42,400	T	63,300	54,800	T	74,000	58,200	B
	2	35,300	30,800	TS	51,000	43,600	T	64,100	52,000	T	73,700	54,800	B
	3	35,600	31,800	TS	53,800	46,000	T	63,400	52,000	T	73,400	54,200	B
	Av.	36,000	31,800		52,000	44,000		63,600	52,900		73,700	55,700	
AM403-C	1				19,200	12,900	T	24,100	11,900	T	30,100	15,100	[4]T
	2				21,000	10,700	T	24,700	13,100	T	25,700	13,400	T
	3				20,100	11,900	T	24,900	12,900	T	34,800	15,500	[4]T
	Av.				20,100	11,800		24,600	12,600		32,400	[4]15,300	
Tests made on 1/4-in.-diameter steel pin in 1/8-in.-thick × $2\frac{3}{16}$-in.-wide specimens													
AM265-T4	1				36,600	32,000	S	59,500	40,800	S	73,200	51,400	B
	2				34,600	29,600	S	57,500	40,400	S	77,500	50,200	B
	3				36,500	32,600	S	60,800	39,200	S	77,100	49,200	B
	Av.				35,900	31,400		59,300	40,100		75,900	50,300	
AM265-T6	1				39,900	36,400	S	69,900	56,000	S	75,600	61,600	B
	2				41,200	37,000	TS	71,300	60,000	S	82,300	66,000	B
	3				39,300	37,200	TS	70,800	52,200	S	81,600	57,800	B
	Av.				40,100	36,900		70,700	56,100		79,800	61,800	

[1]Yield stress corresponds to offset of 2 percent of pin diam. from initial straight-line portion of bearing stress - hole elongation curves.

[2]Types of failure: T - tension on transverse section through pin hole; S - shear of specimen above pin; TS - combination of shear and tension; B - bearing or crushing of specimen above pin

[3]Melt No. R22M - Tests not included in average. All other tests of AM260-T6 from Melt No. R01M.

[4]Melt No. 403-02 - All other tests of AM403-C from Melt No. 403-01.

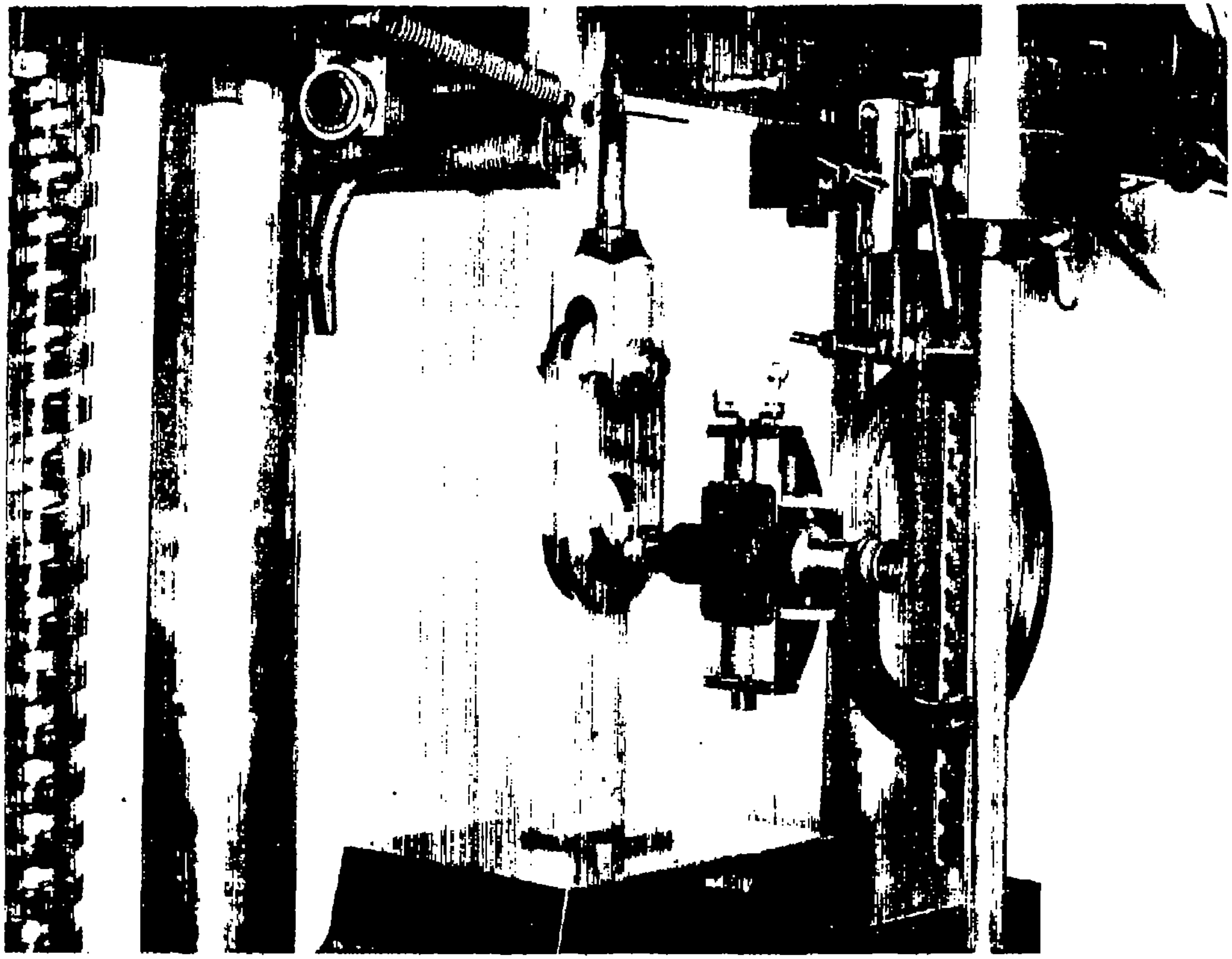
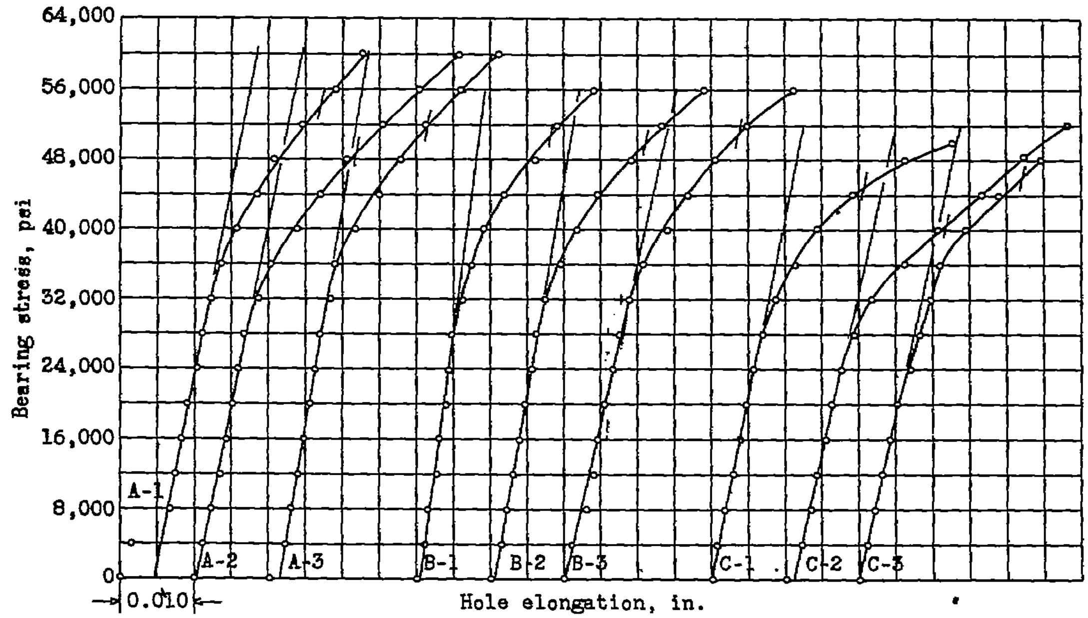
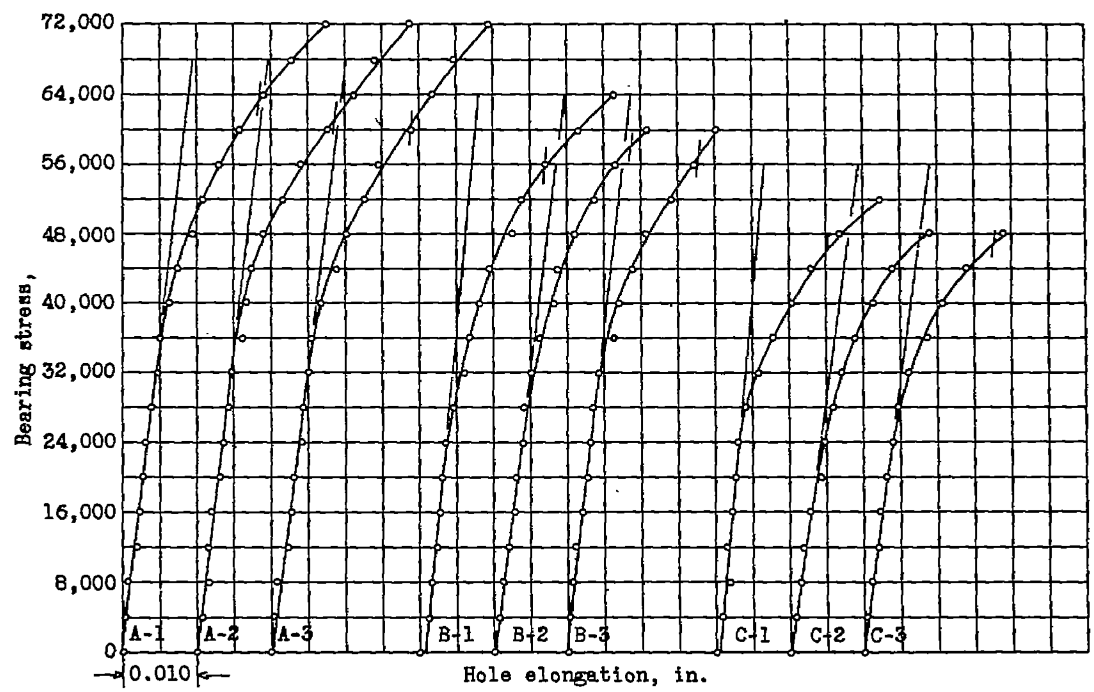


Figure 1.- Arrangement for bearing tests. Pin supports slotted vertically under pin to permit viewing hole deformation.



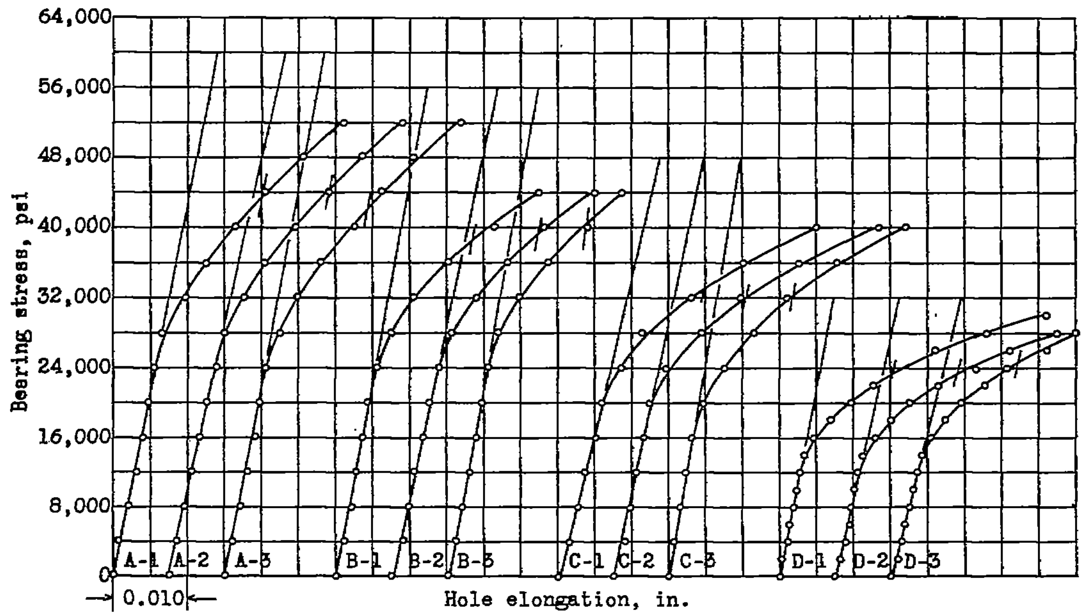
Pin diameter, D, = 1/2 in. A-1, A-2, A-3; edge distance = 4D
Specimen thickness = 1/4 in. B-1, B-2, B-3; edge distance = 2D
Specimen width = 2-3/16 in. C-1, C-2, C-3; edge distance = 1.5D

Figure 2.- Bearing stress - hole elongation curves for magnesium alloy castings, 260-T4.



Pin diameter, D, = 1/2 in. A-1, A-2, A-3; edge distance = 4D
Specimen thickness = 1/4 in. B-1, B-2, B-3; edge distance = 2D
Specimen width = 2-3/16 in. C-1, C-2, C-3; edge distance = 1.5D

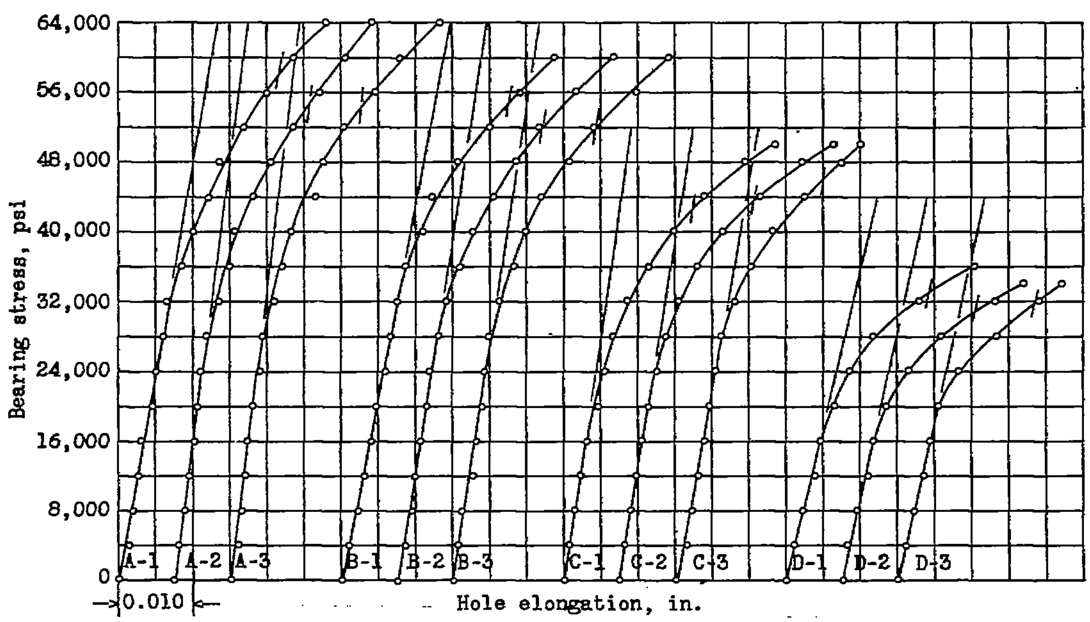
Figure 3.- Bearing stress - hole elongation curves for magnesium alloy castings, 260-T6.



Pin diameter, D, = 1/2 in.
Specimen thickness = 1/4 in.
Specimen width = 2-3/16 in.

A-1, A-2, A-3; edge distance = 4D
B-1, B-2, B-3; edge distance = 2D
C-1, C-2, C-3; edge distance = 1.5D
D-1, D-2, D-3; edge distance = 1D

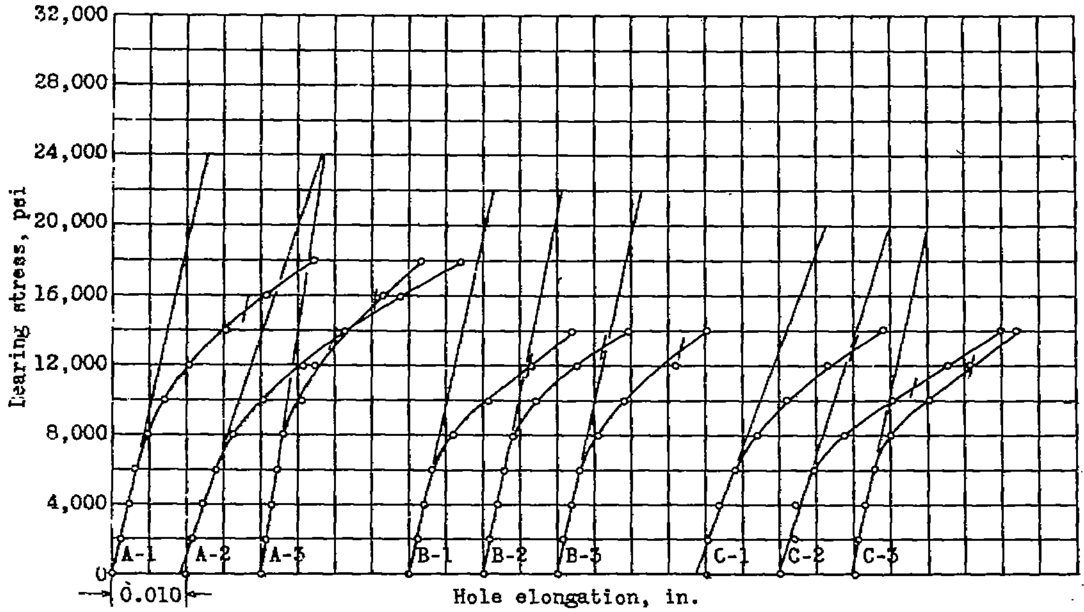
Figure 4.- Bearing stress - hole elongation curves for magnesium alloy castings, 265-T4.



Pin diameter, D, = 1/2 in.
Specimen thickness = 1/4 in.
Specimen width = 2-3/16 in.

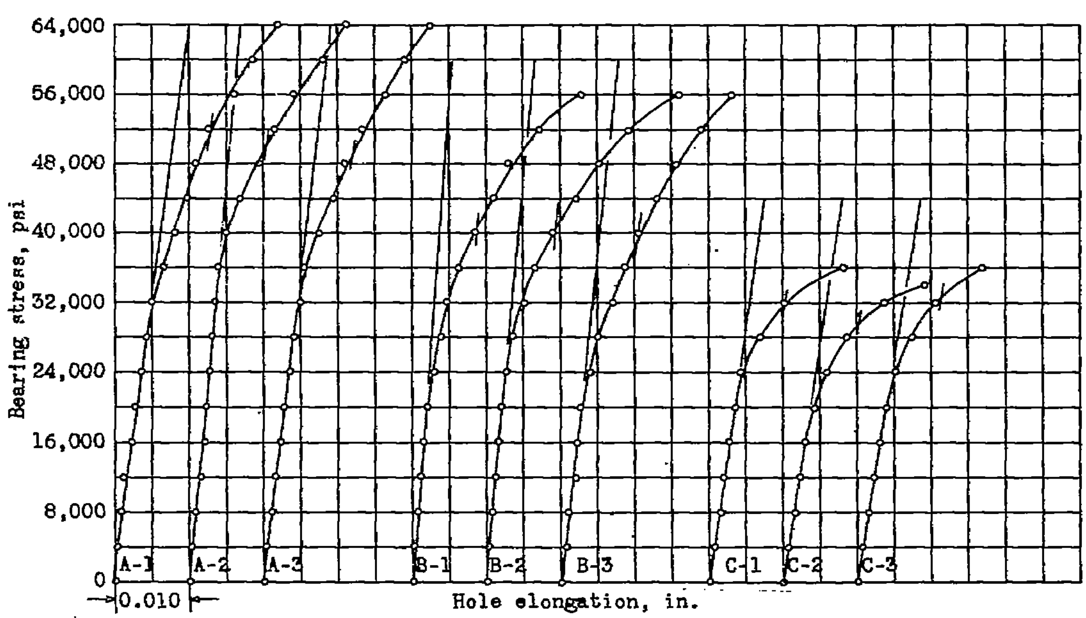
A-1, A-2, A-3; edge distance = 4D
B-1, B-2, B-3; edge distance = 2D
C-1, C-2, C-3; edge distance = 1.5D
D-1, D-2, D-3; edge distance = 1D

Figure 5.- Bearing stress - hole elongation curves for magnesium alloy castings, 265-T6.



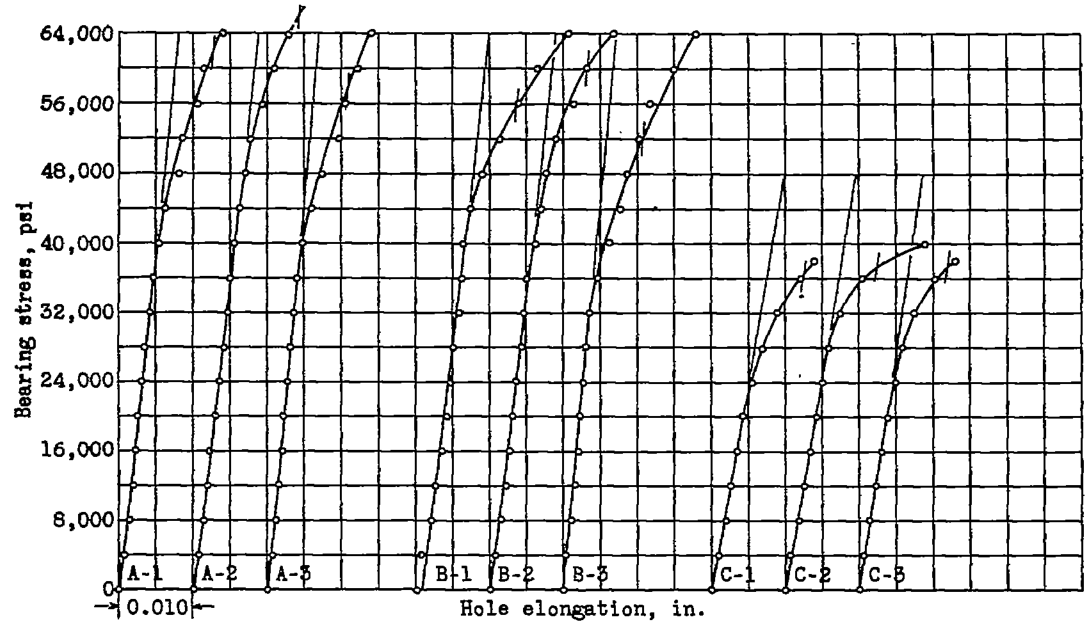
Pin diameter, D, = 1/2 in. A-1, A-2, A-3; edge distance = 4D
Specimen thickness = 1/4 in. B-1, B-2, B-3; edge distance = 2D
Specimen width = 2-3/16 in. C-1, C-2, C-3; edge distance = 1.5D

Figure 6.- Bearing stress - hole elongation curves for magnesium alloy castings, 403-C.



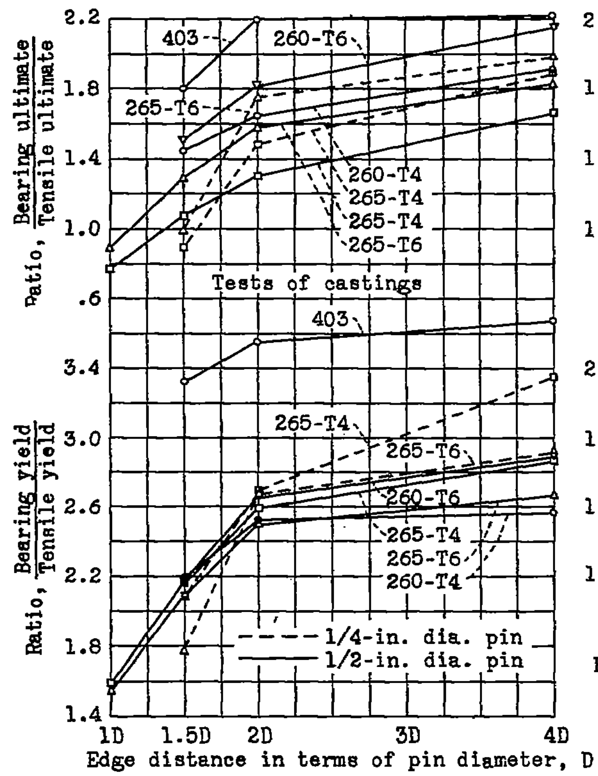
Pin diameter, D, = 1/4 in. A-1, A-2, A-3; edge distance = 4D
Specimen thickness = 1/8 in. B-1, B-2, B-3; edge distance = 2D
Specimen width = 2-3/16 in. C-1, C-2, C-3; edge distance = 1.5D

Figure 7.- Bearing stress - hole elongation curves for magnesium alloy castings, 265-T4.



Pin diameter, D, = 1/4 in. A-1, A-2, A-3; edge distance = 4D
Specimen thickness =1/8 in. B-1, B-2, B-3; edge distance = 2D
Specimen width = 2-3/16 in. C-1, C-2, C-3; edge distance = 1.5D

Figure 8.- Bearing stress - hole elongation curves for magnesium alloy castings, 265-T6.



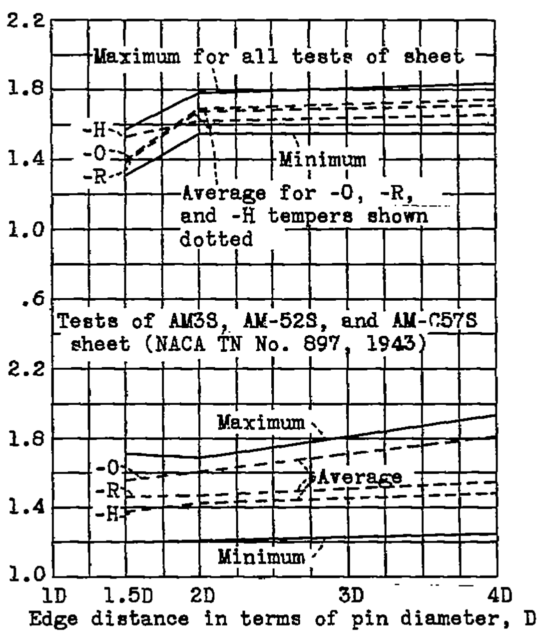
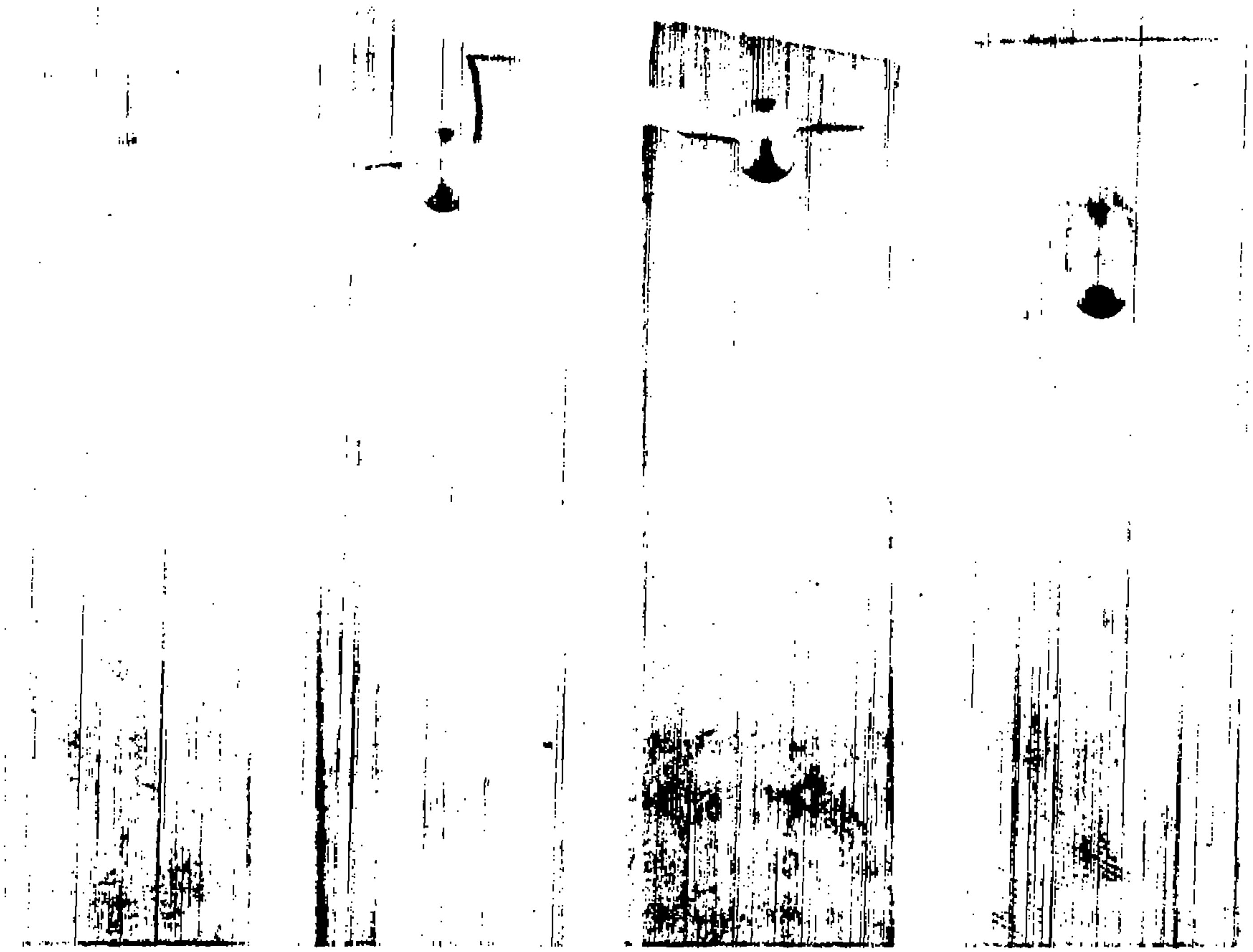


Figure 10.- Ratios of bearing to tensile strengths, magnesium alloys.



S ST T B

Figure 9.- Failures of sand-cast magnesium alloy bearing specimens. S, shear; ST, combination of shear and tension; T, tension; B, bearing.