PROBLEMS INVOLVED IN ESTABLISHING A NEW FOUNDRY IN THE NEW ENGLAND AREA

by

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Signatures of Authors

Certified by

111 Bay State Road
Boston 15, Massachusetts
May 6, 1952

Professor Joseph S. Newell
Secretary of the Faculty
Massachusetts Institute of Technology
Cambridge 39, Massachusetts

Dear Professor Newell:

In accordance with the requirements for graduation, we herewith submit a thesis entitled "Problems Involved in Establishing a New Foundry in the New England Area".

We would like to express our appreciation for the assistance rendered by Professor William E. Ritchie, Professor Howard F. Taylor and the librarians of Dewey and Lindgren libraries.

Sincerely,

George M. Shields, Jr.

Edward W. Neumann, Jr.

Assumptions and Limitations

The basic premise behind this study is the establishment of a new foundry in New England. Our approach consisted of two parts -- one, investigation to determine what type of foundry by type of metal and casting method was best suited, that is, had the best potential and showed the most promise, for the establishment of a new unit and, two, the carrying out of all the preliminary planning necessary to establish this unit.

Due to the limitations of time and material available our first section referred to as the Market Analysis might leave something to be desired. This something is an actual analytic study of all the industries using castings with past histories of their use of castings and a possible extrapolation of their future demand for castings. This is needed, ideally, because the foundry market is a derived demand market, that is, is dependent on activity in another industry or industries.

Obviously this study was beyond the scope of our efforts, but equally obviously some sort of study had to be made to determine demand. We chose to do this by studying past records on shipments, production, orders, geographic distribution, type distribution, and size distribution for the foundry industry as such. Using these facts and reliable opinion on the future outlook of each category of foundry we hoped to arrive at a conclusion which would be almost as well, if not just as well grounded, as one based on the complete analysis previously mentioned.

In setting up the actual foundry -- its size, operations, and organization -- we operated on the premise that the entrepreneurs who set up the unit would be two M. I. T. graduates -- one man with considerable metallurgical background, the other with considerable business background and some metallurgical background. Thus they would between them be able to handle most of the administrative and supervisory work. The size, systems, and methods of this foundry are geared to the resources, capacities, and abilities of these two hypothetical men.

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MARKET ANALYSIS

Introduction to Market Analysis

Due to the lack of certain specific data on the New England area as unit, available data on the foundary industry in the United States was examined in order to compare statistics for the New England area with those of the country as a whole. In the course of this study it was apparent that, although the foundry industry of New England did not dominate the national statistics, it seemed to be a closely representative portion of the industry in the entire United States.

To answer the question, "Is the foundry industry in New England representative of the foundry industry in the United States to the extent that statistics for the United States can be used as indications of or substitutes for statistics and trends in New England?", we have set up the three tables which follow this discussion. These tables give a comparison of selected statistics which were available for both the New England area and the entire United States and which were thought to be of the type which, if compatible, would give good basis to assume that the entire industry was compatible in both breakdowns.

Table I shows that on a percentage basis the distribution of foundries according to number of employees correlated very well in the four classes below 500 employees. In the two classes above 500 employees New England has a lower percentage than does the United States as a whole. Since most of the classes correlate so closely, it is reasonable to say that these facts prove correlation with the provision that we must make allowance for absence of large foundries in New England.

Table II shows that, based on the ratio of the number of New England foundries melting a particular type of metal to the number of United States foundries melting the same type of metal and on a comparison of the ratios of number of foundries melting each type of metal for the United States and New England, there is a greater concentration of malleable, brass and bronze, and magnesium foundries in New England than the ratio of total number of foundries in New England to the total number of foundries in the United States would indicate a representative area should have. Similar analysis shows that there is a smaller concentration of steel foundries in New England.

While Table III actually shows the customer distribution pattern for gray iron castings by percentage of total product sold to each type of industry, essentially it also gives the relative distribution of these industries in New England as compared with the country as a whole since we can reasonably assume that a particular industry would take the same percentage regardless of where it is located.

Used in this way, Table III shows that, on the average, the distribution of industry among the categories listed in the table in New England is representative of the distribution of industry among these same categories in the United States with the exceptions that New England has a greater concentration on machine tool industries and shipbuilding industries and a lesser concentration of steel industries, diesel and auto engine industries, and railroad industries.

Because of these correlations, it was believed permissable to use foundry industry statistics for the entire nation as indicative of the situation in New England in case specific data for the area was not available. Of course, when the data was further classified by geographical divisions and states, it was broken down accordingly in order to provide a more specific analysis. When sources of data which were not completely comprehensive had to be consulted for certain desired types of statistical information the analysis used to classify this information is presented in the text.

TABLE I

Distribution of Foundries, United States and New England by Number of Employees

No. of Employees	United States		New England	
	No. of Foundries	% of total	No.	% of Total
Over 1000	45	0.8%	0	0
500 - 999	110	2.0%	3	.6%
100 - 499	914	17.4%	68	14.4%
50 - 99	773	14.3%	62	13.1%
20 - 49	1,231	22.7%	124	26.2%
20	2,331	43.2%	217	45.7%
Total	5,404	100.0%	477	100.0%

Source: <u>Foundry Industry Data Book 1949-1950</u>

TABLE II

Distribution of Foundries, United States and New England
by Type of Metal Cast

Type of Metal	United States		New England		
	No.	% of Total	No.	% of Total	% of U.S.
Gray Iron	2,919	53.7%	241	50.5%	8.30%
Steel	367	6.8	18	3.8	4.90
Malleable	138	2.5	17	3.6	12.30
Aluminum	2,750	50.8	254	53.0	9.25
Brass and Bronze	2,538	46.9	273	57.0	10.80
Magnesium	145	2.7	19	4.0	13.10
Total Nonferrous	3,215	59.5	306	64.0	9.55
All Foundries	5,404	100.0%	477	100.0%	8.82%

Source: Foundry Industry Data Book 1949-1950

TABLE III

Geographic Customer Distribution Pattern for Gray Iron Castings

Consuming Industry	U.S. % Consumption	N.E. % Consumption
Machine Tools	30.2%	54.8%
Diesel and Auto Engines	13.7	0.5
Aircraft and Ordinance	6.4	5.0
General Machinery	6.1	4.7
Steel	6.0	-
Building and Construction	4.5	4.2
Shipbuilding	4.2	8.5
Utilities	3.9	2.2
Railroads	3.8	0.5
Electrical	3.7	1.5
Chemical & Ceramics	2.1	1.0
All others	15.4	17.3
	100.0%	100.0%

Source: Study by the Gray Iron Founder's Society made early in World War II

The foundry industry has had a long and basic role in the manufacturing scheme that is not likely to be drastically affected by industrial changes in the near future. The markets for foundry products among the various industries may become more widely distributed than at present, however, castings are already used in a great many manufacturing industries, especially in equipment used for manufacture. Therefore, any increase in markets of castings will probably come from replacement of other materials and of other processing methods, rather than from seeking markets in industries which do not now use castings.

This fact that the foundry market is already so broad, limits the market study needed to determine a potential market for various types of castings to a survey of the demands of the presently existing consumers of castings. This we have attempted to do in the following Market Analysis section by first dividing the entire foundry industry into smaller classifications according to type of metal case. Since some division was needed to separate the data into sufficiently small compartments to facilitate uncluttered analysis, this division was chosen as most logical because it facilitated the next step in our study -- that of deciding which type of foundry had the most promising outlook for the establishment of a new unit.

Where possible the facts and analysis of the market for each type of metal case have been presented in accordance with the following general outline:

I. General Industry Information

A. Characteristics of the Metal

B. Consuming Industries

II. Statistics on Existing Foundries

A. Number of Firms

B. Size Characteristics

C. Geographical Distribution

III. Shipments and Orders in Recent Years

IV. General Comment

V. Analysis

After all the classifications have been analyzed separately, the evaluation and decision as to which type has the most favorable outlook for the establishment of a new firm was made, using the results of the separate analyses to answer the following questions:

What type of foundry has the best potential?

Volume of present production?

Is a large present production good?

Is a small present production good?

What is potential market?

How do you estimate it?

Competition?

Is it good, bad, tough, easy?

Well established?

What is the average size of the competition?

How does this affect new foundry?

Is it better to compete in a field of small plants or large plants?

At what rate has the industry been expanding recently?

Market?

Where are consumers located? Is this very important?

What do consumers want? What do they need?

What is the future demand?

Is use of castings in general, and of each type, increasing or decreasing?

How is production of primary metal planned for future?

Status of Art and Future of Art?

Does the art at present incorporate recent developments?

Are new methods of casting, equipment, etc., in the process of development?

Have any new methods of casting, types of equipment, and uses for castings been developed recently?

Gray Iron

Gray iron castings are defined as ferrous or ferrous-base castings other than steel or malleable iron castings. Gray iron castings are produced for sale commercially on the open market and by manufacturers in "captive foundries" for use in their own finished products. Nearly every manufacturing industry uses gray iron castings. However, the twelve leading consuming industries are: Machine Tools; Motor Vehicles and Parts; Tractors; Internal Combustion Engines; Farm Machinery; Motors and Generators; Pumps and Compressors; Valves and Fittings; Railroad and Street Cars; Construction and Mining Machinery; Metal Working Machinery; Special Industrial Machinery.

There were approximately 2920 gray iron foundries in the United States in 1950; 1550 of which were strictly jobbing foundries, which sell gray iron castings commercially; 560 of which were exclusively captive foundries, which produce gray iron castings for use in their own finished products; 870 of which produced castings both for their own use and for sale to the trade.[1] There were 1254 gray iron foundries in 1939; 1654 gray iron foundries in 1947.

The Gray Iron Founders' Society, Inc., estimates that

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1. The Foundry Industry Data Book 1949-1950, Cleveland: Penton Publishing Company, 1950, p. 1.

45% of all gray iron castings are normally produced by manufacturers for use in own products, and 55% are produced for sale in the open market.

There are three broad classifications of foundry operation in this industry, which cover both the commercial foundries and the captive foundries. The Gray Iron Founders' Society reports the following distribution of these classifications from a study made recently:

	No. of Foundries	% of Total
Jobbing - Non Mechanized	204	46.3%
Jobbing - Mechanized	42	9.5
Semi-Production - Non Mech.	58	13.2
Semi-Production - Mech.	29	6.6
Production (Captive) - Non Mechanized	61	13.7
Production (Captive) - Mechanized	47	10.7
	441	100.0%

There are few large units or groups of units in the industry. In 1941 about half of the gray iron foundries had 8% of the total sales in the industry, which indicates the small size of a large percentage of the foundries. Also in 1941, about 5% of the foundries had about a third of the total sales. In between these two extremes, about 45% of the foundries accounted for the remaining 57% of total annual casting's sales. It is apparent that this industry is to a large extent composed of small and medium-sized units.

The following table shows the tonnage of gray iron castings produced for sale and ordered from 1948 to 1951:

Year	Produced for Sale -Tons	Order for Sale-Tons	Unfilled Orders for Sale-Tons
1948	7,131,405	38,310,687	31,179,282
1949	5,517,527	5,517,527	----------
1950	6,880,352	6,880,352	----------
1951*	6,482,696*	26,717,558*	20,234,862*

* First nine months only.

Source: Bureau of Census

On the basis of number of the number of employees in gray iron foundries in the United States as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

1.0% of the foundries have over 1,000 employees

2.4% of the foundries have between 500-999 employees

21.8% of the foundries have between 100-499 employees

20.5% of the foundries have between 50-99 employees

26.4% of the foundries have between 20-49 employees

27.9% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 241 or 8.30% of the total of 2919 gray iron foundries in the United States were located in New England during that period of 1949-1950.

The following table shows the tonnage of gray iron castings shipped from 1943 through December, 1951:

Year	Shipments of Gray Iron Castings-Tons
1943	9,217,800
1944	9,794,541
1945	9,578,295
1946	10,269,657
1947	12,540,960
1948	12,785,909
1949	10,549,284
1950	12,905,562
1951	14,986,882

Source: Bureau of Cencus, Facts for Industry

The shipment of nearly 15 million tons of gray iron castings in 1951 is indicative of the fact that gray iron components are in wide demand as the nation tools up for defense.

"Castings for machine tools, trucks, internal combustion engines, farm machinery, etc., are keeping pace with the production of companion materials required for this equipment. The industry has nearly a two months backlog of unfilled orders at the present time. However, the rate of production can be quickly accelerated in greater emergency if ample supplies of raw materials are provided and if the industry's manpower is not depleted through loss to armed services, to other industries, or by lack of business due to the curtailment of production."[1] This would seem to indicate that the gray iron foundries are not producing up to capacity at present.

The fact that gray iron castings are used in such a great variety of industries insures a wide market regardless of defense situation and consumer vagaries. The fact that the machine tool industry is one of the industries which is more concentrated in New England and is also the most important industrial market for gray iron castings makes New England look like a good area for a gray iron foundry if any area is good, even though lesser industrial markets such as the internal combustion engine industry and the railroad industry are in small concentration in New England.

The countrywide expansion from 1254 gray iron foundries in 1939 to 1654 gray iron foundries in 1947 to 2920 gray iron foundries in 1950 shows a favorable trend and it also along with practically unchanged shipments from 1947 to 1950 indicates that the business is either tending toward small units or has excess capacity.

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1. Facts About the Gray Iron Foundry Industry, prepared by Gray Iron Founders' Society, Inc., Cleveland, March 3, 1952.

Since approximately half of the gray iron foundries in the United States are jobbing foundries there is some indication of industry expanding vertically, thus tending to eliminate some of the market for the independents, but this tendency is not great enough to be alarming. It appears there will be demand for independent products for some time at least.

The fact that 82% of the jobbing foundries are non-mechanized indicates possible inefficiency which might lead to a competitive advantage for a mechanized newcomer. Since the foundry industry is definitely a competitive industry depending greatly on price, this could be a big factor.

Although the figures on tonnage shipments show a somewhat steady increase, this increase appears to be nothing more than normal in light of overall industrial expansion. The gray iron industry thus appears as an old established industry with years of experience whose potential is not too impressive for the newcomer if he foresees great expansion as one of his goals.

Steel

Steel castings may be defined as castings made from an alloy which is primarily iron and carbon with possible slight additions of silicon, manganese, or molybdenum. This alloy is usually malleable as cast. The maximum carbon content of this alloy is around 1.7 per cent. The classes of commercial steel castings may be listed as follows:

1. Low-carbon steels (less than 0.20% carbon)
2. Medium-carbon steels (0.20% to 0.50% carbon)
3. High-carbon steels (above 0.50% carbon)
4. Low-alloy steels (less than 8.0% alloy content)
5. High-alloy steels (above 8.0% alloy content)

Nearly every manufacturing industry uses steel castings of some variety.

Steel castings are used in a great many industries, in fact, almost any industry which produces large machinery of any type has some use for steel castings. However, the most important industrial markets for steel castings are Railroads, Industrial Machinery, Farm Machinery, Motor Vehicles and Parts, and Structural Components.

There were 367 steel foundries in the United States in 1950.[1] There were 204 steel foundries in the United States in 1947; 164 steel foundries in the United States in 1939.[2]

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1. The Foundry Industry Data Book 1949-1950, Cleveland: Penton Publishing Company, 1950, p. 1.

2. Bureau of Census, Facts for Industry.

As shown by the following table the steel foundry industry consists of units of all sizes. However, the predominant size with respect to number of employees is the 100-499 employee range. 61.5% of the foundries employ over 100 people. It is apparent that this industry is largely made up of medium and large-sized units.

On the basis of number of employees in steel foundries in the United States as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

4.9% of the foundries have over 1,000 employees
10.6% of the foundries have between 500-999 employees
46.6% of the foundries have between 100-499 employees
16.4% of the foundries have between 50-99 employees
12.3% of the foundries have betwen 20-49 employees
9.8% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 18 or 4.9% of the total of 367 steel foundries in the United States were located in New England.

The following table shows the tonnage of steel castings produced and ordered from 1943 through September, 1951:

Year	Production Tons	Orders Booked less Cancellations Tons	Orders outstanding Tons
1943	1,928,645	2,333,420	404,775
1944	1,843,386	1,914,294	70,909
1945	1,484,957	1,529,912	44,955
1946	1,043,356	1,069,842	26,486
1947	1,203,504	1,330,081	126,577
1948	1,760,894	---------	-------
1949	1,243,502	2,351,354	107,852
1950	1,461,089	3,776,831	1,315,742
1951*	1,568,727*	7,597,820*	6,029,093

*First nine months only

Source: Bureau of Census

The production of more steel castings by weight in the first nine months of 1951 than in the entire year 1950 shows a slight upward trend. There has been no outstanding increase in production, however, so it is doubtful if any great expansion in facilities has taken place. Demand by comparison has shown a great increase.

The large increase in orders booked and consequently orders outstanding starting in 1949 is an indication of the importance of steel castings in the current defense production. The slump in 1945, 1946, and 1947 indicates this demand is due to defense orders and is not a reflection of civilian orders. It is doubtful whether large expansion could be justified on the basis of these orders since no one can predict how long these orders will continue.

The fact that the steel industry as a producing unit is practically nonexistent in New England makes a steel foundry in New England seem a very poor risk. This is born out by the actual lack of steel foundries in New England at the present time. If a New England steel mill is ever built, this situation may change. The lack of railroad and internal combustion engine industries in New England would also indicate a poor potential for a steel foundry in New England because these two industries are very important markets for steel castings.

On the other hand, the machine tool industry in New England should create a very good market for steel castings. If the market is present the low concentration of steel foundries in New England could mean that there was a great opportunity for a new steel foundry. However, this is rather difficult to substantiate in view of the foregoing facts.

Since 61.5 per cent of steel foundries have over 100 employees and carry on large scale mechanized operations, a small foundry trying to break into the market might find some difficulty in meeting competitive prices especially if a large foundry decided that it did not approve of the competition.

Malleable Iron

Malleable cast iron is produced by the annealing of white cast iron which is an iron containing almost no free graphite. In this process some or all of the carbon (which is the combined form in white cast iron) is changed into fine graphite powder which agglomerates and forms rosettes scattered through the matrix. This matrix may have one of several forms depending on the heating cycle to which the white cast iron was subjected. Malleable cast iron has excellent strength, ductility, impact and corrosion resistance, and molding and machining qualities, compared with other cast irons.

The usual cost of malleable cast iron will be between that of gray iron and softer steel. Its handicap is the relatively long time for delivery, because of the time required for the annealing treatment after casting.

There were 138 malleable iron foundries in the United States in 1950.[1] There were 78 malleable iron foundries in the United States in 1947; 83 malleable iron foundries in the United States in 1939.[2]

From the following table it is obvious that the malleable cast iron industry is made of largely medium sized units with somewhat fewer very small units than very large units. A small foundry might be at a competitive disadvantage in meeting competitive prices because of this size distribution.

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1. The Foundry Industry Data Book 1949-1950, Cleveland: Penton Publishing Co., 1950, p. 1.

2. Bureau of Census, Facts for Industry.

On the basis of number of employees in malleable iron foundries in the United States as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

7.2% of the foundries have over 1000 employees
15.2% of the foundries have between 500-999 employees
58.7% of the foundries have between 100-499 employees
12.3% of the foundries have between 50-99 employees
2.2% of the foundries have between 20-49 employees
4.4% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 17 or 12.3% of the total of 138 malleable iron foundries in the United States were located in New England.

The following table shows the tonnage of the malleable iron castings shipped and ordered from 1943 to 1951 in the United States:

Malleable Iron Castings Shipments and Orders 1943-to 1951

(Tons)

Year	Shipments			New Orders, Less Canc.			Backlogs of Orders		
	Total	For Sale	Own Use	Total	For Sale	Own Use	Total	For Sale	Own Use
1943	844,639	635,884	190,775	1,054,225	826,422	227,802	209,585	172,538	37,047
1944	878,233	619,588	258,645	969,483	685,511	283,972	91,250	65,923	25,327
1945	790,731	520,887	269,844	766,711	426,159	340,552	------	------	70,708
1946	752,028	452,355	299,673	-------	483,368	-------	------	31,013	------
1947	895,054	513,228	381,826	-------	447,975	-------	------	------	------
1948	933,265	525,212	408,053	-------	460,189	-------	------	------	------
1949	713,330	371,214	434,416	430,530	226,483	204,047	------	------	230,369
1950	920,502	512,192	408,310	-------	646,307	-------	------	134,115	------
1951*	825,406*	496,904*	328,812*	2,331,812*	-------	-------	1,506,380*	-------	------

* First nine months only

Source: Bureau of Census

The fluctuation of the number of malleable iron foundries from 1939 to 1947 and from 1947 to 1950 is rather difficult to rationalize since it first decreased and increased. This would have been due to a rather hasty development when the process was first introduced and a later lack of acceptance by the consumer probably due to lack of knowledge about the praduct and its cost.

The cost of malleable iron is probably the main factor limiting the development of wider markets for it. At present there does not seem to be any great promise for malleable iron. This is, in part at least, due to the fact that to go anywhere it must replace gray iron to a large extent and these users are just not changing. What part cost plays and what part resistance to change plays is difficult to ascertain. The increase in the number of foundries might seem to indicate that there is some acceptance of late. However, the net tonnage shipped contradicts this hypothesis. Shipments have fluctuated widely over the past years, thus making it difficult to draw any conclusions as to future demand.

There seems to be a disproportionate share of malleable iron foundries in the New England area but this does not necessarily indicate too much. It could, along with the act that New England has a disproportionate share of the machine tool industry, indicate the presence of a good potential market for a new firm or it could indicate a saturation of the market in New England. Back orders do not give a clear enough indication to be a deciding factor.

Since 81 per cent of the malleable iron foundries have over 100 employees, it would seem that there are many operating efficiencies or at least a large capital investment associated with this industry. Licensing under the patents for nodular iron may have something to do with this. The process is being closely controlled to eliminate any possible customer dissatisfaction due to faulty products.

From the increase in the shipments for their own use, and the decrease in shipments for sale from 1943 to 1951, it appears that many industries prefer to produce their own malleable iron castings rather than to purchase them from independents. This might be attributed to the fact that independents have not supplied consistently good quality and industry feels that they can get better quality castings if they make their own. In any case, it indicates a trend which certainly does not look good for an independent foundry, especially a new unit.

Brass and Bronze

Brasses are alloys of copper and zinc. Bronzes are alloys of copper base and any other metal. The high electrical and thermal conductivity of copper its malleability, and good corrosion resistance make it particularly suitable for many engineering applications in spite of its high cost. Fire refined copper containing 0.03 to 0.05% oxygen is the usual casting copper because the residual oxygen content improves the castability as well as mechanical strength. Copper castings are made almost entirely in sand molds. Brasses are more widely used than bronzes.

The brass and bronze castings market may be divided roughly into three main categories -- cast bearings, marine fixtures, and plumbing fixtures. This means that the main markets for these castings are Industrial Machinery, Farm Machinery, Motor Vehicle Components, Plumbing Industry, and Shipbuilding.

There were 2538 brass and bronze foundries in the United States in 1950.[1] In 1946, according to Bureau of Census figures, there were 2,005 brass and bronze foundries in the United States of which 1158 were exclusively jobbing foundries; 568 were exclusively captive foundries; and 279 produced both for own consumption and for sale. The following table gives

1. The Foundry Industry Data Book 1949-1950, Cleveland: Penton Publishing Co., 1950, p. 1.

a more detailed breakdown of these categories in 1946:

Number of Brass and Bronze Foundries Active in December, 1946

Type of Casting	Total	Jobbing	Captive	Both Captive & Jobbing
Sand	1939	1125	441	273
Permanent	48	22	10	3
Die	21	10	8	3
All Other	48	21	23	4
Total	2156	1178	482	283

Source: Nonferrous Castings, 1946, Facts for Industry (Bureau of Census)

On the basis of number of employees in brass and bronze foundries in the United States as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

0.2% of the foundries have over 1000 employees

1.0% of the foundries have between 500-999 employees

8.8% of the foundries have between 100-499 employees

12.9% of the foundries have between 50-99 employees

20.9% of the foundries have between 20-49 employees

56.2% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 273 or 10.8% of the total of 2538 brass and bronze foundries in the United States were located in New England.

The following table shows the poundage of copper base castings shipped from 1947 through August, 1951.

Copper Base Castings Shipments 1947 to 1951

(Pounds)

Year	Sand	Perm. Mold	Die	All Other	Total, All Types
1947	960,732,000	51,139,000	12,657,000	----------	1,051,742,000
1948	930,790,000	59,009,000	12,672,000	----------	1,030,825,000
1949	654,444,000	37,311,000	10,082,000	23,481,000	725,318,000
1950	918,883,000	52,756,000	13,224,000	30,816,000	1,015,679,000
1951*	708,838,000*	44,502,000*	8,426,000*	24,143,000*	789,979,000*

* First eight months only.

Source: Bureau of Census

New England enjoys a disproportionate share of the brass and bronze foundries of the United States. This is partly the result of history and partly the result of the fact that the shipbuilding industry created a considerable demand. Brass and bronze foundries show a tendency to be small independent units. Over 75 per cent have less than fifty employees. A low capital investment necessary to begin operations makes it fairly easy to get started on a comparable basis with a long standing firm as far as facilities go.

The shipments of copper castings from 1947 to August, 1951, show no great tendency for expansion in this industry. The waning future supplies of copper ores are forcing many industries to consider substitutes for copper and as a result the future prospects of this industry are not too promising.

Sand casting of brasses and bronzes is by far the type of casting for which there is the greatest demand. Less than 7 per cent of all casting in this field is done by all other methods. This is probably due to the fact that copper alloys are very sluggish and viscous when molten and will not flow into narrow openings.

Aluminum

Aluminum produces many useful alloys for casting. It is practically never cast as pure aluminum. Copper serves to harden and strengthen the aluminum. Silicon improves the casting characteristics, and for that reason the silicon-containing alloys are the most widely used. The aluminum magnesium alloy provide superior resistance to corrosion and tarnish. Aluminum is used primarily in applications where light weight is desirable or necessary. Aluminum castings possess good corrosion resistance under ordinary atmospheric exposures and are also resistant to many chemicals. They machine readily and some of them take and hold a high polish without plating. A variety of colored finishes may be produced on them by chemical treatment.

The main markets for aluminum castings are Electrical Machinery, Motor Vehicles and Components, Domestic Home Appliances, Sporting Goods and Toys, and Structural Components.

There were 2750 aluminum foundries in the United States in 1950.[1] In 1946 there were 1,643 aluminum foundries in the United States, of which 1,056 were exclusively jobbing; 345 were exclusively captive; and 242 were both captive and jobbing.

The following table gives a more detailed breakdown of the categories of aluminum foundries in 1946 according to

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1. Ibid., p. 1.

the Bureau of Census:

Number of Aluminum Foundries in December 1946, by Type of Casting

Type of Casting	Total	Jobbing	Captive	Both
Sand	1456	932	304	220
Permanent Mold	138	89	34	15
Die	128	84	31	13
All Other	35	26	8	1

Source: Nonferrous Castings, 1946.
Facts for Industry (Bureau of Census)

The aluminum foundry industry is primarily a small unit industry. As shown by the tabulation of aluminum foundries in the United States by number of employees, less than 10% of all foundries have over 100 employees. The biggest size group by far is the less than 20 employees group.

On the basis of number of employees in aluminum foundries in the United States as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

0.3% of the foundries have over 1000 employees
1.2% of the foundries have between 500-999 employees
8.4% of the foundries have between 100-499 employees
8.9% of the foundries have between 50-99 employees
20.2% of the foundries have between 20-49 employees
61.0% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 254 or 9.25 per cent of the total of 2750 aluminum foundries in the United States are located in New England.

The following table shows the tonnage of aluminum castings shipped and for which orders were not filled from 1943 to August, 1951:

Aluminum Castings Shipments 1943 to 1951

(Tons)

Year	Total	Sand	Perm. Mold	Die	Other	Unfilled Orders*
1943	115,125	-------	-------	-------	-------	-------
1944	128,725	-------	-------	-------	-------	-------
1945	93,475	-------	-------	-------	-------	-------
1946	97,475	40,212	38,285	18,426	257	-------
1947	110,499	38,778	43,629	27,635	458	-------
1948	106,123	34,946	40,334	29,685	1160	-------
1949	152,308	53,423	51,454	44,010	3432	-------
1950	226,305	77,007	71,911	72,331	5058	-------
1951**	305,133**	112,379**	95,095**	91,010**	3352**	857,136**

* For sale only

** First eight months only

Source: Bureau of Census

The increasing size of the yearly shipments from 1948 to 1950 and the very greatly increased size of shipments and back orders for the first eight months of 1951 clearly indicate that aluminum castings are an important component in defense mobilization. Shipments from 1943 to 1951 show a decided trend toward steady expansion of the industry in the future.

New England has an average share of the nation's aluminum foundries. This correlates with the New England share of the industrial markets for aluminum.

Sand castings carry by far the large part of the industry with only 14% of the foundries doing permanent mold and die casting.

As with most nonferrous metals, aluminum casting is well suited to small enterprise. Over 81% of the existing aluminum foundries have less than 50 employees. The capital investment required is not too great. In fact, one can be very small and still be profitable.

The increase in the number of aluminum foundries from 1946 to 1950 is worthy of note since the number almost doubled in this four year period. At the same time the shipments increased by a factor of about two and one-half.

In examining the role of aluminum foundries in the defense program, we must think about the type of work to be expected of them and the alloys which will be most in demand. According to W. A. Mader in an article in the

American Foundryman for April, 1951, aluminum foundries can expect a demand for their castings greater than World War II requirements because engineers have learned to make greater use of the excellent properties of aluminum -- high strength-weight ration, corrosion resistance, machinability, and ease of fabrication. Our military today places prime emphasis on mobility and aluminum alloy castings have proved indispensable for this purpose. Aluminum castings will be used in aircraft, tank engines, weapons, carriers, jeeps, gun mounts and carriages, various types of airborne equipment, guided missiles, radar, and all equipment where weight is a critical factor.

Because these castings for defense are generally more complicated, require more core work, have much more stringent tolerances and specifications, and in general require a better foundry technique than most commercial products, this potential market will not be open to all foundries but only to those that have managed to keep up with the times and have incorporated the most modern methods.

Big markets are expected to develop in the transportation field for aluminum. There has already been considerable acceptance of aluminum for streamlined trains, trucks and trailer components. In the passenger car field there is also a rapidly growing interest. The automatic transmissions of many cars are mainly aluminum. An aluminum engine has been successfully road-tested, and a wide range of components have been engineered into aluminum. Most of these are cast products.

The emphasis on safety and gas economy coupled with the low aluminum prices will also stimulate the greater use of aluminum in passenger cars. The lighter the car the shorter the distance in which it can be stopped and that is especially important at present road speeds. With the use of aluminum, auto makers will be able to increase safety and gas economy without cutting down riding comfort. Just a few additional aluminum parts on a car will mean a tremendous growth of the aluminum casting industry. The only pessimistic outlook in this picture is the fact that the big auto companies have expanded vertically so far that they are virtually self sufficient from ore to finished product and do not ordinarily purchase much material from independents. This would especially apply to a New England foundry.

Another reason for optimism in the aluminum industry is the abundance of the raw material needed for production in contrast to the shortage of other metal ores. Geologists say that one-eighth of the earth's crust is aluminum, making it by far the most plentiful metal. Aluminum is being considered as a substitute for many metals which have dwindling ore supplies -- especially copper.

Magnesium

Magnesium is the lightest of the commercial metals; its density is about two-thirds that of aluminum, one-fourth that of steel. Pure magnesium is seldom used as a structural material because of its low strength, but its alloys are stronger, and many of them can be hardened by precipitation heat treatment. The uses for magnesium in alloys for portable or high-speed machinery have multiplied many fold during recent years and its price has dropped correspondingly. The strength-to-weight ration of the precipitation-hardened magnesium alloys is comparable with that of the strong alloys of aluminum or with alloy steels. Magnesium alloys, however, have a lower density and stand greater column loading per unit weight. They are also used when great strength is not necessary, but where a thick, light form is desired. Examples are complicated castings, such as housings or cases for aircraft, and parts for rapidly rotating or reciprocating machines.

Magnesium and its alloys have very good resistance to corrosion by most atmospheres. The rate of corrosion is very slow compared with the rusting of mild steel in the same atmospheres; however, it is not quite as good as aluminum. Protective coatings which are easily applied eliminate most of the difficulty with corrosion.

Sand, permanent mold, and die casting methods may be used in casting magnesium.

At present the main market for magnesium castings is the Aircraft Industry. Magnesium castings can also be used as structural members and component parts, such as compressor rings, for jet engines. If the price can be reduced they will undoubtedly be used in many other applications where they are now considered impractical because of their cost.

There were 145 magnesium foundries in the United States in 1950.[1] In 1946, according to the Bureau of Census, there were 74 magnesium foundries in the United States of which 53 were exclusively jobbing; 11 were exclusively captive; and 10 were engaged in both jobbing and production for own use.

The following table shows a detailed breakdown by type of casting for magnesium foundries in 1946 according to Bureau of Census figures:

Number of Magnesium Foundries in December 1946 by Type of Casting

Type of Casting	Total	Jobbing	Captive	Both
Sand	55	40	8	7
Permanent Mold	7	6	1	0
Die	17	11	3	3
All Other	1	1	0	0

On the basis of number of employees in magnesium foundries as given in The Foundry Industry Data Book 1949-1950: (See Appendix)

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1. Ibid., p. 1.

0.7% of the foundries have over 1000 employees (1 foundry)

0.0% of the foundries have between 500-999 employees

19.3% of the foundries have between 100-499 employees

10.3% of the foundries have between 50-99 employees

12.4% of the foundries have between 20-49 employees

57.3% of the foundries have less than 20 employees

Based on figures from The Foundry Industry Data Book 1949-1950, 19 or 13.1% of the total of 145 magnesium foundries in the United States are located in New England. As a matter of interest, 17 of these 19 have less than twenty employees; the other two have between 100-499 employees.

The following is a table of consumption of primary magnesium for use in castings for the years 1948, 1949, and 1950:

Magnesium Consumption for Castings

(Short Tons, Primary Metal Only)

Type of Casting	1948	1949	1950
Sand	1,930	3,088	3,090
Die	213	127	242
Permanent Mold	12	44	573

Source: Bureau of Census

The following table gives the magnesium castings' shipments and back orders for the period 1947 to 1951:

Shipments and Orders of Magnesium Castings

(Pounds)

Year	Shipments Total	For Sale	Unfilled Orders*
1947	7,693,000	7,050,000	-------------
1948	8,214,000	7,488,000	-------------
1949	9,364,000	8,781,000	-------------
1950	12,314,000	11,582,000	-------------
1951**	15,908,000**	15,299,000**	102,702,000**

* For Sale Only

** First eight months only

Source: Bureau of Census

The following quotation appeared as an editorial in the February 1952 issue of Modern Metals:

"Magnesium supply situation has already been eased by Air Force stretch-out. Greatly increased primary output has also been a big help. Ingot will be in much greater supply next month. Ingot expansion goal apparently will be reached with present plans, according to Defense Production Administration. The goal calls for the production by early 1953 of 29,500 tons by privately owned facilities, and 102,000 tons by reactivated government facilities."

The following quotations appeared as editorial comments in the January 1952 issue of Modern Metals:

"Most magnesium foundries are currently turning away more business than they can handle. With the trend toward larger, more complicated castings, some magnesium foundrymen are predicting a tight supply situation throughout 1952."

"Automotive industries promise to be the biggest potential market for aluminum and magnesium."

The fact that the Howard Foundry Company within the last two months added a 240,000 square foot plant in Indianapolis, Indiana, devoted exclusively to magnesium sand castings to (quote their announcement of the expansion) "help meet the increasing military demand for quality magnesium castings." gives an indication of what an old line company thinks of the future in magnesium casting.

"Continued expansion in consumption and production of all forms of magnesium is in prospect for coming months," it was stated at the sixth annual meeting of the Magnesium Association, November 9-10, 1951. "Civilian demands recently have been 25 per cent in excess of supply, but coming reactivation of six government-owned stand-by plants will increase production capacity of the primary metal from 48 million pounds annually to 240 million pounds."

"Strictly commercial uses of magnesium have increased steadily since the war," it was pointed out by Edward S. Christiansen, president, Magnesium Company of America, and past president of the Magnesium Association. He said that he predicted use of 75 million pounds in 1951 and 102 million in 1952. "Moreover", he added, "this generation should see annual production approaching 1 billion pounds." Currently, castings account for 28 per cent of total magnesium consumption.

The steadily increasing size of shipments from 1947 through 1951, with shipments in the first eight months of 1951 almost double those of 1947, itself indicates a very ripe market for the newcomer in the field. However, the tremendous backlog of orders for the first eight months of 1951, approximately six times the total shipped for sale, is an even greater indication of a market which has expanded way beyond the present producers' ability to meet.

In the period from 1946 to 1950 the number of magnesium foundries in the United States has doubled but not many have grown too large as yet. 80 per cent have less than 100 employees and 57.3 per cent have less than 20 employees.

The disproportionate share of magnesium foundries in New England can be taken as an indication of a good market but more realistically it can be attributed to the fact that many of these New England foundries are not exclusively such but are actually just departments in many brass and bronze foundries which are attempting to lessen the shock of the predicted cut-backs in copper supplies in the near future.

Magnesium is a new and growing industry which appears to show a good potential for a new unit. None of the presently existing units in New England are yet very large, only 2 have over 20 employees; therefore a new firm can grow right along with the "old timers" and not suffer any immediate size disadvantages. With the current defense demand as indicated, a young firm could get a good start completely on defense work and wait until established as a reliable producer before having to break into the civilian market. Since the defense effort is going to require jet aircraft and the other components of modern warfare for some time regardless of any immediate changes in international politics, this market can certainly be counted on for at least long enough to get a new firm started and established. By the time it is necessary to break into the civilian market the expansion of the primary ingot capacity which is planned for the near future should have reduced the price of magnesium to a point where it could economically compete with other metals of similar but not comparable characteristics -- this should be especially true in the case of aluminum.

Conclusions

From the foregoing market analysis we have picked a magnesium sand casting foundry as the type of foundry for which there is the greatest potential because of its

1. Extremely optimistic future outlook
2. Newness as an industry
3. Rate of growth in the last few years
4. Expanding primary metal production
5. Government interest and demand due to defense
6. Backlog of orders in 1951
7. Low capital investment required as compared with other methods of casting magnesium such as die and permanent mold casting

Upon talking to Professor H. F. Taylor of the Department of Metallurgy at Massachusetts Institute of Technology after making this analysis and arriving at our conclusion, we were advised that a new magnesium foundry is the only type of new foundry which could possibly succeed on the basis of market potentials. While our data did not indicate this quite so definitely, we were happy to have one who is closely associated with the foundry industry in the United States agree with our conclusion.

FOUNDRY PLANNING

Introduction

As the second section of this report we have attempted to do all the preliminary planning which would be necessary to insure a good start for a new magnesium sand casting foundry in New England.

We would like to stress the fact that in planning a new enterprise a great many estimates and predictions necessarily play an important role. While these estimates and predictions are not identified as such, except where very little information could be found and the estimates became almost speculative, we feel that they will be obvious to the reader as estimates. The production figures for the first six months of operation are an example of this type of prediction which we wish to point out as being an estimate rather than a fact.

We feel that these estimates are as accurate as could possibly be made. They are all grounded on a firm basis of much study and reflection.

Plant Location

The factors which determine the location of a new foundry are:

1. Labor supply
2. Consuming industries
3. Transportation
4. Raw materials
5. Entrepreneur's preference
6. Availability of suitable buildings

While we do not propose to pinpoint the location of our new foundry, we do intend to evaluate general areas with respect to the above considerations.

The first two location factors tend to indicate that the best location would be in an area which has a relatively dense concentration of population since industry, population, and labor supply are all dependent on one another. These two factors thus point toward a location in the urban areas of either Connecticut, Massachusetts, or Rhode Island but to no location in particular.

The second two location factors -- transportation facilities and raw material location -- do not indicate any great advantages of one urban area over the next. New England is very comprehensively covered by railroad and highway networks. Ray material considerations favor no specific location other than that further south the raw materials will be slightly cheaper because, in the main, raw materials will have to be shipped into New England.

The last two location factors are the main reason behind not picking a specific location other than an urban area since they are so completely indeterminate in general. We feel that in New England these two factors can be given the most weight in picking the location and that almost any urban location will be as good as the next. Allowing these two factors to determine the location of a new foundry is not as illogical as it might at first sound in view of the latitude of choice shown to be present upon consideration of the first four location factors. Of course, this assumes reasonable consideration of these factors since they cannot be completely neglected.

Small foundries are essentially local industries depending mainly on personal contact and service rather than on wide distribution (average market coverage by small foundries is an area 250 miles in diameter) and as such do not have to give the consideration to location that a company which is engaged in nationwide distribution would have to give to this problem.

Mechanization

Foundry mechanization is often a case of "Too much, too soon". Many foundries, especially smaller ones, found this to be true after they had, at great cost, mechanized their plant after the war. From the production demanded during the war and the expected boom of prosperity immediately following, their stand may have been justified on a short term basis, but a little common sense would have encouraged caution. Foundry equipment is expensive and the market for castings may not support the cost of the machinery in added sales.

The advantages of mechanization include the following:[1]

1. The elimination of many of the heavy-lifting and other laborious operations which were in the past considered part of foundry work.

2. Providing a means whereby foundry workers can increase their earnings and raise their standard of living.

3. Increased production from a given floor space.

4. Production of castings with closer dimensional tolerances and, on the average, smoother surfaces.

5. Maintenance of the competitive position with respect to other processes such as forging or fabrication by welding.

6. Attracting to foundries workers who are now

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1. Campbell, James S., Jr., Casting and Forming Processes in Manufacturing, New York: McGraw-Hill Book Co., Inc., 1950 p. 227.

employed elsewhere because of working conditions prevalent in foundries prior to mechanization. "To the average person a foundry is a dark, dank, poorly-lighted, smoke-filled place where dirty men sweat and swelter and breathe noxious fumes in the making of castings."[1]

7. Potential savings resulting from the elimination of numerous manual operations.

Regardless of the above named advantages there remain three main reasons why mechanization of foundries is essentially a slow process. First, there is the problem of cost; the equipment is expensive and there is a great deal of money tied up in present equipment. Second, a production problem arises when new equipment is being installed -- how do you keep up present output and still change the manufacturing system? The change-over can usually be accomplished by partial mechanization at a time and justified on the savings and advantages inherent in mechanization if the market is high and steady enough to warrant such a change. Third, there is the age-old problem of resistance to change - "It has always been done this way", "What my father did is good enough for me", etc., etc.

These problems do not concern the new foundry. It has no investment in old equipment, no current production schedules to be concerned with and the amount of mechanization feasible may be gathered from the potential market by deciding production

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1. Campbell, James S., Jr., op. cit., p. 218.

(4) private investment in small concerns is not ample because of loss of fortunes in crash of 1929, high progressive income tax, more opportunity to safely invest in larger companies, and the loss of the personal touch in local banks. Basically, it was determined that small concerns are put to a competitive disadvantage with larger concerns due to their inability to get capital on an equal basis.

To alleviate the capital shortage, changes in taxation policy were recommended along with a system to enlarge the volume of the loans made by the existing banking system. Tax exemption for increased employment and increased capital appropriations, a graduated corporate income tax, and a graduated excess profits tax are all included in the taxation proposals made. To provide additional short term capital, government insurance of loans up to $25,000 made by local banks is advocated. To provide long term capital, it is advised funds be raised by private sources to be lent out by certain existing banks controlled by the Federal Reserve System. If the loss on these loans is too great, than the government should consider stepping in and setting up a fund to take care of the losses - if the loans on a whole perform a valuable service. The basic trouble confronting the extension of credit is emphasized: it is the setting of "credit worthiness" standards.

rates; - equipment necessary to meet these rates chosen within the financial capacity of the entrepreneurs. There is no existing procedure to resist change.

Foundry Equipment

The chief classes of foundry equipment are:

1. Material Conditioning and Handling Equipment
2. Mold Handling Equipment
3. Casting Inspection and Finishing Equipment
4. Safety and Protective Devices

Our equipment will have versatility as its main feature. The market we are aiming at calls for a variety of castings and small orders with not much chance for standardization of product. Two other considerations we are keeping in mind are the possibility (and probability) of expansion and the amount of money we have to invest.

Materials Conditioning and Handling Equipment

Conditioning the sand consists of mixing three ingredients - sand, clay and water. The clay forms a coating around each sand grain and the water forms an adhesive layer between the clay-coated particles. All sand used in our foundry will be conditioned by a sand muller. This includes both unused sand and sand from the shakeout pit that has been used. The machine is a barrel-shaped metal cylinder, standing upright with the bottom closed.[1] Inside this cylinder, a rotating shaft mounted centrally drives a pair of wheels which roll around the bottom of the cylinder. Sets of plows also

1. Heuchling, Frederick G., Jr., "A Study of Foundry Equipment", Department of Business and Engineering Administration Thesis, M.I.T, 1948, p. 34.

rotate inside the barrel, scraping the sand from the bottom and walls of the cylinder. Mullers are loaded from the top, and discharge from the bottom. The mulling action includes the application of pressure, agitation and aeration to the sand. The sand is mulled in batches. Mulled sand is more thoroughly mixed and blended than sand conditioned in any other way... The action of the wheels and plows turns the sand over, crushing lumps, and mixing and blending it constantly.

A muller is expensive; one with a batch size of three cubic feet costs around $3000; in our case we justify its use on the following grounds:

a) Consistent good quality castings depend to a very large degree upon mulled sand - opinion of majority of foundrymen interviewed.[1]

b) This size muller will be fully utilized during a day's production (see scheduled production, page).

c) Using a muller frees molder from conditioning his own sand (at pay rate for molding).

d) This type of unit can easily be fitted into a further mechanized program if the occasion arises.

e) One man can handle a muller, whereas three to four men are needed for a sand mixer or other sand conditioning equipment.

Sand will be conveyed to the muller by an inexpensive portable bucket elevator which, taking sand from the storage

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1. Heuchling, Frederick G., Jr., op. cit., p. 36.

bins will discharge it into the top of the muller. Sand from the shake-out pit will be conveyed on a trough- belt conveyor (underground) to the storage bins. New sand shipped in will be placed in the bins via chutes from railroad gondolas or trucks.

To condition the metal (melting) we are using three oil or gas-fired crucible type furnaces. These furnaces, either flush with the floor or raised about two feet above floor level (to facilitate loading), are of very simple construction - a refractory lined pit, into which a crucible containing the metal ingots and scrap is lowered, with means for two flame jets on either side of the bottom; a cover and ventilating flues for gas and fumes to be taken away.

There are several reasons why we choose to have three furnaces of moderate capacity rather than one large melting unit. Melting in a large unit necessitates repouring of the molten metal into smaller crucibles for pouring into the molds. We are eliminating this by melting in 210 pound crucibles (crucibles which hold 210 pounds of magnesium alloy) from which the metal may be poured directly into the molds. A large melting unit means that pouring would only take place once, or at most twice, during the day. Inspection of the poured castings would prevent - if something was wrong - one-half, at most, of the day's run from being spoiled. Our system of three furnaces gives us twelve pourings a day so that errors causing bad castings may be promptly remedied.

After melting, the crucibles containing the liquid metal will be lifted from the furnace by means of a chain hoist suspended from a monorail conveyor. This monorail conveyor enables the pourers to reach all the molds ready for pouring and to fill them directly from the large curcible. Installation of a monorail system costs around twelve dollars a foot with each bend in the system costing fifteen dollars and a switch seventy-five dollars.[1]

Mold Handling Equipment

To enable the molders to do only molding and to separate them from the pouring stations (distractions, bad vapors and gases) - the molds, after completion are conveyed to the pouring stations and thence to the shake-out pit. This involves the transportation of the sand used in molding twice - to the shakeout pit and back to the molders. However, the advantages derived, in worker comfort and efficiency, justify this expense. The conveyors will cost six to eight dollars a foot installed.[2]

In separating the castings from the mold, a shakeout machine which consists of a flat grill-like top through which the sand falls when the machine vibrates, will be used. One man operating this machine can separate the flasks and castings with a minimum of effort while the sand falls onto the trough belt conveyor which conveys it to the storage bins for further use.

1. Watters, Warren K., "Increasing Capacity and Reducing Handling Costs of a Small Brass Foundry," Department of Business And Engineering Administration Thesis, M.I.T., 1950, p. 39.

2. Heuchling, Frederick G., Jr., op. cit., p. 106.

Casting Inspection and Finishing Equipment

The equipment to be used for inspection of the castings will be described in the section of the report under Quality Control.

Immediately after shakeout the castings will undergo the rough machining where the risers, sprues and gates will be cut off and sent to metal supply to be roused in melting. The castings will then be sandblasted to remove any dirt or foreign matter and to facilitate inspection.[1] After inspection the final machining and finish grinding will be done. Tools used in the machining and grinding operations are grinding wheels, bandsaws and rotary file tools, etc.

Heat treatment, which improves the mechanical properties of magnesium-base alloy castings, is to be carried out in gas-tight furnaces, electrically heated.[2] Final sandblasting to give good surface appearance is done just before a protective pickling treatment is given. Tank materials for the pickling treatment are either pure aluminum plate, stainless steel, ceramic, or synthetic rubber materials applied over a steel base.[3]

Safety and Protective Devices

The two major dangers inherent in producing magnesium-base alloy castings are fire and fumes. Neither of these need be troublesome if adequate precautions are taken.

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1. "Magnesium Alloys Foundry Practice", American Foundrymen's Association, Chicago, Ill., 1944, p. 10.

2. American Foundrymen's Association, op. cit., p. 12.

3. Ibid, p. 12.

Because inhibiting agents are added to the sand to hinder the action of the water vapor upon the hot metal, sulphur dioxide and fluoride fumes, pungent and disagreeable, arise from the pouring stations to the shakeout pit and also in the core-making room. This necessitates flues and other ventilating equipment for protection of the workers. Studies have been made to determine the intensity level below which the concentration of these vapors must be kept and the protective devices are set accordingly.[1]

Danger from fire arises from the grinding, sanding and melting operations. The sanding and grinding operations produce highly flammable dust and chips which must be carefully collected and disposed of. When melting the metal will oxidize rapidly and burning results unless the melt is covered with a protective atmosphere.

For these reasons, the dust and chips are collected in a liquid-filled tank and burned on an outside dump where nothing else will catch fire. The sandblasting will be done with sand, not grit, because it has been found that there is not a hazard with the particles caused by the use of sand for blasting.

In the melting procedure, fluxes are used to prevent the metal from oxidizing and burning. Leggings, aprons, arm-guards and goggles are used to protect the men working with the hot metal.

All of these precautions would be taught or known to the workmen as a part of the specialized knowledge necessary to producing magnesium-base alloy castings.

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1. Ibid, p. 128.

Layout

Most foundries have always had to adopt their layout to the building they were in. It was rare indeed if the layout were planned first and the building erected around the layout. This is one of the main reasons why so many foundries are inefficient in time, money and effort spent for production.

It seems strange that with all we know today about laying out a production set-up, companies still buy a building and say, "This will be our foundry - fit your layout into it!" The ideal situation in our case would be to build a structure around our proposed layout, but we do not have the financial resources available. Therefore, we will rent a building into which our layout, with no inefficient changes, may be placed.

Our layout should accomplish the following general ideas and concepts:

1. To have the workers devote the maximum amount of possible time to their respective skills and jobs with a minimum of outside interference; encourage specialization and division of labor.[1]

2. To reduce physical effort to a minimum to increase efficiency, yet find a median between cost and exertion.[2]

3. To obtain, with minimum expenditure for machines,

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1. Malkovsky, Robert L., "Applied Factors Governing Non-Ferrous Foundry Layouts", Department of Business and Engineering Thesis, M.I.T., 1948, p. 5.

2. Malkovsky, op. cit., p. 5.

a smooth production flow that will meet our desired production rates and still have possibilities of expansion.

4. To make our foundry a safe and desirable place of employment.

Figure 1 shows our proposed layout. Three molding stations have been set up using bench molding equipment. Each molder working on a medium-sized mold will make about one mold a minute, according to Professor Howard F. Taylor of the Metallurgy Department of M.I.T. This time limit will of course vary with the size and complexity of the casting so we have planned our production schedule on the amount of metal poured per melt and the average yield per pound of metal poured. This yield is approximately 50% - that is, for every two pounds of metal poured you would obtain one pound of actual casting. The excess metal poundage is in the gates, risers and sprues necessary to pour the casting. At present, every two hours we pour 600 pounds of metal and obtain 300 pounds of actual castings.

If the average rough-finished casting weighs five pounds we would need, for the two hour period, sixty molds; for castings weighing four pounds we would need seventy-five molds, and so forth. From what we have been able to determine, the majority of magnesium castings now being produced are in the one-half to twenty pound range. The castings are intricate and the molding takes more time than for other metal castings. This is because of the elaborate gating arrangements necessary

FOUNDRY LAYOUT

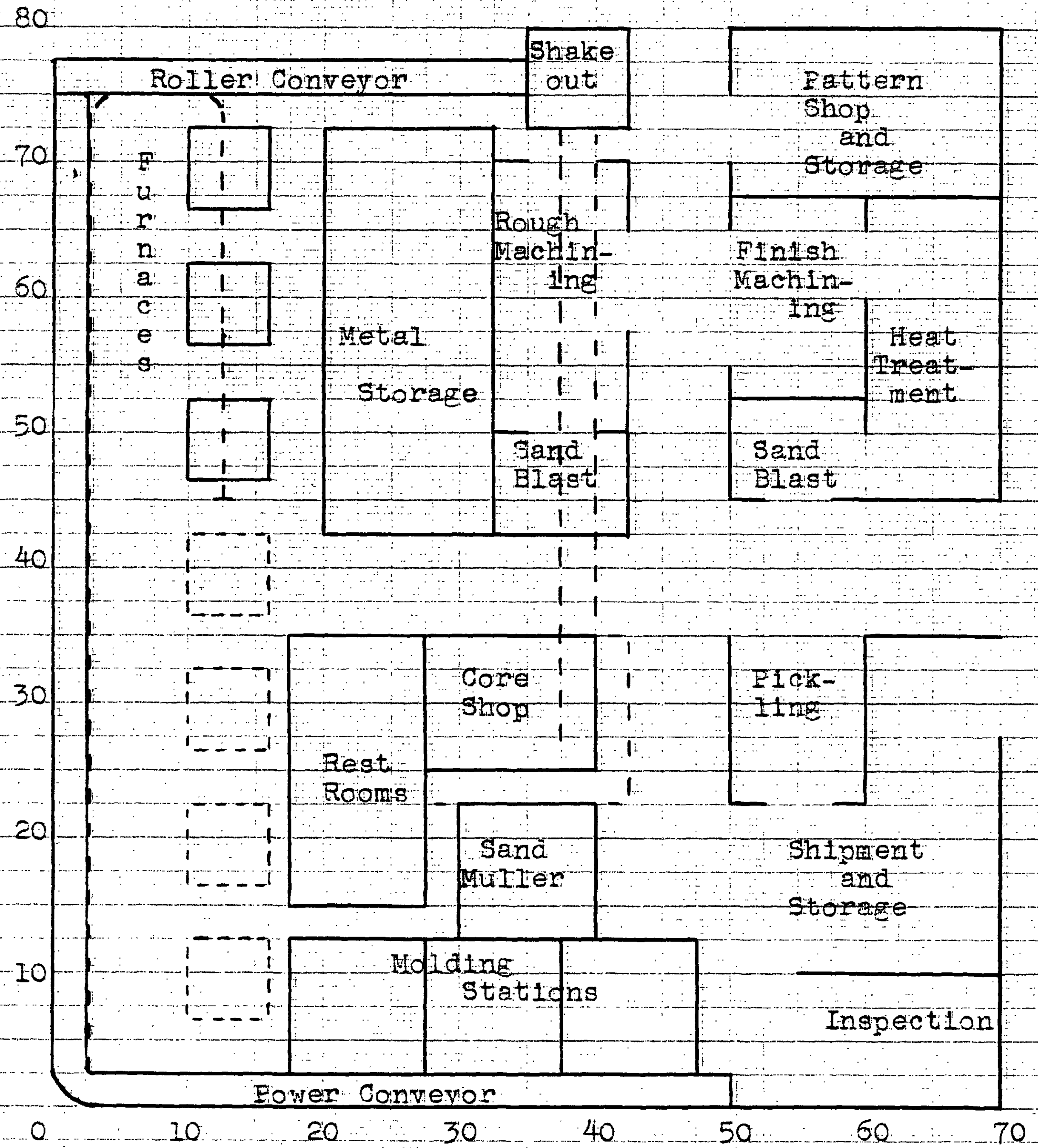


Figure I - Foundry Layout showing operational areas

Distances in feet

Scale: 5mm equals 2.5 ft.

to insure a very smooth flow of metal into the mold to prevent turbulence which would cause oxidation, burning and defects in the final casting. Thus we feel that to begin with, three molders are necessary. For a one pound casting, 300 molds would be needed in a two hour period which would require each molder to make fifty molds an hour. If we find, after data on the operations has been gathered, that two molders can handle the work, we will arrange it.

The molding stations are allowed ten square feet of floor space each and arranged so that the molder may place the completed mold directly on the power conveyor. Patterns, cores and sands are delivered to him so his time is spent at molding and nothing else.

If expansion takes place, the bench-molding equipment may be replaced with molding machines which have a high production rate. For our present rate of 1200 pounds of finished castings per day, the molding machines are too fast and too expensive to be bought and not fully utilized.

When the completed molds are placed on the conveyor belt they are taken to the pouring stations. The rate of travel of the conveyor is set so that for any given casting order a two hour's production of molds is, at the end of two hours, lined up along side 3 for pouring. An overhead monorail conveyor enables the two pourers to lift a crucible from a furnace and pour the metal into the molds on the conveyor belt. The three furnaces are emptied at regular intervals (see Production Schedule) and the molds filled at these intervals. One man (the melter) tends the three furnaces and has the responsibility for their care and control. The two pourers assist the melter in obtaining metal from metal storage for loading of the furnaces. Expansion is provided for by leaving room for other furnaces to be placed in the same general area (the dotted squares in Figure 1).

After pouring, the molds move onto a roller conveyor which leads to the shakeout machine, cooling as they move. Flues and hoods are placed all along the conveyors on sides 3 and 4 to protect the workers from the fumes and heat. Two men work at the shakeout machine, one putting the castings into a roller bin and the other placing the empty molding flasks on pallets or in a bin for the fork truck to take back to the molding stations. The sand falls through the shakeout machine onto a trough belt conveyor and is taken (underground) to the storage bins to wait for reconditioning. The castings receive 100% visual inspection here and bad ones are marked for metal storage. They next go to the rough-finishing department where the riser, gates and sprues are cut off with bandsaws and other equipment. Then they receive a sand-blasting and a few may be sent to inspection to detect any internal defects. If the lot is declared sound finish machining is carried out and the castings move to the heat treatment department. After being heat-treated the castings are given a final sandblasting for surface appearance and are then pickled to preserve the surface during storage and shipment. The cut-off risers, gates and sprues are sent to metal supply for remelting in future heats.

Incoming metal and sand shipments arrive at side 1 where adequate aisle space is provided so that fork-lift trucks may transfer the metal (which is shipped on pallets) into metal storage and the sand may be placed via chutes into the storage bins below the floor. Notice that outgoing shipments leave from the same side 1; actually from the same spot as the incoming shipments. Aisle space is at least seven and one-half feet wide at all spots and is ten feet wide at the sand bins to allow trucks to come into the plant and deliver sand to the chutes.

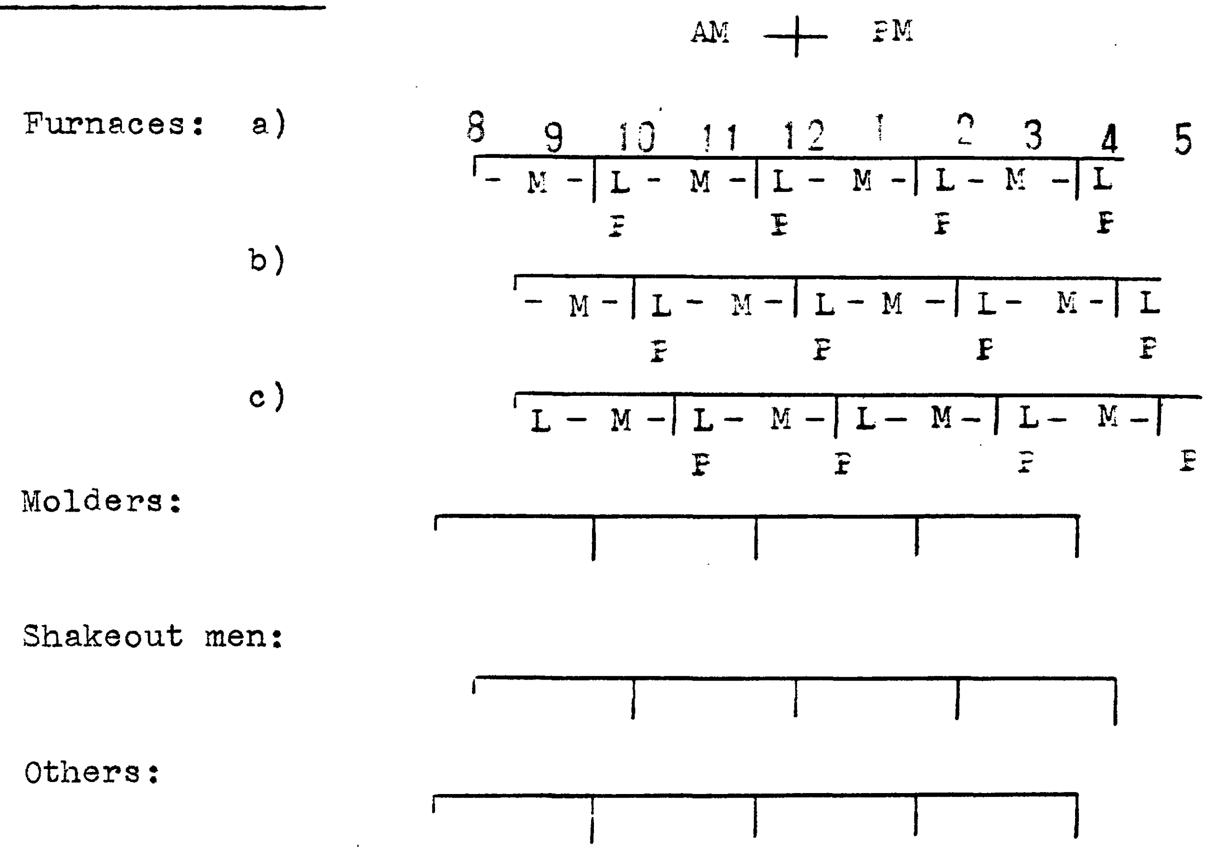
The pattern shop is placed as far away from the molders as possible. Originally we planned to have it right next to the molders but upon the advice of Professor Taylor the change was made. It seems that molders would mislay, mix up and, in general, confuse the pattern stores if they could have access to them. Therefore, patterns for specific jobs will be brought to the molders and picked up and returned to pattern stores when the particular job is finished.

The core room is close to the molders, as it should be, and cores for a certain job will be made available to them when needed. One man will be responsible for making the cores; he will have a core-blowing machine and a core oven and will be informed of the types and shapes to make for enough ahead so that they will be ready for the molders.

A rest room with space for lockers is provided for the twenty-one employees in this foundry. A list of the employees is given in the section on costs of the foundry.

This layout is predicated on the assumption that we can rent the bottom floor of a building (underground sand conveyor and sand storage); however, if necessary it can be on higher floors with elevators for incoming and outgoing shipments, using overhead sand conveyors and sand storage.

Production Schedule



This is the tentative daily production schedule that has been worked out. The molders and other employees who are engaged on work-in-process will begin work at seven-thirty in the morning. The melter begins at eight o'clock by starting the melting in furnace (a). At nine o'clock the pourers begin and help get metal stock for loading the furnaces. Since the pourers take care of two hours production of the molders in one and one-half hours, the molders need to be working two hours before the first melt is ready to pour. The shakeout men have two hours to take care of an hour and a half's pouring, therefore they start at eight o'clock.

Everyone works a regular eight hour shift except the melter who works eight and one-half hours per day.

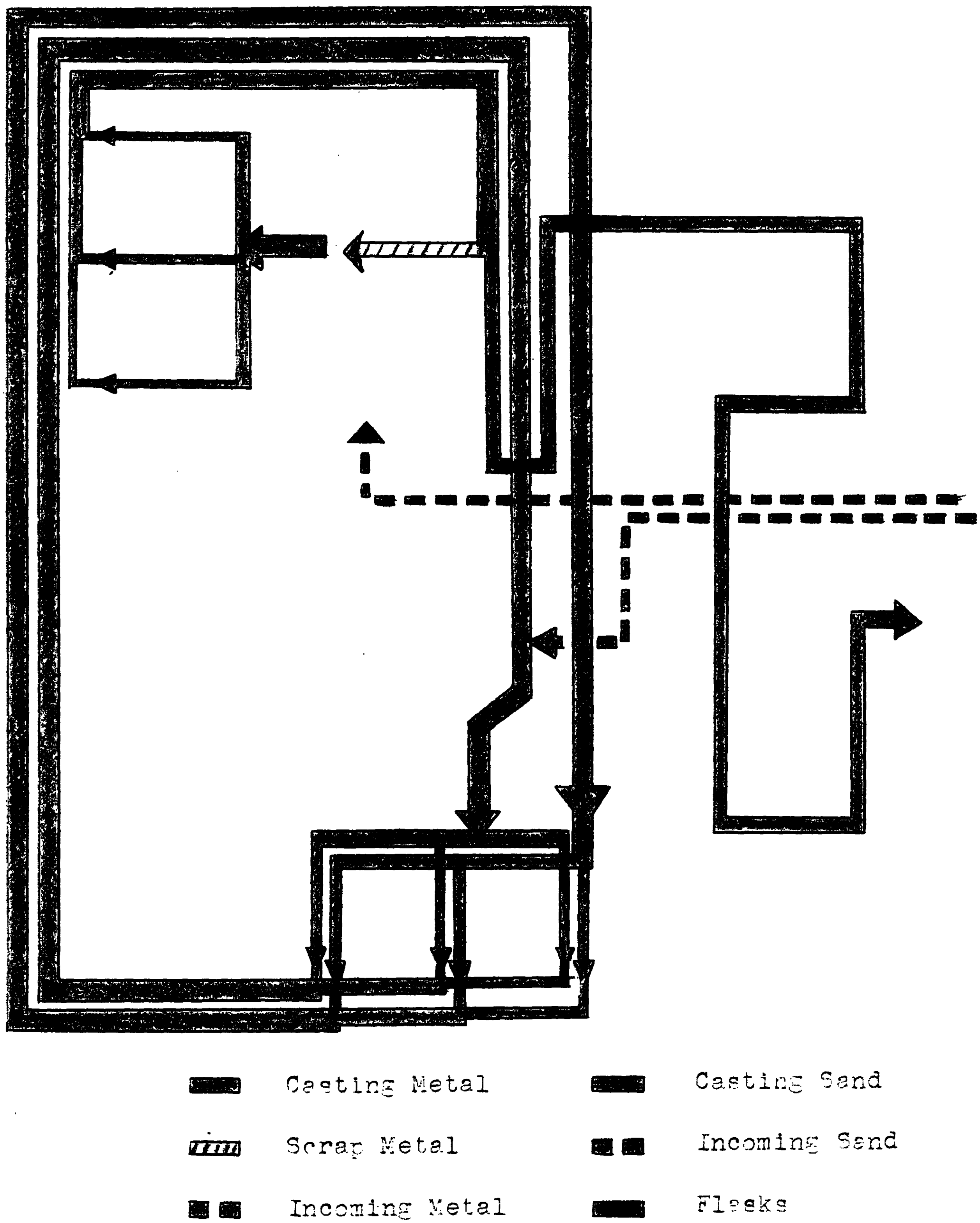
Running at this rate with the other departments in gear, 2400# of metal are poured in one shift and supposedly 1200# of good castings result. Synchronization of the other departments will come as a result of time and motion study on the various operations.

Theoretically this schedule works - in actual practice changes will probably be made as we become more familiar with the actual operations. Our flow of materials and castings is shown on the following page and corresponds to the layout shown in Figure 1.

Schematic Flow Chart

for

Various Materials



Quality Control

Casting Tests and Inspection

Defects in castings may be found by using various inspection methods. These methods may be broadly classified as destructive or nondestructive. Destructive tests have been employed for years in inspecting castings. When a new casting was first put into production, some sample castings were broken or sawed at places where voids or shrinkage were suspected. If no shrinks or voids were detected, the castings were accepted as sound, although the break or cuts might have missed a void by a thousandth of an inch, or the saw teeth might have burred over the porous metal in the shrinkage portion. The destructive tests were not conclusive.

At present, nondestructive tests are used to show internal defects in castings, and these tests are suitable for inspecting castings in mass production. These nondestructive methods include:

1. Laboratory tests for chemical analysis and mechanical properties of the metal.
2. Visual inspection
3. Layout inspection
4. Gaging, using special gages
5. Sound or percussion tests
6. Pressure testing

7. Static-loading nondestructive tests
8. Dynamic-loading nondestructive tests
9. Gamma-ray radiography
10. X-ray radiography
11. Magnetic-particle testing
12. Penetrant fluourescent testing
13. Supersonic testing

We do not propose to regularly use all of these nondestructive methods but only the four which are most essential for a small jobbing foundry. In our opinion, these are Laboratory Tests, Visual Inspection, Layout Inspection, and Gamma-ray Radiography. Any other method will be used only for special requirements of particular castings.

Although the first of these methods -- routine laboratory tests -- is not generally considered as being an inspection procedure, these tests are made solely to insure highest quality product obtainable, and to make certain that the casting meets the customer's specifications. Sand tests, tensile tests made on test bars which have been cast and machined, use of metallurgical microscope for checking heat-treatments and melting processes, tests for impact resistance, chemical analysis and hardness tests are examples of some routine laboratory tests which must be made.

The second of the methods which we will use is visual inspection which is the oldest and most widely used method.

As the name implies, this method consists of examining the surfaces of the castings. The number of surface defects which may be found by a trained inspector but which might not be located by an ordinary observer is sometimes surprising.

The third method we will use is layout inspection which is an inspection performed by using measuring tools such as those used in the machine shop. This type of inspection is very important since the present market is largely made up of close tolerance work. The casting to be checked is placed on a surface plate or clamped to some holding device such as an angle plate. The dimensions of the casting are then checked against those given by the blueprint using micrometers, surface gages, height gages, scales, calipers and other measuring tools.

The fourth method of inspection we will use is radiography. Radiography has the faculty of being able to show most of the internal defects in castings. Both the gamma rays emitted from radium and the x-rays produced by an x-ray tube are of the short wave lengths needed to penetrate metal.

Radiography can be explained as the production of shadow pictures, usually on photographic films, which indicate the comparative densities of the various portions of the casting being examined. In radiography the difference in density between a sound area and an area containing a defect must be sufficiently great to cause a change on the film which can be seen by eye. For this reason certain small defects may not be detected. This method of inspection can be used for detecting blowholes, internal shrinkage, inclusions of foreign material, and larger internal hot tears. Small closed cracks, especially when they do not run parallel to the rays, usually cannot be seen by this method. A two per cent change in the density, or of the total thickness, of the metal is about the minimum which can be seen.

There are essentially two methods which fall under the category of radiography. They are x-ray and gamma-ray inspection. The x-ray method uses an electronic apparatus; the gamma-ray method uses a capsule of radium. We will use the radium method although it is very much slower because our volume of production cannot justify the increased cost of an x-ray unit.

Since we propose to buy our metal in the alloy form, we will not need to perform detailed chemical analysis on every melt. A periodic inspection by an outside laboratory should suffice to insure that no contamination is taking place in the melting and pouring process. Analysis of the mechanical properties of the cast metal will have to be done in the shop since casting and heat treating greatly affect the mechanical properties of cast magnesium. Test bars will be cast at intervals preferably from each melt and will be run through the standard casting and heat treating processes of the shop and then subjected to mechanical tests such as tensile, impact, and hardness tests. Microscopic inspection of heat treating results will also be carried on.

Visual inspection will be a 100 per cent inspection procedure of the castings after the risers and gates have been cut off and also after final finishing immediately before going to the shipping department.

Layout inspection will be random with the first five castings of each lot being inspected along with approximately one out of every twenty-five of the following castings.

Gamma-ray radiography and layout inspection will be used only infrequently. The first three castings of every lot will be radiogrammed and layout inspected along with approximately one out of every fifty where the lots are over two hundred. This should give a satisfactory balance of consumer risk and cost of inspection provided sand mixtures and molding technique are held rather tightly controlled.

Casting Inspection Equipment Needed

Metallurgical microscope (used)	$150
Mechanical test machines (used)	350
Micrometers and equipment for layout inspection	300
Plates and equipment for radiography	200
Miscellaneous equipment	250
Total Investment (Estimated	$1250

(Note: Radium pill will be rented at low cost)

In the past few years there have been many advancements in the applications of quality control to foundry operations and we are very cognizant of the economies which quality control is striving for in the line of less foundry scrap, higher productivity, lower operating costs, better customer relations, and minimum returns of castings by customers. Quality control data in addition can be analyzed or collected by means of known methods, called statistical quality control methods, to insure lowest possible rejection of satisfactory castings, and guarantee that acceptable lots contain no more than a previously determined proportion of defective castings while, at the same time, cutting inspection costs. However, to apply these methods one must know certain data about his processes and products which can be obtained only after a period of time; therefore, we have made provision for the eventual installation of statistical quality control into this foundry by setting up the following three records on inspection defects and returned castings.

The first of these, the daily inspection report, is to be made out by the inspector at the time of inspection from his tally sheet. This record will provide invaluable information when the statistical scheme is later installed and will also give some valuable information for current planning and troubleshooting.

The record of returned castings which is the second form in our scheme is designed not only to give data for the statistical plan we shall have in the future but also to make current operating data available which will show how well the present inspection scheme is working with regard to passing bad castings on to the customer. One of these forms will be kept for each customer and all his returns will be recorded on it. This form could also be used in conjunction with shipping and invoice records to determine exactly how a particular customer's specifications have been met in the past.

The third quality control form to be used involves a record of the castings scrapped in production and the reasons for scrapping. This record will be valuable in later setting up our statistical plan and will also be currently valuable to give data on production practices and how well they are being controlled and to give figures which will help determine the actual costs of production over a period.

DAILY INSPECTION REPORT

Date ____________________

Pattern or Part No.	Customer	Total Insp'd	Total OK	Salvage		Reason for Scrapping						Remarks
				Weld	Rework	Cracks	Blow Holes	Shrinks	Core Shift	Bad Snags	Broken	

RETURNED CASTINGS

Customer ______________________

Date ______________

Address ______________________

										Received			No. OK'd To				
				Tears							Fault of		Salvage				
Sand Holes	Blow Holes	Shrinks	Core Shift	Hot	Cold	Porous Leaks	Misc.	Mach. Scrap	Broken	Total	Sup	Cust	Weld	Rework	Scrap	Order No.	Remark

CASTINGS SCRAPPED IN PRODUCTION

Month of_____________ 19_____

Order No.	Casting No.	Date Cast	Description	Defect	Weight	Cost	Salvage Value	Net Cost	Remarks
				Total					
Previous Balance									
Year to Date									

Sand Testing

One of the basic premises of quality control is that you can't inspect quality into a product. All the foregoing inspection setup won't improve the product quality one bit, quality must start from the beginning, which in the case of the foundry is in the mold. The only way to produce good molds is to control sand practices. All our sand conditioning and handling equipment is designed to produce and maintain sand of the optimum composition for quality casting, but these machines cannot do the whole job. The sand testing laboratory must not only set up the sand specifications which will produce the best castings but they must also police the production of the sand. For this reason the following tests will be made on every batch of sand, both mold and core where applicable:

1. Moisture test
2. Green strength
3. Permeability
4. Baked Strength

The moisture test will be made by the moisture teller method. This method consists of weighing a 50 gram sample of sand on a previously balanced especially constructed brass pan. This pan is fitted with a fine meshed wire screen bottom so that air and moisture can pass through, but small particles of clay and sand will not be lost. The pan fits under the exhaust part of a high speed electric fan which also has an electric heater. Hot air is blown through the wet sand, thus drying it. After a period of from one to two minutes, which is sufficient to thoroughly dry most samples, the pan and sand are reweighed on the balance and the loss of weight is multiplied by two to get the per cent of water in the sand.

The permeability test is made by first ramming a cylinder of sand in a special sand rammer which simulates the actual ramming of a mold. The sample is then tested by placing it in a permeability meter and observing the time required for a measured amount of air to pass through the sample. The shorter the time the greater the permeability.

The green compression strength test and the baked compression strength are made for mold sand and cores, respectively, in a universal sand testing machine which actually measures the breaking strength of the sand.

All of these tests will be made on every batch of sand mixed and only sand which possesses all the desirable quality characteristics will be used for molding.

All results of these tests will be recorded on the following two forms to serve as data for the quality control program and to check with casting quality data for possible causes of defects.

MOLDING

SAND TESTS

Date & Time	Mix No.	Permeability	Moisture	Green Strength

CORE SAND TESTS

Date & Time	Mix. No.	Permeability	Green Strength	Baked Strength	Moisture

<u>Sand Testing Equipment Needed</u>

Moisture Teller Machine	$40
Sand Rammer	15
Permeability Meter	35
Universal Sand Testing Machine	30
Ro-Tap Sieve Shaker	50
Miscellaneous Equipment	80
Total Investment (Estimated)	$250

Costing and Prices

In order to estimate the cost of producing a casting and, as a result, to estimate the price of the casting to the customer, consideration must be given to the cost of material, cost of direct labor, and the indirect expense. It is easy to estimate the cost of materials. It is in estimating the cost of direct labor and the indirect expense that it will take time to establish the standards needed.

In order to estimate the cost of direct labor within a reasonable degree of accuracy, it will first be necessary to thoroughly analyze wither the drawing or pattern for the casting and then prescribe the exact process to be used for each operation. This can be done only after some time study and methods data has been built up. Then and only then are the best and most economical methods likely to be used. After the process for each casting order has been prescribed, it will be necessary to determine the time and cost of each operation by the use of element standard times and standard base pay rates. Since a new foundry will not be able to set up element times immediately, some estimating will be necessary until such data can be built up through use of time and motion studies.

Indirect cost expense will be estimated by the use of predetermined overhead rates. The setting up of this item will involve quite a bit of estimation until past performance records can be established.

In order to build up the data which will facilitate good cost and price setting policy in the future the following three processes will be carried out:

1. Making a comparison between actual and estimated costs to determine what variations have occurred.
2. Determining what caused the variation.
3. Reviewing methods and/or practices to correct the error.

The forms described under the quality control section of this report are designed to give information which will help in this program after a backlog of data accumulates. In addition the following forms will facilitate the actual computations of costs.

The first form is the estimated cost and pricing form. The mechanics of this form are as follows:

"Estimate_____Actual_____"--one or the other of these should always be checked, so that whenever a question arises as to the basis on which a price was established, it is possible to ascertain the answer definitely and quickly. "Estimate" would be checked when working from the blueprint or a pattern that has not been run. "Actual" would be checked only after experience has been gained by actually running the job and the work involved is definitely known.

Now--to continue with the important thing we are after--the price of the casting. The first item of cost to be determined is the metal and melting costs of the casting. To find this it is necessary to know four things: the net casting weight, the kind of alloy to be used in making the casting, the ingot price of the metal, and the percentage of yield from gross weight of metal poured per mold to the net casting weight. By adding a fixed melting charge per pound of metal times the difference between the total weight of the casting and the net weight of the casting to the product of the cost per pound of alloy and the net weight of the casting, we arrive at the casting cost for metal.

The next consideration is the casting cost for coremaking. A specification is set up for the core, then the time required and allowed for the making of the core is determined. When we eventually have them available, a standard form standard data expressed in minutes would be the figure used here. However, at the outset, we will make considered estimates of the time it will take to do the operation. To determine the coremaking cost per casting, multiply the minutes of coremaking minute. This figure will be an estimate at first but will be more accurately determined as time study data is compiled.

The following cost items are determined in analogous ways except for job risk which is an estimate of percentage scrap which will be encountered in production. Again this will have to be estimated at first but the accumulation of data on scrapped castings will make this more and more accurate as time progresses. Administrative, selling, and profit is entered as a percentage figure which when added to the job risk percentage is multiplied by the subtotal per casting; this total is then added to the set-up cost per casting to give the price per casting. As a general rule, foundries using this system of setting prices use a figure of 150 per cent to cover administrative, selling, and profit.[1] We shall use this figure until further data either accepts or rejects this as valid.

The second form is a self-explanatory form which will give the monthly overhead cost to be compared with the charges made for administrative and selling expenses as estimated in the above form.

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1. Westover, J. A., "Pricing Castings Using StandardsCosts," American Foundrymen's Society, Preprint No. 52-84, 1952.

ESTIMATED COST AND PRICING FORM

Customer ______________________________ Date ___________

Part Name ___________________________ Part No. ___________

	Stand.	Meas. /cstg.	Cstg. Cost $
Each Casting Net Weight	------	lb.	
Metal @$ Yield %@			
Coremaking		m.	
Material		lb.	
Core Finishing		m.	
Molding		m.	
Material			
Pouring			
Shakeout			
Sand Condition			
Saw		m.	
Grind		m.	
Sandblast		m.	
Heat Treating		lb.	
Chem. & Phys. Tests		lb.	
SUBTOTAL PER CASTING			
Job Risk			
Admin., Selling & Profit			
Set-up/Casting			
PRICE PER CASTING			

MONTHLY OVERHEAD COST

Date ______________

Item No.	Description - Overhead Items of Cost	Monthly Cost
1.	Rent	
2.	Telephone & Telegraph	
3.	Investment Return __% on __M/12	
4.	Insurance	
5.	Taxes	
6.	Depreciation	
7.	Heating	
9.	Expendable Tools and Equipment	
10.	Miscellaneous Items	
11.	Plant Maintenance - Parts	
	- Labor	
12.	Personnel - Nonproduction	

TOTAL MONTHLY OVERHEAD COST

Terms and Conditions of Sale

General Conditions

All quotations will be made and all castings will be sold upon the following terms and conditions:

1. Unless otherwise agreed, quotations must be accepted and patterns furnished the foundry within thirty days from date of quotation.

2. All castings are sold as unmachined castings, with heads, gates, fins and similar extraneous metal removed, f.o.b. cars, foundry point. Terms -- thirty days net, from invoice date, unless otherwise stated.

3. Claims for error and weight or number must be made within ten days after the receipt of the castings.

4. Foundry is responsible for the replacement of castings rejected due to foundry defects and such claims must be reported and returned to the foundry within ninety days after their receipt. Foundry is not responsible for machine work, welding, labor charges or other losses or damages caused by defective castings unless otherwise agreed in writing.

Quotations

5. Blue prints submitted for estimating purposes should be marked with rough casting weight, if known,

or an estimated weight upon which quotations will be based. A detailed description of the pattern equipment should be furnished.

6. Unless otherwise specified, quotations are based on castings with gates, fins and other projections removed to approximately the contour of the pattern.

Orders

7. No order shall be changed unless notice of revision is made and accepted in writing before work is in process. If work is in process, customer is to be charged for any castings made as well as cost of cores, molds or equipment discarded because of such changes.

8. Cancellations of orders are to be made only by mutual consent of buyer and foundry.

9. Unless otherwise stipulated, the customer shall accept an overrun of ten per cent above quantities specified on order. However, the foundry is to make an effort at all times to furnish as near the exact quantity as operating conditions will permit.

Pattern and Core Box Equipment

10. Customer must supply pattern and core box equipment in condition to produce economically the quality and quantity of castings required.

11. Foundry is not responsible for variations existing

between blue prints and pattern and core box equipment supplied by customer.

12. All patterns, core boxes, and loose pieces should be marked properly for identification.

13. Repairs and changes to patterns by customer's orders will be made at expense of customer.

14. All freight charges on patterns, both to and from the foundry, shall be assumed by customer.

15. Pattern storage facilities are provided by foundry for active patterns only. Patterns not in use for a period of six months will be returned to the owner or will be subject to storage charges.

Wage Administration

Although an incentive system has been well established as being the best wage system for getting the most productivity per dollar of wages and per hour of machine or shop time in industries such as foundries, where a great deal of the work is manual, there is considerable detailed clerical work required to administer a wage incentive plan. Not only must each employee's work be counted and recorded individually but each employee's salary has to be computed individually from these records. There must also be some system of discounting scrap produced if the system is not to promote inferior quality.

In view of the foregoing disadvantages of a wage incentive system and the source of confusion which they might be for a foundry which has just been started and in which procedures have not had the benefit of the proof of time, we feel that although a straight hourly wage will not give as efficient use of facilities as might be desired the consequences will not be so bad as those of a wage incentive system which ran the risk of inaccuracies and mistakes.

From figures on wages for workers in malleable iron foundries in 1950 given by Charles T. Hassell in an article entitled "Wage Incentive Administration" in the Transactions of the American Foundrymen's Society the following hourly wage rates have been set up for use in this foundry:[1]

1. Hassell, Charles T., "Wage Incentive Administration, "Transactions of the American Foundryman's Society, Vol. 58, 1950, PP. 604.-610.

	Hourly Wage Rate
Spruing	$1.63
Shakeout	1.66
Bull Ladle Men	1.75
Trimmers	1.75
Oven Tenders	1.75
Shearing	1.75
Shifters	1.81
Grinders	1.81
Chippers	1.81
Molders	1.96
Pouring	1.96
Coremakers	1.98

These hourly wage rates were obtained by taking the wage figure which was given as the incentive rate for the average worker in malleable iron foundries in 1950 and multiplying this figure by a factor equal to the average weekly wage in malleable iron foundries in January, 1952, divided by the average weekly wage in malleable iron foundries in 1950. The factor used was equal to 70.78 divided by 64.33 or 1.1. The average weekly wage data used came from the statistics section of various Foundry magazines. Malleable iron statistics were used because they were the most recent to be found. The statistics in various Foundry magazines showed no appreciable difference in wages between types of foundries.

These rates are for experienced workers in each field and are designed to get good men. The plant will regularly operate 40 hours per week five days per week. Lunch period will be one-half hour.

The vacation plan will be as follows:

1 year service - 1 week

5 years service - 2 weeks

Explanation of Equipment Production & Material Figures

Equipment

The cost of the various pièces of equipment were gathered from many various sources. A foundry plant manager who had just bought some similar equipment was able to give us some data; equipment sales houses gave us some more; periodicals and old theses had figures we could use. There remained several items which we had to use our own estimations on, however. Of these, the ventilating equipment was the only major item. Not knowing just what capacity or type would be needed we set aside an amount we considered adequate to cover the cost.

The prices of this equipment are the maximum we would have to pay. Much of it would be available at second hand prices and thus our initial investment would be cut down by a sizable amount. By what amount it is, however, impossible to judge until we actually tried to buy the items.

Production and Material

Each melt in each furnace consumes 210 lbs. of metal of which, considering a 50 per cent yield and a five per cent loss in metal shrinkage and machining, 100 lbs. of good castings should result. Using three furnaces and a cycle of two hours for melting and pouring we plan on 4 x 100 x 3 or

1200 lbs. of salable castings per day. This is, considering 250 working days, 300,000 lbs. of castings per year. Our 5% loss due to shrinkage and machining dust and chips amounts to 30,000 lbs. per year (120 lbs./day x 250 days) making our metal needs 300,000 plus 30,000 or 330,000 lbs. per year.

Since our sand will be reconditioned, the only loss will be spilled and unreclaimable sand. We have used a figure of one per cent to cover this and estimating our needs at 1200 lbs. sand/hour (four times the metal poured) we shall buy approximately twelve and one-half tons of sand per year (25,000 lbs.)

In estimating operating costs of machinery a certain horsepower motor was taken as the driving force, converted to kilowatts, multiplied by hours used per day to get kilowatt-hours, multiplied by the cost of a kilowatt-hour ($0.03) and then divided by the poundage of metal (salable castings) per day to obtain a charge per pound of metal tracable to the machinery used in production.

Equipment Costs

a.	Sand Muller	$3000.00
b.	Roller Conveyor (35 ft. at $10/ft.)	350.00
c.	Monorail " (105 ft. at $12/ft. plus two bends @ $15/bend)	1290.00
d.	Core oven	3500.00
e.	Heat treating furnace	5000.00
f.	Melting furnaces ($2000/furnace)	6000.00
g.	Sandblasting rooms & equipment	500.00
h.	Misc. grinding and finishing eq.	1000.00
i.	Shakeout machine	3000.00
j.	Flasks and bench molding eq.	4000.00
k.	Bucket elevator	2000.00
l.	Pickling tanks and supplies	500.00
m.	Inspection equipment	1500.00
n.	$\frac{1}{4}$-ton chain hoists ($125 apiece)	375.00
o.	Lift trucks ($1200 apiece)	2400.00
p.	Trough-belt conveyor (45 ft. @ $10/ft.)	450.00
q.	Bottom boards	4095.00
r.	Core-blowing machine (up to 5#)	250.00
s.	Platform truck	75.00
t.	Roller bins ($60/bin)	120.00
u.	Ventilating equipment	5000.00
	Total	$44,005.00

Employees and Wages

Employees		Wages		
Number	Type	Hour	Day	Year
1	Melter	$ 1.75	$ 14.00	$ 3500.00
2	Pourers	1.96	15.68	3920.00
3	Molders	1.96	15.68	3920.00
2	Shakeout	1.66	13.28	3320.00
2	Fork-lift	1.25	10.00	2500.00
1	Heat Treatment	1.75	14.00	3500.00
1	Core Maker	1.98	15.84	3960.00
3	Machining	1.81	14.48	3620.00
1	Pickler	1.50*	12.00	3000.00
1	Sand Muller	1.70*	13.60	3400.00
1	Pattern Man	1.85*	14.80	3700.00
2	Maintenance	1.80*	14.40	3600.00
1	Sandblast	1.70*	13.60	3400.00
21		Total		$ 73,750.00

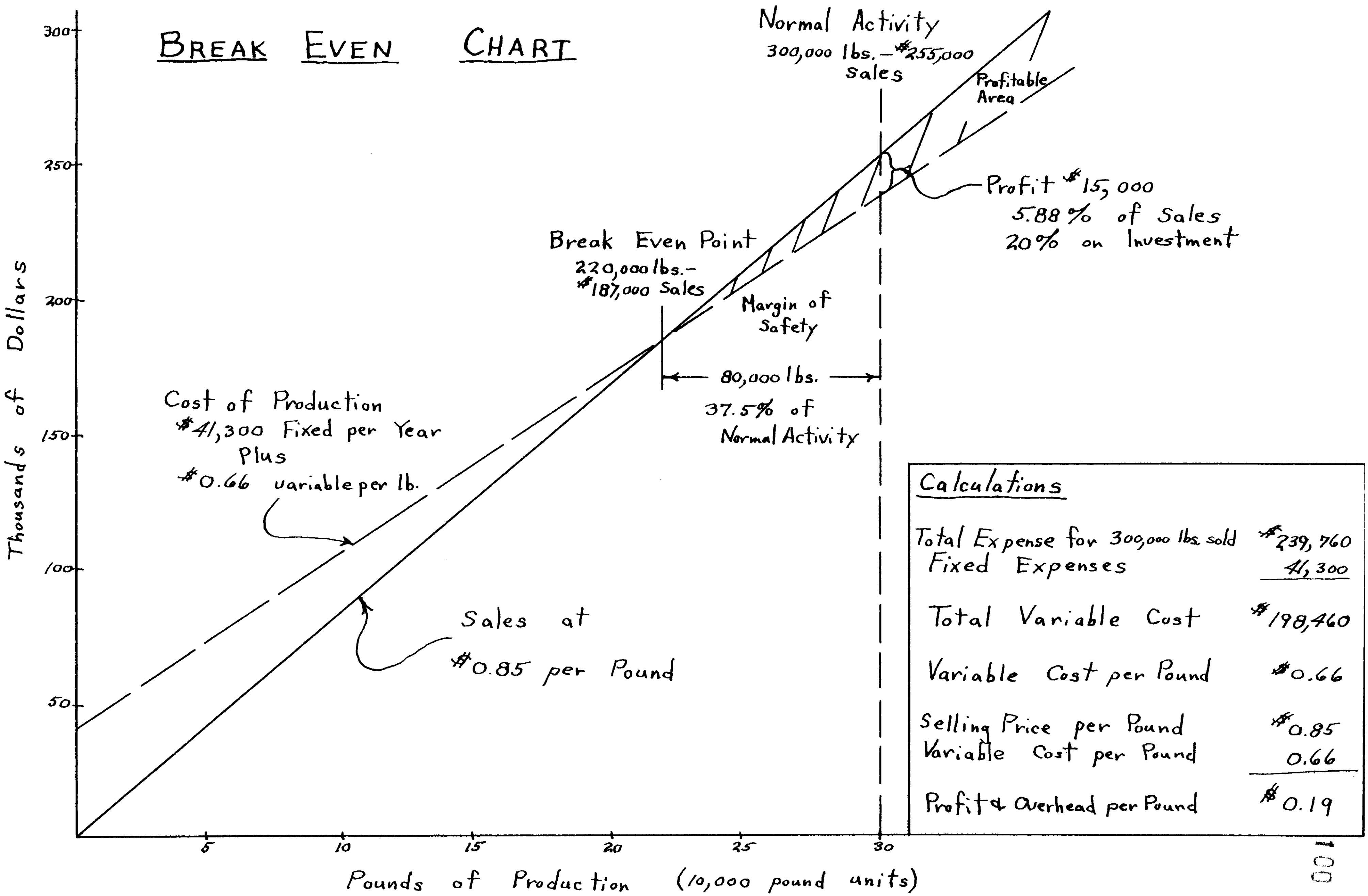
* estimated

Note: All rates except those marked * are justified in Wage Administration Section.

ESTIMATED COSTS AND EXPENSES FOR FIRST YEAR

(300,000 pounds of metal sold)

Cost of Doing Business	Amount		
Interest on Investment	$ 6,000 (8% on 75,000)		
Payment on Principal	10,000		
Bad accounts	500		
		16,500	
Fixed Overhead			
Rent	4,800		
Building Maintenance	1,500		
Taxes	1,000		
Insurance	700		
Depreciation of Equipment	9,000 (5 years)		
Administration	2,000		
Plant Supervision	4,800		
Sales Promotion Expense	1,000		
		24,800	
Total Fixed Expense			41,300
Operating Overhead			
Labor	73,760		
Heat for Plant	300		
Supplies	700		
Equipment Operating Costs	8,700		
Raw Metal (330,000 lbs,10% loss)	115,000 ($.35/lb.)		
Total Variable Expenses			198,460
TOTAL EXPENSE			$ 239,760


BREAK EVEN CHART
Normal Activity
300,000 lbs. – $255,000 Sales
Profitable Area
Profit $15,000
5.88 % of Sales
20% on Investment
Break Even Point
220,000 lbs. – $187,000 Sales
Margin of Safety
80,000 lbs.
37.5% of Normal Activity
Cost of Production
$41,300 Fixed per Year
Plus
$0.66 variable per lb.
Sales at
$0.85 per Pound
Thousands of Dollars
300
250
200
150
100
50
5
10
15
20
25
30
Pounds of Production (10,000 pound units)
Calculations
Total Expense for 300,000 lbs. sold $239,760
Fixed Expenses 41,300
Total Variable Cost $198,460
Variable Cost per Pound $0.66
Selling Price per Pound $0.85
Variable Cost per Pound 0.66
Profit & Overhead per Pound $0.19

PROJECTED CASH FLOW FIRST SIX MONTHS

Based on estimated sales as indicated (Sales at approximately $0.85 per pound)
Assuming that collections are made in an average of 15 days.

Sales, pounds	15,000	20,000	25,000	28,000	28,000	25,000
Cash Balance start	$19,500	7,875,	9,400	12,825	21,350	15,975
Income	6,000	18,500	20,000	25,000	26,000	26,000
Total	25,500	26,375	29,400	37,825	47,350	41,975
Disbursements						
Rent	400	400	400	400	400	400
Maintenance	100	100	100	100	100	100
Insurance	700					
Administration	600	400	100	100	100	100
Sales Promotion	500	400	200	100	100	100
Plant Supervision	400	400	400	400	400	400
Labor	6,000	6,150	6,150	6,150	6,150	6,150
Supplies	200	150	50	50	50	50
Equipment Operation	725	725	725	725	725	725
Metal	7,000	7,700	8,000	8,050	8,050	8,000
Miscellaneous	2,000	2,000	1,000	400	300	200
Principal Payment					15,000	15,000
Total	17,125	16,975	16,575	16,475	31,375	31,375
Cash Balance Closing	$7,875	$ 9,400	$12,825	$21,350	$15,975	$10,700

BALANCE SHEET

Before Operations Commence But After Purchase of Equipment

Assets

Cash	19,500	
Accounts Receivable		
Supplies Inventory (Sand, etc.)	2,000	
Raw Metal Inventory (10,000 lbs.)	3,500	
Finished Inventory		
Equipment (1,000 installation)	45,000	
Organization Costs	5,000	
Prepaid Insurance	5,000	
Total Assets		75,000

Liabilities

Accounts Payable		
Accrued Taxes		
Loans @ 8% interest (average)	75,000	

Net Worth

Surplus		
TOTAL LIABILITIES AND NET WORTH		75,000

BALANCE SHEET

After Six Month's Operation

Assets

Cash	10,700	
Accounts Receivable	1,150	
Supplies Inventory (Sand, etc.)	2,000	
Raw Metal Inventory (10,000 lbs.)	3,500	
Finished Inventory	1,000	
Equipment	40,500	
Organization Costs	4,500	
Prepaid Insurance	350	
Total Assets		63,700

Liabilities

Accounts Payable	4,700	
Accrued Taxes	500	
Loans @ 8% interest (average)	45,000	
	50,200	

Net Worth

Surplus	13,500	
	13,500	
TOTAL LIABILITIES AND NET WORTH		63,700

The actual financing of this enterprise is planned on the following basis:

All money will be secured on a loan basis from savings, friends, relatives, banks, and equipment manufacturers.

$30,000 will be from a short term bank loan at about 6 per cent interest. (Term of 6 months)

$25,000 will be from equipment manufacturers as equipment loans at about 6 per cent interest for a period of about 2 years.

$20,000 will be from savings, friends, relatives at about 10 per cent interest to be paid any time within 10 years. (Bonds will be issued.)

As a basis for cost and production estimates, selling price per pound will be estimated as $0.85 per pound of casting. We were not able to get any reliable information on the average price per pound in current use in the magnesium sand casting industry because of reluctance to give out this information and also because by and large castings are not sold on a per pound basis but on a job basis. However, we feel that a good estimate of the current price for magnesium sand castings of the type we will produce is around $0.90 to $1.00 per pound. Therefore, our price would give us the competitive advantage which we have aimed for from the beginning.

While the profit shown on the break even chart is necessarily based on estimates we feel that they have all been conservative and that the results are reasonably accurate. The big assumption behind the whole scheme, of course, is the volume of production we can expect to justify on the basis of orders we can get.

Based on the shipments and back orders for magnesium castings in 1951, we are attempting to get about 2 per cent of the total shipped for sale in the United States or, based on the assumption that New England shipped 10 per cent of the United States shipments, 20% of New England shipments. In view of the small size of the relatively few units in New England we do not feel that this in itself is unreasonable. However, a look at the unfilled orders for 1951 shows an even brighter picture. We are attempting to get only about .3 of a per cent of the total orders outstanding in 1951 in the United States or, with New England on a 10 per cent of National basis, only 3 per cent of the total orders outstanding for New England. This should be easily possible.

Our sales estimates of the first six months of operations are based on the assumption that defense contracts and subcontracts would be negotiated before commencing operations. The first two months are rated below capacity to allow for production difficulties which will most certainly be met.

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Bureau of Census Data

APPENDIX

Number of Foundries, Their Distribution by Size According to Employment, and The Metals They Cast

from

<u>The Foundry Industry Data Book 1949-1950</u>

Data compiled by <u>The Foundry</u>
Market Research Department
Penton Building
Cleveland 13, Ohio

UNITED STATES

Type of Metal Cast	Total for U.S.	Analysis by Size of Foundries (No. of Employees) Over 1000	500-999	100-499	50-99	20-49	20
Gray Iron	2,919	29	71	636	600	770	813
Steel	367	18	39	169	60	45	36
Malleable	138	10	21	81	17	3	6
Aluminum	2,750	9	32	231	244	557	1,677
Brass & Bronze	2,538	5	26	236	340	556	1,475
Magnesium	145	1	--	28	15	18	83
Total Nonferrous	3,215	10	38	309	310	667	1,881
All Foundries	5,404	45	110	914	773	1,231	2,331

NEW ENGLAND AREA

Type of Metal Cast	Total for N.E.	Analysis by Size of Foundries (No. of Employees) Over 1000	500-999	100-499	50-99	20-49	>20
Gray Iron	241		4	51	49	*75	62
Steel	18		1	*8	4	4	1
Malleable	17			*10	5	1	1
Aluminum	254		2	24	21	55	*152
Brass & Bronze	273		3	28	22	67	*153
Magnesium	19			2			* 17
Total Nonferrous	306		4	34	24	71	*175
All foundries	477		3	68	62	124	*217