THE METAL MIXER

The easiest, simplest and most exact method of mixing iron by chemical analysis, with tables and ready made mixtures.

Indispensable to Molders, Melters and Foundry Men.

By W. W. ELLIS

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INTRODUCTION

In presenting this book to molders and foundry foremen I do so, believing there is a real demand for a book,—written in plain every day foundry language that anyone may understand, showing a simple and easy method of mixing iron by chemical analysis. I have endeavored to explain every mixture in a manner so simple, that the man who has never mixed iron, or understands anything whatever about foundry work, can, with a few minutes study, make any kind of a mixture, from any number of different grades of iron, by this easy method, almost as well as the more experienced foundry man. We do not require a knowledge of chemistry to be able to mix by analysis. In fact, the average foundry man or foreman has very little use or time for it. But what we must know is the composition of the iron we are mixing, and the percentage of the different elements it contains. The broker generally gives an approximate analysis. Drillings should be analyzed for the exact composition. In regard to the influence and relation the elements have to one another, and above all the percentage of the most important of these elements, castings designed for different kinds of work, should contain, I have endeavored to explain, and if followed, will give the reader a good working knowledge of the characteristics of the different elements, which is a big help in making mixtures.

Foundry iron contains several of these elements, or impurities as they are sometimes called, but there are only five in which we are mostly interested in. They are silicon, phosphorus, sulphur, manganese and the carbons. Of these five, I think the carbons are the most important, because carbon is the element that gives the iron its character. Foundry iron contains carbon in two distinct forms, called graphite carbon and combined carbon. And according to the percentage of each of these carbons, so will the iron be hard or soft. Graphite, or soft carbon, is always high in very soft open grained iron. Combined or hard carbon is always high in very hard, close grained iron. In making mixtures for the cupola it is a more difficult proposition to take hold of the carbons and figure their content than it is silicon or some other element, so, as a rule if we wish to reduce or change the carbons, we generally add some low carbon steel scrap, or change the carbons by using high or low silicon in the mixture, as the case may require. In making mixtures for the ordinary run of machinery castings, we do not trouble about the carbons because we find if silicon is high, graphite carbon will be high also, and if silicon is lowered, graphite carbon will be lower, and combined carbon will be higher, and the more we lower the silicon the more combined carbon we will get in our castings. Chemists long ago proved, if we wish to regulate the carbons it can be done through the silicon, which at once proves that silicon is one of the most important, if not the most important element the founder has to work with. Not only does it influence the carbons, but the other elements also, to a certain extent. For we find if we get silicon normal for the class of work we are making, the other elements also will be normal, especially so, if we use the ordinary run of foundry irons. As the silicon can be raised or lowered as required, it is the first element that should be figured in mixing iron by chemical analysis. When iron contains more than 3.5 per cent silicon, it will begin to get hard. Not hard and strong like a low silicon close grained iron, but hard, short and brittle. So in making mixtures, we never go above 3.25 per cent silicon, and even that percentage is very rarely used, except in fine stove plate, or work similar to it. There are special mixtures however, for acid proof castings, that call for a much higher percentage of silicon, but these are exceptional, and are not included in the ordinary run of foundry products. Silicon and manganese are not affected by mineral and vegetable acids, like graphite carbon, sulphur and phosphorus are. So in making mixtures for this kind of work, the combined carbon, silicon and manganese should be high, especially the silicon, which of course will make the casting very brittle. To make such mixtures takes considerable experimenting, even by the most experienced chemist and metallurgist. In arranging the different mixtures I have tried to make them as progressive as possible. The few mixtures from my note books, I thought would give the reader an idea of what has been done with steel mixing. These were made when pig iron was very much cheaper than now, as some were made as far back as 1904. The analysis of different pig irons will also give beginners a working idea of the composition of iron. The few remarks on the influence the different elements have upon the iron will all help the student how to use, and mix them to accomplish a certain purpose.

In selecting and using scraps, of course is more or less guess work. But, by careful study and selection, and by getting a determination now and then, one will soon be able to judge the silicon content for all practical purposes. But if special work is to be made to specification, such as shells or other governmental work, all the scraps must be melted and pigged, and analysis taken of each cast. Only then can we say with confidence, just what is the composition of the scrap.

In the mixtures showing the method of mixing three or more irons together, I have used a higher per cent of steel than I would advise to use without experience. Although I have made mixtures containing more than 25 per cent steel, still I am convinced by actual tests, that no improvement or benefit can be obtained by using more. This opinion seems to be general among other foundry men, who have had any experience with steel and iron mixtures. I have also found if using a higher per cent the best results was obtained when using all pig and steel scrap. Steel mixtures must be melted hot and handled quick when in the ladle. The few examples on decimals and percentage will help refresh our memories, and are handy to refer to while studying this method, as they deal directly with the work of the book. The last chapter deals with the cupola, which are chiefly personal experiences, and agrees closely with our leading foundry men. And if followed as near as possible together with other information in the book, the young foundry man should have no trouble in handling the mixing and melting end of any shop, independent of the class of work being made.

—W. W. ELLIS.

MIXTURE FOR MEDIUM MACHINERY CASTINGS.

In this mixture we will figure for silicon only, and I would advise the student to work over this first mixture until you understand it. You will then be surprised how simple it is. You will then have the foundation for making any kind of a mixture from any number of different grades of iron. A mixture for medium machinery work should contain about 2 per cent silicon, with that percentage, castings from $\frac{5}{8}$-inch in section should machine quite easy. As we lose about two tenths (0.2) of one per cent silicon in melting, we must add that much to our mixture before it goes into the cupola. On account of this loss we must figure our mixture to contain 2.2 per cent silicon. To make this we will use pig iron and scrap enough to make a mixture of 2000 pounds. The pig contains 3.25 per cent silicon, and the scrap 1.75 per cent. As we desire only 2.2 per cent, you will notice that I have selected one iron with a higher, and one with a lower per cent of silicon. We will now put the lowest silicon under A, the amount we desire under B, and the highest silicon under C. So placing them in that order they stand as follows:

A.	B.	C.
1.75	2.20	3.25

RULE: By subtracting A from B we get .45 remainder; substracing B from C we get 1.05. We now add both remainders together, getting 1.50. Taking the first remainder .45 and after affixing two ciphers to it, and moving the decimal point two places to the right, and dividing it by the sum of the two remainders 1.50, we get 30, the percentage of the C iron to be used in the mixture. Taking the second remainder 1.05, and after affixing two ciphers, and moving the point two places to the right, dividing it also by 1.50 we get the percentage of the A iron, which is 70,—to be used in the mixture.

Example	A.	B.	C.	
	1.75	2.20	3.25	
Take A from B.		1.75	2.20	Take B from C.
1st Remainder		.45	1.05	2nd Remainder
Add both remainders		1.05		
Sum of the two		1.50		

TABLE No. 1

1st remainder .45 representing C iron.

Two ciphers affixed and point moved two places and divided by 1.50)45.00(30% of C iron to be used.
45.00

TABLE No. 2

2nd Remainder 1.05 representing A iron. With two ciphers affixed and point moved two places we divide by
1.50)105.00(70% of A iron to be used in the mixture.
10500

TABLE No. 3

Don't miss this one point of setting the different silicons under their proper heading.

Always set the lowest silicon under A, what we desire under B and the highest under C. Then take A from B, and the first remainder will always represent the C iron. Then take B from C and the second remainder will always represent the A iron. As these remainders only represent the A and C irons, they do not tell us how much per cent of each one to take. To find a rate so we can figure what percentage of these two irons to use, we add these two remainders together, and after affixing two ciphers to each one, we divide each one by the base, or sum of the two. The result of this division is of course the percentage of the iron we are to use that each remainder represent, which is clearly shown in tables 2 and 3. When affixing the two ciphers to each of the remainders, be sure and move the decimal point two places to the right even though it does point off ciphers as in this example.

We will now check off our mixture.

According to our figures we are to use 30 per cent of C iron, and 70 per cent of A iron. By multiplying the 3.25 per cent of silicon by the 30 per cent, we get .9750 per cent, and by multiplying the 1.75 per cent by the 70 per cent we get 1.2250 per cent. Adding these two percentages together will give us our desired percentage of 2.2 per cent silicon.

Example:—	Percentage of silicon in C iron	3.25
	Percentage of C iron to be used	.30
	Per cent of silicon	.9750

TABLE No. 4

Percentage of silicon in A iron	1.75
Percentage of A iron to be used	.70
Per cent of silicon	1.2250
Percentage of silicon from C iron	.9750
The required per cent amount of silicon	2.2000

TABLE No. 5

This method gives the percentage of silicon as well as the percentage of the iron.

Example:—

30 per cent of 2,000 lbs. = 600 lbs. of C. pig iron.
70 per cent of 2,000 lbs. = 1400 lbs. of A scrap iron.

Mixture of 2000 lbs.

TABLE No. 6

In tables 2 and 3 the divisors and dividends has each two decimal places which make the quotients whole numbers, —see decimals.

SOFT MIXTURES FOR PULLEYS

We will make this another two iron mixture, and figure for silicon only, introducing shorter method with less figuring. In making mixtures for pulleys, we should try and keep the silicon three or four points higher than we would for castings in our first mixture. The metal will be softer and of course the shrinkage will be lower. Even with this percentage, all pulley hubs should be stripped and cores taken out.

Suppose we want a mixture of 1500 pounds containing 2.4 per cent silicon in the castings. That means with the loss of silicon in melting our mixture must contain 2.6 per cent before going into the cupola. To make this mixture we will use some of the gates of our first mixture containing 2.0 per cent silicon, and No. 1 Sloss pig iron containing 3.6 per cent silicon. Putting the lowest silicon under A, our desired under B and the highest silicon under C. We then work out as in table No. 1.

By substracting A from B we get our first remainder .6, which represents the C iron to be used in the mixture. Substracting B from C we get our second remainder, 1.0 which represents the A iron to be used in the mixture. After adding these two remainders together and getting 1.6, we take the first remainder and after affixing two ciphers to it, we move the decimal point two places to the right, making 60.0. We now divide the 60.0 by the sum of the two remainders 1.6; which we find goes $37\frac{1}{2}$ times. As this first remainder represents the C iron, it shows we are to take 37.5 per cent of C iron to use in our mixture. Now, if we are to use 37.5 per cent of C iron, it stands to reason we must use 62.5 per cent of A iron, as 37.5 and 62.5 equals 100. So that being the case, further figuring are unnecessary. Example:

	A.	B.	C.	
	2.0	2.6	3.6	
Take A from B		2.0	2.6	Take B from C.
1st remainder		.6	1.0	2nd remainder
Add both remainders		1.0		

Divide by 1.6)60.00(37.5 % of C iron.

```
1.6)60.00(37.5 % of C iron.
    48
    ---
    120
    112     62.5 % of A iron.
    ---
     80
     80
```

TABLE No. 7.

You will notice instead of making two separate tables as in our first mixture, we simply take the first remainder .6 put it to the right of the 1.6, add two ciphers to it, and move the point two places, then divide it by the 1.6. The result of this division completes all the figures required to get the percentage of the irons to be used in any mixture, so make yourself familiar with the first mixture, then you will be able to follow table 7 with ease. For table 7 is the form in which you will make all your mixtures in actual practice, except, of course, when correcting mixtures, or mixtures that have even number remainders, which will be explained in other mixtures following.

Percentage of silicon in C iron	3.6
Percentage of C iron to be used	37.5
Per cent of silicon	1.3500

TABLE No. 8

Percentage of silicon in A iron	2.
Percentage of A iron to be used	62.5
Per cent of silicon	1.250
Silicon from C iron	1.350
The per cent amount of silicon required	2.600

TABLE No. 9

37.5 per cent of 1500 = 562.5 pounds of C pig iron.
62.5 per cent of 1500 = 937.5 pounds of A gate scrap.

Charge of 1500.0 pounds

TABLE No. 10.

Note: In multiplying by the rate for percentage, you point off two for the whole numbers, and as many decimals as there are in the multiplier and multipliant, which makes four in table 8, and three in table 9. See decimals. In actual practice we would only require tables 7 and 10. Tables 8 and 9 are merely used to prove our figures.

MIXTURE FOR A ROLL SEMI-STEEL USING FOUR DIFFERENT KINDS OF IRON

In this mixture we will explain a method whereby any number of different kinds of iron can be mixed together.

When making a mixture to contain several different brands of iron, and not being particular how much of each, the best way is to segregate them, putting all the irons together that contain a lower silicon than we require in our mixture into one group, and all the irons that contain a higher per cent of silicon into another group. After getting the mean percentage of silicon from each of these groups, we have practically but two irons to figure on, and can be worked out as in table 7. Then, after we have found what percentage of each group we are to use, we must divide each percentage into as many parts as there are irons composing each group.

Example: Suppose we wish a mixture of 4,000 pounds for a 20 inch dia-chilled roll, containing 0.6 per cent silicon, adding the usual 0.2 per cent for loss of silicon, would make our desired silicon 0.8 per cent before it goes into the cupola. To make this mixture we will use some of the following irons.

	Sil.	Phos.	Sul.	Mang.	T. C.
Heavy scrap	1.50	0.40	0.08	0.60	
Salisbury pig	1.29	0.30	0.045	0.40	3.85
Steel scrap	0.2	0.05	0.05	0.50	0.10
Cargo fleet-pig	0.79	1.52	0.027	0.23	3.12

TABLE No. 11.

By putting the two lowest silicons together and dividing them by 2. we find their mean silicon content is 0.495 per cent, which must be put down under A. Putting the two highest silicons together and dividing them also by 2, we find their mean silicon content is 1.395 per cent, which must be put down under C. The desired silicon of course must be put down under B. This gives us practically a two iron mixture, and they stand ready to be figured as in table No. 7.

	A.	B.	C.	
	0.495	0.800	1.395	
Take A from B		.495	.80	Take B from C.
1st Remainder		.305	.595	2nd Remainder.
Add both		.595		
Divided by		.900)30.500(	33-8/9% of C iron	
		2700	66-1/9% of A iron	
		3500		
		2700		
		800 / 900	equals 8/9	

TABLE No. 12.

Table No. 12 shows we are to take 33-8/9 per cent of C iron. Then, of course we must take 66-1/9 per cent of A iron.

As each of these percentages have to be divided into two equal parts, we will do away with the fractions, and call each one a whole number, which will save extra figuring and will not affect the result any. By making them whole numbers we have 34 per cent of C iron and 66 per cent of A iron. As the C iron is composed of heavy scrap and Salsbury pig, we must use 17 per cent of each, and of course 33 per cent of each of steel and Cargo Fleet. In checking them off at these rates, we find we have a shade more silicon than we desire, brought about of course by using all whole numbers instead of the fractions.

Example:

17% of 1.50%	silicon in Heavy scrap, equals	0.2550%
17% of 1.25%	silicon in Salisbury scrap, equals	0.2193%
33% of 0.20%	silicon in Steel scrap, equals	0.0660%
33% of 0.79%	silicon in Cargo Fleet-pig, equals	0.2607%
100	Total silicon equals	0.8010%
	Loss in melting	0.20
		0.6010%

TABLE No. 13

17% of 4000 pounds equals	680	pounds Heavy scrap.
17% of 4000 pounds equals	680	pounds Salisbury pig.
33% of 4000 pounds equals	1320	pounds Steel scrap.
33% of 4000 pounds equals	1320	pounds Cargo Fleet-pig.
Charge of	4000	pounds

TABLE No. 14

To multiply one percentage by another percentage, see percentage.

In shop practice when this method is understood, we would require only tables 12 and 14, saving the figuring of table 13, which we know would be correct.

The other elements can be figured the same way as silicon. The manganese which would be low for a casting of this kind, could be corrected with ferro-manganese, as explained in following mixtures.

METHOD FOR CORRECTING MIXTURES WITH FERRO-SILICON OR FERRO-MANGANESE.

This method is useful when we wish to add more silicon or manganese, as the case may be, to a mixture already figured.

We wish to make a mixture of 2000 pounds for medium floor work containing 2.2 per cent silicon. We have 1000 pounds of foundry scrap which we know contains 2 per cent silicon and 1000 pounds of heavy scrap containing 1.5 per cent silicon. As these two lots of iron are the amount we require in our mixture, we will see how much silicon they will bring into it. 50 per cent of 2 per cent silicon in foundry scrap gives us 1.0 per cent, and 50% of 1.5% silicon in heavy scrap gives us 0.75% more, making a totoal of 1.75 per cent silicon, leaving 0.45 per cent more to be supplied by the ferro-silicon to make our mixture contain 2.2 per cent. This 0.45 per cent is what we want, and must go down under B. The ferro-silicon containing 80 per cent silicon must be put down under C, and as we are working with one iron only, we will put a cipher under A. Setting them down in that order, they stand ready to be figured as in table 7.

Example:

	A.	B.	C.	
	0	.45	80.00	
Take A from B		0	.45	Take B from C.
1st Remainder		.45	79.55	2nd Remainder.
Add both		79.55		

```
Divided by        80.)45.0000(.5625% of C Fer. sil.
                      400
                      ---
                       500
                       480
                       ---
                        200
                        160
                        ---
                         400
                         400
```

TABLE No. 15

```
  2000 Pounds
00.5625
-------
11.250000 Pounds
```

TABLE No. 16

```
  11.25 Pounds
    .80
  -----
20)9.0000(.45%
   80
   --
    100
    100
```

TABLE No. 17

80
00.5625

.450000% of silicon from Ferro Silicon
1.75 % of silicon from scrap iron

2.20 Total silicon.

TABLE No. 18

Table 15 shows we are to add 0.5625 per cent of ferro silicon to the mixture. To find the amount of ferro-silicon in pounds we are to use, we will multiply the 2000 pounds of iron by .5625% making it 11.25 lbs. Multiply 11.25 pounds by the per cent of silicon it contains (which is 80,) and dividing the result by 20, the number of hundred pounds in the mixture will give us our required silicon 0.45 per cent. Or, multiply the 80 per cent ferro-silicon by the percentage we are to take, .5625, will also give us our required 0.45 per cent. See tables 16, 17 and 18 above. I have used 80 per cent ferro-silicon, it serves our purpose as well as 50% or any other per cent.

THREE IRON SEMI-STEEL MIXTURES WITH APPROXIMATE FIGURING OF ALL THE ELEMENTS.

This mixture if melted hot and under proper conditions would be suitable for marine piston rings, piston valve liners, cut and cast gears, etc. Although we are using high steel in this mixture it is advisable not to attempt high steel mixtures without previous experience. In making a mixture of this kind, there are always two elements we are sure of getting exact. These are silicon and manganese, which will be proved in this mixture. The other elements will be influenced by these two, and can be made normal for the mixture, especially so, if we select irons suitable for the work in hand.

Keep the sulphur and phosphorus low. If the sulphur is high, raise the manganese a point or two. We will make a mixture of 2000 pounds to contain

Silicon	Phos.	Sulphur	Mang.	Total Carbon
1.8%	0.45%	0.07%	0.75%	

From the following irons:

Buckeye	3.6%	0.55%	0.016%	0.50%	3.50%
Scrap iron	2.2	0.60	0.070	0.45	3.25
Scrap steel	0.2	0.05	0.050	0.50	0.08

TABLE No. 19.

As we are not particular what per cent of each iron we use, the best way is to put the two lowest silicon's together, and get their mean percentage. In this case we will put scrap iron and scrap steel together. So adding 2.2 and 0.2 together making 2.4 per cent silicon, and dividing by 2. will give us their mean per cent, 1.2. This gives us now, practically, but two irons to figure on. Putting them under their proper headings they stand ready to be figured as in table 7. Adding 0.2 for loss of silicon in melting will make our desired 2.0%.

	A.	B.	C.	
	1.2	2.0	3.6	
Take A from B		1.2	2.0	Take B from C.
1st remainder		.8	1.6	2nd remainder

TABLE No. 20

When one remainder is just twice as much as the other, it shows we are to take 33⅓ per cent of the C iron, and 66⅔ per cent of the A, and no more figuring are required. If both remainders should come the same it would mean 50 per cent of each A and C, and if one remainder should happen to come three times as much as the other, we would have to take 75 per cent of one, and 25 per cent of the other. In this case we are to take 33⅓ per cent of C and 66⅔ per cent of A iron. As the A iron is composed of scrap iron and scrap steel, it means we are to use 33⅓ per cent of each pig iron, scrap iron and steel. In checking off at these percentages we get the following results:

Example—

Silicon.

Pig iron	33⅓% of 3.6% silicon equals	1.200 %
Scrap iron	33⅓% of 2.2% silicon equals	0.733⅓ %
Scrap steel	33⅓% of 0.2% silicon equals	0.066⅔%
A—	Total silicon	2.000 %
	Loss in melting equals	0.2 %
	Silicon in casting	1.8 %

Phosphorus.

Pig iron	33⅓% of 0.55% phos., equals	0.1833⅓ %
Scrap iron	33⅓% of 0.60% phos., equals	0.2000
Scrap steel	33⅓% of 0.05% phos., equals	0.0166⅔
Phosphorus does not lose or gain in melting		.4000 %

B—	Sulphur.	
Pig iron	33⅓% of 0.016% sulp., equals	0.00533 ⅓%
Scrap iron	33⅓% of 0.07 % sulp., equals	0.02330⅓
Scrap steel	33⅓% of 0.05 % sulp., equals	0.0166 ⅔
		.04524⅓
	Gain in melting equals	.03
		.07524⅓%
C—	Manganese.	
Pig iron	33⅓% of 0.50% mang., equals	0.166⅔%
Scrap iron	33⅓% of 0.45 % mang., equals	0.150
Scrap steel	33⅓% of 0.50% mang., equals	0.166⅔
		0.483⅓
	Loss in melting, equals	0.100
		0.383
	Manganese from 80% ferro-mang., equals	0.367
		0.750 %
D—	Total Carbon.	
Pig iron	33⅓% of 3.50% carbon, equals	1.1666⅔%
Scrap iron	33⅓% of 3.25% carbon, equals	1.0743⅓
Scrap steel	33⅓% of 0.08% carbon, equals	0.0266⅔
	Total carbon	2.2676⅔%
E—		
Pig iron	33⅓% of 2000 lbs., equals	666⅔ lbs.
Scrap iron	33⅓% of 2000 lbs., equals	666⅔ lbs.
Scrap steel	33⅓% of 2000 lbs., equals	666⅔ lbs.
F—		2000 lbs.

TABLE No. 21.

This table shows that all the elements are nearly as we want them, except the manganese, which of course can be corrected to what we require with ferro-manganese. The sulphur is slightly higher, but the high manganese will be liable to offset that much. As we desire 0.75 per cent manganese in our mixture and our irons have given us only 0.383 per cent, it is evident we must get 0.367 per cent from the ferro-manganese.

To find the number of pounds of ferro-manganese to use, so as to get this 0.367 per cent manganese in the mixture, we will set the 80 per cent under C, the desired 0.367 under B, and figure out as in table 15 on correcting mixtures or, using a shorter method which can always be done when figuring a one iron mixture like this, we will simply affix two ciphers to B, move the point two places to the right, then divide it by C. Example:—

TABLE No. 22.

```
A.      B.      C.
0.     .367    .80

80)36.700(.45 7/8%
   320
   ---
    470
    400
    ---
     70
     -- = 7/8
     80
```

TABLE No. 23

```
    80
  .45 7/8
  -------
    70
   400
  320
  -------
 .3670%
```

TABLE No. 24

```
  2000 pounds
   .45 7/8
  -------
   1750
  10000
  8000
  -------
   9.1750 pounds
```

If you will look over Table 22, you will see we have accomplished the same results as we did in table 15, with considerable less figuring. The figures show we are to use $45\frac{7}{8}\%$ of ferro-manganese. Multiplying 80 per cent manganese by the $.45\frac{7}{8}\%$, gives us our required 0.367%, as in table 23, and to get the number of pounds of fero-manganese we are to use to get this percentage of manganese, we multiply the full charge of 2000 pounds by the $.45\frac{7}{8}\%$, which shows we are to use, 9.175 pounds of ferro-manganese as in table 24. By multiplying the 9.175 pounds by the 80%, will give us the exact number of pounds of manganese, we will get from the fero-manganese which is 7.34 pounds. Now divide this 7.34 by 20, the number of 100 pounds in the mixture, will again give us our required per cent, 0.367 of manganese, as in table 25.

Example:—

```
          9.175
             80
    20)7.34000(.367% manganese.
    -----------
          60
          ---
          134
          120
          ---
           140
           140
```

TABLE No. 25

Manganese from pig iron and scrap, equals	0.383%
Manganese from 80% Ferro-Manganese, equals	0.367%
Manganese in mixture	0.750%

In shop practice the per cent of D and F in table No. 21, and tables 22 and 24 is all we need figure. The other tables are worked merely to prove the mixture.

MIXTURE FOR LARGE CYLINDER LINERS, ETC.

Show Methods, if a Certain Per Cent of Some of the Irons Are to be Used

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We will make a mixture of 2000 pounds to contain 1.0 per cent silicon. We must use 500 pounds of steel scrap containing 0.2 per cent silicon, and 500 pounds of liner scrap containing 1.0 per cent silicon. We have besides some scrap containing 1.6 per cent silicon, and pig iron containing 2.2 per cent silicon. By adding the 0.2 per cent silicon to make up for loss in melting, our mixture will have to contain 1.2 per cent silicon. The first thing to do when making a mixture with a given per cent of some of the irons is to find how many pounds of silicon the mixture must contain. Here we want 2000 pounds to contain 1.2 per cent silicon, multiplying the 2000 by the 1.2 per cent gives us 24 pounds of silicon. This is the amount we must get in this mixture. The next is to find how much the given irons will contribute to the 24 pounds, multiplying 500 pounds of steel by 0.2 per cent will give us 1 pound of silicon. The 500 pounds of liner scrap containing 1.0 per cent will contribute 5 pounds more. This makes 6 pounds, leaving 18 pounds more for the other 1000 pounds of iron to bring in. Now, if we had some 1.8 per cent silicon iron, 1000 pounds of that would just make our mixture complete, by giving us the 18 pounds of silicon we require. And of course no more mixing would be necessary, but we have only 1.6 per cent scrap, and the 2.2 per cent pig iron. So we must find how much of each of these we must use to complete the mixture. As we want 1000 pounds more iron, and 18 pounds of it must be silicon, that means it must contain 1.8 per cent silicon, which of course is our desired silicon, and must be put under B, setting them down under their proper headings, they stand ready to be figured as in table 1. Example:—

	A.	B.	C.	
	1.6	1.8	2.2	
Take A from B		1.6	1.8	Take B from C.
1st Remainder		.2	.4	2nd Remainder.

TABLE No. 26.

As we have shown in previous mixtures, when one remainder is as much again as the other, it means we are to take 33⅓% of the iron the smallest remainder represents, (which is C), and 66⅔% of the iron that the largest represents—which is A. As we only want 1000 pounds more iron to complete the mixture this means we are to take 333⅓ pounds of pig iron, 666⅔ pounds of scrap iron. By taking the 500 pounds of steel, 500 pounds of liner scrap, 333⅓ pounds of pig iron, 666⅔ pounds of scrap iron, and multiply each one by the per cent of silicon it contains, will give us the 24 pounds of silicon we require in the mixture. Example:—

Steel	500	pounds x 0.2%	equals	1	lb. silicon
Liner scrap	500	pounds x 1.0%	equals	5	lb. silicon
Pig iron	333⅓	pounds x 2.2%	equals	7⅓	lb. silicon
Scrap	666⅔	pounds x 1.6%	equals	10⅔	lb. silicon

```
20)24.0(1.2% sil.
   20
   --
    40
    40
```

TABLE No. 27.

By dividing the 24 pounds by the number of 100 pounds in the mixture, (which is 20), gives us our required 1.2 per cent silicon. Here is another way to check it off, but as we were only figuring for half the mixture in table 26, we must take only half of each percentage thus obtained, making it 16⅔% of pig, or "C" iron, and 33⅓% of the scrap, or "A" iron. Example:—

Steel	25%	of	0.2%	silicon	equals	0.050%	silicon
Liner scrap	25%	of	1.0%	silicon	equals	0.250%	silicon
Pig iron	16⅔%	of	2.2%	silicon	equals	0.366⅔	silicon
Scrap	33⅓%	of	1.6%	silicon	equals	0.533%	silicon
						1.200%	silicon

TABLE No. 28.

By using this same percentage, the other elements if known, can be figured as in table No. 21. And the Manganese corrected as in tables 22, 23 and 24.

Any number of different grades of iron can be mixed this way. Always leaving two irons,—one with lower and one with a higher silicon content than we desire to corect the mixture with.

METHOD OF FIGURING WHEN A CERTAIN PER CENT OF STEEL MUST BE USED.

This mixture would be suitable for heavy gas and hydraulic cylinders and other castings that require strength and close grained enough to stand water pressure. We wish a 25 per cent steel mixture of 2000 lbs., to contain 1.6 per cent silicon, and 0.75 per cent manganese. We will use 12 per cent manganese scrap steel to corect the manganese with, we will use the following irons:

	Silicon	Phos.	Sulp.	Mang.
Pig iron	3.00%	0.5%	0.016%	0.5%
Scrap iron	1.8	0.5	0.08	0.4
Scrap steel	0.0	0.02	0.05	0.5

TABLE No. 29

By adding 0.2 per cent silicon, and 0.1 per cent manganese for loss while melting, will make our required silicon 1.8 per cent, and the manganese 0.85 per cent. When making a mixture of this kind, I figure to get all the silicon from the iron, because of the small amount of silicon in the steel. On account of having to get all the silicon from the 1500 pounds of iron, that of course changes our desired silicon for the present, because the 1500 pounds of iron will have to carry enough silicon to give 1.8 per cent to the full charge of 2000 pounds of both iron and steel. To get this new required per cent of silicon, we will divide the percentage of silicon required in the whole charge, by the per cent of the iron used,—which is 75 per cent. Please take note of this rule. Example:—

TABLE No. 30

```
.75)1.800(2.4% silicon.
     150
     ———
     300
     300
```

TABLE No. 31

A.	B.	C.
1.8	2.4	3.0
	1.8	2.4
	.6	.6

Table No. 30 shows our new required silicon must be 2.4 per cent, which means we are take enough of the pig iron and scrap to give us that amount and, according to table 31 we must use 50 per cent of each. As we only require 1500, that means we are to take 750 pounds of each A and C, together with the 500 pounds of steel and no more figuring is required,—except of course for the manganese. Example:—

As we have 25 per cent steel, the other 75 per cent must be divided between A and C.

Steel	25%	of 0.0%	silicon equals	0.0 %	silicon
Pig	37.5%	of 3.0%	silicon equals	1.125%	silicon
Scrap	37.5%	of 1.8%	silicon equals	0.675%	silicon
				1.800%	silicon

TABLE No. 32.

Table 32 shows our figures are correct and is a much shorter method than table 27. We will now figure the manganese. Taking the same percentage as in table 32 we will see how much manganese the irons figured have already brought into the mixture. Example:—

Steel	25%	of 0.5%	equals	0.125 %	manganese
Pig	37.5%	of 0.5%	equals	0.1875%	manganese
Scrap	37.5%	of 0.4%	equals	0.150 %	manganese
				0.4625%	

TABLE No. 33.

Table 33 shows our mixture already has 0.4625 per cent manganese. As we desire 0.85 per cent we must get the other 0.3875 per cent from the 12 per cent manganese steel scrap. This 0.3875 per cent of course is what we desire, and must be put down under B. The 12 per cent manganese under C, and figured as in table 22. Example:—

By using the figure 3 in table 34, we save a lot of figures and it does not affect the result.

A.	B.	C.
0.	.3875	12

```
12)38.7500(3.23%
   36
   --
    27
    24
    --
     35
     36
```

TABLE No. 34.

Table 34 shows we are to take 3.23 per cent of C. To find how much steel scrap we are to use, we will multiply the full charge of 2000 pounds by 3.23 per cent, which gives us 64.6 pounds. Multiplying the 64.6 pounds by the per cent of manganese it contains, which is 12,—gives us the exact amount of manganese this 64.6 pounds adds,—which is 7.752 pounds. This again divided by 20, the number of 100 pounds in the mixture, will give us our required per cent of manganese. Multiplying the 12 by 3.23 per cent, will also give us our required per cent of manganese. Example:—

```
 2000                20)7.7520
03.23                 -------
-----                 .3876% man.
64.6000 lbs.

 64.6                12
  .12                03.23
 -----               -----
 7.7752 lbs.         .3876%
```

Manganese from mixture	0.4625
Manganese from 12% steel	0.3876
Total manganese equals	0.8501%

TABLE No. 35

Using the figure 3 in table 34, altered the result but slightly, and saved a lot of figures. To use this 64.6 lbs. of 12 per cent manganese steel, we would take out that amount from the 500 pounds of the common steel scrap.

METHOD OF FIGURING THREE OR MORE ELEMENTS EXACT IN THE SAME MIXTURE

We have shown in previous mixtures how to get the exact percentage of both silicon and manganese in the same mixture. The silicon is figured correct, and the manganese is corrected by the use of ferro-manganese. But now, suppose we have to get another element exact,—say phosphorus—to specification?

The best way to do it is to make two mixtures, both to contain the same per cent of silicon we desire in the final mixture, but one mixture to contain a lower and the other to contain a higher per cent of phosphorus than we desire in our final mixture. We then take the phosphorus contained in each of these two mixtures to figure the exact percentage of phosphorus we desire in our final mixture. So you see, when we have two mixtures, each containing the same per cent of silicon, no matter how much we use of each one to get our desired per cent of phosphorus in the final mixture, the silicon will not be changed. Example:—

We wish to make a mixture of 2000 pounds to contain 2.3 per cent silicon, 0.65 per cent phosphorus, and 0.75 per cent manganese. As we lose from 0.10 to 0.15 per cent in melting, we will make our mixture to contain 0.9 per cent manganese.

Silicon	Phosphorus	Sulphur	Manganese
2.00%	0.4%	0.04%	0.60%
3.00%	0.7%	0.02%	0.75%
2.25%	0.6%	0.03%	0.65%
2.75%	0.9%	0.01%	1.00%

TABLE No. 37.

When mixing for Phosphorus no allowance is made for gain or loss in melting. For silicon we will add the 0.2 per cent, making our desired silicon for the mixture 2.5 per cent.

We will make our first mixture from the first two irons, and our second mixture from the next two. You will notice we have tried to select two irons that will give us a lower and two that will give us a higher per cent of phosphorus than we want in our final mixture.

Setting the first two irons under their proper heading they stand ready to be figured.

First Mixture Silicon			Second Mixture Silicon		
A.	B.	C.	A.	B.	C.
2.0	2.5	3.0	2.25	2.50	2.75
	2.0	2.5		2.25	2.50
	.5	.5		.25	.25

TABLE No. 38.

In both of these mixtures we get even remainders, which shows we are to take 50 per cent of all the irons.

In our first mixture we get the lowest phosphorus 0.55 per cent, as 50 per cent of 0.4 per cent equals 0.20 per cent and 50 per cent of 0.7 per cent equals 0.35 per cent, adding these two together we get 0.55 per cent phosphorus, which is lower then we desire in the final mixture, but we get our desired silicon 2.5 per cent.

In the second mixture taking 50 per cent of 0.6 per cent phosphorus equals 0.3 per cent and 50 per cent of 0.9 per cent equals 0.45 per cent. Adding these together we get 0.75 per cent phosphorus which is higher than we require in the final mixture. But, we also have the same silicon (2.5 per cent) in both mixtures. Now we have two mixtures, both containing the same per cent silicon, but one has a higher and the other has a lower per cent of phosphorus than we want in the final mixture. So we will take these two per cents of phosphorus with our desired per cent and set them under their proper heading and figure as in table No. 1. Example:—

A.	B.	C.	Phosphorus
.55	.65	.75	
	.55	.65	
	.10	.10	

TABLE No. 39

As both remainders are the same again, it shows we are to take 50 per cent of each mixture, which will give us our required per cent of phosphorus and the required per cent of silicon in the final mixture.

As we are to take 50 per cent of each of the first mixtures, and each mixture contains two irons, it is apparent that we are to take 25 per cent of each iron. Example:

25% of 2.00% silicon equals	0.50 %
25% of 3.00% silicon equals	0.75 %
25% of 2.25% silicon equals	0.5625%
25% of 2.75% silicon equals	0.6875%
	2.5000%
Silicon loss in melting	0.2 %
Silicon in castings	2.3 %
25% of 0.4% phosphorus equals	0.100%
25% of 0.7% phosphorus equals	0.175%
25% of 0.6% phosphorus equals	0.150%
25% of 0.9% phosphorus equals	0.225%
Total phosphorus	0.650%
25% of 0.6 % Manganese equals	0.150 %
25% of 0.75% Manganese equals	0.1875%
25% of 0.65% Manganese equals	0.1625%
25% of 1.00% Manganese equals	0.25 %
	0.7500%

TABLE No. 40

Our mixture gives us 0.75 per cent Manganese, leaving 0.15 per cent for the fero-manganese to bring in. As this 0.15 per cent is what we require, we will set it under B. The 80 per cent ferro-manganese under C and figure as in tables 22, 23, 24 and 25.

A.	B.	C.
0	0.15	80

Affix two ciphers to B, move the decimal point two places to the right and divide by .80. Example:—

```
80)15.0000(.1875% of C. Ferro-Manganese.
   80
   ---
    700
    640
    ---
     600
     560
     ---
      400
      400
```

```
    2000 lbs.                          80
  .001875                         .001875
 ---------                        -------
 3.750000 lbs. Ferro-Mang.        .150000%
```

TABLE No. 41

Our figures show we are to take 00.1875 per cent of C ferro-manganese, by multiplying the 80 per cent ferro-manganese, by the 00.1875 per cent will give us our required manganese. And by multiplying the 2000 lb. charge by the percentage of ferro-manganese 00.1875 we are to use, will give us the amount of fero-manganese in pounds we are to use.

Manganese from mixture equals	0.75%
Manganese from ferro-man. equals	0.15%
	0.90
Loss in melting	0.15
Total manganese equals	0.75%

FRENCH SPECIFICATIONS FOR SHELLS OF 122 TO 155 MILLIMETERS CALIBER TO BE CAST IN SAND

By Edgar Allen Custer in "The Foundry"

Silicon	Phos.	Sulphur	Mang.	C. Carb.	G.Carb.
1.2%	0.15%	0.08%	0.70%	0.70%	2.40%

The above analysis are for dry sand molds, if cast in green sand, the silicon should be about 1.35 per cent. The total carbon and silicon must not exceed 4.7 per cent. If this limit is exceeded, the iron will lack toughness, at least 20 per cent of the total carbon must be combined to produce proper fragmentation. The percentage of dust increases as the combined carbon decreases. The charge should be as follows: Pig iron 40 per cent, scrap 40 per cent and steel 20 per cent. The term scrap is used to denote scrap melted, pigged and charged according to analysis. All the foundries in France engaged in this work have been mobilized on a common basis, and are using precisely the same methods of selection, analysis and general foundry procedure. This has not been done without enormous losses and vexatious delays. There have been many cases where the loss of a total heat has been reported, and the loss of 40 per cent was not uncommon in the first stages. Team work, scientific methods and keeping everlastingly at it, have brought results. Today, September 1917, the output has reached staggering proportions, over 1,000,000 rounds per day are being made.

This must certainly be interesting to every metal mixer, and should have a tendency to induce him to try his hand at making mixtures for shells, so as to be prepared, to some extent, for any emergency.

We will make a mixture as near as possible to the French specifications, from some Iron Mountain pig iron which I recently had analyzed, and some scrap we will presume contains the following analysis after it has been melted and pigged.

	Sil.	Phos.	Sul.	Mang.	C. C.	G. C.
Iron Mountain	1.4%	0.14	0.011	1.22	0.60	2.70
Selected scrap	2.0	0.40	0.080	0.55	0.40	3.00
Steel scrap	0.2	0.01	0.040	0.50	0.10	

TABLE No. 42

In making this mixture we will use the silicon in the steel, although as a rule I leave it out when making a mixture to contain a certain percentage of steel. According to the specifications our mixture must contain 1.2 per cent silicon, adding 0.2 per cent for loss in melting, will make our desired silicon 1.4 per cent. As we are to use 20 per cent steel, we will get 0.04 per cent from it, leaving 1.36 per cent for the pig iron and scrap to bring into the mixture. Now, as we only want 80 per cent more iron, and this 80 per cent will have to carry enough silicon to give us 1.36 per cent for the whole mixture of 2000 pounds, that means we are to find a new temporary per cent of silicon to work with. So by using the same rule as in table 30—that is by dividing the actual per cent of silicon desired by the percentage of iron used in the mixture, which in this case is 80 per cent, we get the new per cent of silicon, 1.7 to work with,—see the point. We must get 1.7 per cent silicon in 80 per cent of the mixture to give us 1.36 per cent more silicon to the whole mixture. Example:—

TABLE No. 43.

```
.80)1.360(1.7% silicon.
     80
    ———
     560
     560
```

TABLE No. 44

A.	B.	C.
1.4	1.7	2.0
	1.4	1.7
	3	.3

The result of table 44 shows we are to use the same percentage of each pig iron and scrap, which in this case is 40 per cent, with 20 per cent of steel. So figuring all the elements on that basis, we will see how near our mixture is to the specifications. Example:—

Iron Mountain	40% of 1.4% silicon equals	0.560%
Selected scrap	40% of 2.0% silicon equals	0.800%
Steel scrap	20% of 0.2% silicon equals	0.040%
		1.400%
	Loss in melting	0.2 %
	Silicon in mixture	1.2 %

Phosphorus.

Iron Mountain	40% of 0.14% phosphorus equals	0.056%
Selected scrap	40% of 0.40% phosphorus equals	0.160%
Steel scrap	20% of 0.01% phosphorus equals	0.002%
	Phosphorus in mixture	0.218%

Sulphur.

Iron Mountain	40% of 0.011% sulphur equals	0.0044%
Selected scrap	40% of 0.080% sulphur equals	0.0320%
Steel scrap	20% of 0.040% sulphur equals	0.0080%
		0.0444%
	Gain in melting	0.0350%
	Sulphur in mixture	0.0794%

Manganese.

Iron Mountain	40% of 1.22% manganese equals	0.488%
Selected scrap	40% of 0.55% manganese equals	0.220%
Steel scrap	20% of 0.50% manganese equals	0.100%
		0.808%
	Loss in Melting	0.100%
	Manganese in mixture	0.708%

Combined Carbon

Iron Mountain	40% of 0.6% C. C. equals	0.240%
Selected scrap	40% of 0.4% C. C. equals	0.160%
Steel scrap	20% of 0.1% C. C. equals	0.020%
		0.420%

Graphite Carbon

Iron Mountain	40% of 2.7% G. C. equals	1.08%
Selected scrap	40% of 3.0% G. C. equals	1.20%
Steel scrap	20% of 0.0% G. C. equals	0.00%
		2.28%

TABLE No. 45.

These tables show that all the elements are very nearly what the specifications call for. Even though phosphorus is a little higher here, there is not the least doubt it would be lower in actual practice, even from this mixture. If is was not, we would use two grades of pig iron, and melt and pig two different grades of scrap, and get our phosphorus exact, by the same method as in table 38 and 39. The carbons we cannot tell very much about till after analysis has been made from the mixture, because it is a semi-steel mixture. But both carbons will be well within specifications, which says the combined should be at least 20 per cent of the total carbon. As this mixture shows over 15 per cent, it is bound to be higher in the casting on account of the low silicon, and high steel in the mixture. Successful mixtures of this kind are not accomplished with one trial. And like the French foundrymen, only sticking everlastingly at it, would we accomplish the desired results.

SIDE LIGHTS ON MIXTURES

In making some mixtures you will find when dividing your first remainder, that to get the exact result, you would be compelled to carry it out to several decimal places. Now, if it will not finish with one decimal place, just raise the last decimal or figure in the quotient, one more. Although the divisor will not go that many times, still it will save a lot of figures, and will not affect the result any. But, be sure and do this with the first remainder only, then you will always have the full percentage of the element you are figuring for. Example:—

Suppose we wish a mixture of 1500 pounds to contain 2.2 per cent silicon. We will make it from 1.8 per cent silicon scrap, and 50 per cent ferro-silicon.

TABLE No. 46

A.	B.	C.
1.8	2.2	50.0
	1.8	2.2
	.4	47.8
	47.8	

```
48.2)40.000( .83% of C iron
      3856   99.17% of A iron
      ----
      1440
      1446
```

As there are two more decimal places in the dividend than in the divisor, we point off two decimal places in the quotient making it .83 hundredths per cent of C iron to be used, and 99.17 per cent of A iron to be used.

A iron	1.8% silicon	C iron	50% silicon
Take	99.17% of A iron	Take	.0083% of C iron
	1.78506% silicon		.4150% silicon
	.4150		
	2.20006% silicon		

You will notice, by using the figure 3 in table 46 did not make any material difference to the result. But saved carrying the quotient to several decimal places.

We will try another from 3.25 per cent pig iron, instead of ferro-silicon.

A.	B.	C.
1.8	2.2	3.25
	1.8	2.2
	.4	1.05
	1.05	

```
1.45)40.00(28% of C iron.
     290    72% of A iron.
     ----
     1100
     1160
     ----
```

TABLE No. 47.

A iron	1.8% silicon	C iron	3.25% silicon
Take	72% of A iron	Take	28% of C iron
	1.296		.9100
			1.296
			2.2060% silicon

Even by having too much by 60 in table 47 only added 6 thousandths of one per cent to the silicon, but saved quite a lot of figures.

By taking advantage of this idea when you are dividing your first remainder, if the figures are inclined to run to several decimal places, you will always get the full percentage of silicon, or any other element you may be figuring for. Table 46 says we are to take. .83 hundredths of one per cent of the C iron and 99.17 per cent of A iron.

Example:—

Charge	1500 pounds	1500 pounds
	00.83% of C iron	99.17% of A iron
	4500	1487.5500 lbs. of A iron
	12000	12.4500
	12.4500 lbs. of C iron	1500.0000 pounds

Table 47 says we are to take 28 per cent of C iron and 72 per cent of A iron. Example:—

Charge	1500 pounds	1500 pounds
	.28% of C iron	.72% of A iron
	12000	3000
	3000	10500
	420.00 lbs. C of iron	1080.00 lbs. A iron
		420.00
		1500.00 pounds.

MISCELLANEOUS MIXTURES

These mixtures are taken from my note books and was cast several years ago from the following irons. The castings answered their purpose and finished up clean. You will notice the steel mixtures are made from irons low in sulphur and phosphorus with manganese from 0.75 per cent up.

Piston Valve Liners

70% Carron No. 1; Tranverse 2800 per sq. inch.
30% steel scrap; Silicon 1.6 per cent in casting.

Hammer Block

60% Foundry scrap; Tranverse 3600.
40% Steel scrap; Silicon 1.16 per cent.

Stamp Heads

68% Shop scrap; Tranverse 3900.
32% Steel scrap; Silicon 1.09 per cent.

V Gear 8′ 6″ Dia. 9″ Face, Hub Split.

74% cyl. Niagara; Silicon 1.2 per cent.
26% Steel scrap.

Large Marine Cylinder. Net Weight 34,020 lbs.

30% Gun iron; Silicon 1.7 per cent in casting.
30% Cyl. Niagara.
30% Shop scrap.
10% Carron No. 1.

McCully Crusher No. 7

85% Texada No. 2; Test piece Chilled 2¾ deep.
15% Steel scrap; Silicon 0.85 per cent.

90-inch Snap and Bull Rings

67% Carron No. 1; Silicon 1.6 per cent in casting.
33% Steel scrap.

Two Marine Cyl-Liners, 6927 and 7134 lbs. Net

56.25% Gun iron; Silicon estimated 1.2%.
25.00% Carron; 1st liner cast 1.07%.
18.75% Steel scrap; 2nd liner cast 0.97% silicon.

16.000 pounds.

Good For Strong Castings and Semi-Steel

Brand—	Sil.	Phos.	Sul.	Mang.	C.C.	F.C.	G.C.
Carron	2.8	0.50	0.035	1.45	....	3.64	....
Texada No. 2	1.25	0.30	0.025	0.90	....	....	....
Cyl. Niagara	1.80	0.50	0.044	0.75	....	....	....
Car Wheels	0.70	0.40	0.16	0.50	0.9	....	2.90
Gun iron	1.25	0.31	0.070	0.60	....	....	....
Iron Mountain	1.40	0.14	0.011	1.22	0.6	....	2.70
Irondale	2.30	0.16	0.035	1.10	....	....	....
Niagara No. 2	2.20	0.40	0.04	0.60	....	3.58	....
Muirkirk	2.21	0.28	0.031	2.22	0.55	....	3.01
Good for Soft Iron Work							
Sloss No. 1	3.60	0.65	0.03	0.45	....	....	....
Crown No. 1	3.25	0.71	0.022	0.50	....	....	....
Clifton No. 1	3.50	0.50	0.015	1.40	0.3	....	3.30
Mississippi	3.34	0.294	0.022	0.90	....	....	....

Grading numbers will correspond closely to the following percentages of silicon and sulphur.

	No. 1 Pig	No. 2.	No. 3.	No. 4.
Silicon	2.75 to 3.50%	2.25 to 2.75	2.00 to 2.25	1.75 to 2.00
Sulphur	0.02 to 0.04%	0.01 to 0.03	0.01 to 0.03	0.01 to 0.03

	No. 5.	No. 6.	No. 7.	No. 8.
Silicon	1.50 to 1.75%	1.25 to 1.50	1.00 to 1.25	0.75 to 1.00
Sulphur	0.02 to 0.04%	0.02 to 0.04	0.03 to 0.04	0.03 to 0.05

The following analysis of a few of the most important castings, will give the young student some idea to work on while making mixtures.

If from five to ten per cent of steel is mixed in these mixtures, it will strengthen and improve the castings for this class of work.

	Silicon	Phos.	Sulp.	Mang.
Hydraulic Cylinders	1.5	.40	.08	.8
Amonia Cylinders	1.6	.60	.09	.7
Air Cylinders	1.3	.45	.09	.8
Steam Cylinders, Heavy	1.6	.40	.09	.8
Steam Cylinders, Small	1.9	.55	.08	.6
Gas Engine Cylinders	1.8	.50	.07	.7
Locomotive Cylinders	1.6	.55	.08	.6
Automobile Cylinders	2.2	.50	.08	.7
Propeller Wheels	1.4	.30	.09	.8
Bed Plates, Heavy	1.9	.55	.08	.6
Dynamo Frames	2.5	.80	.07	.5

Approximate rule for weighing pig iron in piles:

If piled in the usual way 7¼ cubic feet will weigh one ton. If very closely piled 7 cubic feet will weigh one ton.

THE INFLUENCE DIFFERENT ELEMENTS HAVE UPON THE IRON.

Silicon.

Silicon will soften the iron up to 3.50 per cent. When iron contains more it begins to get hard, short and brittle. Silicon increases fluidity, decreases shrinkage, open the grain of the iron and helps to turn combined carbon into graphite carbon, which helps to reduce the strength of the iron. In melting we lose about 0.2 per cent of silicon, which amount must be taken into account when figuring for silicon.

Phosphorus.

Phosphorus helps to make iron fluid and weak, so for all kinds of castings except the very thinnest, it should not be over 0.7 per cent. But for light, thin castings where strength is of no importance, it can run as high as 1.0 or 1.25 per cent. In fact iron for stove plate and that line of work require that much. Phosphorous lowers the melting point of iron, and decreases the shrinkage. In melting it neither loses or gains very much. So no provision for loss or gain is required when making mixtures.

Sulphur

Sulphur if too high will make the iron hard. Increase the shrinkage and promote chill, and cause the iron to congeal quickly. If very high it will cause blow holes, shrinkage cracks and dirty iron. In all machinery castings it should be kept below 0.9 per cent if possible. In melting it gains about 0.03 to 0.035 per cent, chiefly from the fuel. This gain must be taken into account when making mixtures.

Manganese.

Manganese is one of the best elements we have in iron. It is a regular scavenger. There is no element that will cleanse the iron, reduce the blow holes, reduce the sulphur, increase the strength and improve the grain like manganese. When silicon is normal for the work being made, manganese from 0.5 to 0.8 per cent will be alright. In melting we lose from 0.10 to 0.15 per cent.

Graphite Carbon.

Graphite carbon is a softener. It opens the grain of the iron, makes it soft, weaker and reduces shrinkage and chill.

Combined Carbon

Combined carbon is a hardener. It closes the grain of the iron, increases the strength, shrinkage and chill. In melting there is no gain or loss, only that one form will change to the other according to the rate of cooling, and influence of the other elements, especially silicon and manganese. In the common, soft foundry pig irons, combined carbon will run about 0.30 per cent to 0.50 per cent. Graphite carbon will run about 3.0 per cent to 3.5 per cent. But as the iron is made harder by mixing, the carbons will change, Graphite carbon getting lower in per cent and combined carbon increasing in percentage, according, of course, to the per cent of silicon put into the mixture. Graphite carbon will be high, when silicon is high, and combined carbon will increase as silicon is lowered.

Approximate per cent of Silicon for Different Castings

I have found castings containing the following percentages of silicon, were satisfactory, both in machining and use.

For light castings from 3/8 to one-inch in section. From 2.25 to 1.9 per cent silicon. Castings from 1 inch to 2 inches in section. From 1.9 to 1.6 per cent silicon. Castings from 2 inches to 3 inches in section, from 1.6 to 1.3 per cent silicon. These figures are given to give the reader an idea how to regulate the silicon for castings of different section, and if the other elements are kept normal by selecting irons suitable for the class of work being made, will be entirely satisfactory for all kinds of general machinery castings when figuring for silicon only. For pulleys the silicon should range from 2.3 per cent to 2.6 per cent, and the sulphur should be kept below 0.06 per cent if possible. For large Marine cylinders with brackets and flanges liable to crack through unequal sections, the silicon should run from 1.6 per cent to 1.8 per cent. The castings of course, always have liners of much harder metal. Small and medium sized cylinders with no liners should run from 2.0 to 1.6 per cent silicon, with 10 to 15 per cent steel. For large gear wheels, blank or otherwise should contain,—after 20 to 25 per cent steel has been added,—about 1.6 per cent silicon. Car wheels, from 10-inch mining wheels, up to regular passenger car wheels, from 1.5 to 0.70 per cent silicon. From 5 to 10 per cent steel scrap always helps the chill and strength of the wheels. All car wheels should be annealed as soon as possible after casting, by putting into a pit altogether.

When selecting pig iron for small and medium castings, try and get iron containing less than 0.03 per cent sulphur, phosphorus about 0.7 per cent, Manganese about 0.6 per cent or 0.8 per cent, with graphite carbon about 3.25 per cent and combined carbon 0.25 per cent or under. In the castings the sulphur will average about 0.08 per cent. The other elements will not vary very much. In the heavier castings the sulphur should not exceed 0.095%, phosphorus should be kept down from 0.4 to 0.5%, manganese about 0.8 to 0.9 per cent. Graphite carbon will run from 2.50 per cent to 2.75 and combined about 0.75 per cent.

Judging the percentage of silicon in Different Kinds of Scrap.

As a general rule light machinery scrap will contain about 1.9 per cent to 2.25 per cent silicon. But sometimes we run across heavy scrap that runs that high in silicon. In that case, as a rule, the fracture will show a dark rough surface, full of shining particles of graphite, whereas the low silicon heavy scrap, will show a lightish, slightly rough fracture.

Heavy scrap from $1\frac{1}{2}$ inches to 3 inches in section, will run from 1.8 per cent to 1.25 per cent silicon.

Standard car wheels—silicon 0.7 per cent, phosphorus not over 0.4 per cent, manganese 0.4 to 0.5 per cent, sulphur not over 0.17 per cent, graphite carbon from 2.5 to 2.9 per cent, combined carbon not over 0.90 per cent.

Steel plate scrap contains silicon about 0.2 per cent, phosphorus from 0.01 to 0.05 per cent, sulphur form 0.03 to 0.05 per cent, and manganese 0.5 per cent, with total carbon about 0.10 per cent.

Stove plate scrap runs about 2.75 per cent silicon, phosphorus about 1.0 per cent. Although stove plate scrap is high in silicon, it is a quantity that cannot be depended upon, on account of its thin section, both the iron and the elements in it are burnt somewhat, especially so if melted under high blast. Use it with judgment. If light and heavy scrap are brought together, it will pay to sort, and give each its proper rating, which with a little experience can soon be learned.

DECIMAL FRACTIONS

In adding a few examples on decimal fractions and percentage, I thought would be an advantage to those who have allowed themselves to get rusty on decimals—to have under the same cover,—as a ready reference while working over the mixtures.

Addition of Decimals

The only respect in which addition of decimals differ from simple addition is, in placing the decimal point directly over one another. Example:—

$$\begin{array}{r} 26.346 \\ .263 \\ \hline 26.609 \end{array}$$

Substraction of Decimals

Substract as in whole numbers, but keep the decimal points directly under each other, as in addition. Example:—

```
 80.312
 79.200
 ------
  1.112
```

Multiplication of Decimals

Multiply as in whole numbers, and point off in the product as many decimal places as there are decimal places in the two factors, and if the product has not so many, supply the defect by writing ciphers on the left hand.

Example:—

```
1st—        2nd—

 .33         32.3
  .2          2.3
 ----       -----
.066          969
             646
            -----
            74.29
```

Note: In the first example there are three decimal places, so must make three decimal places in the product by adding one cipher to the left hand of it.

Division of Decimals

Divide as in simple numbers and point off as many decimal places in the quotient, as the number of decimal places in the dividend exceeds the number in the divisor. If necessary prefix ciphers to the quotient; or affix ciphers to the dividend. When both dividend and divisor contain the same number of decimal places, the quotient is a whole number, without or with a remainder as the case may be.

Example:—

No. 1 Divide 60 by 1.5.

No. 2. Divide 34.75 by 2.5.

```
   Divisor          Dividend        Quotient
     1.5       )      60.0      (      40
                      600
           2.5)34.75(13.9
                25
                ----
                 97
                 75
                ----
                 225
                 225
```

In the first example the divisor has one decimal place, but the dividend has none, so one must be affixed to it. As the dividend must have as many, if not more, decimal places as the divisor. with the added decimal place in the dividend makes the quotient a whole number. In the other example the dividend has one decimal place more than the divisor, so we point off one in the quotient.

Example No. 3. Divide 30.5 by .9.

Example No. 4. Divide 70 by 11.2.

```
  .9)30.5(33-8/9          11.2)70.000(6.25
     27                        672
    ----                       ----
     35                         280
     27                         224
    ----                        ----
      8                          560
                                 560
```

In the 3rd example we find we could not bring it to an end, so to save carrying it on to several decimal places, we have finished with a vulgar fraction, and as the dividend has the same number of decimal places as the devisor, the quotient is a whole number, with the fraction 8/9.

In the 4th example we had to add three more ciphers to the dividend, giving it two more decimal places than the divisor, so we point off two decimal places in the quotient.

Percentage

Percentage is the process of calculating by the hundreths. Thus 5 per cent of a quantity is 5 of every hundred, or 5 hundredths of the quantity. When multiplying for a percentage of a certain number, the multiplier is expressed decimally. That is, if we are to take 5%, 25% and 12½% of a number, we would set them down to multiply like this: .05.25 and .125. The following table will show our meaning:

PER CENT	DECIMAL	PER CENT	DECIMAL	PER CENT	DECIMAL
1%	.01	75%	.75	½%	.005
2%	.02	100%	1.00	¾%	.0075
3.1%	.031	150%	1.50	1½%	.015
10%	.10	500%	5.00	8⅓%	.08⅓
50%	.50	¼%	.0025	12½%	.125

In the first place the base is the number on which the percentage is computed.

Example:—Suppose we wish to take 6¼ per cent of 12.7 per cent. The 12.7 is the base, and the 6¼ is the rate, so multiplying the base by the rate decimally expressed we get the percentage of .79375.

Example:—

```
      12.7
     .0625
    ------
      635
     254
    762
   ------
   .79375%
```

As explained in the multiplication of decimals, we must point off as many places in the product as there are in the multiplier, and the multiplicant, which is five. It will be noticed that although we called 12.7 a per cent, it became a base as soon as we wished to take a percentage from it. Examples.

2. Take 50% of 2.75%.
3. Take 30% of 3.25%.
4. Take 70% of 1.75%.

2.75	3.25	1.75	Base.
50	.30	.70	Rate
1.3750%	.9750%	1.2250%	Percentage

When two numbers are given and we wish to know the rate of each one, we add the two together, and divide each number,—after affixing two ciphers and moving the points two places to the right, by the sum of the two.

Example:—

What per cent of 1.50 is .45 and 1.05?

```
      .45
     1.05
     ----
1.50)45.00(30%
      4500
1.50)105.00(70%
      10500
```

When multiplying for percentage with decimals, we must always point off two extra in the result for the whole numbers. Example: Suppose we wish to take .5625 per cent of 80 per cent

```
      80
 .005625
 -------
 .450000
```

You notice we have added two ciphers, which represent the two whole numbers, and of course moves the decimal point two places to the left, so in pointing off the result, we count six decimal places. Of course in actual practice, we imagine the two whole numbers are there, and point off the result accordingly.

Hoping these few suggestions will carry the point, we will not go any deeper on this subject.

CUPOLA PRACTICE

Although it is not the purpose of this book to treat on cupola practice, I feel I could not conclude it without a word or two. We may make our mixtures as they should be made, still there is a possibility of them going wrong by improper handling and charging of the cupola.

If every melter would take the trouble to find the proper height the coke bed should be for his particular cupola, then make all his charges of iron from first to last as near the same weight as possible, he will get a more uniform grade and even flow of iron, with less coke consumption, than the man who crowds his coke bed to the limit with an extra heavy first charge of iron. The proper practice calls for the same weight of charge on the bed as every succeeding charge, and the weight of that charge is figured by the weight of coke it takes to fill four inches high in the cupola. Then use a ten to one ratio, that is if it takes 150 pounds of coke to fill four inches high in the cupola, the iron charges should be about 1500 pounds and so on.

Experimenting foundry men have proved the melting zone averages from four to five inches in depth. And they have also found that amount of fairly good coke will melt 10 times its weight in iron and when that amount of iron is melted, the bed is then ready for another four inch layer of coke. Now, when I speak of a four inch layer of coke, I do not mean that we must put four inches all over the inside area of the cupola. That rule is only used as a standard on which to figure our iron charges. It has been proved that the best results have been derived by putting all the coke in the center, and all the iron as close to the lining as possible, excepting of course, when making different mixtures which must be separated by coke. By this method of charging, the coke can be reduced and still have hot iron if the bed and first charge have been started right. When the bed is the right height it is only the top four inches that does the real melting, so if the bed is higher than it should be the extra coke will be burnt and wasted until it lets the iron down to the real melting zone, which will vary from 15 to 28 inches above the tuyers according to high or low blast, so the main point is to find the proper height of the bed for every cupola, and the best way to find it is by the time it takes the iron to drop lively after the blast is on. If it takes more than three minutes at the most the bed is too high, and the extra time will be taken up burning coke that is not required. Now then, it is generally upon high coke beds that extra heavy first charges of iron are put, because we are under the impression that so much coke on the bed ought to melt a much heavier charge than the rest of the charges. But it is a wrong impression. Another reason for heavy first charges are, that most foundries have some special mixtures to make, different from their regular run of work, and if they happen to be heavier than their regular charges, the bed is considered the best place, so as to get them down, and out of the way of the regular mixtures. But, as we must put an heavier split of coke between two different mixtures, the bed is built up somewhat, the amount it has lost by having an extra heavy first charge to melt, and I believe, that one reason of having to put an heavier split of coke between two different mixtures, have saved many a coke bed from getting dangerously low without the melter being aware of it. Now here's the point: We know, if we wish to retard the melting between two different mixtures, we must put an heavy split of coke between them. By so doing we keep the iron high above the melting zone, until a part of the coke is burnt away, when the top part or last four inches of the coke wil drop to a point where it can melt the iron above it.

It is just the same with the high coke bed. It is only the last, or top four inches that does the real melting, and like the heavy split of coke, even that four inches will not melt iron until it drops to the real melting zone, and then it will only melt so much; so if burdened with an extra heavy first charge of iron, the bed proper is bound to suffer, and can only be built up again at the expense of irregular iron, and extra coke, which would not be, if all the charges had been made as near as possible what they should be, according to the size of the cupola. It is not very good cupola practice to let the iron soak too long in the cupola before starting the blast, as I believe the iron absorbs more or less sulphur from the fuel during that time. It is a fact, that "converter steel" men, if they have to make castings to strict specifications, will not use first charges for that class of work if they can help it. The reason, that sulphur always runs higher in first charges than in the following charges. Fairly good practice calls for the fire to be started about one hour before charging. As charging will take from three quarters to one hour, the blast should then be put on as soon as possible. If the bed is the right height, the iron will begin to drop within a minute or so, and will be droping quite fast within three minutes, as can be seen through tuyer glasses.

Although I have mentioned that the melting zone will average about 20 inches above the tuyers, I do not mean that to be the height of the bed. We may have to make it 30 inches, or even more, because the bed will settle from 8 to 12 inches as soon as the first charge of iron is dumped on it—that point will have to be settled by the time it takes the iron to begin to drop after the blast is put on, the melting zone being located entirely by the force of the blast. If the blast is high and strong, so will the melting zone be located high, so make the coke bed rather high at first then reduce till you find proper height by above instructions.