GREENMAN

A General Description of the Methods & Processes Involved in the Manufacture of Brass Goods

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A GENERAL DESCRIPTION OF THE METHODS AND PROCESSES INVOLVED IN THE MANUFACTURE OF BRASS GOODS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

EDWIN GARDNER GREENMAN

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IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Mechanical Engineer

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HEAD OF DEPARTMENT OF Mechanical Engineering

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INTRODUCTION.

This description is concerned only with so called Engineering Specialties, including in general valves, cocks, injectors, oil cups, lubricators and lubricating devices.

The methods and processes described may in many cases be similar to those involved in the manufacture of a large number of similar interchangeable pieces, whatever be the kind or material.

It is the purpose of the writer to consider first the design and then to follow the article through the various processes of manufacture, discussing successively patterns, foundry, factory, tools, and costs and endeavoring to point out the influence of each on the finished product.

A General Description of the Methods and Processes Involved in the Manufacture of Brass Valves and Lubricating Devices.

Design.

The design of brass valves, cocks, lubricators, etc., is influenced by the pressures under which they are to be used, the permissible working strain in the material, the price of the material, and by different standards, which have been adopted by associations of manufacturers or users, or by engineering societies, or by some competing manufacturer. There are other standards adopted for use in the factory, which must be adhered to for economical production, as will be noted later.

Valves and cocks are generally designed for three pressures, light, medium, and heavy, light being up to about 100 lbs., medium up to about 200 lbs., and heavy up to about 350 lbs. These pressures are approximate and different manufacturers will give different names to the same weight of valve or will have different divisions, thus "standard" valves are common, their weight being between the light and medium. Besides the above an extra heavy pattern is usually made for pressures up to

600 or 800 lbs. of water but this is likely to be an iron body valve with possibly brass trimmings for the weight of a brass valve to stand these pressures is likely to make the price prohibitive and the metal is so soft that it is difficult to prevent the pressure from working through even several inches of material. Even with a sound casting, if the scale is finished off on the inside to form a seat, the pressure is likely to work from this point out to the face of the valve, which would also be finished. This may occur at 350 lbs. pressure and it is a most difficult leak to stop effectively.

The working stress in a good quality of brass having a tensile or transverse strength of say 33,000 lbs. may run from 3000 to 6000 lbs. per sq. in. The stresses in the valve shell, due to the pressure, will never run anywhere near the lowest figure, but these values may safely be used for yokes and stems. As just stated, the stresses in the valve shell will be comparatively low due to pressure only but when a valve is put in the middle of a pipe line of some length it will have to resist the combined moments of its weight and the weight of the pipe, and the shell must be made stiff enough to withstand these strains with little or no deformation. If it is made too weak, the diaphragm in which the seat is located will be strained out of shape so that the disc cannot seat properly and the valve will leak.

There are also strains due to contraction and expansion, which must not be lost sight of even though no definite amount of material can be added with the assurance that it will take care of strains due to this cause.

Price of the material used in the manufacture of brass goods affects the design by limiting the sizes. For ordinary purposes brass valves are used up to and including 3", and above this iron body brass mounted. For salt water and a few other purposes they may be used up to 8" or even 10" or 12". These larger sizes are used mostly in navy work and the proportionate number used is very small.

The high price of the material also leads to minute savings in the design, which in other materials would not be thought of and which for a few pieces would hardly be worth while, but on one hundred pieces or more each day the year around it becomes necessary. Thus thicknesses of metal, and many other dimensions, are carried in 64ths of an inch and a saving of 1/32" is more thought of than an inch on a single casting in iron and steel. A chance for saving is afforded by the use of cheaper mixtures for some trimmings of valves, and oil cup parts not subject to pressure are constructed entirely of a similar mixture. Unscrupulous manufacturers are known to furnish a cheap brass instead of a good steam metal for valve bodies and the weight of the article may be thus increased while its strength and utility are decreased. It may be said in this connection that a comparison of weights alone is of no value in determining the better of two brass valves. The character of the metal and the workmanship should be the characteristics considered.

The method of design deserves notice. It would be applicable to any set of articles or parts running in a series of sizes, which increase by equal or known increments. The size of which the largest number are to be furnished is first laid

out and then the largest and the smallest of the series. Any questions as to the design or any suggested changes should be worked out on these three sizes. It is well to make up a sample of the middle size in order to detect any difficulties in the manufacture and also to see if the looks of the article can be improved. After the sample is satisfactory the other sizes of the series can be laid out and all dimensions which vary with the size of the article should be plotted on a base proportional to the respective sizes. Dimensions for the middle size and the two extremes will first be plotted and then the other sizes filled in so that the respective dimensions give a smooth curve. This curve may or may not be a straight line but is likely to be curved at the extremes at least. With these curves plotted it is easy to lay out the complete series and the work can be intrusted to comparatively inexperienced help for it is only necessary to follow the plotted dimensions. Such work proves very good training for a boy who is learning and fits him for original work later. It is necessary to have efficient inspection in connection with this method but even this proves cheaper and is sure to be more satisfactory than with more experienced draftsmen and no checker. It is a noticeable fact that boys so trained up are better satisfied and more likely to stick to the business than men from the outside, whose general education makes them dissatisfied with this class of work because of its monotony.

Standards adopted by engineering societies or by associations of manufacturers affect design in many cases. It is

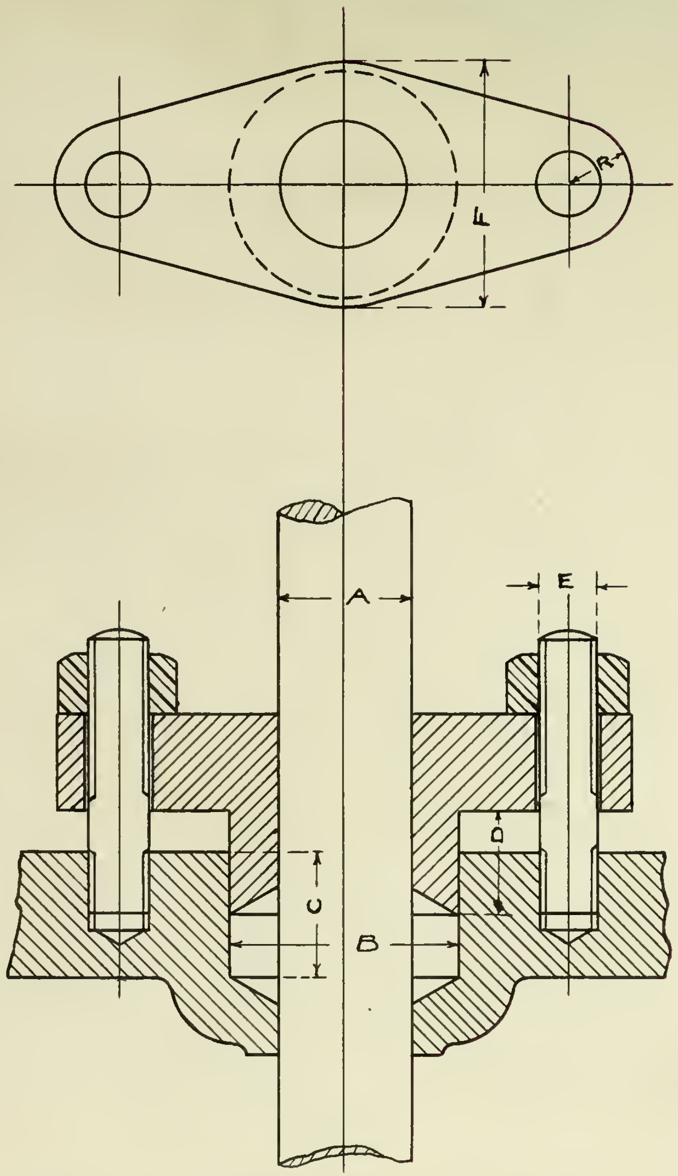
essential that a manufacturer entering the field should adhere to the face to face dimensions of valves made by his older competitor. Unless he does he will experience difficulty in getting samples of his product out for trial. His lubricators and injectors also must have the same center dimensions so that they may replace those of another make. He will also find that he must furnish the same diameter of oil or grease cup for the same price and that valve stems must be the same diameters as those of his competitor. Aside from such standards as are followed from commercial considerations manufacturers' associations have adopted certain diameters of flanges and of bolt circles for different pressures and these are adhered to by all makers and users. This refers to iron valves only there being no generally accepted standard for brass flanges although such a standard is much needed, however as brass valves are mostly made in small sizes and as these valves are generally made with screw ends it is not such an important matter as is the iron standard. It is important that fire hose threads should be standardized also so that should a department wish to render assistance to a neighboring city in case of a great conflagration, their hose connections will be interchangable. There are a number of standards in use in the U. S. and they are not at all the same so a manufacturer must be prepared to furnish any thread ordered.

Finally there are what will be termed internal standards, which have a very considerable effect on design and manufacture:

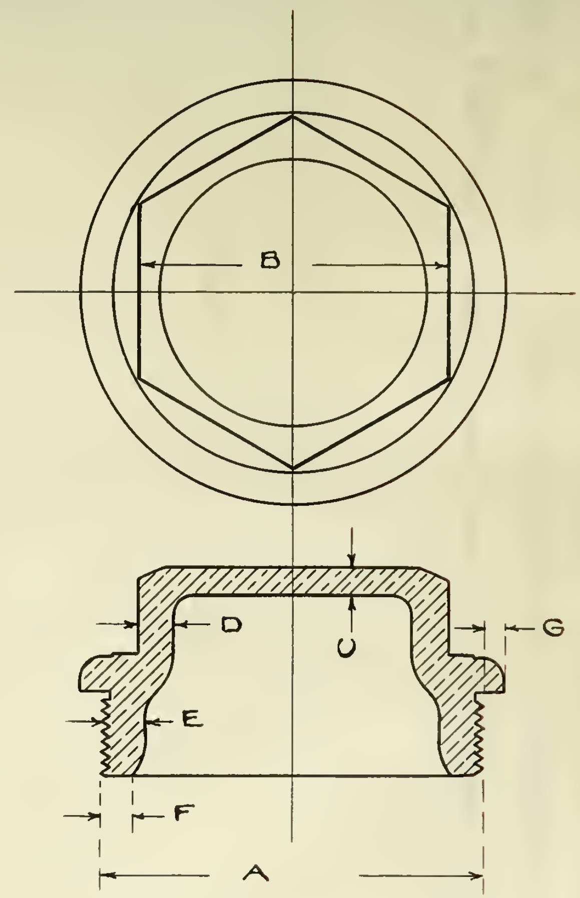
on design by saving the draftsman the trouble of laying out proportions for similar parts on different designs, and on manufacture by a saving in tools and in the number of small parts used as will be noted a little further on. The saving to the draftsman is illustrated by the cap shown on page 12. It represents an ordinary cast brass cap, such as would be used on two or three different styles of check valves and the proportions are suitable for globe and gate valves with screwed hubs. Now, if a table is made up giving standard quantities for all the dimensions indicated by letters, for different diameters of thread covering the range of diameters used, it will only be necessary for the draftsman to read off dimensions from the table for any new design. The preparation of the table is best accomplished after a number of sizes have been drawn up and made. Intermediate dimensions can be filled in by use of a curve in the same manner as previously noted. As a further illustration the other figure is given showing dimensions which may be proportioned on a bolted gland and stuffing box. The basis for these proportions would be stem diameters and suitable proportions once determined and proved by trial the design of stuffing boxes becomes merely a matter of taking dimensions from a table.

Following this scheme brings about a saving in tools because similar parts of a large number of designs are either identical or are the same in certain particulars which enable the use of the same tools for certain operations.

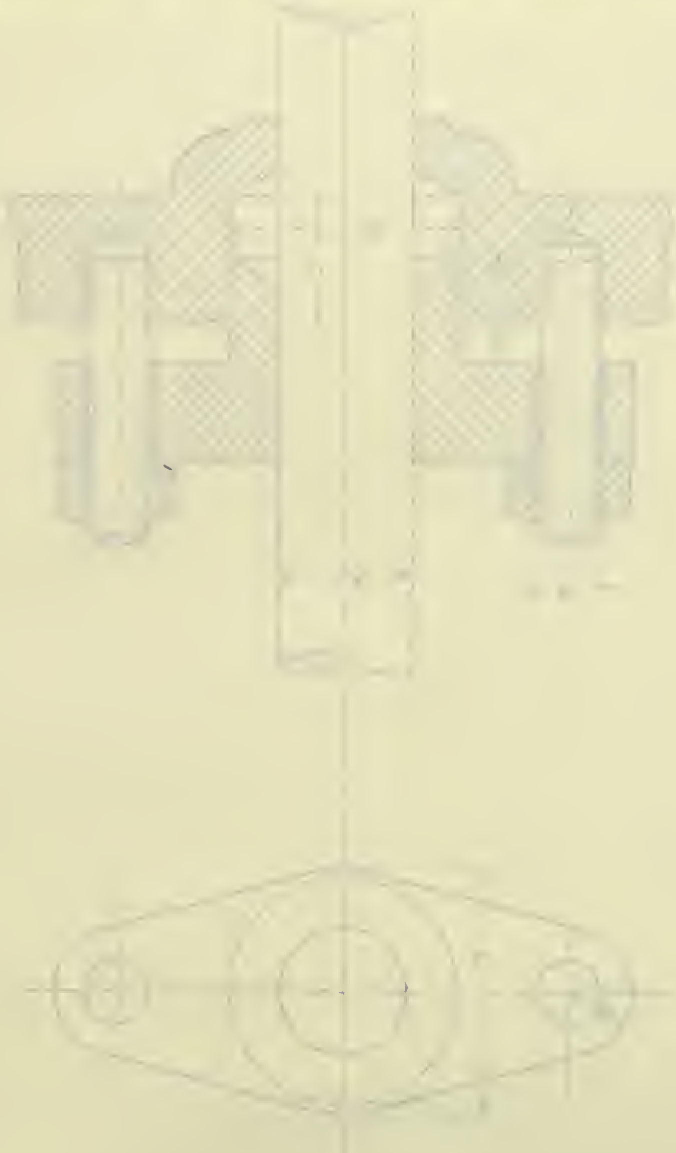
Referring to the cap as an illustration, a limited number of taps and dies and shaping knives would take care of caps for a very large number of different designs.



SECTION OF STUFFING BOX WITH GLAND.



CHECK VALVE CAP.

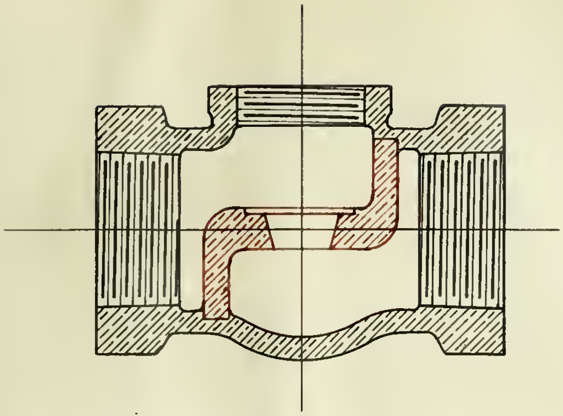


Some of the things which could be made identical for various designs by the use of a proper system of standards are handwheels, glands, stuffing boxes, stems, seat rings, discs, oil cup shanks, etc.

Patterns.

Patterns for the articles under consideration will usually be of metal because of the number of castings to be made. For a new design the patterns should be made first of wood because they will be much cheaper and can be easily changed. Wood is also used for patterns of which a comparatively few pieces are to be made and for large work where metal would be too heavy to handle. In general it may be said that on small work and comparatively simple patterns metal should be used if more than fifty per year are made off of one pattern. Iron core boxes may be made for even a less number, if they are comparatively simple or if of a construction that will not last any time in wood. For example the needle valve body illustrated on page 15 will have an iron core box parted on the plane of the paper and with the part outlined in red made in one piece extending through the box so that it can be drawn out from the back before the core is removed. All small valve patterns will of course be of metal, all screw end patterns up to 3 inch being on plates for moulding machine work, and brass is the most suitable metal for these. Valve patterns in sizes 4" and above can advantageously be made of an aluminum composition to reduce the weight.

If more than say three hundred pieces per year are wanted of any article or if the orders come in lots of one hundred or more, it will generally pay to make a plate of patterns and if



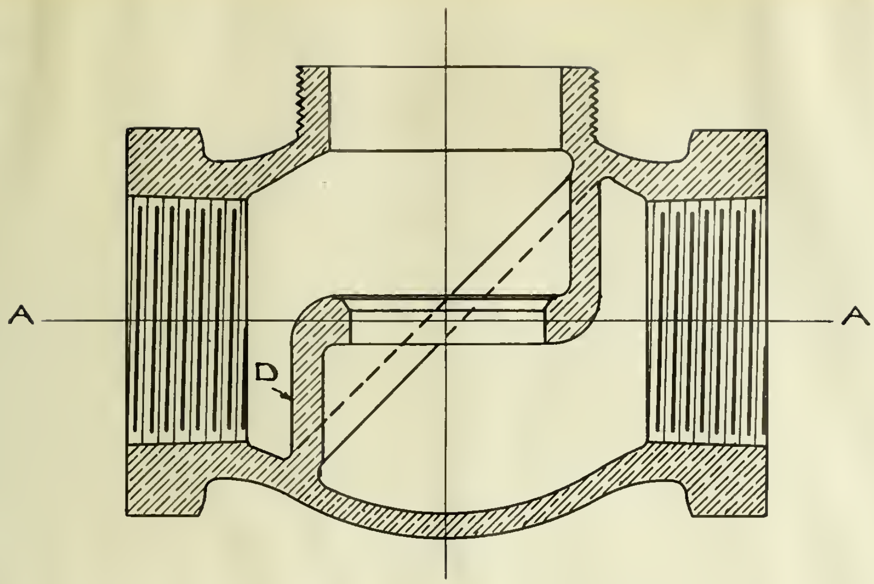
NEEDLE VALVE BODY.

Portion outlined in red is made by loose piece in core-box, see p. 14.

cores are required a number of core boxes will also be needed.

Machine core making has not yet been successfully worked out for valve work. The principal difficulties are in gauging the proper quantities of sand for each core and in packing it uniformly. The writer is firmly of the opinion, however, that these difficulties can be surmounted and that a machine can be made that will reduce the time required by two thirds.

There are two principal methods of making cores for valves with a diaphragm. An inspection of the cut on page 16 of an ordinary globe valve body will show that the core may be parted on the plane of the paper if some means of drawing out the circular diaphragm "D" is provided, or it may be parted on the section "AA" and the two pieces pasted together. The latter method means a very much simpler and cheaper core box but a less



Section of
Brass Globe Valve Body

reliable casting for the cores will sometimes be so pasted together that the diaphragm will be thick in one place and thin in another, though ordinary inspection would not detect it, and the valve may fail on that account and cause a large amount of damage. The much safer, though more expensive method is to part the core box on the section shown in cut and draw the diaphragm out of the box. This kind of a core cannot shift so as to give a varying thickness of metal in the diaphragm. The diaphragm in such a box will be made in two pieces for each half of the box and will be fitted with a flange for rotating it out of the core before the core itself is removed from the box. To do this a stripper plate is laid on the half box and it preserves the corners of the core while the diaphragm is being removed. Any such work as this can only be done in metal boxes because a wooden box would soon swell so that the parts would not fit together or would

wear so that no degree of accuracy could be obtained. This serves only as an illustration of the necessity of giving attention to the best design of patterns and often times of adopting expensive methods of producing the product in order to insure its safety. The globe valve is taken as an illustration because it represents a large proportion of the output and presents the most difficulties in its manufacture.

Relative to core work in general it may be said that aside from the cases where cores are necessary, they are put in for two other reasons, namely - to secure uniform thickness of metal in various portions of a casting and so prevent spongy places, and to secure true flat surfaces in a casting where other pieces come in contact with it and yet where it is inconvenient or too expensive to finish.

It is difficult to find workmen who are sufficiently well trained for the accuracy required in this kind of pattern work. Metal must come of uniform thickness or else it is necessary to add enough to insure the safe minimum and that can't be done with brass on account of its cost so it is necessary to employ very careful men and to inspect all the work carefully. This means that every pattern and every core dimension on every piece made must be checked by the drawing. It is not sufficient that a certain pattern and core box will go together, for a number of patterns and core boxes may be made and it would be impossible to keep the corresponding ones together. On iron work, particularly when only one pattern and box are made, this extreme accuracy is not insisted upon.

It would seem that with such a degree of accuracy required, patterns would be very costly but such is not the case and the reason is found in the method of running the shop - the workmen are not skilled pattern-makers as a rule, but accurate workmen are chosen and the patterns are all designed and sketched out for them, they doing the mechanical work only. This same principle is applied all through the shop to save money and because skilled workmen are not to be had. When a good man is found he is put in charge of a squad and does the thinking and planning for them - they do only the mechanical work.

Foundry.

The use of plates of patterns for moulding machine work has been spoken of. The most successful machines for this class of work are of three general types, which will be described briefly. The first division should be into whole and split pattern machines and of the latter there are two types, one of a squeezer type using a cast iron flask and requiring no hand packing or tucking, a machine that can be used only for small or shallow work having plenty of draft, such as valve stems up to 3", small cock bodies and keys, etc; and the other a type suitable for all size valve work on which the sand is packed around the pattern and tucked around the edges of the box before the squeezer is applied. This machine also uses iron flasks and in fact no split pattern work can safely be done in snap boxes because one half of the mould is likely to slip over the other. Only one half of the mould is made at a time by this machine and after it is tucked by hand and filled up with sand the pressure is brought on by somewhat of a blow. In the ordinary squeezer type machine the pressure is applied more slowly so that there is no blow. Air is the most convenient and economical motive power for all of these machines and it may also be used to vibrate the pattern plate before lifting the mould off. This is done instead of the usual rapping of the pattern. In so far as possible split pattern plates are made with patterns equally spaced on the two halves of the plate so that the two halves of the mould are ex-

actly alike and it is unnecessary to change the plate on the machine. Any work that is not symmetrical or that cannot be arranged symmetrically must have two plates and when the moulder fills up his floor with lower halves he changes plates and makes upper halves for all of them.

On the squeezer type of machine both halves of the mould are made up before the squeezer is applied and snap boxes are used. Shifting of one half of the mould over the other is of no importance since whole pattern plates are used.

Moulding and pouring are an almost continuous operation. The furnaces will give up to six heats per day and at the rate of two hundred and fifty moulds per day a man would have as a maximum forty or fifty moulds on the floor at a time. Cores, if needed, are started far enough ahead so that they will be ready and when the metal is ready the moulds are closed up as rapidly as possible and poured so as to give space for more work within easy reach of the machine. The moulder stays at his machine continually and is assisted by the general help in the foundry to temper the sand, riddle it, and deliver it within easy reach of the machine and he has a helper to dust his moulds and carry them away, and a boy from the core room to put in the cores. The moulds are set in rows each side of an overhead track and when the metal is ready it is brought in by carriers from the furnace room and a skimmer takes charge of the pouring. Just ahead of them is a man who moves the weights from mould to mould as soon as one is partly cooled, and following them is a man who pulls out the risers on valve work or on any work that

is to be unfinished where a good color of metal is wanted, and covers up the mould with a board to let it steam. This work must not be dumped until the sand is about through steaming and that means say one half hour on 1 inch valves, or an hour on 2 inch. Other work is pulled out of the sand very rapidly and then the boxes and mould boards are dumped and piled back in reach of the man at the machine, and the sand is tempered and riddled to be used over again. The gates of castings that are to be finished are piled up and taken to the cleaners with no special care, but valve body castings when taken from the moulds are first dipped in water to help give a good color and are then cleaned in the usual way. The cores are first cleaned out and the surplus sand on the outside, after which they are separated by a power gate cutter and are then sent to the sand blast room, where all the sand inside and out is carefully removed. Next they go to the bench men and grinders, who remove the seams with a file and grind off any lumps that appear. They are then ready to go to the rough stock room. A few other articles which are not to be finished and on which a good appearance is desired, are treated the same as valve bodies but almost everything else is rumbled instead of sandblasted.

The best moulding sand for brass work comes from near Albany, New York, and is called Albany sand. Its life, if used once a day, will average about fifteen days, after which it must be used too wet or it will not stick,and the part of it that cannot be used for cores must go on the dump. The best method of handling the sand is to have it on the floor below the moulding floor. Here it can be mixed and elevated and dropped at the moulder's

side. The moulds may then be arranged both sides of a grating onto which the sand can be dumped to fall through to the lower floor, where it is wet down and returned the next day. A damper arranged under the grating will dump all the sand on one side one day and on the opposite side the next day. With this scheme the moulding floor would consist of a series of gratings along which the moulds would be arranged on both sides and the length of the grating would be sufficient for say sixty moulds. Between each two gratings there will be an overhead track to carry the metal in pouring.

The furnace room should be on the same floor with the moulding floor but in a separate room to keep the heat from the moulders in the summer and so that the moulding room can be warmed in the winter.

It should be a one story structure or on the top floor of a building and of a construction that will allow plenty of roof opening without letting in the rain. At least a third of the wall space on two sides ought to be sliding doors to allow of plentious ventilation in the summer,and the whole construction must be absolutely fireproof. Corrugated steel for siding and roofing is not altogether satisfactory because it will rust or burn out in a short time. There is now on the market a corrugated asbestos board, which bids fair to replace steel sheeting for fireproofing but its lasting qualities are yet to be proven.

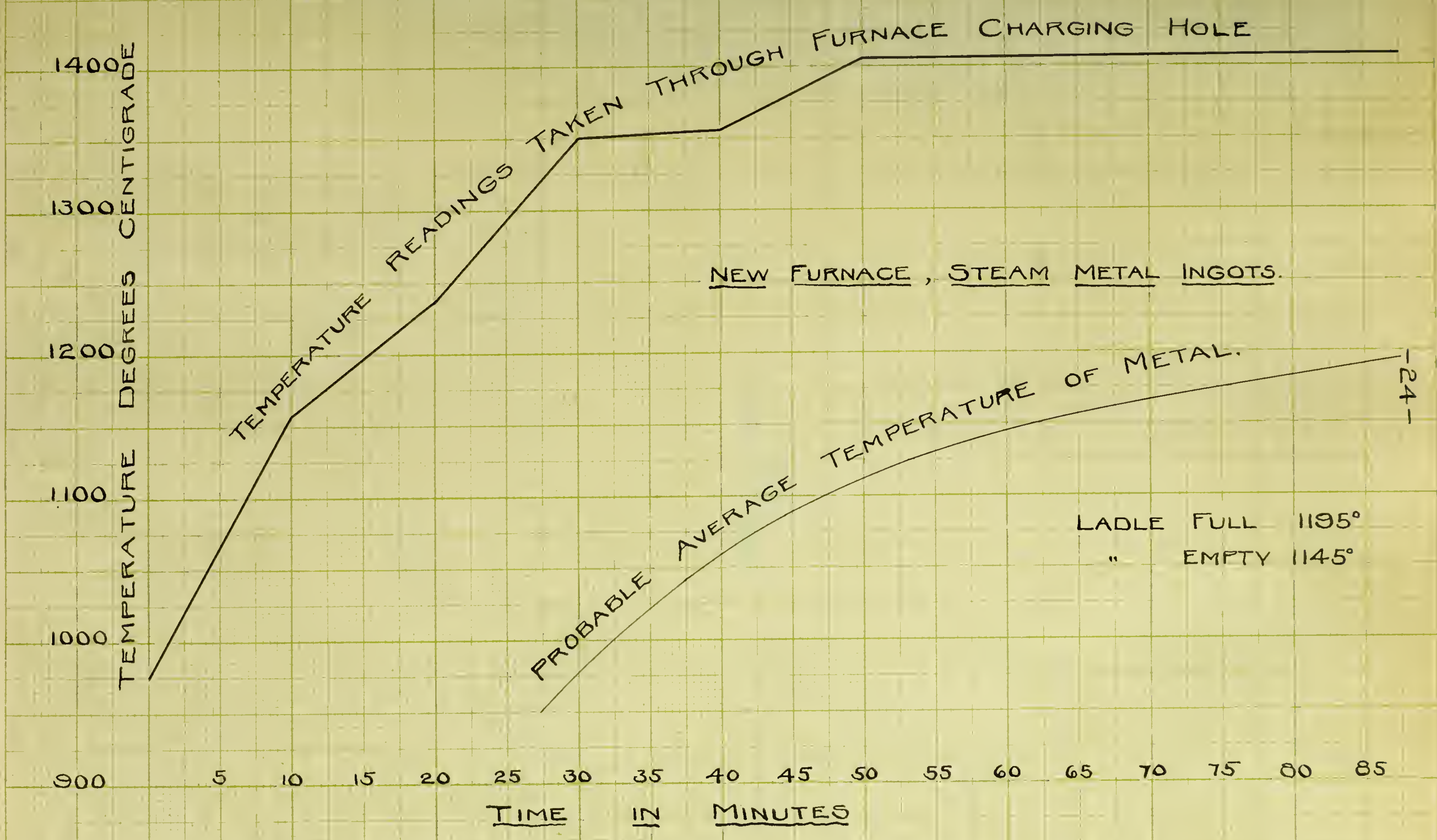
Oil or gas melting furnaces are the most economical and convenient to handle. Oil will probably be the cheapest fuel unless natural gas is available. The writer advocates a cylindrical rolling furnace of about 1000 pounds capacity. Several such

furnaces are to be had on the market, the essential features being an outside shell of sheet metal about 50 inches in diameter with two cast iron heads, and with about a 4 inch fire-brick lining, and having two charging and pouring holes located on opposite sides of the drum near the blast end of the furnace. The blast and fuel connection will be in the center of one end and a spindle with a handwheel, or gearing for ease in operation, are located on the opposite end. One charging and pouring hole is covered with a brick and a plate when the furnace is lined up and when the furnace is partly burned out this hole is opened and the other closed up. In this manner the lining may be well burned out all around before it need be renewed. The renewal is accomplished by taking out one head and knocking out the lining and then building in, beginning with the head left in. One lining will stand about 72 heats or at 6 heats per day about 12 days work.

The curves shown on page 24 represent the temperature in such a furnace as taken with an optical pyrometer. The heavy line represents actual readings taken at ten minute intervals through the charging hole with the blast turned off and the light line represents the probable average temperature of the metal.

A rotary blower gives sufficient blast for these furnaces although compressed air can also be used with good results.

Coke furnaces are still used more or less for small charges of metal and for special mixtures but a small crucible oil furnace, similar to the "Steele-Harvey", manufactured by The Monarch Engineering and Mfg. Co., is much more economical and convenient.



Performance of Brass Furnace with Oil as Fuel.

The whole question of different mixtures suitable for valve work is too broad for discussion here but a few practical points will be mentioned. The standard U. S. Navy Composition, 88 per cent of Copper, 10 per cent of Tin, and 2 per cent of Zinc, is as good a mixture for valve work as is known but it is an expensive mixture because of the large percentage of tin, and its toughness makes it very hard to machine. A very good steam metal can be made of 87 per cent of Copper, 6 per cent of Tin, 5 per cent of Zinc, and 2 per cent of Lead. This metal is easy to machine, has a tensile strength of over thirty thousand pounds per square inch and is considerably cheaper than the navy mixture. This metal is suitable for valve bodies, and trimmings in which strength is required, such as yokes and stems. For valve trimmings a somewhat poorer mixture is just as efficient and will reduce the cost appreciably. A good trimming mixture would be about 83 per cent of Copper, 3 to 4 1/2 per cent of Tin, 10 to 8 1/2 per cent of Zinc, and 4 per cent of Lead. In this mixture there can be used chips and imperfect castings returned from the shop, old metal, such as copper wire and brass tubing, and old brass of all kinds, such as would be accumulated by a junk dealer. It is impossible to analize the returns from the factory or the other old material, so that the composition will vary more or less, but with no detrimental effect on the product. For lubricator and oil cup trimmings not subject to pressure yellow brass is used. A composition of 66 per cent Copper, 32 1/2 per cent Zinc, 1 per cent Tin, and 1/2 per cent Lead being suitable for such work. The same composition may be used on manifolds and other low

pressure fittings.

For inside screw hubs a different metal from the stems is required to get good lasting qualities and it may be had by replacing 2 per cent of Zinc in the trimming mixture by 2 per cent of Lead. Such a metal will be enough softer than the stems to wear well with them.

For valves to be used on high temperatures and superheated steam work it is important to keep the softer metals down to a minimum. Lead will melt out and leave the structure honey-combed but zinc may more safely be used. As an ideal mixture for superheated steam work 87 per cent Copper, 5 per cent Tin, 7 per cent Nickel and 2 per cent Zinc may safely be recommended but this mixture is difficult to machine and unless the foundry is running a good deal of such work it probably would not pay to make it, for the small amount of lead in the steam mixture makes the latter practically good enough. Navy composition is a good superheated steam mixture also and less expensive than the formula given. The comparative costs, tensile strengths and elongations of the several mixtures are about as follows:-

Mixture.	Relative Cost.	Tensile Strength lbs. per sq. in.	Elongation.
Steam Metal,	152	34,000	22%
Trimming Metal,	141	31,000	14%
Navy Composition,	163	36,000	29%
Superheated Steam Mixture,	177	50,000	30%
Yellow Brass,	117	26,000	32%

The treatment of the chips and turnings from the factory deserves further notice. They will amount to 10 or 15 per cent of the total amount of metal melted, and spillings and waste in the foundry, and imperfect castings returned will average about as much more. All pieces of any size can be run in trimming metal but the turnings would be burned up and lost if run with heavier pieces so the most economical method of utilizing them is to melt them separately with a flux and cast in ingots. With the turnings is melted the metal recovered from the foundry sweepings and from the furnace slag. The slag is ground in a mill with running water to carry away the dirt and is further washed over and over in a trough. No attempt is made to keep different qualities of turnings separated but the clean turnings are kept separate from the sweepings and are melted separately also. The turnings are first picked over and sifted to take out large pieces and are then run through a magnetic separator to take out nails or any particles of iron or steel. The sweepings are picked over to get out pieces of wood and waste before they are run through the separator.

Factory.

The factory work can best be described by following several articles through the processes of manufacture. The work can well be divided among nine separate departments, as follows: Inspection and Testing Department; Brass Valve Department, Lubricator Department; Cock Department; Pop Valve Department; Injector Department; Screw Machine Department; Milling Department; and Buffing Department. Both the Brass Valve and Lubricator Departments will be larger than several others combined but some good reasons for the subdivision will appear in the following.

Inspection and Testing Department.

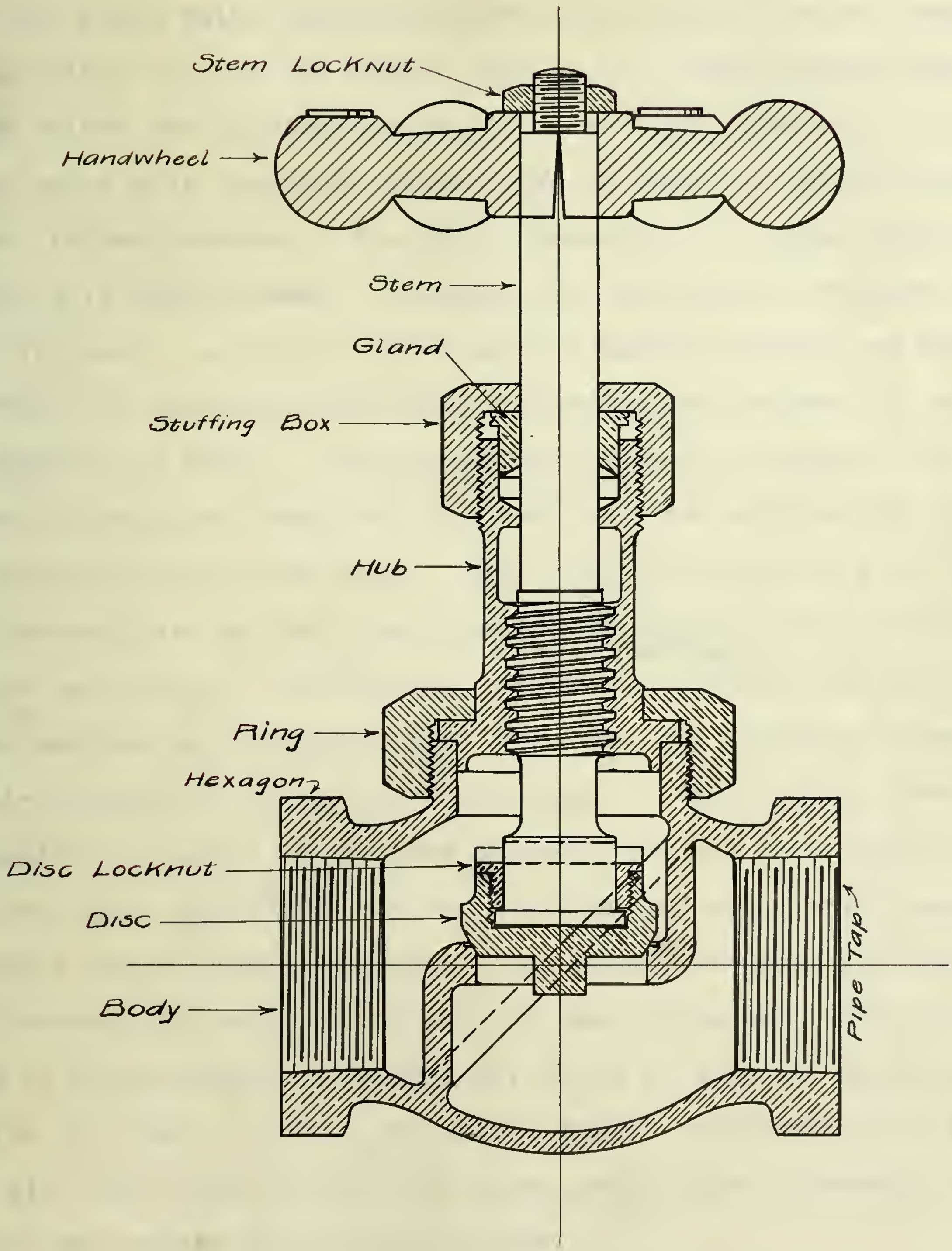
The Inspection and Testing Department handles some of the products, such as valve, oil cup, and lubricator bodies before any machine work is done on them. They are put on a cold water pressure test to discover leaky castings. Some other pieces, such as valve hubs, are tested after they are finished but before they are assembled and every article made goes through an inspector's hands and is put on a pressure test before it goes into finished stock. Pop valves, injectors,and the like are tested under steam pressure, but other articles are subjected to water test only. A steam test would be of doubtful additional value and would cost probably five times as much because the articles would get so hot that they could not be handled rapidly. The test pressure is generally about fifty per cent more than the working pressure and its only value is to discover leaks due either to bad castings or to poor workmanship, for the valve has such a high factor of safety against pressure alone that such a test is no indicator of its strength or durability in use. The steam test on pop valves and injectors is a different matter for the conditions are made as near as possible to those under which the valve will work and if it works on the test it will probably be satisfactory when put on a boiler.

The steam test is necessary on pop valves for sometimes they will not work even though supposedly made exactly like others that were satisfactory. Pop valves are not easy to manufacture and if the workman is careless or inexperienced, as is often the case, a little too much or too little clearance may make enough difference in the working to throw out a valve. Pop valves must also be

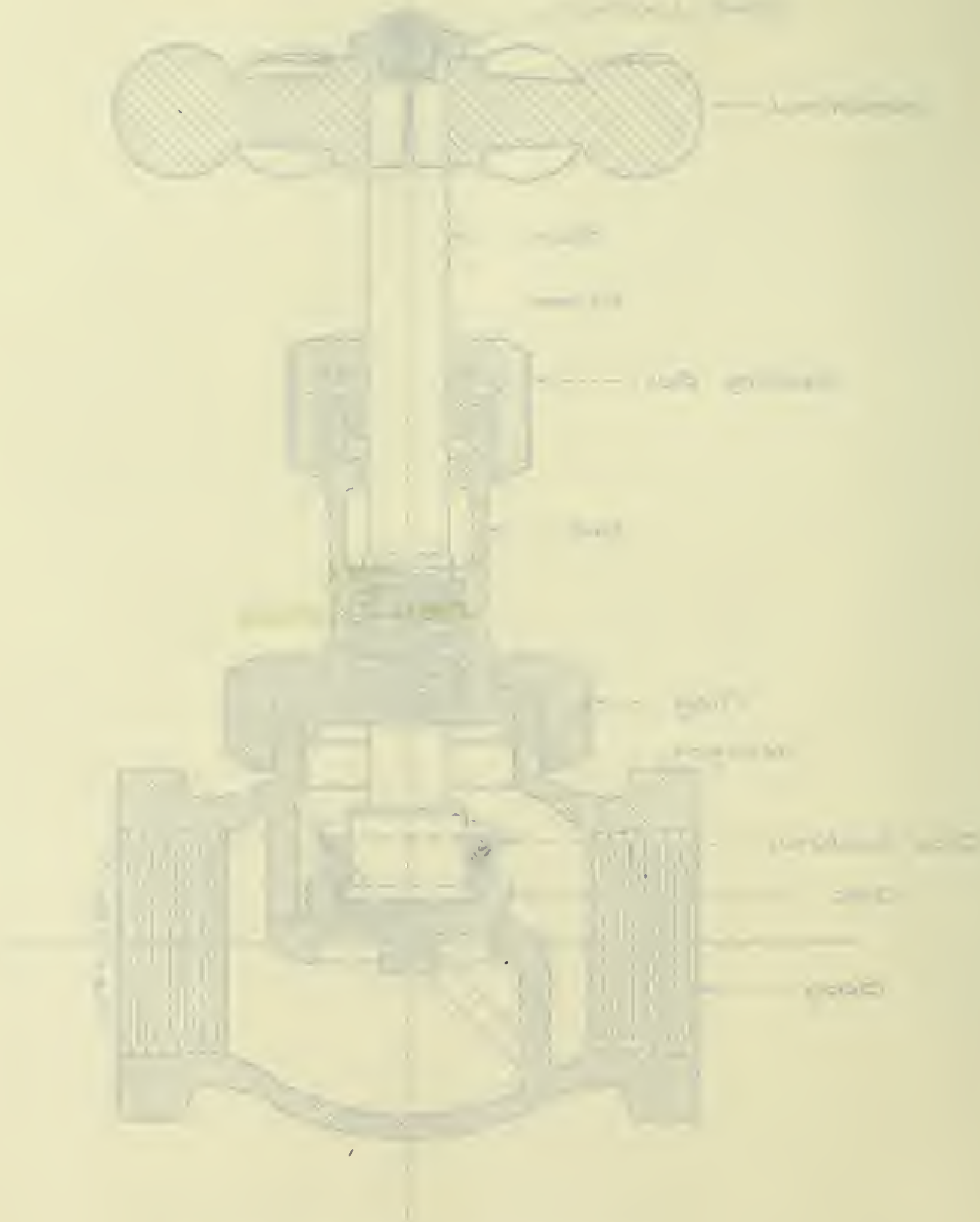
tested on steam to set for the pressure at which they are to be used and to regulate the pop, or number of pounds relieved each time, so that the buyer will not have to make adjustments.

Injectors are tested to see if they come up to their rated capacity, and if not, are adjusted until they do give their capacity.

Testing and inspection are combined in some cases and overlap in many cases but in many others they are entirely separate. A number of articles out of every lot sent through must be taken apart and carefully scrutinized to see that the workmanship is what it should be, and that the parts are made as per drawings and gauges. If several pieces are found to be otherwise than as they should be the whole lot is returned to the foreman for him to go over. If the pieces examined appear to be all right the lot is turned into finished stock and is ready for shipment without further examination. A very large percentage of the articles are packed in paper or in wooden boxes and an inspector's label put on so that the lid cannot be removed without breaking the label. It is the duty of the Inspection Department to make memoranda of defects and suggest changes to prevent their re-occurance.



SECTION OF BRASS INSIDE
SCREW GLOBE VALVE.



Brass Valve Department.

The Brass Valve Department makes all kinds of valves complete. Globe valves will be the larger part of the output because more globe valves are furnished than all other types combined. A globe valve will therefore be followed through the various processes of its manufacture. The first operation on a globe valve body after it is rough tested, is facing and tapping the two pipe ends. This is done in a special valve tapping machine having two heads in which the tools are held, and a chuck located between, in which the bodies are held. The machine has two sets of tools, one set faces the ends and bores the pipe ends for the taps and the other set consists of the two taps. The chuck has three sets of jaws and the two sets of tools are located 120 degrees from each other, one on each side. The operator removes a finished body and inserts another in the upper chuck while the two different operations are in process on the two other castings. The machine then automatically moves 120 degrees bringing the new body in position for the first operation. A man can turn out about one thousand bodies a day on such a machine. The bodies are next finished and threaded on the neck end and the seat finished. This is done in four operations as follows: first a roughing cut is taken inside the neck end; next the end is faced, the outside finished for die, the inside finished to size, and the seat undercut and bored; and fourth the outside is died.

The bodies are then reseated on the same machine in a single operation. The reseating is necessary because the body is held in a chuck during the machine operations and is sure to be sprung

to some extent so that the seat will not be exactly true. In reseating the chuck is removed from the spindle of the machine and the tool inserted, and the body is held up against it by some flat surface on the carriage pushing against the under part of the shell. A short piece of pipe is screwed into one end to hold the body and keep it from rotating. The operator will finish several hundred bodies and then change his machine for the reseating. About three hundred valves can be thus finished per day.

Next the hexagons are milled in the Milling Department and afterward a boy removes the milling burrs in a speed lathe at the rate of one thousand per day.

The last operation on the body is to grind in the disc. It is held on a rotating spindle and the body forced up against it. Soap and a very fine sand are used in grinding the surfaces into a perfect contact,after which the bodies are ready for assembling.

Turning now to the trimmings, the hub is finished first on the lower end in three operations, one to drill for the tap, one to tap the thread, and a box cutter finishes the extreme outside and the projection that fits down inside the body. The hub is then rechucked on the thread and the other end finished in three operations; first a box cutter finishes for the die, faces the end, and finishes the inside for the gland; next a shaping knife finishes the outside below the thread, and last a die cuts the stuffing box thread. The hubs are then ready for the test and then for assembling.

Rings are finished in two operations on the thread end, one

to finish the inside and face the end, and the other tapping it. They are then rechucked on the thread and faced on the back and then go to the millers to have the hexagons milled. One man will handle about six hundred hubs or rings per day in the various operations. Stems are all finished with one chucking except milling the squares for the handwheel and drilling a small hole for the regrinding pin. A chucking lug is put on the lower end of the stems and a box cutter and two dies do the finishing. A cutting off tool separates the stem from the chucking lug and it is sent to be milled and drilled and then to the assemblers or put into stock until needed.

Discs are chucked on the lower lug while the upper end is faced, bored, and tapped. They are then rechucked on the thread and a box cutter and seater finish the lower end.

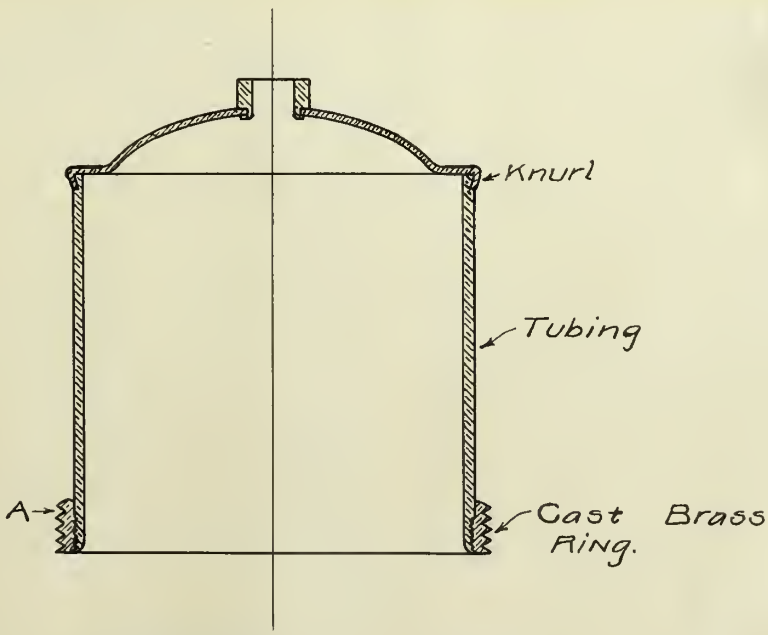
Stuffing boxes are finished all except milling, in three operations on three similar machines. First they are chucked and bored and faced; next they are rechucked and tapped; next rechucked on the other end and back faced; and then go to the millers to have the hexagons finished. Special stuffing box machines are used for the first three operations and they are very interesting machines. The first machine looks like a speed lathe with rather a large head stock and with a massive spring chuck replacing the tail stock. The tool is carried in the spindle of the machine and the chuck is so arranged with a stop that when the lever is pulled back a certain distance, in drawing the work away from the tool, the spring is compressed and releases the stuffing box and it drops in a box with the others that are completed. The operator then inserts another casting and pulls the

lever forward until the casting is firmly gripped, and still further, forcing the casting against the tool. So the operation is repeated and the castings passed on to the next man to tap. The second machine has exactly the same kind of a chuck but the head stock is constructed somewhat differently. It is a sort of a gear box which normally rotates the tap backwards but when the stuffing box is forced up against it, it pushes over the tap and with it a clutch which reverses the direction and speed of rotation of the tap. When the tap has run to the bottom of the hole the operator lets the lever move backward and the tap is first stopped and then as a spring forces it and the clutch over with the chuck its direction of motion is again changed and the tap backed out. So the second operation is completed and the stuffing box drops out of the chuck as the spring pulls it back and opens it. The third operation is very much the same except that the casting is chucked on the opposite end. Three men will thus turn out twenty five hundred stuffing boxes per day while on turret machines they would hardly turn out one half as many.

Glands and stem locknuts are made of rod brass on automatic screw machines. They complete the list of parts for the valve. The assemblers will put together about three hundred and fifty valves per day. They are expected to look over each body and remove any burrs still remaining and they pack the stems so that if no defect shows up on the test the valve will be ready for stock.

Lubricator Department.

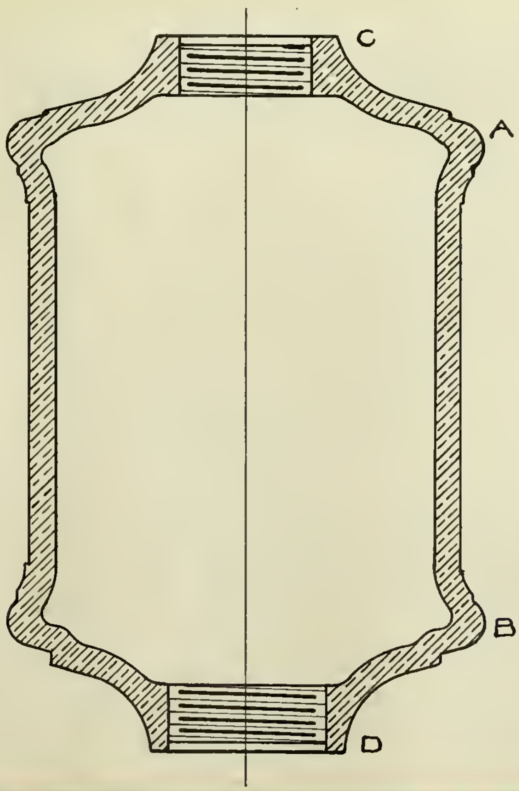
The Lubricator Department will make lubricators, oil cups, and grease cups, in all styles. This work is quite different from valve work and the materials used are different. The large part of the output is subject to little or no pressure, the material may be lighter in weight, and yellow brass can be used in many cases. A fine polished surface is necessary on most of this work, however, and that means that most outside surfaces have to be shaped and then buffed or plated. Tubing and stampings are used to a considerable extent for light grease cup bodies and caps and rod brass is used whenever possible for trimmings. The grease cup shown on this page is an illustration of the use of tubing. The end of the piece of tubing is threaded with a fine thread, then the ring "A" is screwed on and the end of the tubing turned out over it so that it cannot come off. A tool



GREASE CUP BODY
MADE OF TUBING.

then cuts the groove for fastening on the top and the cutting off tool cuts off the piece to the proper length. The top is a stamping and is fastened onto the body by the knurling tool, which forces the narrow flange around the outside into the groove at the top of the body. This makes a very good cup for high speed machinery because it is so light in weight.

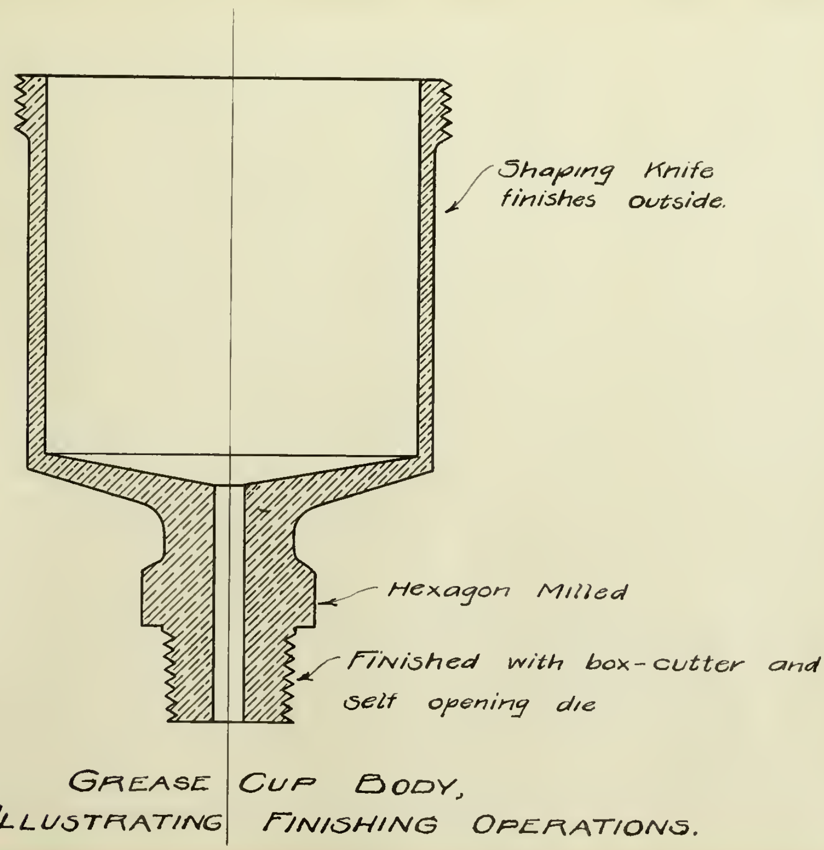
The lubricator body shown on this page illustrates the use of shaping knives. In shaping it is chucked on the thread on one end and is supported by the tail stock of the machine on the other end. The outside of the body is then shaped in three operations by three different knives. One cuts all of the middle section from "A" to "B", one the end section from "A" to "C" and the other the other end from "B" to "D". On some of the smaller sizes of the same style one knife can be made to shape the entire cup. These knives are made in pieces ten or twelve inches long and are ground back from time to time until they are entirely



LUBRICATOR BODY

worn out. Such a knife will cut say one hundred thousand bodies. In a shop of any size there will be enough work making shaping knives alone to keep more than one man busy all of the time. The knives are always ground at an angle with the axis so that only a small part of the width is cutting at one time. If an attempt were made to cut over the entire surface at once, the result would be that the piece would spring so that the knife would scrape the scale and would dull very rapidly. With the knife ground at an angle it gets under the scale when it begins to cut at one side and advances across the piece as the tool is fed towards the work.

The grease cup shown on this page further illustrates different finishing operations. It is first chucked on the shank end and a cutter faces the end and finishes the outside for the die, and another cutter bores the inside. The outside is then died



GREASE CUP BODY,
ILLUSTRATING FINISHING OPERATIONS.

and the cup is sent to another machine where it is chucked on the thread and the other end supported on a center on the turret while the outside of the body is shaped by a tool held in a cross-feed attachment. The pipe end is then finished for the die and the thread cut by the next operation. This work is all done very rapidly, as rapidly as it can be described. Turret machines with spring chucks are used almost entirely on this kind of work and it takes but a second to insert the piece. The work is all done on piece basis so that the operator has every incentive to work as rapidly as he can. The operations take but a few seconds at most and the workman will throw around the turret for the succeeding operations very rapidly. Almost all the dies are self opening so that no time is lost in backing off and an expert operator will work so fast that it will take several minutes of watching to discover just what each operation is.

There is an endless variety of styles and sizes in which grease and oil cups must be made to supply different demands but the processes involved are all similar to those just described. A large proportion of the oil cups made have glass bodies both for cheapness and as an indicator of the quantity of oil in the cup. For these a base is made with a shank extending up through the body to fasten the cap on; an upper lid or cap held on with a locknut and containing a filling hole covered usually with a slide; a feed mechanism which works down through the center of the shank; and a sight feed piece which screws on below the base. The sight feed piece has to be separate because a glass must be inserted to show the amount being fed. The glass is packed top

and bottom with a cork washer, as is also the body glass. Several different sizes of bodies and a number of different styles of cups can use the same sight feed shank, the feeding mechanism possibly being the only difference between the different styles. These sight feeds and oil cup bases and tops are shaped and finished in a manner similar to that already described. All this work is buffed to a bright color after it is assembled and before it is inspected and put into stock.

Cock Department .

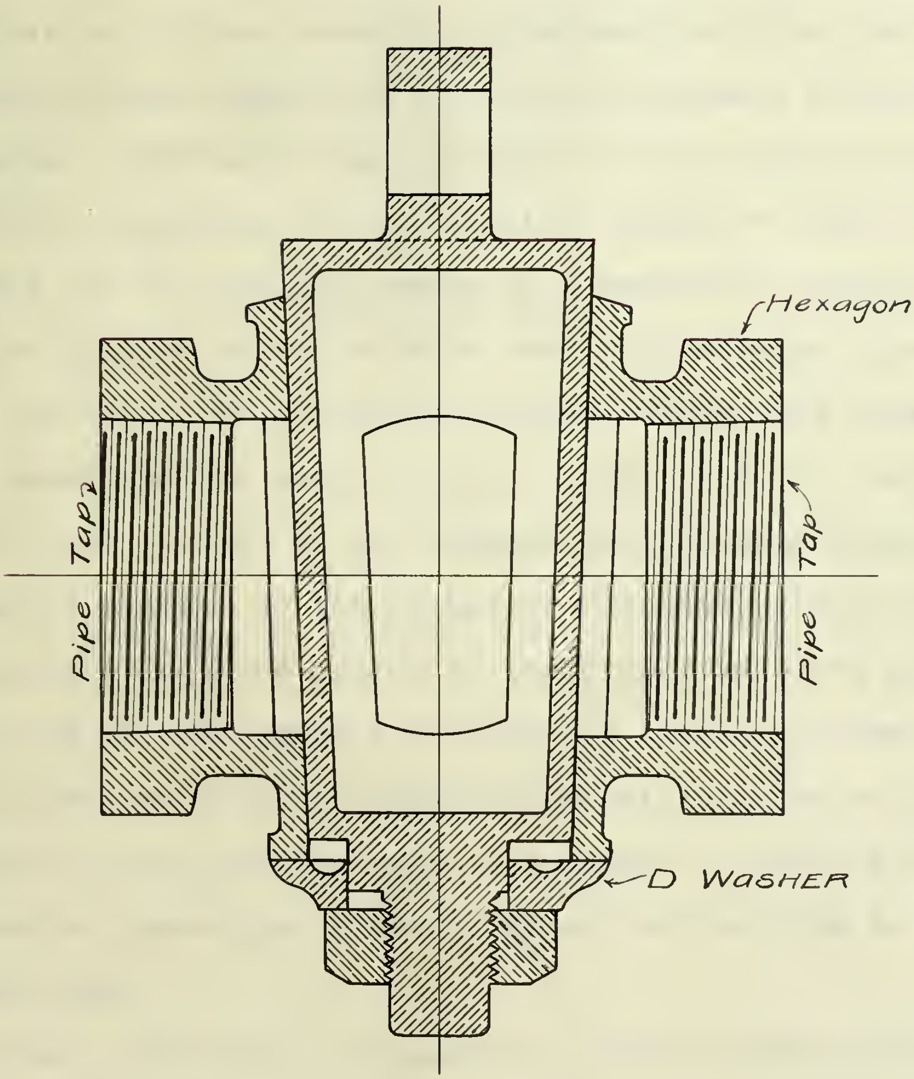
Factory work on cocks presents some difficulties not encountered elsewhere.

A very considerable percentage of the ground key work found on the market is either not tight when new or will not remain tight any length of time in service. It is the writer's purpose to describe methods which do give absolutely tight work. The different varieties of cocks encountered are about as follows: steam stop cocks on which the key is held in the body by a nut and "D" washer fitting on the key; packed key cocks on which the keys are held in by the pressure of the packing on a portion of the top of the key, or as is the somewhat better practice by a spring, the packing serving merely to prevent leakage around the head of the key; air or cylinder cocks, with nut or spring on key; and gasoline cocks, usually made with spring keys.

Steam stop and packed key cocks are made in sizes from 3/8" to 4", two and three way, medium and heavy patterns. The other styles are made in one weight and in sizes ranging from 1/8" to 3/4" pipe.

The first two styles are usually made with female ends, while the other styles are made with male and female ends, male end and round nose, male end and bibb nose, female ends, male or female end and union, etc.

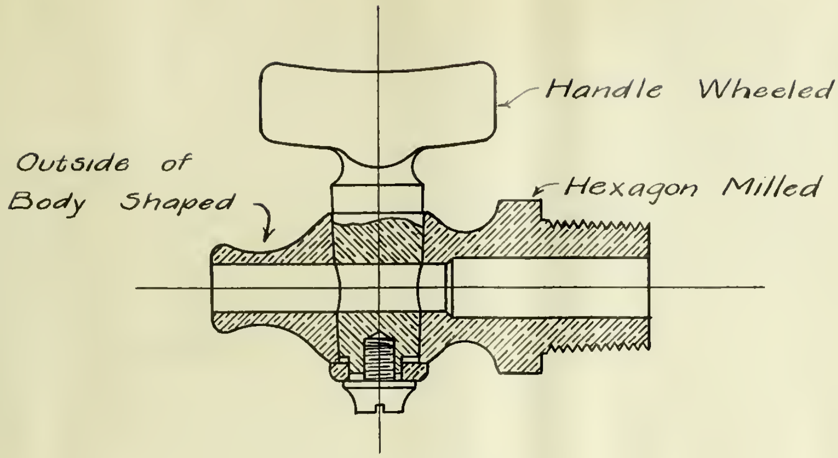
Steam stop and packed key cock bodies are faced and tapped in a turret machine and are then milled in the Milling Department. The Cock Department finishes the keys, and finishes the bodies to take the keys, and grinds them in. One man operates two machines



BRASS STEAM STOP COCK

on these keys. One machine takes a roughing cut across and the other a finishing cut. The keys are either machined to go a certain distance into a cock body or into a gauge. If they are machined to fit a body then that key and body remain together thereafter but if to a gauge the bodies and keys are not matched to each other until they reach the grinders, who pick them more or less finding a large body to fit a key that comes a little large or vice versa. The bodies are finished for the keys in three operations, one roughing cut and in sizes below 3" they are then rough reamed and then smooth reamed in a separate operation. This work is similar to the methods used in finishing globe valve bodies. For the first cut and the rough reaming the bodies are held in a chuck and the tools are in a turret but for the smooth reaming the tool is held in the spindle and the body forced over it in a manner similar to the method of reseating globe valves. This operation brings the bodies to the proper size and taper. On sizes above 3" the bodies are bored and two cuts taken. The bodies are then ready for the keys to be let in or to be sent to the grinders if the keys are made to a gauge. Packed key cocks require another operation on the large end of the body to finish the stuffing box.

Small air, cylinder, and gasoline cocks are finished all over outside. The operations on a cock, such as is shown on the following page are first to finish the pipe end and drill a hole about as far in as the hexagon. This is done by chucking on the nose in a spring chuck on a turret lathe and first cutting the pipe end for the die with a box cutter, then dieing with a self-opening die, and last drilling. A boy will handle over one



AIR COCK

thousand per day in these three operations.

The bodies are then chucked on the pipe thread and a tool on the turret makes a center on the nose end and supports the casting while the body is shaped by a cross feed tool or shaping knife. The hexagons are then milled in the Milling Department and the bodies are afterward rechucked and drilled and rough reamed for the key in two operations on a turret lathe. They cannot be held in a spring chuck for this operation because they must be held crosswise. The chucking takes about as long as the remainder of the operation. The chatter marks are taken out by the smooth reaming which is done on another machine. The keys are generally fitted to or "let in" these bodies so the holes need not always be exactly the same size.

The bodies now go to the man who lets in the keys. On the cock illustrated above,that consists in finishing the key entirely except filing the flat and tapping the lower end, and finishing the handle. The key is first chucked on the handle in a spring

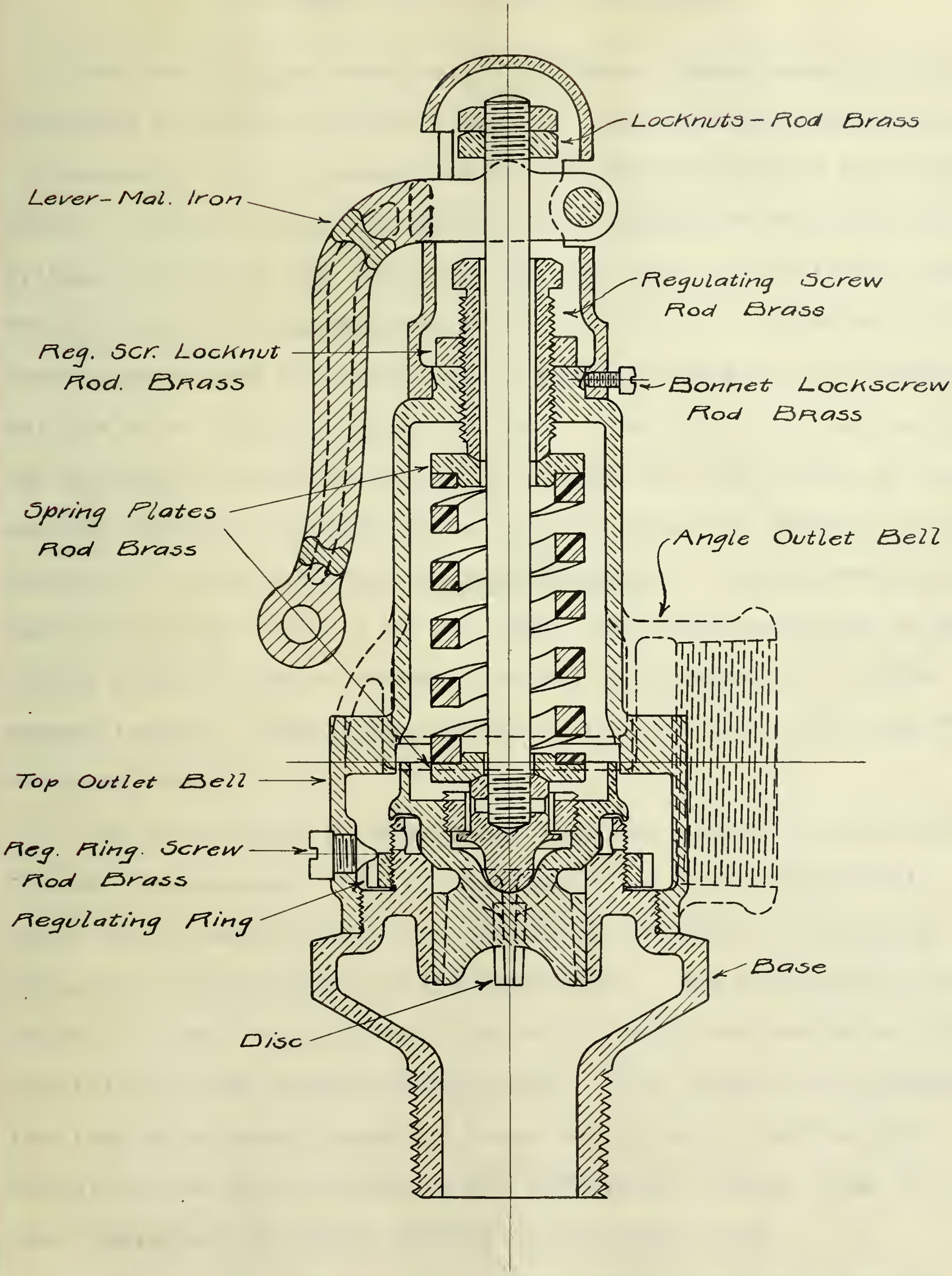
chuck and centered, then a box cutter finishes the lower end. It is then supported on a center in the turret while the contact surface of the key is rough finished with a shaping knife. The next operation is to take a light finishing cut with a side tool in the turret while it is still held on a center. The operator then tries the key in a body and if it comes all right jars the two together and goes on to the next. A good boy will thus let in five hundred or six hundred small keys per day.

The cocks next go to the cock grinding machine, a special apparatus with from four to six spindles for grinding from four to six cocks at the same time. The key is held loosely in a chuck and the body is laid in a frame which moves back and forth periodically first holding it and the key in contact and then separating them a little for a moment. The keys are constantly rotated back and forth by a rack moving in contact with pinions attached to the chuck which holds the key. Any one of the chucks can be thrown out of gear while the key is inserted and the frame holding the body can be pulled back out of contact with the cam which oscillated it to insert a new body. Grease, and soap and sand, are used in the grinding. A very fine grade of moulding sand is suitable.

The operator jars the key and body apart and after they are sufficiently ground in he wipes the grease and sand out and jars them together again. When the keys are let in, bodies and keys are matched, and they are kept together thereafter.

The port is next drilled through the body and key from the nose end and the bottom of the key tapped. A speed lathe is used for these operations. The drill or tap is held in the

spindle and the tail stock is provided with a lever which forces a center forward toward the tool. The operator sets a cock against the center and pulls over the lever forcing it against the tool. The tap is held in a chuck which normally rotates it backwards but which reverses when the cock is forced against it. The mechanism is somewhat simpler than that described on page 35, although the result is the same. The cocks now go to the bench where the flat for the "D" washer is filed and a little grease is put on the key so that it can be turned after the lower screw is put in. The assembling is now completed by putting on the "D" washer and the lower screw. After assembling they are sent to the test where they are tested on air pressure at about fifty pounds. A number of cocks are screwed on a header and it is then let down into a tub of water until the keys are immersed. If no air bubbles appear they are passed on to the buffers who polish the "T" handle first and then buff the entire outside ready for stock. Those that leak on the air test are sent back to be reground. Gasoline is a little more difficult to hold than air even but a little grease put on the key will make the cock perfectly tight even for gasoline. A slight coating of lead on the outside of the keys is also effective in keeping the keys tight in difficult places. Packed key and stop cocks are tested on water the same as globe valves.



BRASS POP VALVE

Pop Valve and Injector Departments.

The work so far described in different departments is of a character that can be done by boys or inexperienced laborers, for if necessary the subforeman can set up the machine and the operator merely inserts a piece and performs one operation after another without the use of any judgment, but pop valve and injector work requires men of some experience, at least in the finishing of the working parts and in assembling. Some of the work is piecework but the more difficult parts are not. Special tools and gauges are provided for pop valves so as to make all the pieces as nearly exactly alike as possible but a certain amount of fitting is often necessary to get the valve to work properly. A good many pop valve trimmings are made of rod brass and others are made in cylinders eight to twelve inches long and the pieces cut off the proper length. Regulating rings for instance, see cut page 47, are made thus.

The disc is one of the pieces that are made by day work for it must be accurate. It is chucked on the lower wings while the upper end is made and is then screwed on a chuck in finishing the wings and the remainder of the lower end. Top outlet bells are shaped all over outside and side outlet bells are shaped as far as possible and the balance wheeled off. The valves are assembled for testing without bonnet or lever and if O.K. then have the bonnet put on and are sent to the buffers who return them to have the levers put in before sending to the stock room.

Injector work requires the same care as pop valve work. Steam, combining and forcing tubes must be machined to exact sizes,

and tapers, and the bodies must be made exactly to gauge or when the whole is assembled and tested the machine will not come up to its rating.

Screw Machine Department.

The Screw Machine Department or its product has been referred to a number of times. Rod brass and steel cap screws, studs, pins screws, nuts, stems, etc., are its output. Small rod brass thumb nuts, some sizes of stuffing boxes, small air cock bodies, lubricator feed wires, swing check valve plugs, etc., are also a part of the output.

Rod brass parts are used wherever practicable in preference to cast brass because they can be made so easily on screw machines. Tubing is also handled to some extent as illustrated in the grease cup described on page 36.

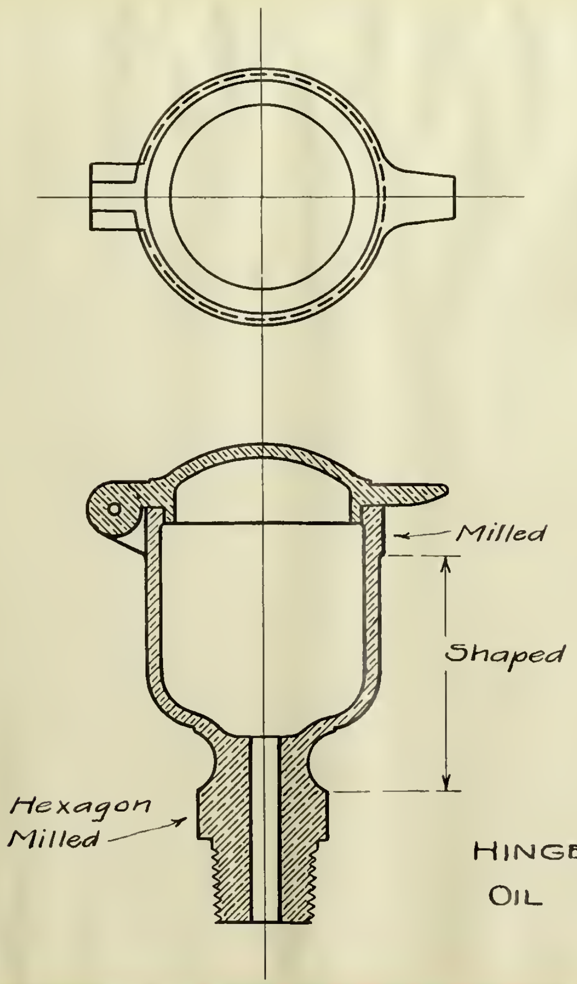
Milling Department.

Milling valve body hexagons is perhaps the largest part of the work done in the Milling Department but small cock bodies with hexagons, hexagons of valve hubs, lubricator sight feed pieces, oil cup caps, etc., besides a considerable variety of special work, is also done. The machines consist of two horizontal spindles in which end mills are held, and a chuck for holding the article, fastened on a cross feed device. The piece is held in the chuck either by screwing on a thread or by a screw or air clamp. If held on the thread it is screwed only two or three times and then adjusted so as to cut straight and tightened in position by a handwheel on an extension of the threaded spindle. Valve bodies are all held in this manner, stuffing boxes and oil cup lids are clamped either in a screw clamp or an air clamp. The screw clamp has a "U" frame and the casting is slipped over a sort of an anvil which just fits inside and is then tightened down with the screw. The anvil has four small projecting points which imbed in the metal so that the piece will not turn. The air clamp is similar, the difference being that an air actuated plunger extends down from the upper part of the frame and thus holds the piece on the anvil. The operator sets the piece by his eye and feeds it over between the mills. When it returns it is rotated one sixth of a turn and the operation repeated.

With a hand operated machine a boy will mill about six hundred one inch valves per day, and of other sizes a proportionate number. A somewhat more satisfactory machine is one with automatic feed in which the operator has only to set the article and remove it when

finished. The two advantages of this machine are increased output, for one man can handle two machines, and power feed, which prevents the operator from forcing the mills too hard. Besides hexagons and similar flat surfaces some circular surfaces which on account of a lug on one side cannot be shaped are milled in a similar manner.

Hinge lid oil cup bodies, illustrated on this page, may be used as an illustration. The hinge lug interferes with the body's being turned on the outside at the top but there is no difficulty in holding it in a chuck and rotating it so that an end mill can finish all around. The lugs on the body of this cup are cast solid and the center milled out and the outside finished in one operation, the cutters being set on an arbor. The outside of the



HINGE LID
OIL CUP

lids could be finished in a similar manner but they can be more cheaply finished by polishing.

Buffing Department.

Buffing is the last operation on a large number of pieces including oil and grease cups, small cocks and priming cups, pop valves, water gauges, and the like.

The Buffing Department does three different things, wheels or polishes a rough casting that cannot be more cheaply shaped or milled, buffs polished or shaped surfaces to take out the tool marks or scratches, and color buffs to give a bright finish and bring out the color of the metal.

Polishing is done on a wheel made of wood covered with leather or made entirely of leather, felt or canvass. The outside surface to be used is covered with glue and dipped in emery powder or dust. These wheels are made in various shapes and widths to accomodate the different articles for which they are used. One man is kept continually busy resurfacing them. On some work a wheel will last only a few hours while on other work it can be used for half of a day. Some pieces that have to be polished have been mentioned already. The following are in addition: all finished elbows and tees, globe valve and cock bodies when ordered finished all over as for fire engine work, brass handwheels and iron handwheel rims which are often ordered finished for navy work or for engine throttle valves, globe valve yokes for navy, cock levers, some oil cup bases of irregular shape, etc.

After polishing, the articles are generally returned to be assembled and come back again for the final buffing. Some small articles on which the chatter marks from the shaping knife are not deep are handled but once but pieces say over two inches in dia-

meter must first be put on rather a coarse wheel to take out the tool marks. The buffing wheels are made of sheets of canvass sewed together but with the edges left frayed. The abrasive material is a sort of a brick dust mixed with grease and moulded into cakes. The polisher applies this to his wheel before each operation or as often as it gets dull. He generally uses a piece of wood as a sort of a handle which he screws into the piece, and some rags, to keep from burning himself as the piece is rotated. Stuffing boxes, or hexagon locknuts which are polished, are strung on a sort of a mandrel a foot or more long and all buffed together. They have to be rehandled to buff the end but this is done by another man.

The wheels for color buffing are of a softer material than the others and the polishing material is very fine, similar to chalk. It comes in cakes and is rubbed on the wheels the same as the abrasive. All nickel plated work is polished in the same manner. After the color buff the pieces are handled as little as possible so as not to tarnish them.

Tools.

Any work that is to be interchangable must be made by the use of accurate tools and gauges. Valve work need not necessarily be absolutely interchangable from year to year for less than 5 per cent will require repairs before the complete article is thrown away but stems, hubs, rings and other trimmings are made up in lots of from five thousand to twenty thousand and they must necessarily be made to gauges or when it comes to assembling they would require fitting. With .005 allowance for working clearance there should be no fitting required. That is each piece must be made within .002 of the proper dimension. Of course some clearance is allowed between stem thread and hub; .02 of an inch in diameter is about right, and about 1/64 of an inch clearance is allowed between disc and stem to allow the disc to find its own seat.

A small concern would probably limit itself more or less in the matter of tools but a concern turning out two thousand valves per day will find itself handicapped in getting its work out and in producing it cheaply, unless it has special jigs and tools for every operation. Even on pieces of which say five hundred are made per year special tools will generally pay for themselves. On any article of which about the same number are finished it will also be found cheaper to do ordinary plain machine work than to chip or file a large percentage of the castings,and in general it may safely be said that it will be cheaper to machine a part to size than to try to cast it in the shape that it is wanted and then file off burrs and lumps, and this must be thought of when the drawings are made and finish allowed on the patterns in all

such places so that the tools will not have to cut on the scale.

Very few of the tools used can be bought outside of the factory so that a large tool-making force is necessary.

To make the tools cheaply a special drafting force on tool design must be maintained and by thus laying out every tool, jig, or fixture, any careful machinist can be used as a toolmaker at a considerable saving in the wages paid per hour and on the time consumed on each job.

In a small shop an effort would be made to use the same tools on different articles but for large capacity separate tools, even though they are identical, are required for each piece,for very often they must both be made at the same time.

This is illustrated by taps and dies, - A complete card index of all the taps in the tool room is kept for reference,with notes on each card as to lead and similar dimensions, and stating the article on which the tap is used. For special work tap sizes may be selected from this index but for regular work a new tap would be made even if of the same diameter, and perfect freedom is allowed in selecting taps for new designs because the greater the variety the easier it is to handle special work rapidly.

If a given tool is used for two or more different articles it is a general rule that these two articles must be made in the same department. This enables the foreman to arrange so that the articles will not need to be made up at the same time.

Perhaps the greatest outlay for tools for a given return is on injectors, and all these tools must be kept exactly to size, so they are never used on any other articles. One item in the cost

of these tools is the fact that they are all made to the metric system for the average workman is unaccustomed to its use and consequently works more slowly.

Some tools are made from the drawings before any pieces are made up while others are made after a sample has been finished. Shaping knives are usually made to fit a sample. When the first castings come from the foundry one piece is shaped carefully by hand and a sheet steel gauge made to fit the finished outline. This gauge is then used to make the shaping knife by and it is kept in the tool room for renewals when necessary. Sheet steel is largely used for gauges of all kinds both for making tools and for depth and distance gauges. Their advantages over solid gauges are the small amount of room required to store them, ease in handling and cheapness.

Costs.

An accurate system of cost estimating and cost keeping is particularly necessary on this class of work because of the close competition and the necessity of making each article as cheaply as possible and because the number of pieces made is so great that no close estimate of the actual cost of the finished product can be made in any other way.

If the actual cost of each piece, and each operation on each piece, is known it is easy to determine along what lines to proceed to reduce costs. It is also possible to try different processes to determine the most economical, and perhaps most important of all there is the assurance with a careful system that no pieces are going into a product that are forgotten in making selling prices.

To most conveniently keep tract of the various articles each should have a complete bill of material and every piece should have a symbol. The Engineering Department can best enter the symbols when the drawings for the article are made and they must see that the same piece, if used again later, is given the same symbol because, as is often the case when a piece is used on several different articles, the method of manufacture can be so changed as to effect the cost by 50 per cent or more. This often occurs when pieces that have been made by the use of a single pattern are put on plates or made of rod brass. The Engineering Department must therefore keep an index of symbols, giving the names of the articles on which the piece is used and the Cost Department will keep a similar index with the addition

of the cost of the various operations on each piece.

Piece work has been mentioned a number of times and this product could hardly be made any other way. The only departments not run on a piece work basis are Drafting Room, Pattern Shop and Tool Room. If to the piece rate is added a premium for extra large output the best interests of workman and employer are benefitted for the workman realizes that extra effort brings a corresponding return and the employer can add a less fixed charge to each piece.

To determine the costs each workman secures a ticket for each job before he starts on it and enters the number of pieces and his time on the ticket from day to day until the job is finished.