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DEVELOPMENT OF A SAND-CAST MAGNESIUM ALLOY BASEPLATE FOR THE MEDIUM MORTAR. PHASE III

by

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PHYSICAL METALLURGY DIVISION

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SUMMARY

This report describes the work in Phase III of the development of a cast magnesium alloy baseplate for the 81 mm mortar, carried out during 1961-62 by the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, for the Army Equipment Engineering Establishment (formerly Army Development Establishment), Department of National Defence, Ottawa, Canada. Phase III of the investigation included work on a substantial redesign of the baseplate and a major effort to improve the product quality by application of techniques relevant to the novel foundry concept of "premium-quality castings".

The report describes in detail the work on the redesign of the baseplate, the choice of a final design, metallurgical development of the castings, the simulated service (static breakdown) tests and, as well, gives the results of the dynamic design (firing) tests carried out at CARDE.

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INTRODUCTION

A Summary Report[1] and two progress reports[2,3] were issued on the development of a cast magnesium baseplate for the 81 mm mortar, carried out during 1960-1964 by the Physical Metallurgy Division, Mines Branch, Department of Mines and Technical Surveys, for the Army Equipment Engineering Establishment (formerly Army Development Establishment), Department of National Defence, Ottawa, Canada.

The present report describes in detail the work on Phase III of the investigation (1961-62), which included work on redesigning the baseplate and a major effort to improve the casting quality by the use of techniques applied to the novel foundry concept of "premium-quality castings".

At a meeting between representatives of the Army Development Establishment, DND, and the Mines Branch, held on 26 September 1961, the results of the first two phases of the investigation were reviewed and, after a thorough discussion of the problem, it was agreed that the work of the third phase should consist of a more substantial redesign of the baseplate and work on considerable improvement of casting quality. To achieve this without undue delay (unavoidable if each design alteration had to be re-ordered in a commercial foundry) it was decided to carry out the work on this phase of the program in the Experimental Foundry of the Mines Branch.

Eight modifications of the design were tried and casting methods for each of these designs had to be worked out to assure consistently high properties in the critical areas of the casting. The new approach was to obtain the maximum properties the alloy is capable of developing under favourable solidification conditions rather than to simply satisfy the minimum property requirements of the CSA.HG.9-1963 specification.

DESIGN DEVELOPMENT

Because of the anticipated large number of changes in this phase of the development, the method of chilling chosen was to use a number of small steel chills (approx. size 1-1/2 x 3/4 x 3/4 in.), placed in selected areas of the casting to induce favourable solidification conditions. This method was selected in preference to cast-to-shape chills because of its greater flexibility. Initially, two castings were produced for each design change to be subjected to breakdown tests, one for a 4-point-support test and the other for a sand test. The castings were used in the T5 condition (aged only), because of lack of a suitable solution heat treating furnace. This was considered satisfactory, in this instance since, although maximum mechanical properties were not obtained, the purpose of the tests was simply to compare the strength of the plate as affected by the various design changes.

Table 1 lists the details of chemical compositions and mechanical test results obtained on separately-cast test bars, cast and heat treated with each baseplate. Other data concerning the testing of baseplates is given in Tables 3 and 4.

Design "A" (Weight - 27.5 lb)

The first change in the design 2 (Mines Branch drawing MBP-17b, reproduced as Figure 1 in the second progress report[3]) was to increase the thickness of the flotation ring from 3/8-in. to 1/2-in. and to incorporate an additional inner reinforcing rib, as shown in Mines Branch drawing MBP-18 (see Figure 1). Figure 2 shows the casting produced in this design and the mode of fracture in the 4-point-support tests.

Design "B" (Weight - 26.8 lb)

This design was a modification of design "A" by the removal of the inner reinforcing rib. Two plates were produced and tested. Figure 3 shows the shape of the casting and the mode of fracture in the 4-point-support test.

Design "C" (Weight - 23.3 lb)

This design was a more extensive modification of design "A"; the major change being the removal of the top flange on the arms between the flotation ring and the hub. The taper of the legs was also changed from 3° to 1° and a 3/8-inch-thick flotation ring was used. The shape of the casting and the mode of fracture in the 4-point-support test are shown in Figure 4.

Design "D" (Weight - 27 lb)

This design was similar to design "C" with the addition of a further reinforcing ring of full height of the leg, 6-in. I.D. and 7-1/2-in. O.D., located between the hub and the flotation ring. Both plates cast to this design were tested under 4-point-support conditions; one was in the T5 (aged only) condition, while the other was fully heat treated to T6 (at Light Alloys Ltd., Haley, Ontario). The shape of the casting and the mode of fracture are shown in Figure 5. It appears that the additional ring introduced a stress concentration at the junction with the legs.

Design "E" (Weight - 25 lb)

This design was basically the same as "D", with the exception that the additional deep reinforcing ring was replaced by a 1-1/2-inch-high reinforcing ring located at the tension side of the plate. Two plates were cast and both tested under 4-point-support conditions, one in the T5 and the other in the fully heat treated T6 condition. The shape of the casting and the mode of fracture are shown in Figure 6.

Design "F" (Weight - 25.8 lb)

This design is similar to design "C" with increased height and changed shape of the legs at the tension side, as shown in Mines Branch drawing MBP-19 (Figure 7). The only change from this drawing was that the legs were carried through to form a completely flat base at the tension side. Two plates were cast to this design, one was tested in sand and the other under 4-point-support conditions. In the 4-point-support test the thin spades at the rollers started to shear off at 160,000 lb. To avoid this, a third plate was cast with increased width at the spades (design F 1). The shape of casting "F" and the mode of fracture are shown in Figure 8.

Design "G" (Weight - 25 lb)

Design "G" is shown in Mines Branch drawing MBP-19 (Figure 7). Two plates were cast, the first of which (G-KZ) was tested in sand and withstood a load of 297,000 lb without breaking (this was the maximum load for the testing machine used). The second plate (G-LA) was tested under 4-point-support conditions to obtain data from dial and strain gauges under loads up to 164,000 lb, at which load the spade failed; this plate was subsequently tested in sand (in a higher capacity testing machine) and broke at a load of 381,000 lb.

Two additional plates were cast with enlarged width of the spades for 4-point-support testing (design "G 1"); one of the plates (G1-LG) was tested in the T5 (aged only) condition, and the other (G1-LI) was tested after ageing, and additionally solution heat treating, and again ageing (T5+T6).

Two more plates (design "G2") were cast with enlarged width of the spades, using cast-to-shape aluminum and magnesium chills at the tension side of the arms and cast-to-shape copper chills at the compression side of the arms, instead of the small flat steel chills used hitherto in the development of the castings. One of these plates (G2-LP) was cast with an additional heavy aluminum chill above the hub, instead of a riser.

The shape of the casting of design "G" and the mode of fracture in the 4-point-support test are shown in Figure 9.

Design "H" (Weight - 24 lb)

Design "H" is the same as "G" but without the inner reinforcing rib. Three plates were cast in this design, one for the sand test, and two with reinforced spades (design "H 1") for the 4-point-support tests. Of these latter two, one was tested in the T5 (aged only) condition, the other was fully heat treated to the T6 condition. The shape of casting "H" and mode of fracture in the 4-point-support test are shown in Figure 10.

Choice of Final Design

After reviewing the results of the breakdown tests, performed on the eight interim designs, and considering the weight factor, it was decided to discard designs "A" to "F", and to concentrate further work on designs "G" and "H". These designs were given permanent design numbers 3 (G) and 4 (H), preceded by the designation of the foundry, in this case the Mines Branch, which was assigned the letter "C"; e.g. C3-2 means the second casting in the third design cast at the Mines Branch. In all cases where the spades were reinforced for the 4-point-support test, an additional "X" was added at the end of the designation (e.g. C3-2X).

Plates Produced for Firing Tests

A total of eight plates each in design 3 and 4 were produced at the Experimental Foundry of the Mines Branch. Cast-to-shape magnesium chills were used in the cope (on the tension side of the arms) and cast-to-shape copper chills were used at the drag side of the mould (at the compression side of the arms and in the recess for the socket); additionally, cast-to-shape aluminum chills were used in the fillet between arms and the outer reinforcing rib, and on the outer reinforcing rib in the middle between the arms; and flat steel chills were used at the drag side on the inner flange between the arms. Four open risers at the ingates into the spades and four blind rectangular risers at the ingates between the arms were used. One centre riser was placed above the hub and exothermic compounds were applied to all open risers as soon as the metal was poured.

Figure 11 shows the mould arrangement for baseplate design C3.

Figure 12 shows casting design C4 before trimming (with attached risers and gating).

All castings, after radiographic examination, were shipped to Light Alloys Ltd., Haley, Ontario, for heat treatment, which consisted of 10-hr solution heat treatment at 480 °C (895 °F), raising the temperature to 500 °C (930 °F) for 15 min, cooling in air blast (each casting separately) and ageing for 48 hr at 130 °C (265 °F). Table 2 lists the chemical composition and results of tensile tests obtained on separately-cast test bars.

METALLURGICAL DEVELOPMENT OF CASTINGS

General Discussion

Experience gained in the first two phases of the project indicated the strength of the casting to be considerably affected by the soundness of the metal in the critical areas, which at that time, was thought to be confined to the tension side of the arms, as shown in Figure 1 of the first progress report(2). It was also considered that the properties in the critical areas of the casting should not only meet the (very low) minimum specifications of CSA.HG.9, but instead a considerable effort should be made to obtain in these areas the maximum properties obtainable for alloy ZK61-T6.

The most important problem was to know exactly the stress distribution in the casting and here the close cooperation of the designer and the metallurgist was essential. One of the most notable features of the new concept of "premium-quality castings" (discussed briefly in the Summary Report(1)) is that highest casting quality and highest mechanical properties are guaranteed only in those areas of the casting where this is essential from the point of view of the designer and end-user, and that properties in "unspecified areas" may be much lower without detriment to the service performance of the casting.

In the earlier stages of development of the baseplate it was learned that, under load, each of the four arms of the casting is subjected to bending stresses, which cause high tensile stresses in the top part of the arms (as shown in Figure 1 of the first progress report[2]). These stresses decrease with the distance from the top to a line somewhere in the middle of the arm (neutral axis) and then change to compression stresses increasing towards the bottom of the arm.

To obtain the highest mechanical properties in areas of highest stress, the metal in this area must solidify under the most favourable conditions (high thermal gradients with adequate cooling rates). To achieve these conditions, chills were used both at the top and at the bottom of the arms. The middle part of the arms, where the stresses are the lowest, can be sacrificed to some extent to feed the metal to the critical areas. This non-critical part in the middle of the arms was fed by the riser in the centre of the casting and risers at the ingates at the outside of the casting. The distance between these risers is appreciable, therefore the metal in these parts was solidifying under relatively unfavourable conditions, resulting in lower properties, which in these areas could be safely tolerated.

Moulding Arrangement

In the development of designs 3 and 4 the following moulding arrangements were used; some of which were slightly modified as development continued:

Sprue:	7/8-in. dia tapered to 1-3/8-in. at the pouring box.
Sprue Well:	4-in. long x 3-1/4-in. wide x 2-1/2-in. deep with two vertical wire screens.
Runner:	1-in. x 1-in. in the cope, decreasing 1/4-in. in height after passing each ingate; 1-in. x 1-in. in the drag.
Ingates:	Four 2-1/4-in. x 3/8-in. into blind risers between the arms, and four into open risers at the spades, 1-in. at the bottom and 5/8-in. at the top of spade, approximately 4-1/2-in. high.
Risers:	Four 2-1/2-in. dia at the spades, four blind 2-1/4-in. square at the bottom tapered to 1-3/4-in. square at the top of the flange gates, one 2-1/4-in. dia tapered to 4-in. dia at the top in the centre of the casting. Feedex (exothermic compound to promote better feeding) was used on each open riser.

Chills: One split copper chill in the recess of the hub, several small steel chills placed on both sides of the arms at the tension side and several at the compression side of the arms, to assure high properties in the critical area of the casting. Also, some small chills were used at fillets of the spades at reinforcing rib and at top of reinforcing rib opposite blind risers, where hot spots were present (to speed up solidification). These arrangements were subsequently modified somewhat, as discussed later, to facilitate the production and further improve the thermal conditions.

Pouring Temperature:

760 - 780 °C (1400 - 1435 °F).

Preparation of Melt

Charge containing up to 100% ZK61 alloy scrap was melted in a steel crucible in a gas-fired furnace. When the melt temperature of 710 °C (1310 °F) was reached, the sludge accumulated at the bottom was removed with a steel spoon, and the temperature raised to 770 °C (1420 °F). Approximately 7% of the weight of scrap and 10% of the weight of new metal of TAM zirconium tetrachloride fused salt was then added, the melt stirred for 10 min, settled for 10 to 15 min, and the casting poured.

Chills

The use of several small steel chills was convenient during the development stage due to the high versatility which allowed the chilling arrangement of the casting to be changed without undue difficulties. As soon as the shape of the final casting was established (designs 3 and 4), cast-to-shape magnesium chills for the tension side of the arms were used; this gave more uniform chilling and, being light, were more easily moulded into the cope. Similarly, cast-to-shape copper chills were used for the compression side of the arms, where the weight of the chills was not important because they were placed in the drag. This arrangement was used in the production of all C3 and C4 castings for static breakdown and firing tests.

Heat Treatment

Another improvement in the properties of the castings was obtained by revision of the heat treatment, which in Phases I and II (in Foundry A) consisted of slowly heating the castings to 480 °C (895 °F), holding at that temperature for 10 hr, removing the heat treating charge from the furnace and cooling in still air, and ageing for 48 hr at 150 °C (300 °F). The slow cooling from the solution heat treating temperature was found to be partially responsible for lower properties.

Substantial improvement in properties was obtained, after carrying out a detailed investigation(4), by cooling the castings in a uniform blast of air. Under commercial foundry conditions of large furnace loads and high air temperature, the castings (design 1 and 2) were cooled very slowly and this could have been responsible for the high deformation in the socket recess during static loading tests.

To improve the cooling conditions, the castings of designs 3 and 4 were cooled individually in a specially designed jig, which ensured uniform cooling by a blast of air from an electric fan.

Additional Improvement of Casting Quality

Castings C3 and C4 which underwent static breakdown tests in sand and under 4-point-support conditions, all fractured through the socket, as shown in Figure 13, and the fractures revealed areas of light and heavy porosity. Subsequent revision of the radiographic examination technique to include the socket area, revealed in each casting varying amounts of microporosity and, in some cases, even hot tearing. The stresscoat analysis of the casting also showed high stress concentrations in the socket area where the fractures in the breakdown tests occurred. This may explain the lower properties obtained on baseplates, particularly in the sand tests.

To eliminate defects in the socket area, additional cast-to-shape chills were applied at the hub between the arms. A comparison of the results of tests on castings C4-1 and C4-14 illustrates the improvement obtained. Figure 13 shows casting C4-1 which broke, when tested in sand, at a load of 245,000 lb revealing hot tearing in the fracture of the socket. To improve the soundness of this area, casting C4-14 was produced using a large split chill in the socket and magnesium cast-to-shape chills on the hub between the arms. This baseplate was tested in sand and broke at a load of 320,000 lb (improvement of 30%); the mode of breaking of casting C4-14 is shown in Figure 15, the fracture and radiographic examination still showed some porosity, but no hot tearing.

Casting C4-4, shown in Figure 14, passed the firing tests and was additionally tested in sand. It broke at a load of 237,000 lb showing heavy porosity in the tension side of the reinforcing rib at the joint with the spades. By application of additional chills in this area this defect was eliminated. At the same time the replacement of the light magnesium chill in the socket area with a heavy copper chill and the decrease of the riser size by elimination of its taper, allowed the production of casting C4-17, which was entirely sound in critical areas. This casting withstood a load of 360,000 lb in sand testing, and Figure 16 shows the unusual mode of fracture. The improvement in strength, as compared with C4-4 is 52%.

Tensile Properties of Test Bars Cut From Casting

Tensile properties of test bars cut from critical areas of the casting (location C as shown in Figure 3 of the first progress report[2]), were obtained on baseplate C4-5X after breakdown testing under 4-point-support conditions. Very high average properties of 46.1 kpsi UTS, 30.1 kpsi 0.2% YS, and 21% El, were obtained, which are equal to, or higher than the properties obtainable on separately-cast test bars, and considerably higher than those specified in CSA.HG.9.

SIMULATED SERVICE TESTS

A detailed description of the simulated service test procedure followed is contained in Mines Branch Investigation Report IR 65-13. While it was attempted to employ SR-4 electrical resistance strain gauges for the static load tests conducted on both baseplates of each interim design, the strain gauges affixed to the embedded surfaces of the baseplates tested in sand were quickly rendered inactive by the shearing action of the sand. Hence, comparative strain gauge measurements could not be obtained for these sand tests. Therefore, strain gauge data obtained from the 4-point-support tests only were recorded.

Type A-5 gauges were affixed along the top and bottom surfaces of the cross-beams, flotation ring and, in some cases, at the fillets on the reinforcing rib of interim designs B, C, E, and F. The location of the strain gauges may be seen in Figures 2 to 6.

From the analysis of the load-strain, load-deflection, and fracture load data obtained from simulated service tests conducted on designs A to F, it became evident that the yield strength value determined from the load-deflection curve was a satisfactory parameter for assessing the relative merits of these baseplate designs. Therefore, since sufficient strain gauge data had been obtained to establish suitable shapes for the critical sections of the baseplates, it was decided that subsequent designs would be assessed on the basis of deflection and fracture load data only.

Test Results

An analysis of the strain gauge readings showed that the maximum strains occurred on the tension side of the cross-beams near the socket in the majority of the baseplates. From these readings, the loads corresponding to permanent strains of 100, 300 and 1000 micro-inches per inch (permanent sets of 0.01%, 0.03% and 0.1%) were determined. These loads are recorded in Table 3.

The yield strengths of designs A to H, shown in Tables 3 and 4, varied from 70,000 lb to 105,000 lb, while the loads required to cause fracture of these plates varied from 168,000 lb to 230,000 lb for the 4-point-support tests and from 247,000 lb to 381,000 lb for tests conducted in sand. This large spread in test loads could be related to a number of factors, including changes in section size, shape and improvements in foundry technique.

From Figures 17 and 18, and Table 5 it may be seen that the yield strengths for plates C3 and C4 reached a value of 120,000 lb in all cases.

While the loads required to cause fracture of the baseplates of these designs varied considerably, these loads were consistent for each particular group tested, both in the sand tests and the 4-point-support tests.

Discussion of Results

Strain data obtained with SR-4 strain gauges during the simulated service tests provided a basis for the progressive changes in beam shape made in designs B, C, E and F; these changes led to the more balanced designs G (C3) and H (C4). In the simulated service tests, designs C3 and C4 appeared to possess the optimum combination of yield strength and breaking load.

The yield strengths, as determined from the deflection versus load curves, provided a convenient basis for the determination of the relative merits of the plates tested. The yield strength value of 120, 000 lb determined for baseplates C3 and C4 was about 70% higher than that recorded for the previous prototype plates A2 and B2.

The average loads to produce fracture for the 4-point-support loading conditions were 50% to 75% greater for plates C3 and C4, than prototype plates from lots A2 and B2 (Phase II). An increase of approximately 10% was recorded for plates C3 and C4 over plates A2 and B2, when tested in sand.

Figure 19 illustrates the difference in the total deflection versus load of the initial prototype castings A1 and A2 (phases I and II of the investigation), the standard forged aluminum baseplate, and the final designs (C3 and C4) of the sand-cast magnesium plate, during simulated service (breakdown) tests under 4-point-support conditions. The considerable increase in the stiffness of the final design is noteworthy.

FIRING TESTS

Eight castings (four each of C3 and C4 design) were subjected to firing trials at the Canadian Armament Research and Development Establishment, DRB, Valcartier, Quebec[5]. Additionally, a stress-coat analysis (brittle lacquer coating) was carried out on a C4 baseplate fired under 4-point-support condition at CARDE[6]. This showed a high strain area at the tension side of the arms (which was known from previous work) and another at the socket between the arms (which was not known).

All eight plates successfully withstood all firing trials and none was broken. Taking into consideration the lower weight of design 4 (24 lb after machining) as compared with design 3 (25 lb), and the easier handling of the plate during the firing tests (the inner reinforcing ring in design 3 was causing difficulties in cleaning the baseplate), it was decided to select design 4 as the final design and to limit all further development work to this design.

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Design work and design calculations on the mortar baseplates were done by Dr. T. W. Wlodek, Senior Scientific Officer, Mines Branch, with the assistance of Mr. J. Harbec.

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TABLE 1

Properties of Separately-Cast Test Bars

Design	Baseplate (Melt) No.	Temper	Chemical Comp., %		UTS, kpsi	0.2% YS, kpsi	El,% in 2 in.
			Zn	Zr sol.			
A	KN	T5*	5.95	0.74	39.4	27.1	6.0
A	KO	T5	5.68	0.78	41.0	29.7	5.0
B	KP	T5	5.7	0.78	41.6	29.6	5.5
B	KQ	T5	5.85	0.82	39.5	28.1	5.0
C	KR	T5	5.95	0.78	42.4	30.1	6.5
C	KS	T5	6.0	0.79	41.1	28.9	6.5
D	KT	T5	6.1	0.84	41.8	29.0	6.0
D	KU	T6**	6.1	0.74	-	-	-
E	KV	T6	5.91	0.83	-	-	-
E	KW	T5	5.77	0.80	42.2	28.5	5.0
F	KX	T5	6.11	0.82	42.2	29.0	6.0
F	KY	T5	6.36	0.79	40.0	27.2	6.0
F1	LN	T5	6.18	0.78	41.8	29.1	5.5
G	KZ	T5	6.0	0.82	42.5	28.8	6.0
G	LA	T5	6.11	0.84	42.2	29.1	6.0
G1	LG	T5	5.75	0.83	40.9	28.6	7.0
G1	LI	T5	5.75	0.79	41.1	28.9	5.0
G2	LO	T5	5.93	0.78	39.8	26.1	7.0
G2	LP	T6	5.89	0.80	44.5	32.8	5.5
H	LJ	T5	5.86	0.81	40.9	28.7	5.0
H1	LH	T5	5.87	0.82	41.0	28.9	5.5
H1	LR	T6	6.01	0.78	45.0	31.9	6.5

* Aged for 64 hr at 130 °C (over the weekend).

** Fully heat treated: 10 hr at 480 °C, raised to 500 °C, held 15 min, cooled in air blast, one at a time, and aged 48 hr at 130 °C.

TABLE 2

Properties of Separately-Cast Test Bars

Base-plate No.	Temper	Chemical Comp., % Zn	Zr sol.	UTS, kpsi	0.2% YS, kpsi	El,% in 2 in.
C3-1	T6	5.97	0.80	43.2	32.8	5.0
C3-2X	T6	6.16	0.81	44.3	32.5	5.0
C3-3	T6	6.29	0.82	43.3	31.8	4.5
C3-4	T6	6.25	0.79	44.3	32.0	4.0
C3-5X	T6	6.40	0.81	45.9	32.7	8.5
C3-6	T6	6.17	0.81	45.9	32.4	8.0
C3-7	T6	6.50	0.81	45.5	34.3	8.0
C3-8	T6	6.42	0.84	45.7	33.2	8.0
C4-1	T6	6.35	0.82	45.5	32.8	8.0
C4-2X	T6	6.48	0.82	44.6	32.9	6.0
C4-3	T6	6.32	0.84	44.3	31.7	6.0
C4-4	T6	6.53	0.82	46.6	32.5	9.0
C4-5X	T6	6.04	0.76	45.3	32.8	9.0
C4-6	T6	6.24	0.77	46.3	33.7	9.0
C4-7	T6	6.01	0.79	46.0	33.3	8.5
C4-8	T6	6.12	0.80	45.6	32.7	8.0

TABLE 3

Permanent Set, Yield Strength and Breaking Load Values Obtained in Simulated Service Tests

Design	Base-plate No.	Type of Support	Load for 0.01% Perm.Set lb	Load for 0.03% Perm.Set lb	Load for 0.1% Perm.Set lb	Yield Strength lb	Breaking Load lb
A	KN	sand	-	-	-	-	303,500
	KO	4-pt	-	-	-	75,000	230,000
B	KP	4-pt	65,000	78,000	100,000	80,000	206,000
	KQ	sand	-	- -	-	-	295,000*
C	KR	4-pt	60,000	75,000	100,000	70,000	200,000
	KS	sand	-	-	-	-	247,000
D	KT	4-pt	-	-	-	75,000	190,000
	KU	4-pt	-	-	-	-	180,000
E	KV	4-pt	-	-	-	-	200,500
	KW	4-pt	55,000	70,000	95,000	70,000	168,000
F	KY	sand	-	-	-	-	289,000
	KX	4-pt	85,000	105,000	140,000	70,000	160,000**
F1	LN	4-pt	-	-	-	105,000	230,000

* No break (reached full capacity of machine).
** Leg chipped (no break)

NOTE: Loads for Permanent Sets determined from strain gauges located on the tension side of arms; Yield Strength determined from load-deflection measurements using dial gauge.

TABLE 4

Yield Strength and Breaking Load Values Obtained in Simulated Service Tests

Design	Baseplate No.	Type of Support	Yield Strength lb	Breaking Load lb
G	KZ	sand	-	297,000*
	LA	4-pt	85,000	164,000**
	LA	sand	-	381,000
G1	LG	4-pt	105,000	229,000
	LI	4-pt	90,000	220,000
G2	LO	4-pt	90,000	223,000
	LP	4-pt	105,000	222,500
H	LJ	sand	-	284,000
H1	LH	4-pt	105,000	224,000
	LR	4-pt	105,000	214,000

* No break (reached full capacity of machine).
** Leg chipped (no break), same plate subsequently loaded in sand.

NOTE: Yield Strength determined from load-deflection measurements using dial gauge.

TABLE 5

Yield Strength and Breaking Load Values Obtained in Simulated Service Tests

Baseplate No.	Type of Support	Yield Strength* lb	Breaking Load lb
C3-2X	4-pt	120,000	237,000
C3-5X	4-pt	120,000	237,000
C4-2X	4-pt	120,000	218,000
C4-5X	4-pt	120,000	194,000
C3-1	sand	-	212,000
C3-4	sand	-	250,000
C4-1	sand	-	245,000
C4-4**	sand	-	237,500
C4-6	sand	-	254,000
C4-14	sand	-	320,000
C4-17	sand	-	360,000

* As determined from load-deflection measurements using dial gauge.
** Initially subjected to firing tests.

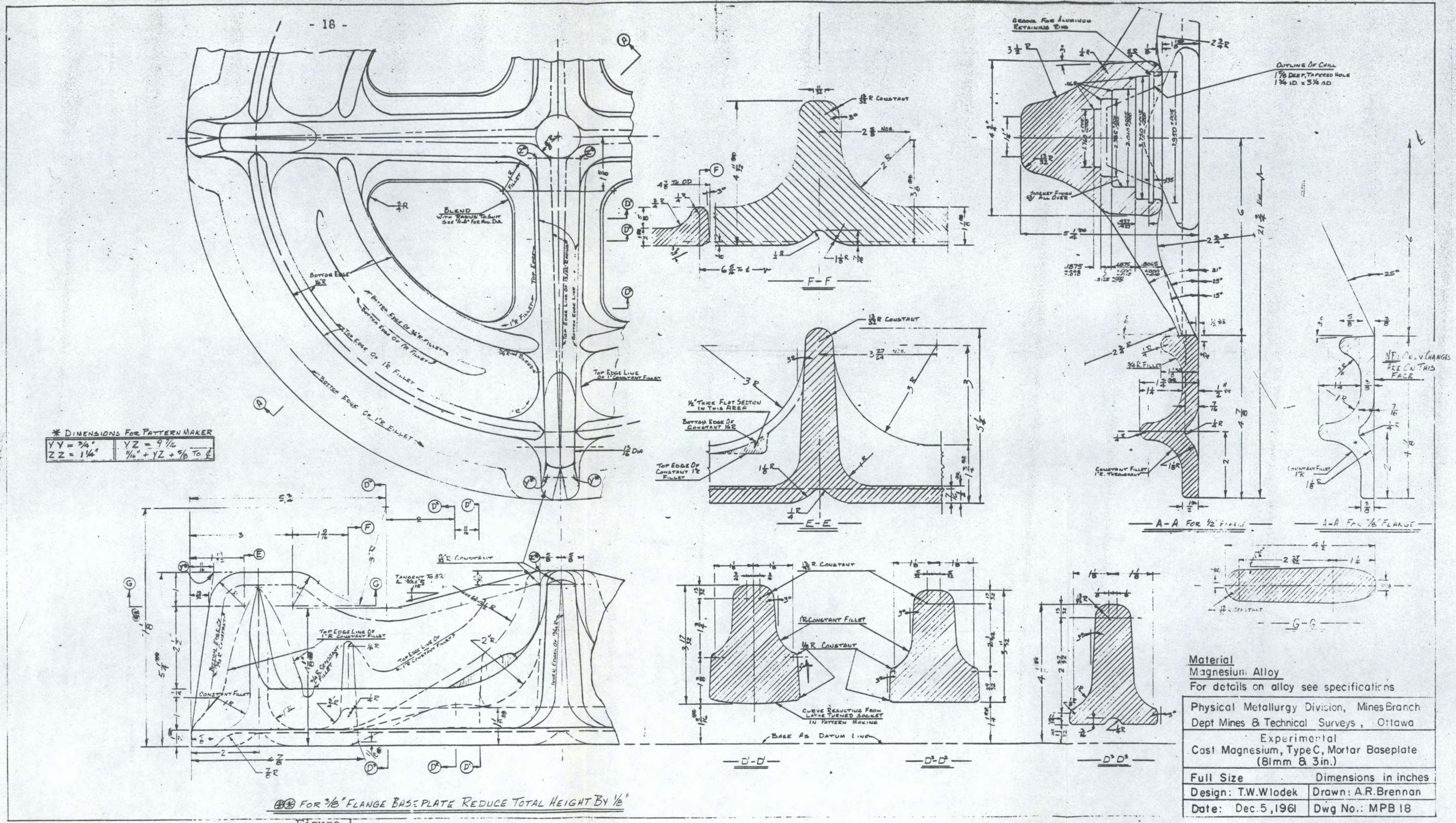

* DIMENSIONS FOR PATTERN MAKER
YY = 3/4"
YZ = 9 1/16
ZZ = 1 1/4"
11/16 + YZ + 5/8 To ℄
F-F
E-E
D'-D'
D²-D²
D³-D³
A-A FOR 1/2" FLANGE
G-G
BLEND WITH RADIUS TO SUIT SEE "A-A" FOR RAD. DIA.
GROOVE FOR ALUMINUM RETAINING RING
OUTLINE OF CHILL
1/2" THICK FLAT SECTION IN THIS AREA
BASE AS DATUM LINE
CURVE RESULTING FROM LATHE TURNED SOCKET IN PATTERN MAKING
** FOR 3/8" FLANGE BASEPLATE REDUCE TOTAL HEIGHT BY 1/8"
Material
Magnesium Alloy
For details on alloy see specifications
Physical Metallurgy Division, Mines Branch
Dept Mines & Technical Surveys, Ottawa
Experimental
Cast Magnesium, Type C, Mortar Baseplate
(81mm & 3in.)
Full Size
Dimensions in inches
Design: T.W.Wlodek
Drawn: A.R.Brennan
Date: Dec.5, 1961
Dwg No.: MPB 18

Figure 1.

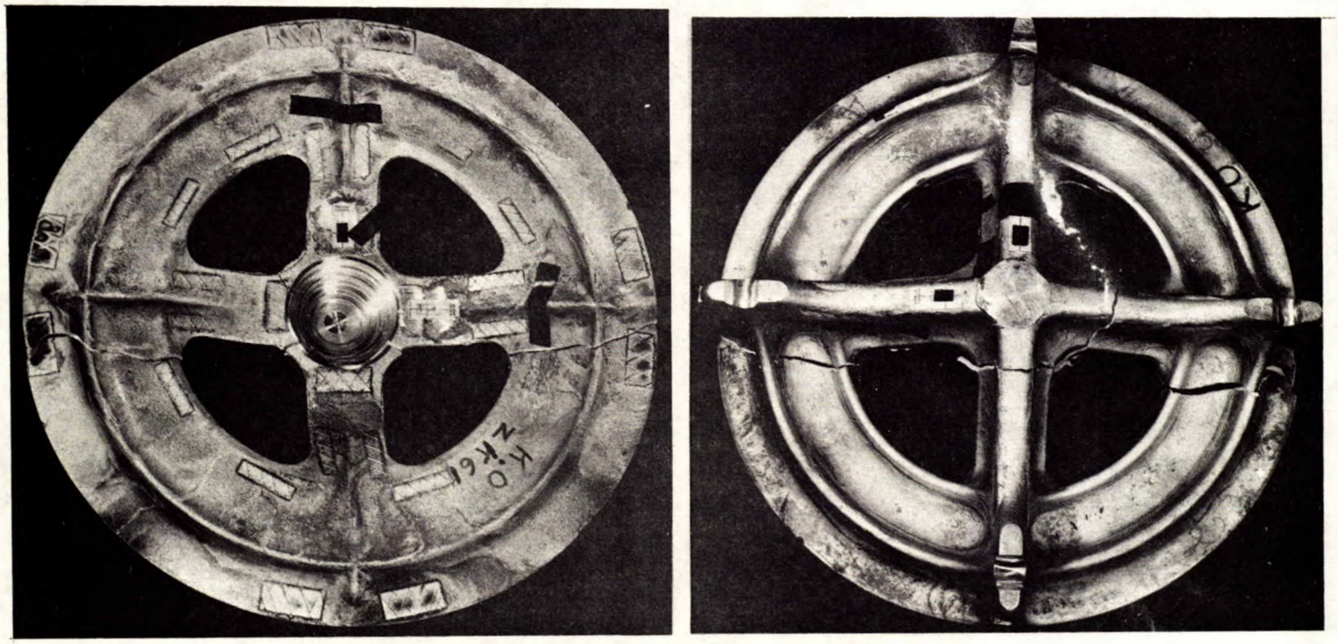


Figure 2 - Design "A" - Mode of fracture in 4-point-support test.

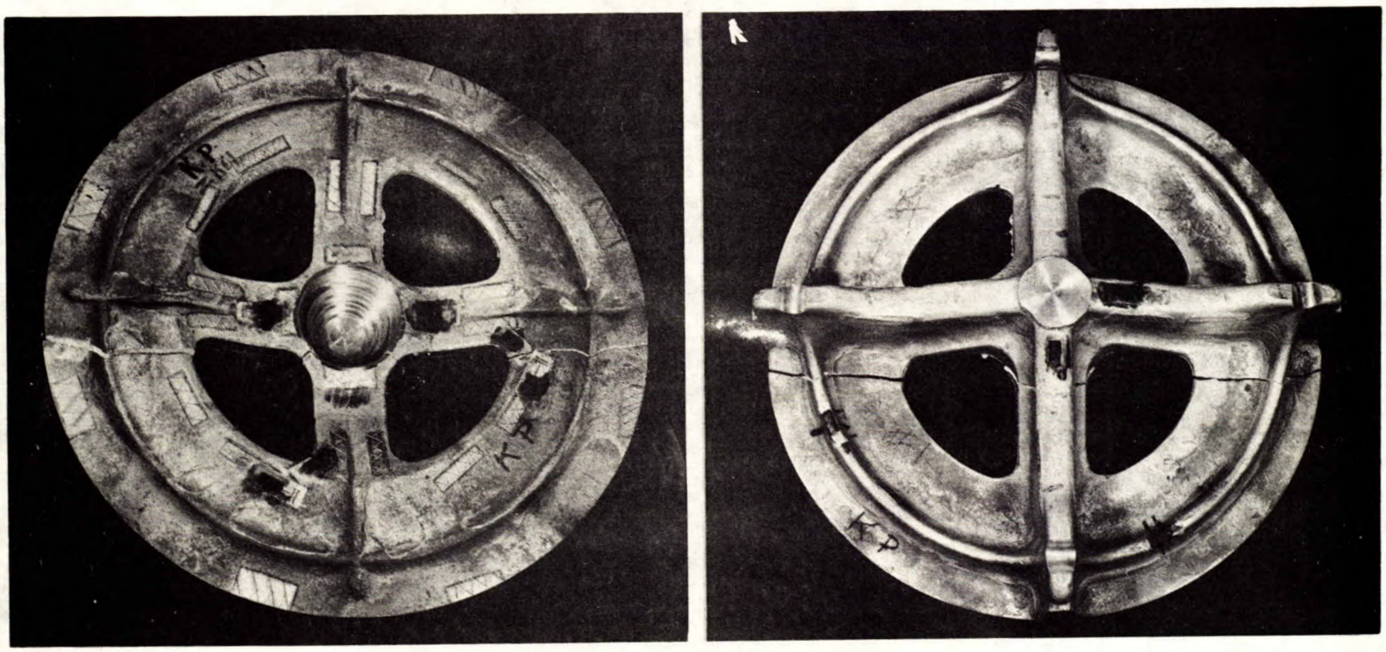


Figure 3. Design "B" - Mode of fracture in 4-point-support test.

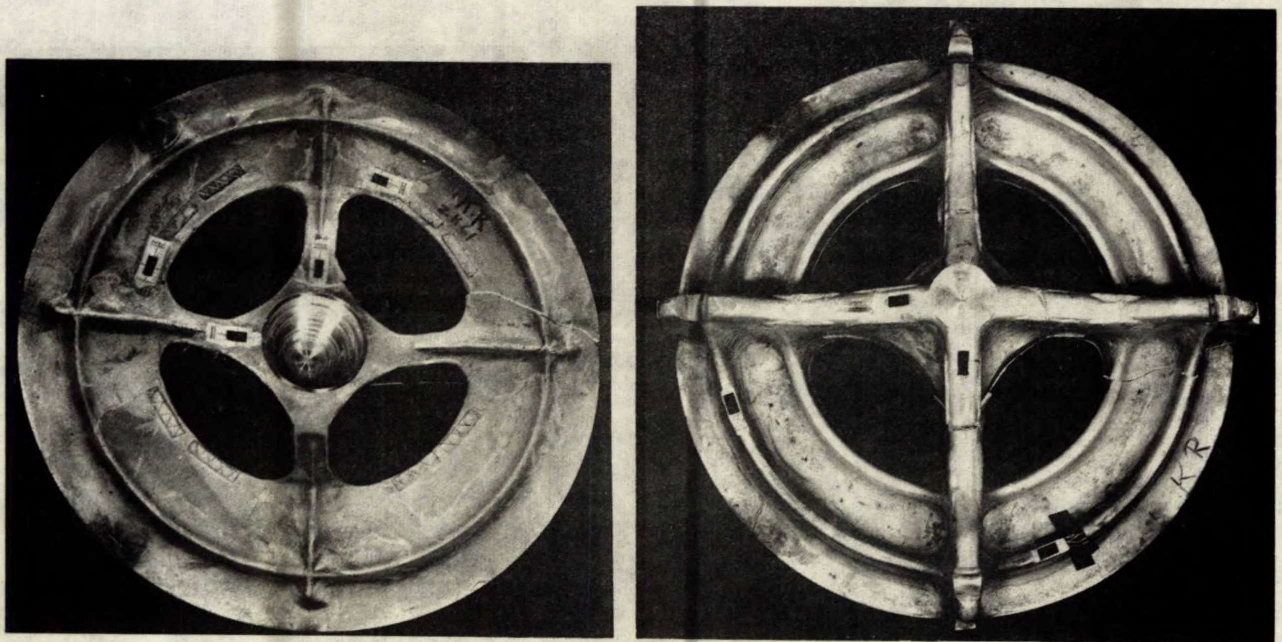


Figure 4. Design "C" - Mode of fracture in 4-point-support test.

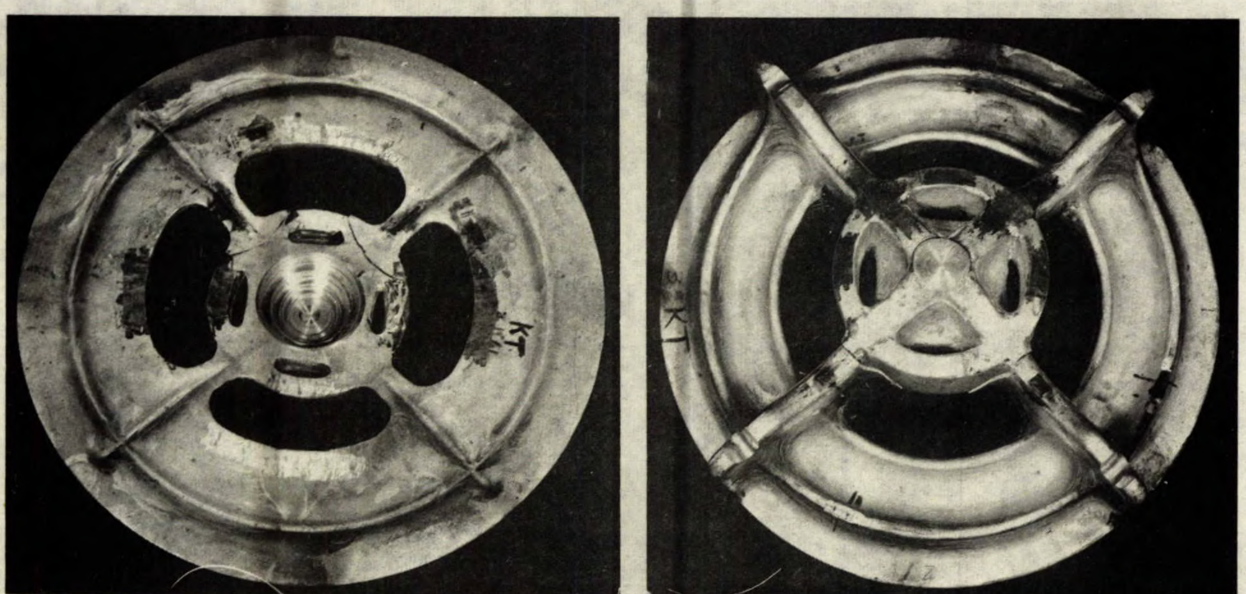


Figure 5. Design "D" - Mode of fracture in 4-point-support test.

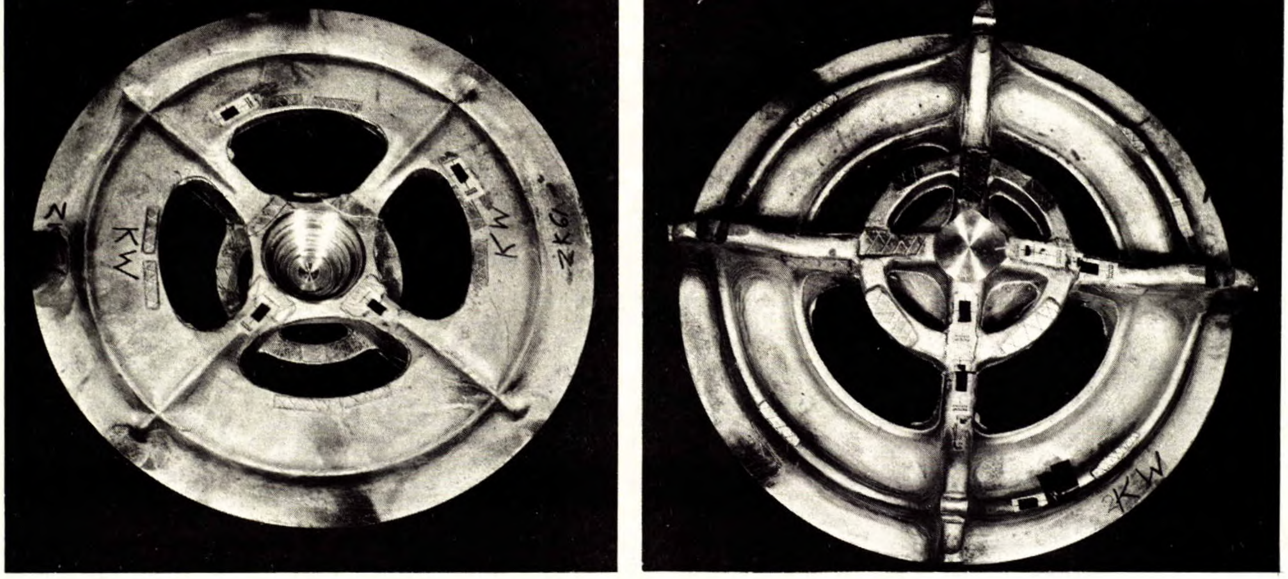


Figure 6. Design "E" - Mode of fracture in 4-point-support test.

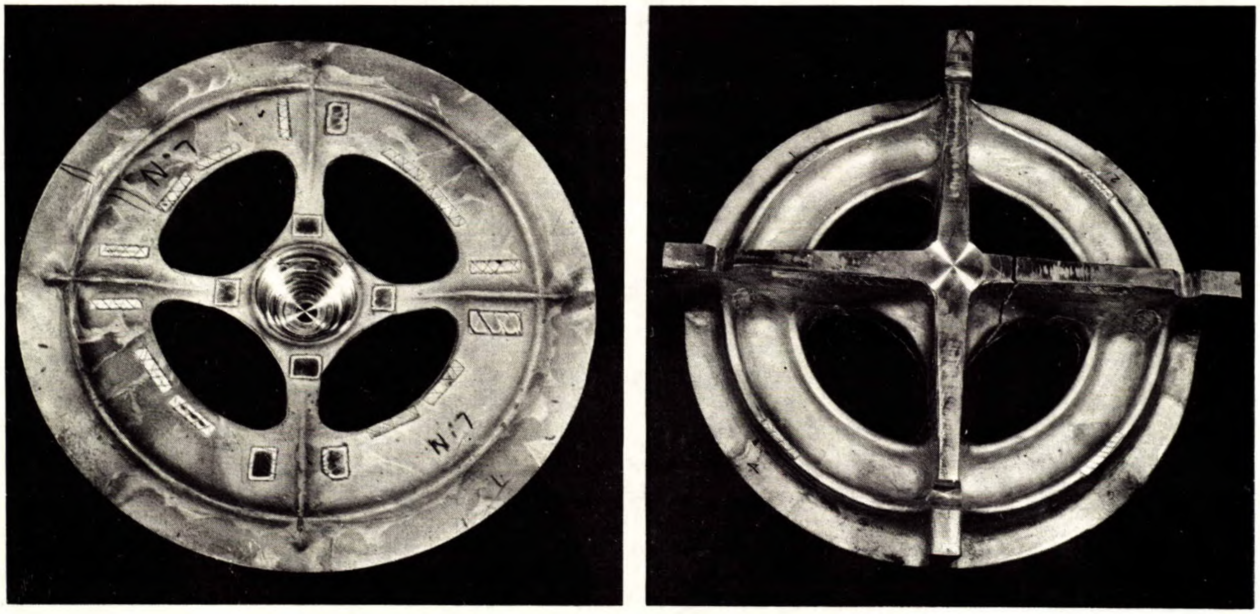


Figure 8. Design "F" - Mode of fracture in 4-point-support test.

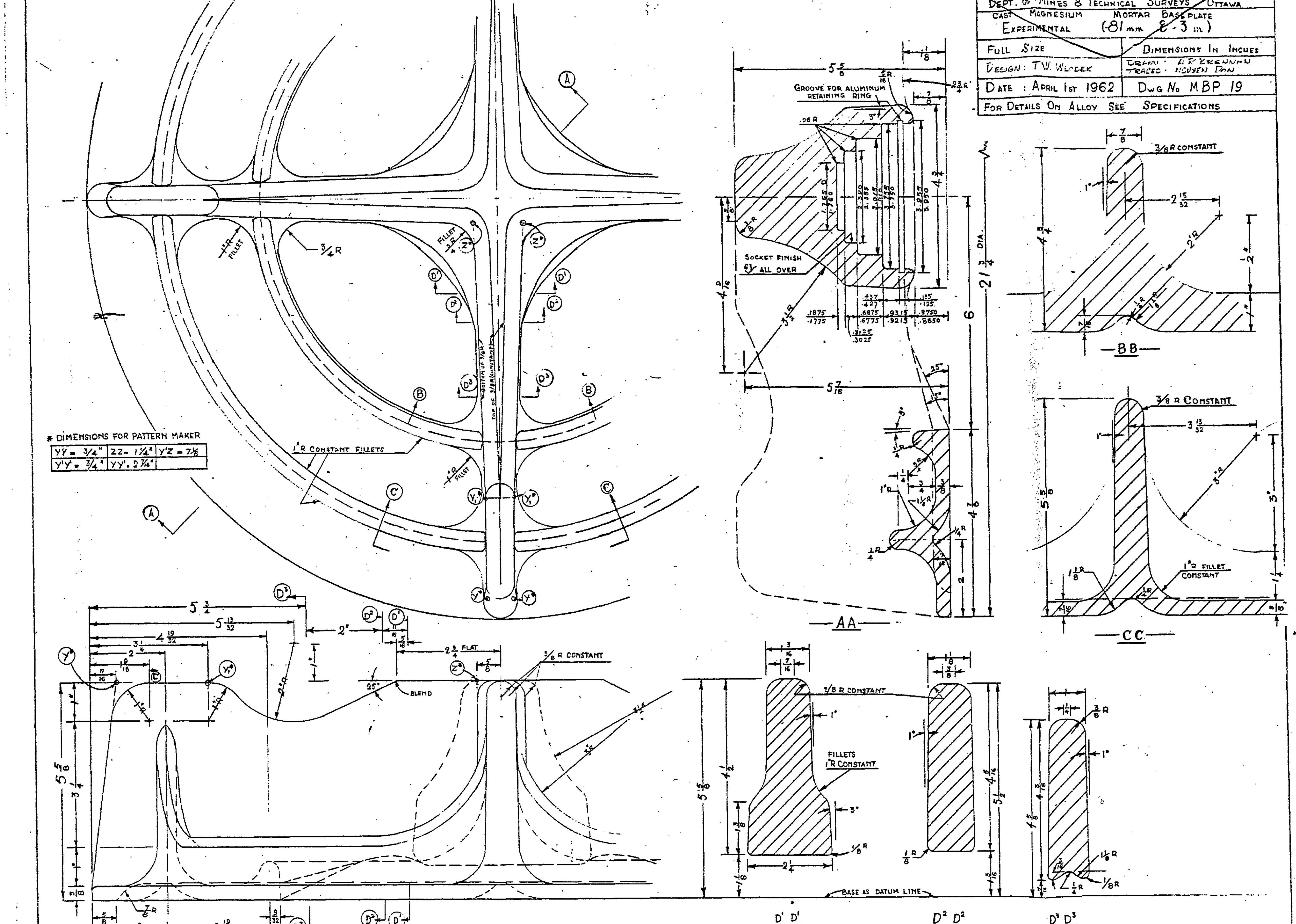

PHYSICAL METALLURGY DIVISION MINES BRANCH
DEPT. OF MINES & TECHNICAL SURVEYS OTTAWA
CAST MAGNESIUM MORTAR BASEPLATE
EXPERIMENTAL (81 mm & 3 in)
FULL SIZE
DIMENSIONS IN INCHES
DESIGN: T.W. WLODEK
DATE: APRIL 1st 1962
DWG No MBP 19
FOR DETAILS ON ALLOY SEE SPECIFICATIONS
* DIMENSIONS FOR PATTERN MAKER
YY' = 3/4" ZZ - 1 1/4" Y'Z = 7 1/8
Y'Y' = 3/4" YY' = 2 7/16"
1" R CONSTANT FILLETS
GROOVE FOR ALUMINUM RETAINING RING
SOCKET FINISH 63 ALL OVER
3/8 R CONSTANT
1" R FILLET CONSTANT
FILLETS 1" R CONSTANT
BASE AS DATUM LINE
2 3/4 FLAT
BLEND
AA
BB
CC
D' D'
D² D²
D³ D³

Figure 7.

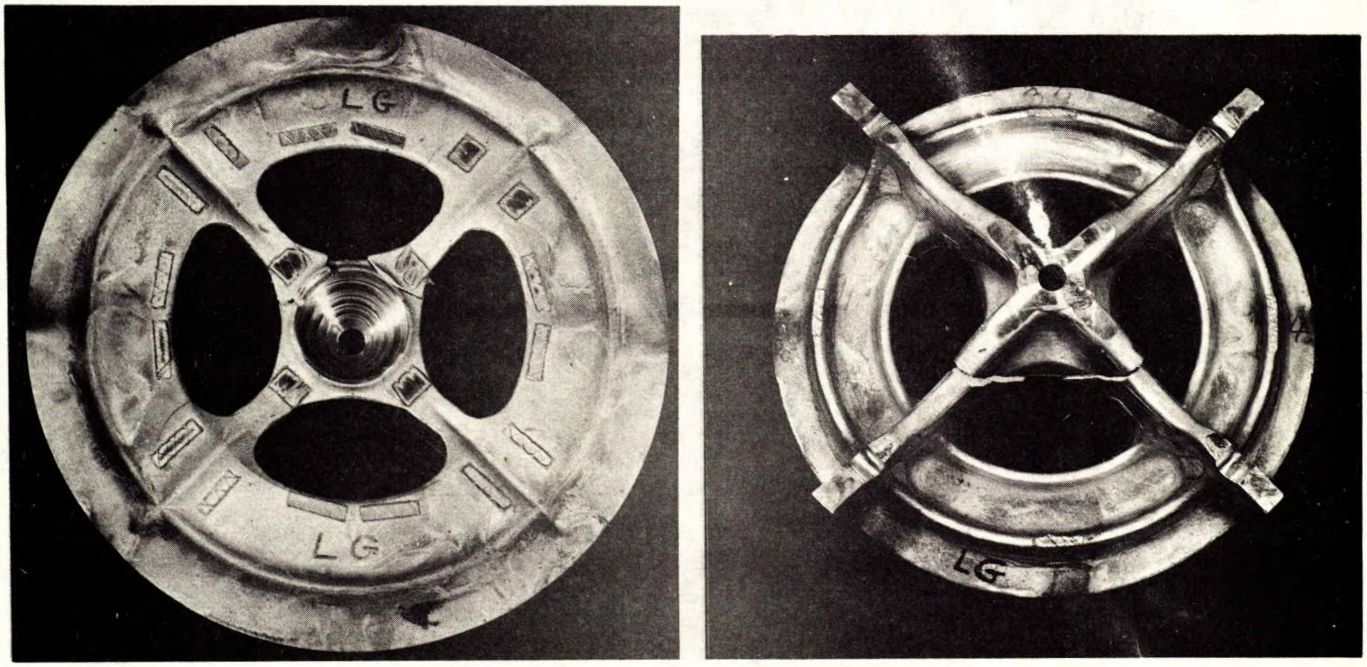


Figure 9. Design "G" - Mode of fracture in 4-point-support test.

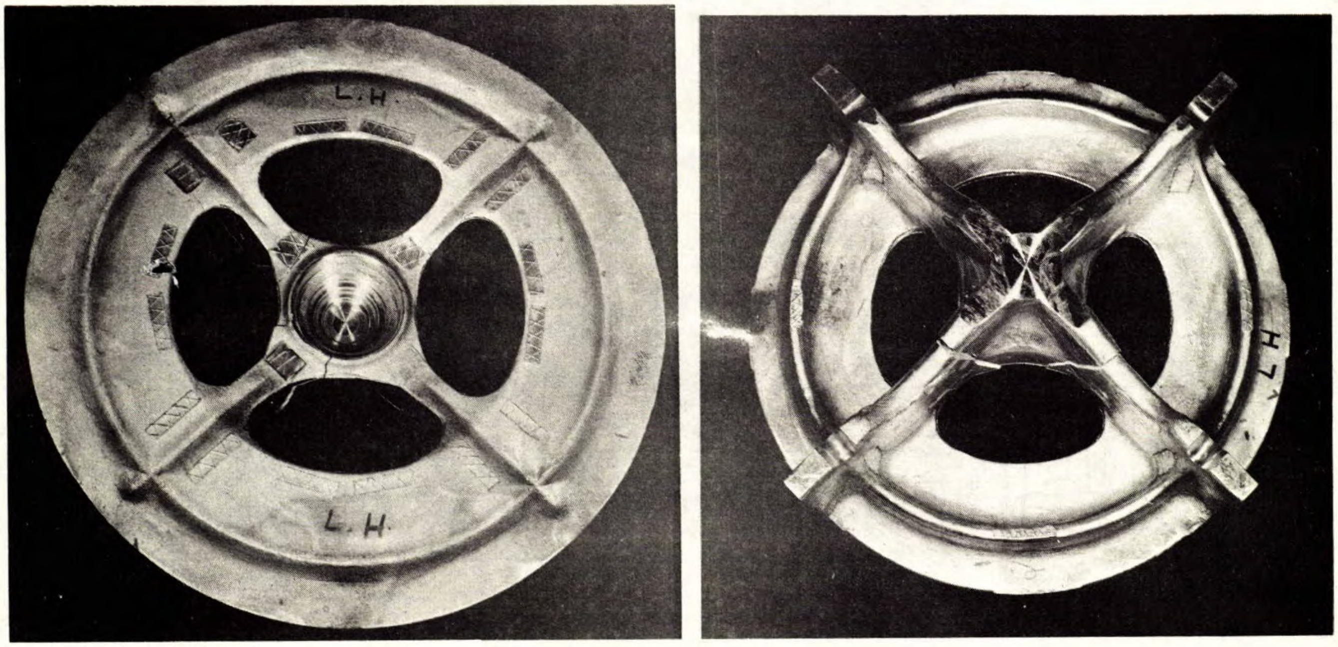
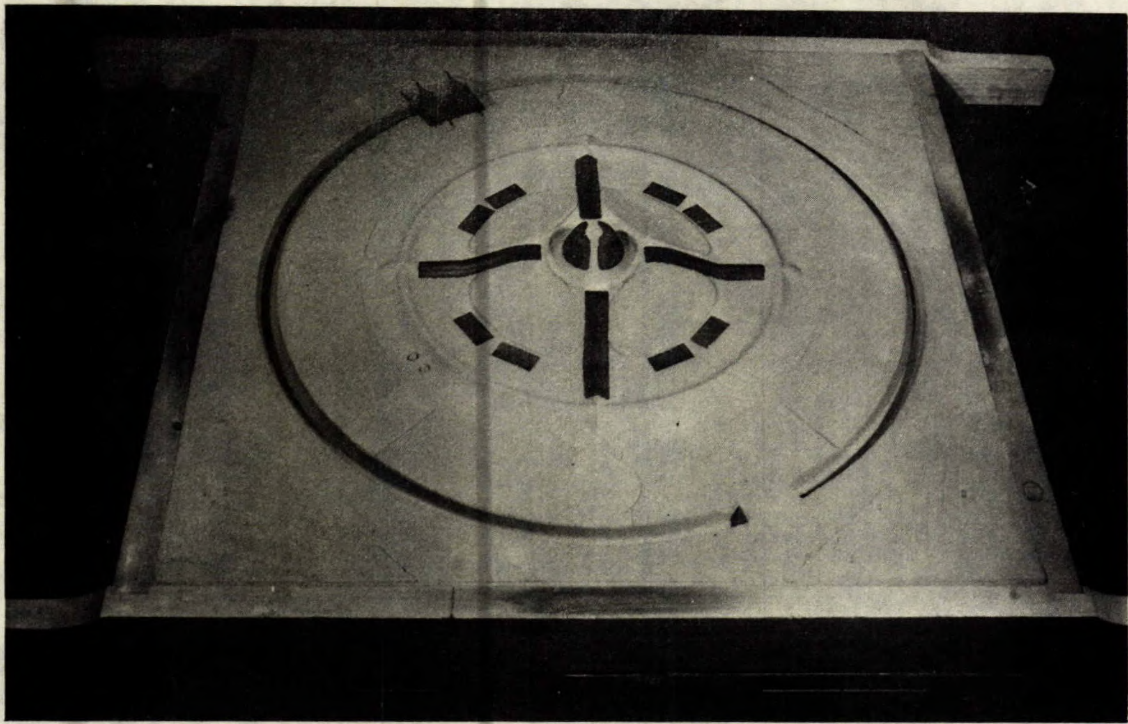


Figure 10. Design "H" - Mode of fracture in 4-point-support test.



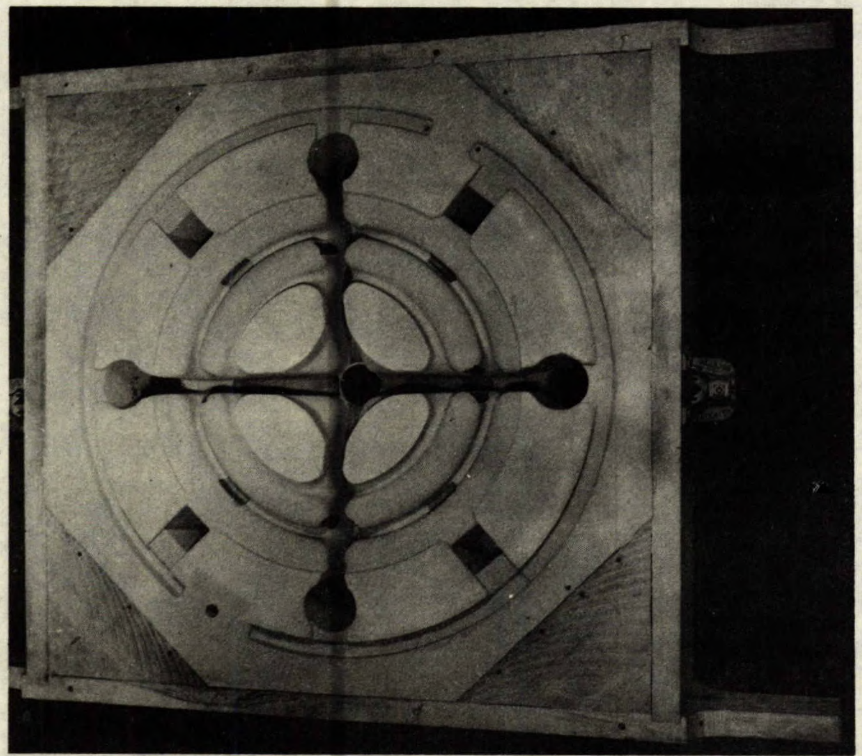


Figure 11. Moulding arrangement for casting design "C3" showing location of gates, risers, chills, etc.

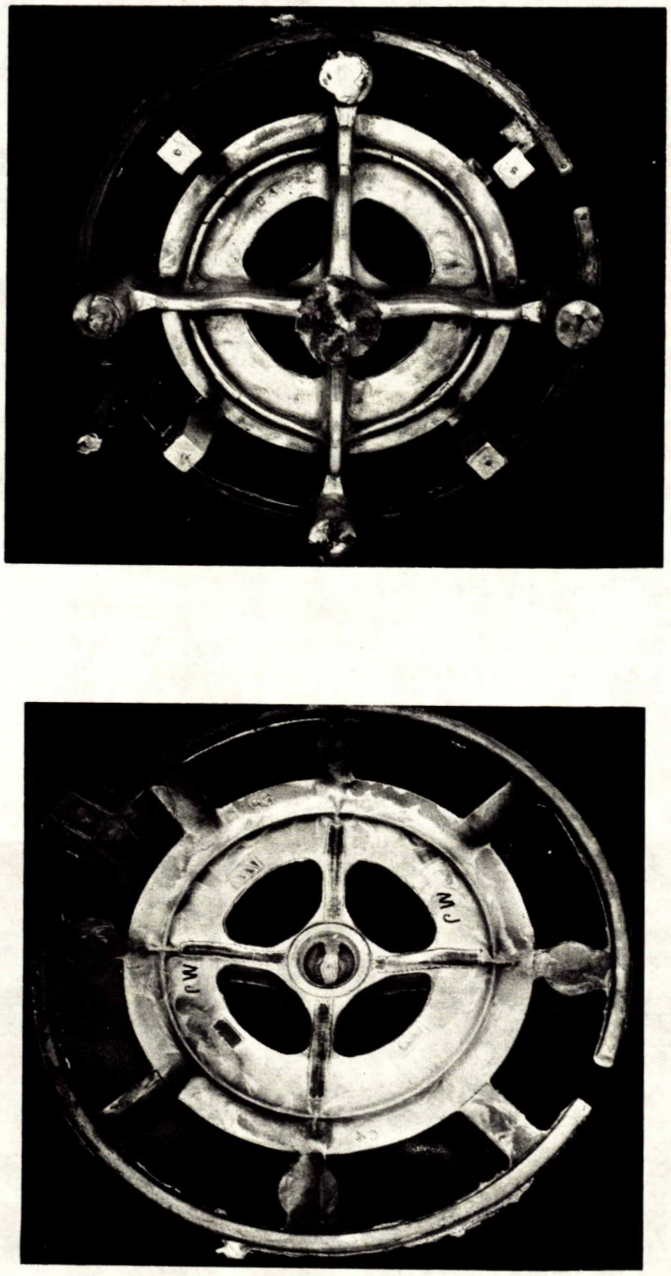


Figure 12. Casting to design "C4" with attached gating and risers (before trimming).

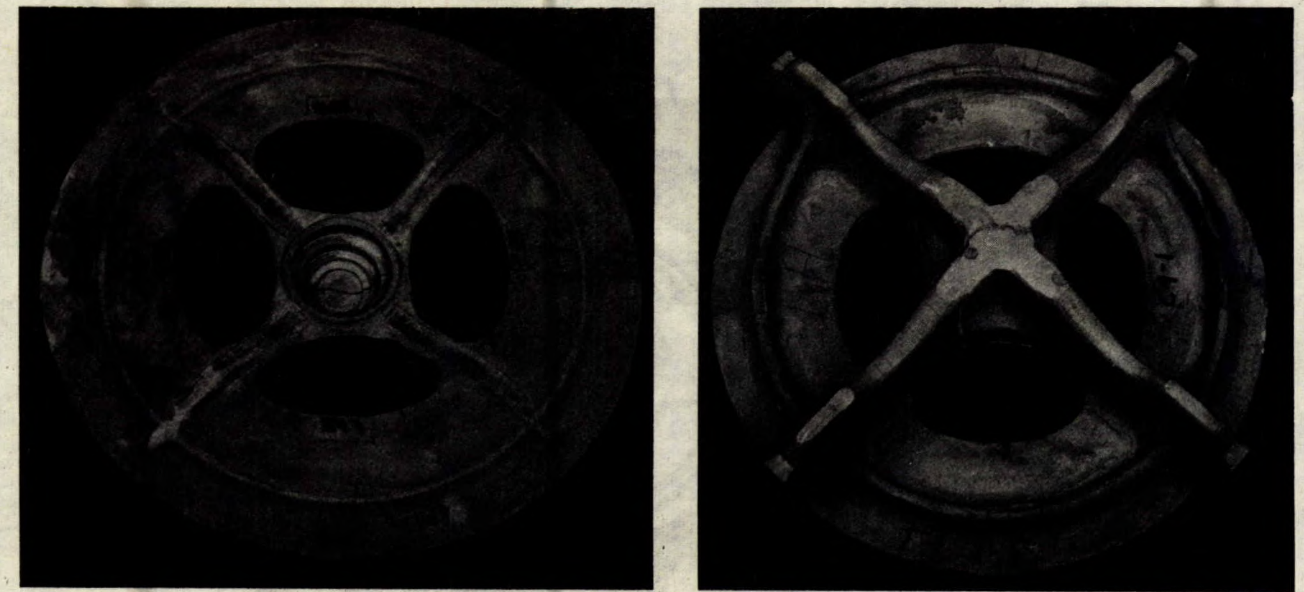


Figure 13. Typical fracture of all castings of C3 and C4 designs in static load breakdown tests.

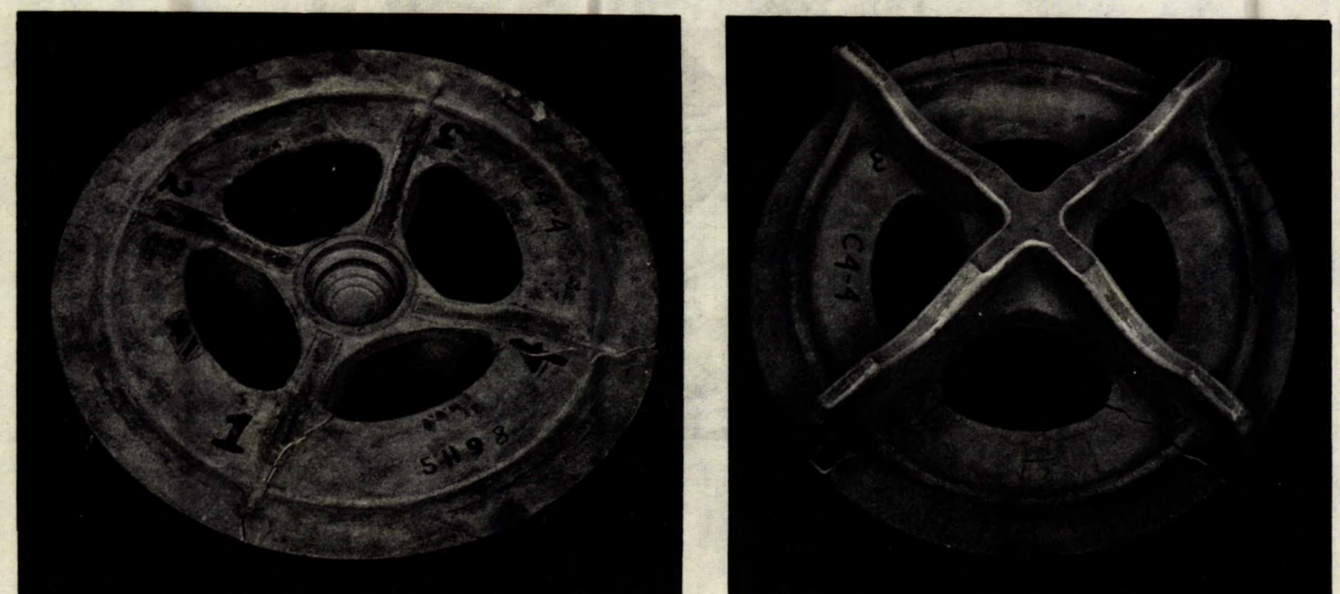


Figure 14. Mode of fracture with improved soundness in socket.

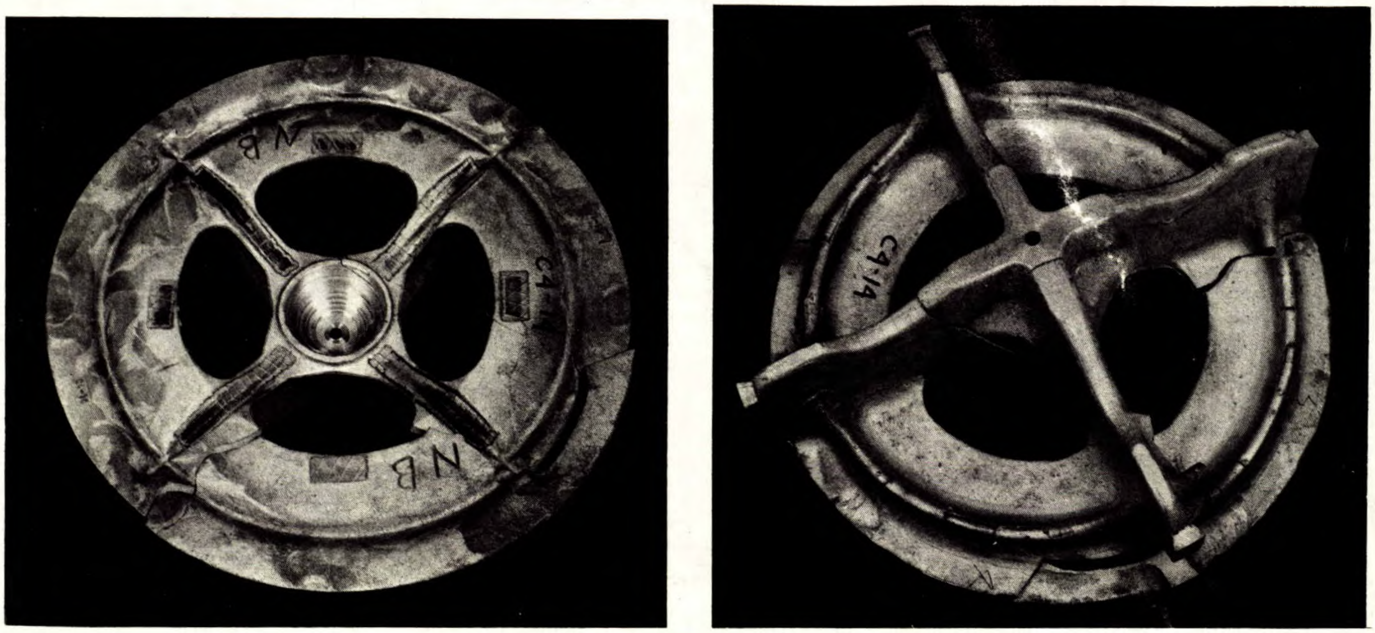


Figure 15. Fracture of casting of C4 design due to unsoundness in reinforcing rib (tested in sand).

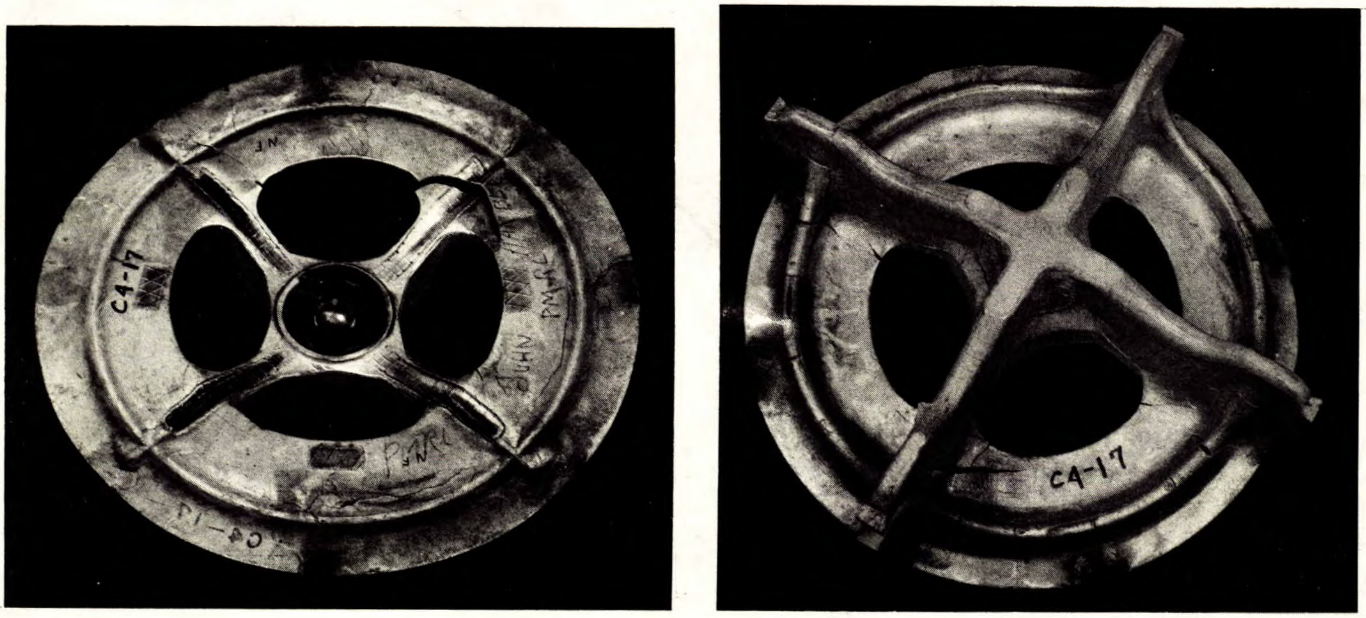


Figure 16. Mode of fracture with satisfactory soundness in both the socket area and the reinforcing rib.

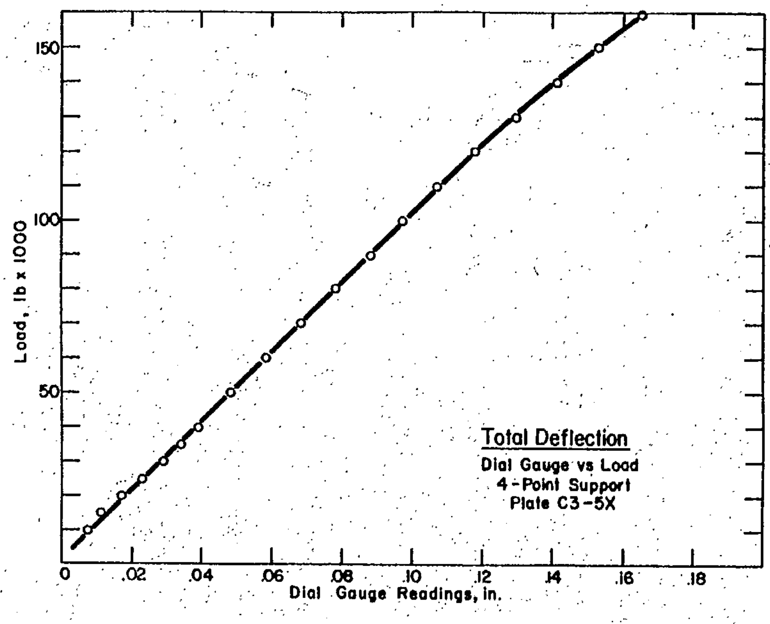


Figure 17. Deflection diagram, representative of lot C3.

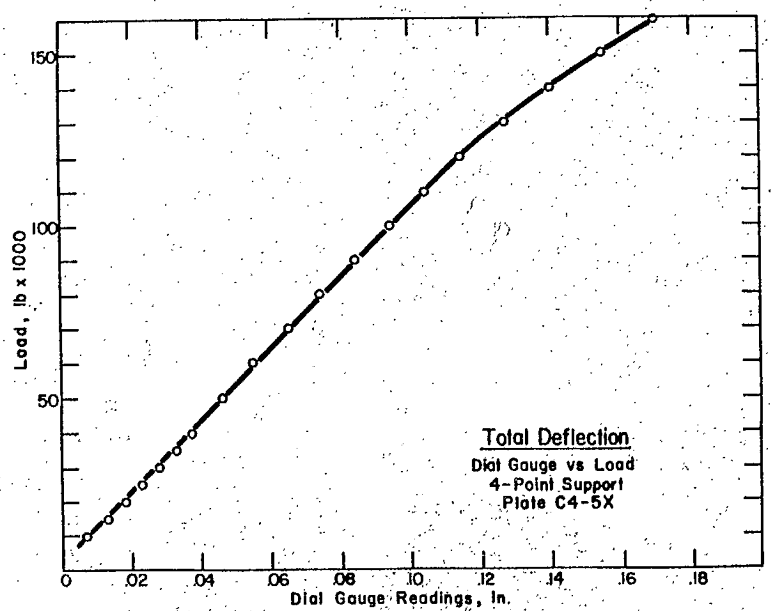


Figure 18. Deflection diagram, representative of lot C4.

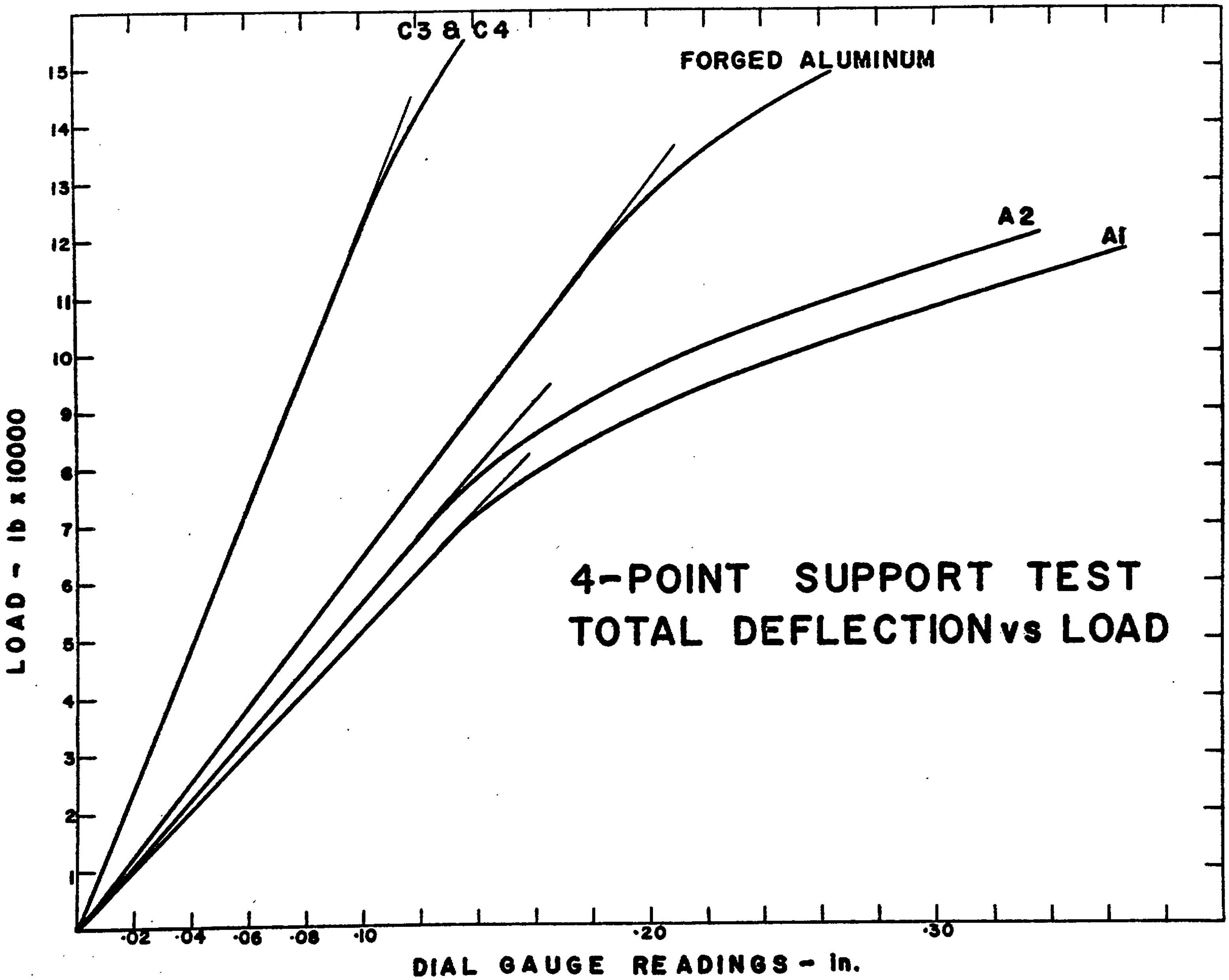


Figure 19. Total deflection vs load in 4-point-support test.