revolves. A holding-down bar holds the bar firmly on the rollers, and a rocker with an adjustable pawl bracket rotates the bar. This rocker is driven by an inclined plate screwed to the reciprocating slide. A stand and pair of adjustable roller brackets for the support of long bars, end stops and extra pawl form part of the equipment of the machine.

The hack-saw in Fig. 2 weighs about 3,500 pounds, occupies 5x4 feet floor space, and uses 23-inch saw blades when cutting up to 10 inches diameter. The general design embraces a strong base on which are mounted two uprights, carrying the crossrail on which a slide is mounted, this in turn carrying the saw frame in a vertical slide. The horizontal slide is moved on the crossrail by a long connecting rod and crank and 4:1 gearing driven by a 14-inch pulley for a 3½-inch belt. It runs on rollers, and so works freely. The saw frame is balanced by an adjustable weight on a long lever, so that the pressure on the saw can be regulated. The saw blade is held in special grips at the ends of the saw frame. The bar to be cut rests on two roller brackets and is turned by a pawl fastened in a reciprocating frame, which is kept up to the bar by a balance weight, and is moved by a roller fastened to the horizontal slide running in an inclined slot which is part of the rocking frame. The bar is held down by a steel bar held in adjustable brackets. The rollers on the back support are set at an angle, and so the bar to be cut is forced back on a back stop. The front roller brackets are adjustable by screw and handle so that they can be quickly adjusted to suit different diameters.

Where large numbers of disks are needed, the small amount of waste involved in their cutting off by hack-saw methods is a somewhat important consideration. Within the last year Messrs. Holroyd have cut off 10,000 4-inch mild steel blanks. The saving of material under such conditions is very appreciable. On the 5-inch machine the cutting off of a 4-inch mild steel blank occupies from 18 to 35 minutes, according to the condition of the saw blades, and one blade usually cuts off between 15 and 20 blanks before needing sharpening. On the 10-inch machine, an 8 1-8 diameter mild-steel blank takes about 2 hours 7 minutes to cut off, and a 7-inch blank 1½ hours. These figures will probably be of service to readers collecting data on the by-no-means simple subject of the efficient and profitable cutting up of metals.

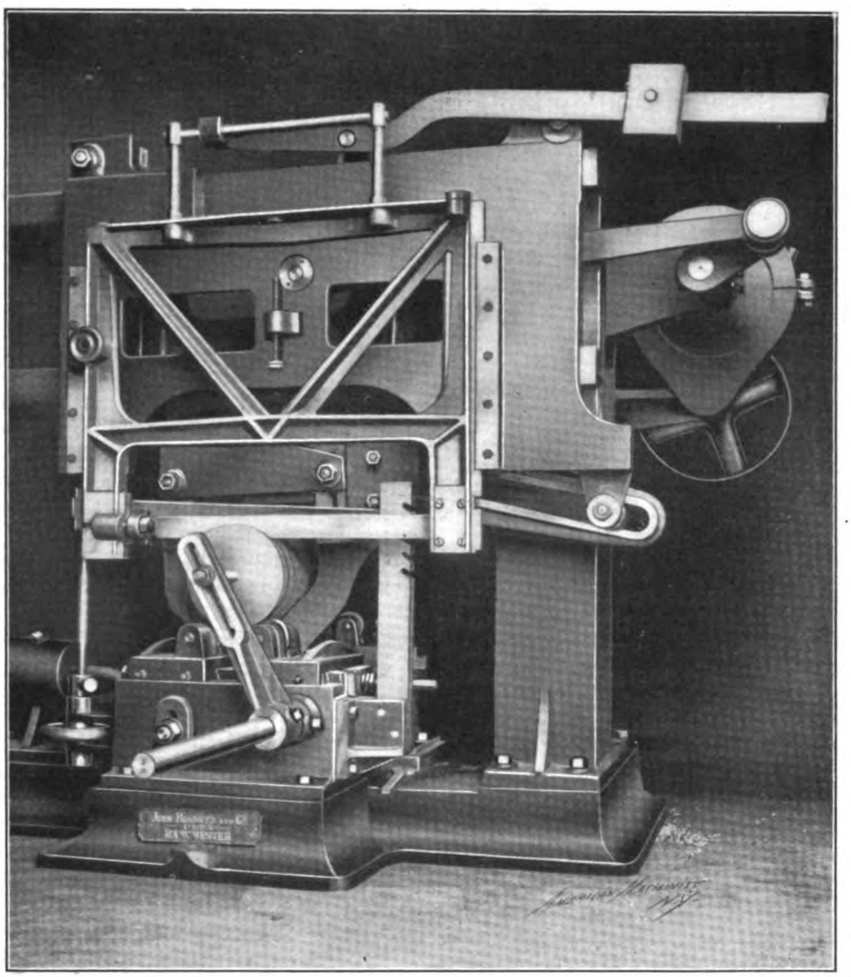


FIG. 2. ENGLISH POWER HACK-SAW FOR STOCK UP TO 10-INCH DIAMETER.

A Symboling System for Machine Parts.

BY W. BANCROFT.

In both the manufacture and marketing of standard machines, a flexible system of symboling the various parts that compose the machine is almost essential. Probably no completed machine has ever been built, for improvements in both design and shop methods are as much in the day's work as the booking of orders and the boxing of machines. It is therefore highly important that the symbols designating parts be absolutely flexible; that is, capable of extension in all directions. The system of symboling must also be simple; it may be possible in time to educate one's own employees to use a complicated system, but customers! Until machines are built both fool proof and unwearable, repair parts will be called for and in a hurry too. A system that is simple enough to enable a customer to find quickly what he wants and order it so that his requisition cannot be misunderstood, does much to avoid adding the last straw to the load of his breakdown troubles. This last straw is the receipt of the wrong part.

A well known shop manager, whose memory runs back to the olden days when systems were not essential, to those rare old days when people were willing to wait, once said, "Unless a system works along the lines of least resistance it won't work long." Which is another way of saying that people are systematic only so long as it is easier to follow the system than not. In a system of symboling parts flexibility is therefore placed first in importance, for unless a system provides for all possible changes, no matter how simple it may have been, it will not long retain the charm of simplicity.

The following method of symboling parts was devised by the Monotype Company to designate the parts of its type-casting and composing machine. This machine contains 1,062 different kinds of parts and 2,028 in all. The machines are built in large quantities and their parts are, of course, interchangeable. In accordance with the best practice, the machine is divided into several sections called groups; each distinct function is performed by one of these groups. The machine is so designed that these groups may be fitted up complete, drawn from stock as required, and bolted to the bases of machines, just as planer crossheads and driving gears are built in quantities and attached to the beds as ordered.

INDICATING THE GROUP AS WELL AS THE PARTS BELONGING TO IT.

Since each group is really a separate machine, it is desirable that the symbol of a piece indicate the group of which it is a part, and this can best be accomplished by designating the piece by a combination of

numbers with a letter. The letter indicates the group to which the part belongs; thus the *Bridge*, or *Matrix Carrying Mechanism* is known as the A group, and the *Bridge* being the first piece, in alphabetical arrangement, in this group is 1A. H group designates the *Pump* mechanism, and the *Pump Body* is symboled 23H.

Extending the group system still further, it is desirable that minor pieces in a group be related to the major pieces which they compose. Thus, in the case of the *Bridge* two of its *Legs* are cast in place, the third, for constructive reasons, is bolted to it. This loose piece is known as the *Bridge Leg*, and its symbol 1A2 states this fact as clearly as its name *Bridge Leg* conveys the idea that it is a leg associated with the *Bridge*. The letter indicates the group of the machine to which the piece belongs, the number at the left of the group letter the section of the group, and the number at the right the particular piece of this section.

The *Bridge* is made up of the following pieces:

A GROUP.

BRIDGE	1	1A
screw (2)	24	1A1
leg	1	1A2
" screw (side) (2)	222 (*1*)	1A3
" " (top)	228 (*1*)	1A4
" spring post for Fibres Stop Spring		1A5
guide rod bushing (2)		1A6
" " " nut (2)		1A7
" " " adjusting screw (front)		1A8
" " " adjusting screw (rear)		1A9
pin for Fiber Stop		1A10
BRIDGE 1A (complete)		
Bridge-centering-pin-stand Adjusting Screw, see Centering-pin-stand Adjusting Screw		6A1

The *Bridge* complete—that is, all the above parts from 1A to 1A10, inclusive, assembled ready for the machine—is known as 1A (complete). Thus, if a customer wants all of the above parts fitted up, he orders *Bridge* 1A (complete).

In a list which goes to the customer it is necessary to designate pieces that cannot be furnished without other pieces. For example, the *Bridge* 1A cannot be furnished without the *Bridge* Leg 1A2 and the *Screws* 1A3 and 1A4 that hold the *Leg* to the *Bridge*, for this is a most accurate part of the machine and the *Bridge* is ground after the *Leg* is bolted to it. It is therefore necessary to indicate that neither the *Bridge* nor its *Leg* can be furnished without the four pieces 1A, 1A2, 1A3 and 1A4. Of course the *Screws* 1A3 and 1A4 can be furnished without either the *Bridge* or its *Leg*.

The relation between the above pieces is indicated by printing on the same line with the *Bridge* 1A and its *Leg* 1A2, a roman figure I and on the line with the *Screws* 1A3 and 1A4 an italic I in parentheses, (*I*). If either of the pieces marked with a roman I be called for, all pieces numbered I must be ordered. Pieces marked with the italic I, however, may be ordered the same as pieces not marked.

Occasionally a combination of parts contains two sets of pieces that cannot be ordered separately. The first set is designated by the number 1, as above, and the second by the number 2. For example:

GALLEY CAM	1	14F
driving pawl		14F1
" " (pin for Spring)	(*2*)	14F2
" " fulcrum screw		14F3
" " fulcrum screw (washer)	47	14F4
driving pawl spring	646	14F5
" " post		14F6
" " stop pin	(*1*)	14F7
sleeve		14F8
GALLEY CAM 14 F (complete)		

The *Galley Cam* 14F cannot be furnished without the *Stop Pin* 14F7 for the *Driving Pawl* 14F1, neither can the *Pawl* be furnished without its *Spring Pin* 14F2, for both *Pins* are forcing fits in the pieces that carry them. This is shown by the numbers 1 and 2, respectively, after the names of the pieces that cannot be furnished separately. Since, however, the *Pins* can be furnished without the pieces that carry them, the numbers following the *Pins* are printed in italic and placed in parentheses.

Ample cross references are provided. To return to the *Bridge* 1A, it carries two adjusting screws for positioning the *Centering-pin Bushing* 6A. The function of these screws is to position the *Bushing*, and this is shown by their symbol 6A1. A person not familiar with the machine might suppose that these were part of the *Bridge* 1A. To avoid this confusion the following note, in italic, is printed immediately below the 1A group:

Bridge - centering - pin - stand Adjusting Screw, see Centering-pin-stand Adjusting Screw——6A1.

TAKING CARE OF ALTERATIONS.

So much for the system before alterations take place; to be effective it must be just as simple after alterations have been made. Changes in pieces are of two kinds: first, those that effect the interchangeability of the particular piece altered, or of parts related to it, and second, those that do not. The latter are properly not alterations. For example, suppose the curve of the *Galley Cam* 14F be altered but that the new *Cam* can be supplied to all machines without any alterations whatever. Obviously this is not a change that should affect the symbol of the piece, since it will not be necessary to carry two kinds of *Galley Cams* in stock. Either the old *Cams* will be scrapped or they will be used up and no more of that kind made. In the latter case the old stock should be used before any of the new is issued. The new *Cams* should therefore not be put with the old in the storeroom, but a tag should be placed on the old pieces, giving the location of the new lot and stating that this new lot must not be issued until the old lot is exhausted.

When, however, the alteration affects the interchangeability of the piece the symbol must be altered, since different kinds of these pieces must be carried (to avoid errors in shipments, the two kinds of the same part should be kept in different sections of the store room). Alterations of this character are designated by prefixing for the first alteration a lower-case a to the symbol of the piece altered; for the second change the a is replaced by b, and so on through the alphabet. The twenty-seventh alteration to the *Bridge*, which exhausts the alphabet, would be designated by aa1A; the twenty-eighth by ab1A. Since, however, the highest alteration letter now used by the Monotype Company is d, it is probable that the combination of alteration letters will not be required.

The following example illustrates this method of symbolizing:

LOCKING-BAR CONNECTING ROD		33E
bearing block		a33E1
" " lock nut	316	a33E2
" " plate (discarded)		
" " rivet (discarded)		
eye		a33E5
" lock nut (L H.)	317	a33F6
spring	667	a33E7
LOCKING-BAR CONNECTING ROD a33E (complete)		

This combination of parts is printed just as it was before any alterations were made, with the following modifications: Since the *Bearing-block Plate* and its *Rivets* are no longer used, the word (discarded) is printed after these parts and their symbols, 33E3 and 33E4, are omitted. A lower-case a is prefixed to the symbols of the altered pieces. It will be noted that although the *Locking-bar Connecting Rod* 33E is not altered, the symbol of this part complete, of course, bears the lower-case a and is written thus, LOCKING-BAR CONNECTING ROD a33E (complete), since some of the pieces composing this combination are altered.

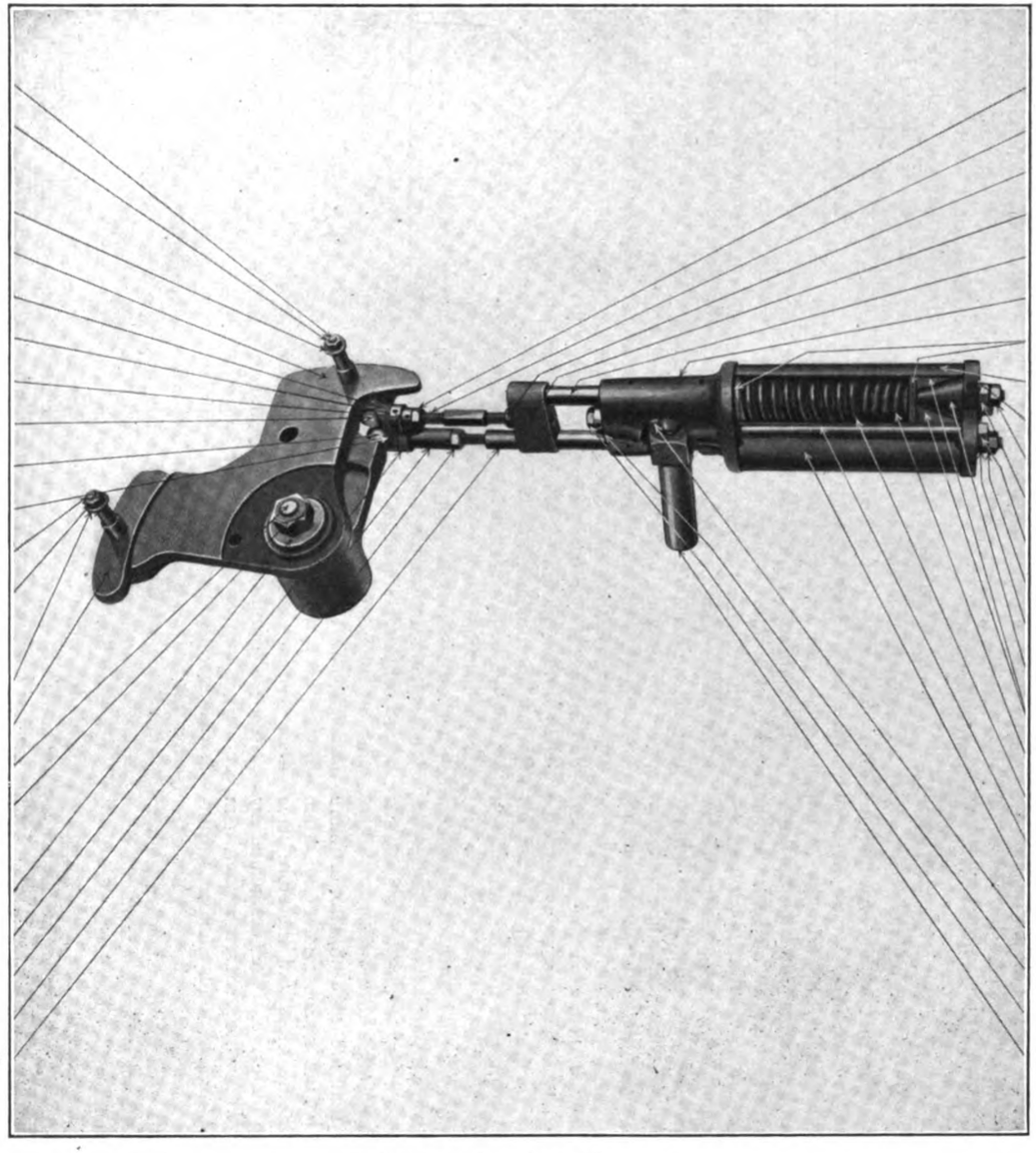
In case a future alteration of this combination introduced new pieces, the discarded symbols 33E3 and 33E4 would be used again, modified by the letter a.

DESIGNATING NEW COMBINATIONS.

For convenience in finding, all combinations bearing the same group letter are arranged alphabetically, and when the list of parts was first made out the numbers at the left of the group letter followed consecutively. The introduction of new combinations changes this; a new combination must take for its number, at the left of the group letter, the next number above the last in the group. Thus, as originally built, the *Locking-bar Bell Cranks* (lower) 28E and (upper) 29E did not have *Latches*. When these were introduced the symbols were altered as follows:

LOCKING-BAR BELL CRANK (lower, for rear Bar)	1	a28E
spring post 78 (*1*)		a28E1
fulcrum pin for Latch 795 (*1*)		a28E2
LOCKING-BAR BELL CRANK a28E (complete)		
LOCKING-BAR BELL CRANK (upper, for front Bar)	1	a29E
spring post 78 (*1*)		a29E1
fulcrum pin for Latch 795 (*1*)		a29E2
LOCKING-BAR BELL CRANK a29E (complete)		
LOCKING-BAR-BELL-CRANK LATCH (lower)	1	a82E
spring pin	(*1*)	a82F1
LOCKING-BAR-BELL-CRANK LATCH a82E (complete)		
LOCKING-BAR-BELL-CRANK LATCH (upper)	1	a83E
spring pin	(*1*)	a83E1
LOCKING-BAR-BELL-CRANK LATCH a83E (complete)		

Jaw Tongs Bell Crank Stud	**a21E2**
Jaw Tongs Bell Crank Stud Nut (upper)	**a21E10**
Jaw Tongs Bell Crank Stud Nut (lower) (not shown)	**a21E9**
Jaw Tongs Bell Crank Stud Washer	**a21E11**
Jaw Tongs Bell Crank (upper)	**a21E6**
Jaw Tongs Spring Box Ball Socket (upper)	**aS1E**
Jaw Tongs Spring Box Ball Socket Lock Nut (upper)	**aS1E1**
Jaw Tongs Spring Box Ball Socket Plug	**aS1E2**
Jaw Tongs Bell Crank Ball Stud	**a21E7**
Jaw Tongs Bell Crank Ball Stud (lower)	**a21E1**
Jaw Tongs Spring Box Ball Socket (lower)	**a27E**
Jaw Tongs Bell Crank Stud	**a21E2**
Jaw Tongs Bell Crank Stud Nut (upper)	**a21E4**
Jaw Tongs Bell Crank Stud Nut (lower) (not shown)	**a21E3**
Jaw Tongs Bell Crank Stud Washer	**a21E5**
Jaw Tongs Bell Crank (lower)	**a21E**
Jaw Tongs Bell Crank Stud	**a22E**
Jaw Tongs Bell Crank Stud Nut	**a22E2**
Jaw Tongs Bell Crank Stud Nut (lower) (not shown)	**a22E1**
Jaw Tongs Bell Crank Stud Washer	**a22E3**
Jaw Tongs Spring Box Ball Socket Lock Nut	**a27E1**
Jaw Tongs Spring Box Ball Socket Plug	**a27E2**
Jaw Tongs Spring Box Ball Socket Plug Lock Nut	**a27E3**
Jaw Tongs Spring Box Spring Rod	**26E14**



A SYMBOLING SYSTEM.

a26E24	Jaw Tongs Spring Box Connecting Rod Lock Nut (L H.)
a26E22	Jaw Tongs Spring Box Connecting Rod
a26E23	Jaw Tongs Spring Box Connecting Rod Lock Nut
a26E21	Jaw Tongs Spring Box Spring Rod Crosshead
a26E17	Jaw Tongs Spring Box Spring Rod (upper)
a26E25	Jaw Tongs Spring Box Tube Cap
a26E11	Jaw Tongs Spring Box Spring Abutment (4)
a26E24	Jaw Tongs Spring Box Tube (2)
a26E28	Jaw Tongs Spring Box Tube Plate
a26E20	Jaw Tongs Spring Box Spring Rod Nut Lock Nut
a26E19	Jaw Tongs Spring Box Spring Rod Nut
a26E27	Jaw Tongs Spring Box Tube Clamp Stud Nut (2)
a26E16	Jaw Tongs Spring Box Spring Rod Nut Lock Nut
a26E19	Jaw Tongs Spring Box Spring Rod Nut
a26E13	Jaw Tongs Spring Box Spring Brake Cone (2)
a26E12	Jaw Tongs Spring Box Spring Brake (wood) (2)
a26E10	Jaw Tongs Spring Box Spring (outside) (2)
a26E9	Jaw Tongs Spring Box Spring (inside) (2)
a26E26	Jaw Tongs Spring Box Tube Clamp Stud (2)
a26E24	Jaw Tongs Spring Box Tube (2)
a26E6	Jaw Tongs Spring Box Ball Plug (right bearing for Ball)
a26E5	Jaw Tongs Spring Box Ball Plug Button
a26E7	Jaw Tongs Spring Box Ball Plug Nut
a26E1	Jaw Tongs Spring Box Ball Extension

It will be noted that the symbols of the new pieces introduced, the *Latches,* a82E and a83E, are modified by the lower case a, for these pieces are alterations. To guide those who know the symbol of the piece and desire to find its name, a cross reference is made opposite this number in its consecutive position on the list. Thus the following list of new pieces introduced is printed at the end of the E group:

Jaw-tongs-spring-box Ball Socket (upper) a81E
Locking-bar-bell-crank Latch (lower) a82E
Locking-bar-bell-crank Latch (upper) a83E
Locking-bar-bell-crank-latch Spring a84E
Locking-bar-bell-crank-latch Spring Post a85E
Locking-bar Cam a86E

This also shows the next consecutive number not appropriated when a later alteration introduces new parts; for example, the next new part introduced in the E group would be symboled a87E.

SYMBOLS FOR PARTS USED IN TWO OR MORE SECTIONS OF A MACHINE.

It is obvious that in any machine the same piece is often used in two or more parts of the machine. Thus, the Monotype Casting Machine contains 966 duplicate parts; for example, to return to the *Bridge* 1A. The *Bridge Screws* 1A1 are standard and are used in several places. Just here arises an important difference that should be fully provided for in a system of symboling. To the shop manufacturing these parts it is a matter of considerable moment that the same part is used in two or more sections of the machine. To the customer, however, ordering a repair part this has no interest whatever; he wants a *Bridge Screw* 1A1 and he cares not a jot for the fact that this *Screw* is also used for the *Galley-pan-shelf Screw* 17F5, although this is of the highest importance to the shop.

Pieces that are used in two or more sections of the machine have no group identity in the shop, and therefore have no group letter, but are designated by numbers. The *Bridge Screw* is known in the shop as No. 24. This number is printed on the same line with its symbol 1A1 in the lists used by the employees, but to avoid confusion is omitted from the price lists furnished to customers. Note: all of the above examples are taken from the list of parts used by employees and consequently show the bold-face numbers, which would be omitted from the price lists.

These manufacturing numbers, *i. e.,* the numbers by which pieces used in different places are known, also designate the character of the piece. Thus the digit 2 of the number 24 shows that the piece is a screw. The 4 is the number of this particular screw on the screw list. This system is absolutely flexible; no matter how many different screws may be made, it is not possible to run out of numbers. The first screw on the list is 21; the seventeen-thousandth, when we get that far, will be 217000. The digits 1 to 9 are used to indicate the different kinds of duplicate parts as follows:

Bolts 1
Screws 2
Nuts 3
Washers 4
Dowels 5
Springs 6
Miscellaneous parts, bushings, spring posts, etc. 7
Wrenches 8
Cotters 9

The Monotype Company has found that the above division of duplicate parts meets all its requirements, but should it be desirable to indicate a new section in the list of manufactured parts these new parts would be indicated by 01. The next section introduced would be 02, etc.

The company supplements its price list with very complete photographs of the various parts of its machines. These do not show the parts separately, which makes their identification difficult, but in their relation to other parts as in the illustration herewith.

SHOP DRAWINGS AND PRINTS.

A word in reference to shop drawings and blueprints. But one piece should be shown on a drawing, and these should be small (the standard size of those used by this company is 5½x8 inches), both for convenience and for clearness, for, speaking within limits, the smaller a drawing is the more easily it is read. With a system of individual drawings for separate pieces the drawing bears the same symbol as the piece, and this symbol is changed just as the piece symbol changes. When the change is not too great the tracing itself is altered, and a blueprint of the tracing before alteration is filed for record. When the change requires a new tracing the old tracing goes into the record file.

Our own efforts to apply bodily to the needs of our business systems that have been most successful in other plants convince us fully that no system is a universal panacea, but that all must be modified to suit the particular needs of each business. We have, however, found the above system so helpful to us in rapidly and accurately filling orders, that we submit it in the hope that it may be as helpful to other readers of the AMERICAN MACHINIST as some of the systems already described there have been to us.

We make no claim whatever to originality in this system of symboling, but its application of the old principle of the flexibility of combinations of letters and numbers is, we think, new.

It is stated that the new harbor works at Antwerp, Belgium, which are mentioned in the article on the Liège Exposition at page 351, are to cost $36,000,000. The state will bear $20,200,000 of the expense. In the neighborhood of $130,000 will be expended by the Ministry of Public Works for harbor improvements in Blankenberghe.

R. D. Nuttall, of Pittsburg, is cutting a gear some 18 feet in diameter and 30-inch face, weighing 30 tons. They think this is record gear cutting.

Letters to the Editor.

Bevel Gear Formulas.

At page 435 Mr. Fish criticizes my article on "Bevel Gear Formulas" as being incomplete in the treatment of cases where shafts are not at right angles.

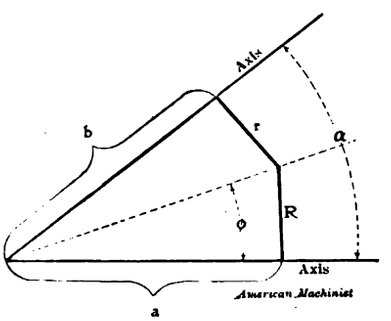
He says, "The way this problem usually confronts a designer is with the angle between the shafts given and either the velocity ratio given or the diameters of the two gears." If he will examine formulas (21) and (23) of the article in question he will find that they require *just this and nothing more* in order to solve for the angle ϕ.

On further examination of the article he will find that his solution for the first case—that of shafts at less than 90 degrees—is identical with the one given by me, and had he reduced his formula still further he would have obtained as a result:

$$\tan.\ \phi = \frac{\sin.\ \alpha}{\frac{r}{R} + \cos.\ \alpha}$$

where, when r and R are radii of pinion and gear respectively, ϕ is the angle of the pitch cone of the gear.

In practice I prefer to use the number



THE BEVEL-GEAR PROBLEM.

of teeth in the gears, since this does away with complications due to fractional dimensions.

In regard to his solution for the case with shafts greater than 90 degrees (and less than 180 degrees) I have nothing to say, except that in deriving formulas (21) and (23) as given in my "Bevel Gear Formulas" article I obtained a variety of different formulas some "most a yard long" and impossibly complicated, making it necessary to resort to the tenth decimal place in order to get accurate results. I think that on second thought Mr. Fish will concede that formula (23) will answer all needs so far as the conditions he has named are concerned, and that it is much simpler and more easily applied than the formula he gives.

The way the problem usually presents itself in practice is illustrated in the sketch. It is generally required to connect two shafts at an angle α with each other with bevel gears of a certain ratio, the distance a or b from the intersection of the shaft centers being given and the diameter of the gears being dependent on these conditions.