Model Engines and Small Boats

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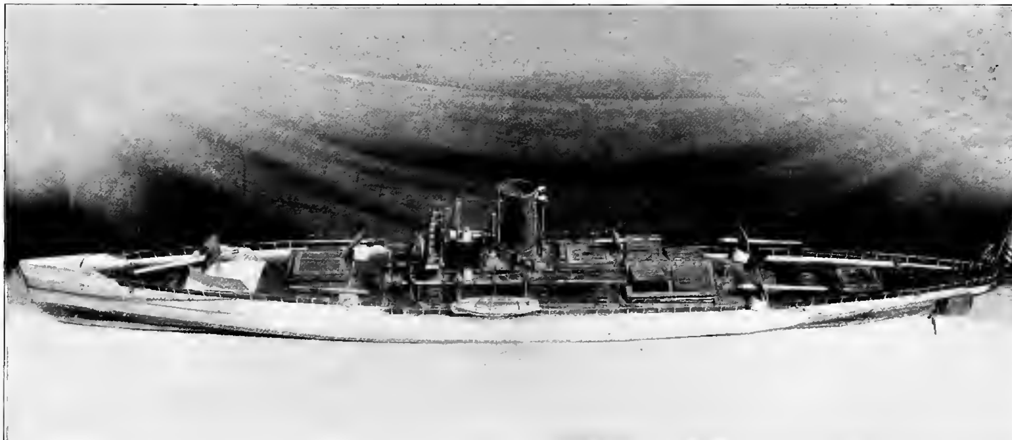
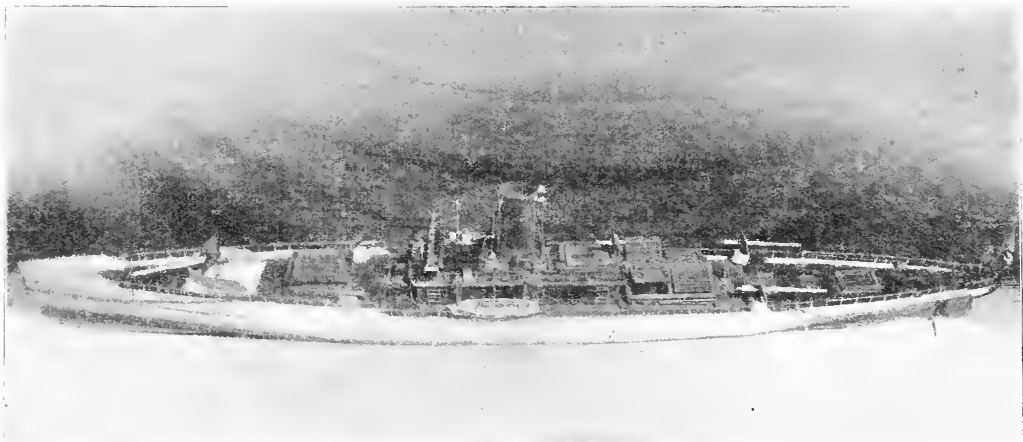
MODEL ENGINES AND SMALL BOATS



MODEL CARDBOARD CRUISER.



MODEL CARDBOARD CRUISER.

MODEL ENGINES AND SMALL BOATS

NEW METHODS OF ENGINE AND BOILER MAKING

WITH A CHAPTER ON

ELEMENTARY SHIP DESIGN AND CONSTRUCTION

BY

NEVIL MONROE HOPKINS

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PREFACE

WHILE the author deals with only the direct-acting screw type of marine engine, and gives directions for the making of shell and water-tube boilers only, the introduction of the writer's system of constructing small steam cylinders without patterns and castings, and boilers without the use of special tools, will enable one with mechanical ability to apply the methods in a general manner, embracing almost any type of model engine and boiler.

It will be observed on reading the following descriptions of engines, boilers, and hulls that no combination of the three is adhered to or directed, allowing the reader full choice in the matter as regards class of steamer and the type of its machinery.

A chapter on elementary boat design is given, followed by a system of hull-construction, using wooden ribs in combination with cardboard plating, which has given entire satisfaction under trying circumstances. Should any of the readers of this little volume acquire a fondness and develop a talent for any of the more advanced engineering vocations, or derive any useful information from its pages, the time expended in its preparation will be, to say the least, far from unprofitably spent.

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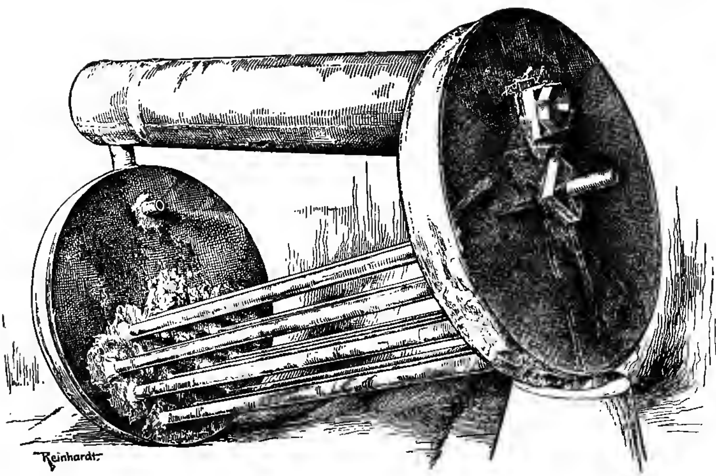

MODEL WATER-TUBE BOILER.

MODEL ENGINES AND SMALL BOATS.

CHAPTER I.

OSCILLATING ENGINES.

PROBABLY the simplest of practical engines possible to construct is the single-acting oscillating cylinder type. This engine, if built with only one cylinder, will have only one propelling impulse for each revolution, making a rather heavy fly-wheel necessary, which unfits the engine for use in model boats. Several types of engines with oscillating cylinders are given in the following pages, the double engine composed of single-acting cylinders being the first design suitable for the propulsion of small boats.

For the sake of practice the beginner had undoubtedly better build a little working-model of a single-cylinder, single-acting engine, for although it will not be powerful enough for doing much work, it will show the necessity of doing neat and careful work, as each part must fit to a nicety, and all seams must be tight, and no binding of the moving parts.

The first steps in the putting together of a single-acting cylinder are shown in Fig. 1. The best seamless brass tubing is used, and the tools employed, while simple in character, must be in good condition. The following dimensions are good, but of course they can be varied, after the first model is built, to meet the demands of power, available space for machinery in a boat, etc. Select the tubing for this little engine, $\frac{5}{8}$ inch external diameter, with walls about $\frac{1}{16}$ inch thick.

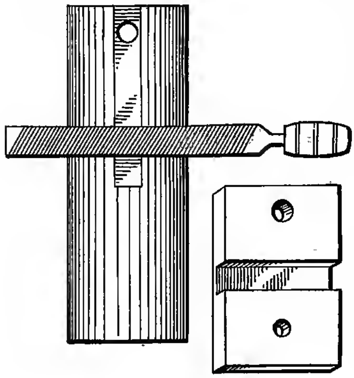

Fig. 1.

The tubing should be carefully sawn off with a hack-saw and the end smoothed perfectly square with a fine flat file. The cylinder should be just $1\frac{7}{8}$ inches long.

The illustrations are from working-drawings, and show the relative sizes of all the parts.

A flat surface is filed on one side of the tube 1 inch long and about $\frac{3}{16}$ inch wide. The hole drilled through, for the port, should be about $\frac{1}{8}$ inch diameter. The little brass block is 1 inch long and $\frac{5}{8}$ inch wide, and about $\frac{3}{16}$ inch thick. A groove is carefully filed in the centre, as shown, and must be at least $\frac{1}{16}$ inch deep. A $\frac{1}{8}$-inch hole is carefully drilled through the top portion of this block, to exactly coincide with the port in the cylinder.

It will be evident that this is a very important point and must not be done carelessly. The smaller hole should now be drilled exactly in the middle of the lower portion of the brass block, and should be a trifle smaller than the brass rod which serves as the supporting trunnion, and which comes in straight lengths. As this little brass block acts as the sliding-port plate, it must be perfectly smooth and bright.

Fig. 2 shows the method of soldering the little block to the cylinder. The brass block is carefully and truly laid on the flat surface of the cylinder, and the two firmly clamped together in a wooden-screw vice. After making sure that the hole in the block comes exactly over the port in the

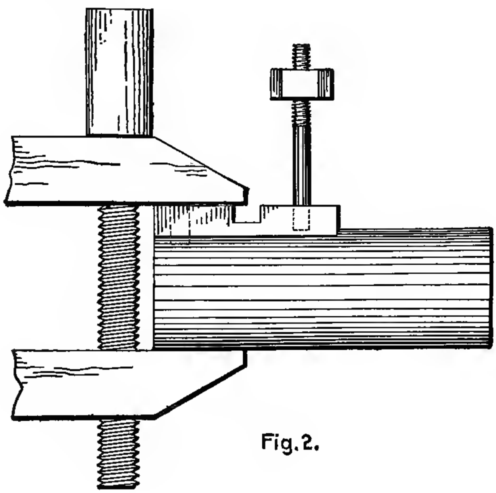

Fig. 2.

cylinder, the work is held in the flame of a spirit-lamp, or Bunsen burner, and heated up to near the melting-point of solder. The seams are carefully wetted with zinc chloride, and solder made to flow along them by applying it with a small hot soldering-copper. The zinc chloride is easily prepared by dissolving as much zinc as possible in a vessel of hydrochloric acid, and afterward diluting to make twice the quantity by adding water.

A Bunsen burner is the best and most convenient source of heat, if gas is at hand, and is cheaper than an alcohol-flame. Always bear in mind that the work to be soldered must be heated up somewhat before the solder can be made to flow freely between the seams and joints. More detailed directions are given for soldering in Chapter II.

In the making of the slide-valve cylinder, apart from being indispensable, without being difficult, the art of soldering will be found a very useful acquirement, after the model oscillating engines have been built. Having satisfactorily joined the block to the cylinder with the seam all round well "flowed" with solder, the little supporting-rod and screw-nut must next be made. This should be screwed in the little block tightly, and must not be soldered. There is nothing about screw-cutting that is at all difficult, and it will be found a fascinating little art to the beginner. He will, however, probably have to invest in a screw-cutting set, having a range for rods from $\frac{1}{16}$ inch to $\frac{1}{4}$ inch. They come complete, ready for work, and all they require is a little oil when cutting. It will require some little practice, however, to match the proper size rod to be cut with a thread, to the cutting-die in the screw set.

If the rod to be cut is too large for a given die the threads will be so deep that they will weaken the work; if, on the other hand, the rod is too small for the die, the threads will not be deep enough to be of any use. The selection of rod for different dies must be governed by practice. The same choice presents itself in drilling holes in metal to receive an inside thread, and the beginner as well as the expert should be equipped with a full set of twist-drills ranging from at least $\frac{1}{16}$ inch to ¼ inch. The little rod which is screwed in to support the cylinder must, of course, be perpendicular to the block, as any angle or variance from a vertical would throw the cylinder out of line and the ports would not fit nicely, allowing steam to escape between the stationary and moving port plate without going into the cylinder. The superfluous solder is now removed from the seams on the cylinder by using old flat and rat-tailed files.

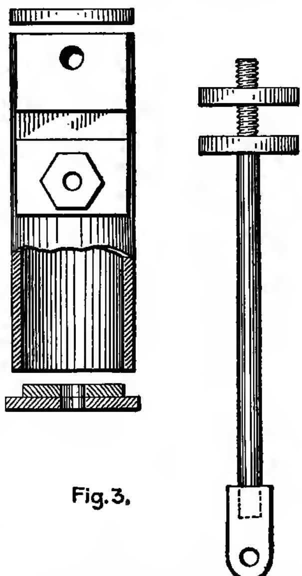

Fig. 3.

One had better keep several files of different type for use on solder only, as a new file is much damaged by being filled up with solder, which is almost impossible to remove without ruining the file.

Fig. 3 shows the cylinder from the port side, also the piston and piston-rod. The upper head of the cylinder must have a cap carefully soldered on steam-tight, and be afterward filed up smoothly to the shape of the cylinder and port-block. The cylinder-head on the lower end should now be made. This had better be turned up on the lathe to a perfect and tight fit, so it can be knocked in place with a small hammer after the piston has been placed in position. It can be easily taken off at any time by hitting one edge, and then the other, with a small hammer. The hole for the piston should be very carefully made in the exact centre of the cylinder-head, otherwise the piston will surely bind. The piston-rod and heads can be made after glancing at the figure. The brass piston-heads must be turned on the lathe to just fit the cylinder and work closely and smoothly. The bottom piston-head is screwed down firmly and soldered to the rod, while the upper one is left free to screw on and off. Cotton-waste is wound in between the two heads and made to occupy one-eighth inch between the two plates. The waste is well oiled and the upper piston-head

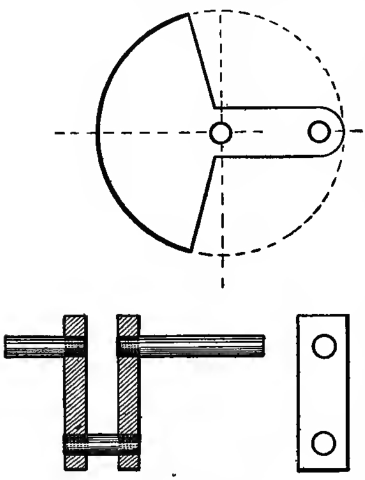

Fig. 4.

screwed down tightly. It will be seen, as the cylinder is only single-acting, that no steam gets on the lower side of the piston, and the hole in the bottom cover, or cylinder-head, need not be a tight fit, as it serves merely to keep the cylinder in line with the piston-rod. The connecting-head which grasps the crank is too simple to require description.

Patterns for cranks are shown in Fig. 4. The stroke for this engine is $\frac{9}{16}$ inch. The balancing

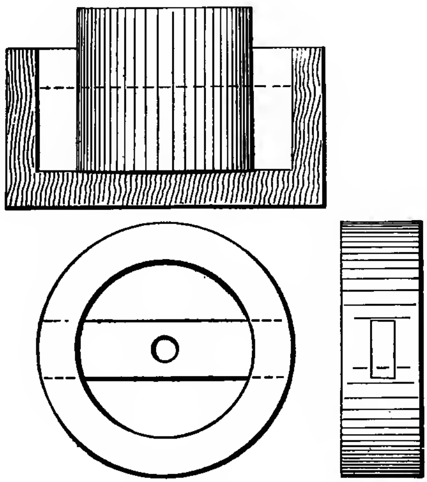

Fig. 5.

crank, shown at the top in Fig. 4, is best adapted to the single-acting engine and should be filed from brass ⅛ inch thick.

Fig. 5 shows how a lead fly-wheel can be easily cast. A large round wooden pill-box, with a smaller one inside to act as a core, will answer very well. The little box must be placed exactly in the centre of the large one and the two firmly clamped together in the wooden-screw vice before the molten lead is poured in the space between the two boxes. If one makes one or two trials, by remelting the lead and casting over again, a successful fly-wheel is sure to result, and should be, of course, smoothed up a little on the sides with the old flat file before painting. The cross-piece, or spoke, of brass, can be successfully cast in the centre as shown, or holes may be cut afterward and the bar pushed through the rim, and the wheel struck with a hammer over the bar in order to hold it permanently in place. Lead is not the easiest thing to solder, but the rim of the wheel had better be "tacked" with solder to the spoke on each end.

The weight of this wheel and the balancing-crank is really not sufficient for smooth running of the single-acting engine with only one cylinder, but if the work on the cylinder and ports has been well done the engine will run, but with a little throb at each revolution.

Fig. 6 shows the simple engine complete, with the exception of the lead fly-wheel. The frame is made from heavy brass rod, screwed in the top-plate, and pushed in holes in the base-plate and soldered. The back-plate, for the cylinder-block to work against, should be $\frac{5}{16}$ inch thick and must be smooth and uninjured on the working-face. It must have two holes drilled to exactly coincide with the port in the cylinder-block when the crank is at the extreme right or left, as shown in the figure. This is an all-important detail in the success of the engine. It matters

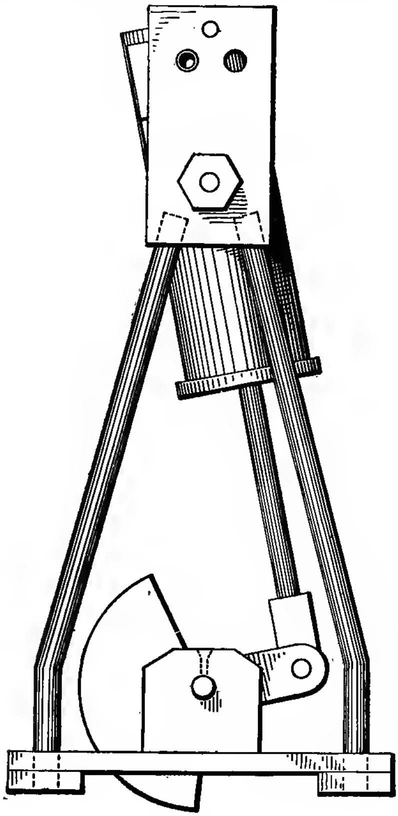

Fig. 6.

not through which hole steam is supplied to the engine; in one case the shaft will be driven righthandedly, and in the other case, the engine will revolve left-handedly.

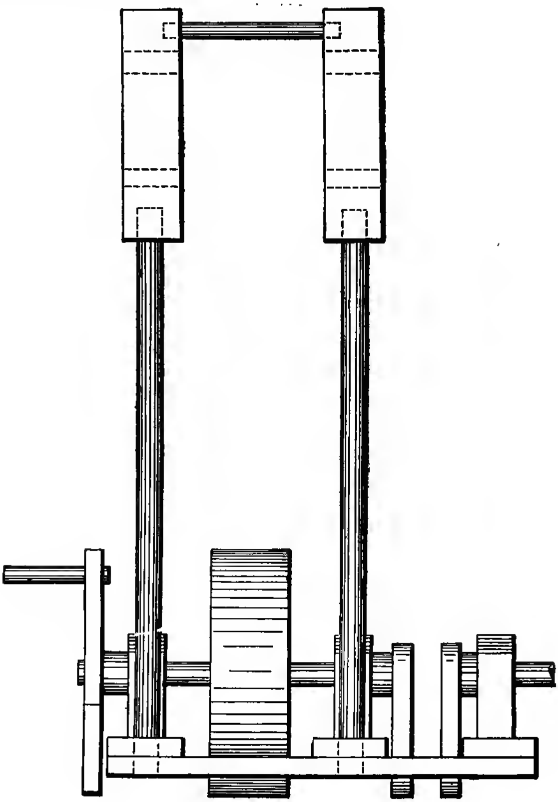

Fig. 7.

It is, of course, preferable to design machinery for right-handed action. A spiral spring of brass wire goes on the rod under the nut, to keep the cylinder under a uniform tension against the stationary port-plate. The little third hole shown above the two ports serves for joining two engine-frames by means of a bar, or rod, as illustrated in Fig. 7.

Having mounted the engine complete, a little fine emery and oil should be applied between the two faces of the port-plates, and the engine driven by a belt from the turning-lathe until the two surfaces have been ground perfectly together.

Several applications of emery and oil will be found necessary, and the spring under the nut must be under high tension. The axle, or main shaft, is made from a piece of $\frac{3}{16}$-inch machine-steel, and the bearings of brass, with oil-holes drilled as shown on the bearing in Fig. 6.

With Fig. 7 the really practical engine for boat-propulsion takes shape, proving many times more efficient in action than the model, Fig. 6.

Having made a successful single-acting model, the work of practical model-engine building can be easily carried on.

The engine frame illustrated in Fig. 7, equipped with a pair of well-made single-acting cylinders, will prove a light and strong engine for small vessels.

THE DOUBLE-ACTING CYLINDER.

This type of cylinder is, of course, a little more difficult to make, but with a little care, and the experience in soldering, no difficulty at all will be encountered. It will be seen that one cylinder of this type is capable of doing the work of two of the single-acting design, consequently a double engine with double-acting cylinders will have twice the power of the double engine in Fig. 7, without taking up any more room and having scarcely any more weight. The double-acting, double-cylinder, model marine screw-engine is the ideal for driving model vessels at a high speed, but with a less real appearance than the engine built from a slide-valve cylinder, described in Chapter II.

Fig. 8 shows the steps in the construction of a double-acting cylinder. The lower cylinder-head in

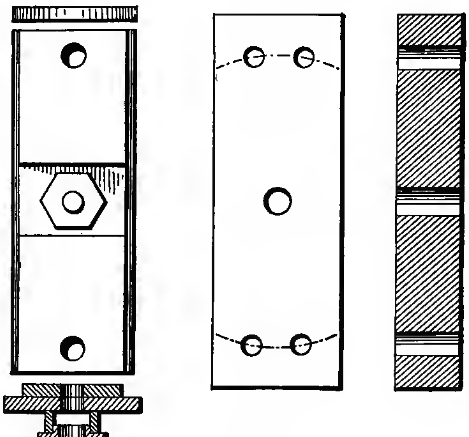

Fig. 8.

this case must be provided with a stuffing-box, as shown. This stuffing-box is not difficult to make; a short section of thick brass tubing, neatly soldered under the cylinder-head, carrying a cap, as illustrated, completes the box. The cylinder-head in this case should be provided with threads, and should be screwed into the cylinder. These threads must be cut in the lathe, as it is not possible to do this work with a screw-cutting set.

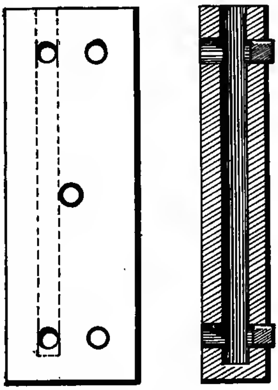

Fig. 9.

As steam is admitted on both sides of the piston in this cylinder, a little white-lead should be applied to the screw-threads before the cylinder-head is screwed in place. The stuffing-box is, of course, filled with oily cotton-waste, and the piston and piston-heads made like the one in the single-acting cylinder. The port-block is soldered on in the same way, the same precautions being taken. The groove filed through the centre of the port-block must be very much wider, the width shown in Fig. 8 being the minimum. The port-block, against which the cylinder-block slides, should be approximately the thickness shown in the illustration, and the holes for the steam-supply had better be drilled through after trial with the crank which is to go with the engine, turning it first to the extreme right, and then to the extreme left of the stroke.

Fig. 9 shows the holes that are bored down from the top of the stationary port-plate, that supply the ports in the moving plate with steam. This hole, being of considerable length, had better be drilled in the lathe.

The back of the holes, as shown in Fig. 9, receives brass plugs, either screwed in with white-lead, to render them steam-tight, or else the seam around the plug is "flowed" with solder. While this is not the prettiest way to close the holes, it is the quickest.

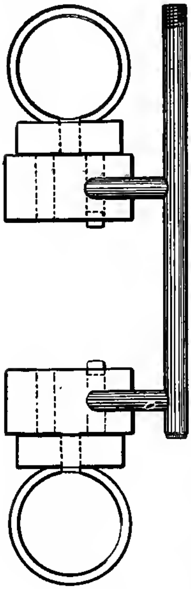
Fig. 10.

Fig. 10 shows the cylinders and port-blocks from above, and gives a clear idea of the pipe connections for steam-supply. The dotted lines illustrating the open ports are the exhaust passages, and may be connected together by a similar system of piping and led to exhaust at any convenient place.

Fig. 11 shows the method of making pipe connections, etc., by means of brazing or soldering, when small curved elbows cannot be had; the rounding bend being preferable to the square brazed joint. Unless one has had experience in brazing and is equipped with the necessary appurtenances for this work, the author advises the amateur to make only soldered joints.

The wheel-valve is made from a short and exceptionally thick piece of brass tubing, or from a piece of solid brass rod, bored through on the lathe. The valve and wheel can also be easily made on the lathe. The valve and the valve-seat must be ground to-

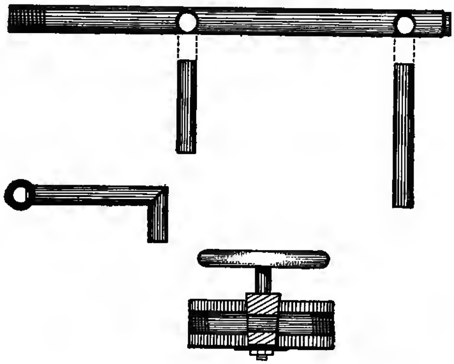

Fig. 11.

gether with emery and oil to insure a steam-tight valve.

Fig. 12 shows a side view of the ideal engine for small vessels. The space between the frames should receive a small balance-wheel, and the bearings, which are to be soldered to the base-frame, must be brought in perfect line first, by having the cranks and axle put in place before the soldering is done.

The base-frame and supports are practically the same as in the other engines. The base-frame, as can be seen from the drawings, consists simply of brass bars soldered at the corners and strengthened by having the heavy rod go through them, which constitutes a part of the engine-frame. Dark-green

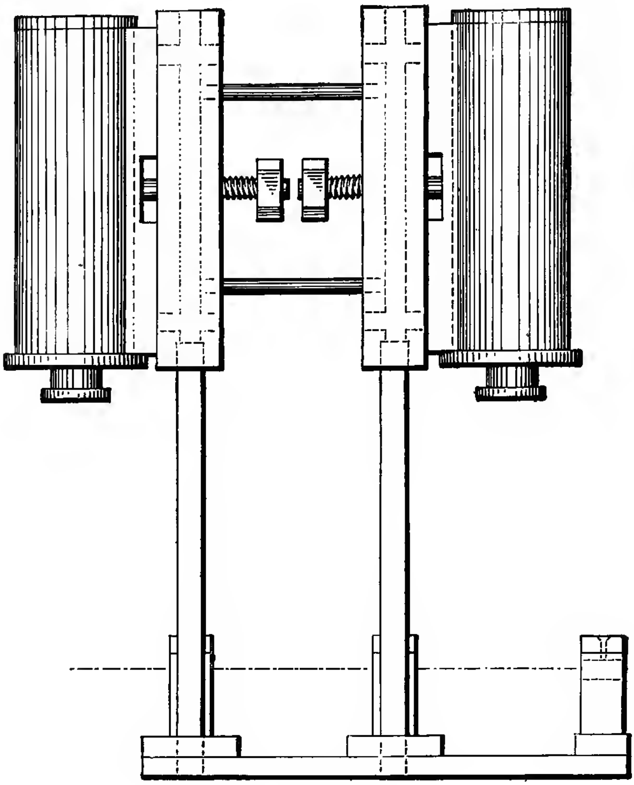

Fig. 12.

bicycle enamel gives the engine a very good appearance, which must not be applied before the engine has had its port-blocks ground together with emery and oil and have had a test under steam. The engine should also be washed in running water before being painted, to remove all traces of the zinc chloride used in soldering.

CHAPTER II.

THE SLIDE-VALVE ENGINE

THE art of soldering plays a very important part in the making of this little cylinder without going into any really difficult methods, a small soldering-copper being all that is required in making the seams and joints.

This small engine is intended for a larger class of vessel than the engines of oscillating design described in the preceding chapter.

The following proportions are good, and the dimensions are the smallest it is advisable to carry out on this system. The thickness of material used is just right for the size of engine described at present, and it will be wise to construct this engine for the first time according to the following figures. Select a piece of seamless brass tubing, 1 inch internal diameter, with walls at least 1/8 inch thick, making the tubing 1 1/4 inches external diameter.

Polish up the tubing by rubbing with fine emery-cloth, and proceed to mark the tubing off with the dividers, as shown in Fig. 13 (*a*). This work will be much simplified if a piece of tubing is selected with one end already sawed off square as the tube comes from the tube-works.

After smoothing with a large flat file (one about 1 inch wide and rather fine) the end should be placed on a flat piece of glass or marble, and a line marked around with a compass, 2 inches from the base, with one limb of the compass resting on the glass or marble, as shown. Having made a decided mark around the tube, it should be placed in a vice in a horizontal position and sawed off carefully with a hack-saw. This should be done slowly, for otherwise the end will not be even around the edges. This end is now ready to be smoothed off with a file.

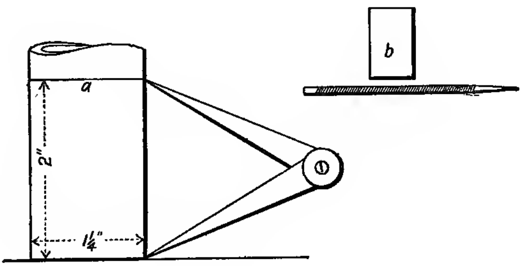

Fig. 13.

A good method of smoothing this work with the large flat file is to take off the wooden handle and place it down flat on the work-bench, moving the surface of the work to be brought down to a plane, along the file, as illustrated in Fig. 13 (*b*). If this method is not employed it will be found very difficult to move the file back and forth over the work without a rocking movement, which spoils a flat or plain surface by giving it rounded edges.

If a lathe is at hand the work of cutting off the tubing and truing up will be, of course, immensely simplified, although the use of a lathe, while desirable, is not absolutely necessary in the making of this engine.

Having finished off the little piece of tubing, measuring just 2 inches, with even ends, it should again be placed in a vice horizontally, and filed flat on one side, where the ports are to be cut. This filed-down flat surface should be ⅜ inch wide, and should extend from end to end, as shown in Fig. 14. The port slots should now be carefully filed down to a distance of ¼ inch and should be just ¼ inch wide.

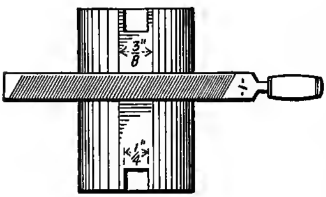

Fig. 14

Our tube, which can scarcely be called a cylinder yet, is ready for its bands, which are to extend partly around the tubing and are to be soldered on. This brass band comes just the width and thickness needed, namely, $\frac{3}{32}$ inch thick and ¼ inch wide.

Two collars are now to be made to just fit the tube and meet all but 1 inch, as illustrated in Fig. 15 (*b*), (*c*). This band is rather hard to handle, especially if one attempts to make collars from it which are perfectly round and only about 1 inch in diameter.

To accomplish this, one end of the band is firmly clamped in a machinist's vise against a piece of tubing 1 inch external diameter, as shown in Fig. 15 (*a*), and bent around tightly 1½ turns, and then cut off to make one collar. The 1-inch tube is used instead of a sample of our 1¼-inch cylinder-tube, for the reason that the collar springs open a trifle after taking from the vise, and otherwise would not just fit.

Having made two collars of the right size, meeting all but one inch, they should be straightened and tinned with solder; that is to say, treated with zinc chloride and held in the flame of the Bunsen burner until it will melt a small piece of solder and cause it to flow around, and become thoroughly lined with it.

The solder used in this work had better be in thin, narrow strips, for it is much easier to melt and handle. A large hunk of solder and a small soldering-copper cannot be made to work well together, as the large mass of solder absorbs the heat immediately, so to speak, from the soldering-copper, which is insufficient to melt off any solder. The tube should be wetted with zinc chloride around the top and bottom, and the collars sprung in place and evenly adjusted. The whole cylinder must be held in the flame of the burner until the collars are securely soldered on to the tube. While the tube and collars are still hot, it is very

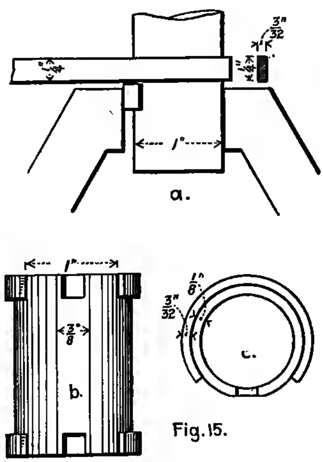

Fig. 15.

easy to make more solder flow around the top edge of the cylinder and collar and effectually fill up any cracks that may exist; but bear in mind always that solder will not flow and unite surfaces that are not bright or polished, that have not been treated with the proper zinc chloride or other equally good substitute, and that have not been brought to a sufficiently high temperature.

It would be useless to try and unite two large masses of metal with solder by using a small soldering-copper, no matter how hot the copper might be, unless the pieces of metal to be soldered and united were raised in temperature first by a flame or very large soldering-copper. The heat from the small copper is immediately dissipated throughout the mass of the large pieces to be soldered, and the amount of heat that will raise a small piece of metal to a high temperature can only heat up a large mass very little. Remember this point in soldering, and practise with scraps of brass, if any difficulty is encountered.

Of course, in uniting small pieces of metal, a small soldering-copper "holds enough heat" to do the work. After soldering with zinc chloride, the surfaces should be well washed in running water, in order to remove all traces of the zinc chloride, which would otherwise corrode the work.

Do not be discouraged by any untidy appearance due to superfluous solder, for the file quickly takes it away and brings the surface down to a beautiful level, polished and neat in appearance. Keep the soldering-copper clean, and apply the zinc chloride from time to time, so the copper will always "pick up solder" in order to carry it to a joint.

Never, under any circumstances, allow the soldering-copper to remain in the flame until it causes the flame to burn with a green color, for it is the sign that it is eating and burning away the soldering-copper.

The writer has described a number of well-known points and precautions in soldering at the risk of being tedious to those who are expert in the art, but hopes some will pick up pointers that will lead to proficiency in the art of soldering.

Having the collars satisfactorily attached, the steam-chest is the next thing to demand attention. This is made from brass band, which comes just as we need it, namely, ⅞ inch wide and $\frac{3}{32}$ inch thick. This steam-chest is to be just 2 inches long and 1 inch wide, and fits on the cylinder, as illustrated in Fig. 16 (*c*).

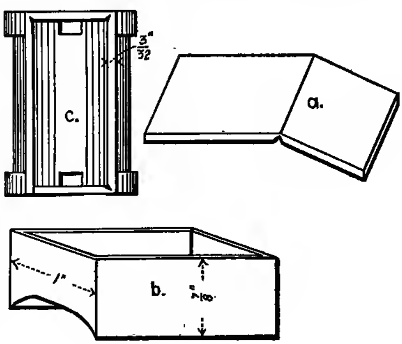

Fig. 16.

After carefully marking off the brass strip, the lines must be cut out neatly with a triangular file and the brass bent against the file-cut, as shown in Fig. 16 (*a*).

Having bent around the corners, the remaining ends are soldered, and the box, or steam-chest, placed in a vise, and with a half-round file, about 1 inch wide, the ends are filed out to fit the curve of the cylinder, as illustrated in Fig. 16 (*b*).

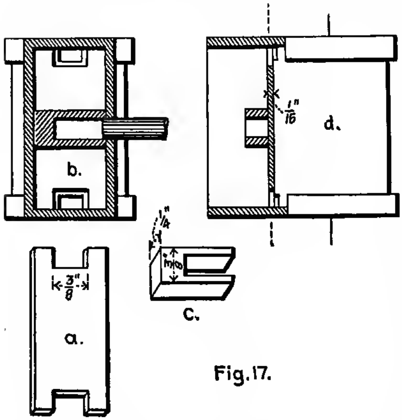

Fig. 17.

A little flat space is to be left to fit against the flattened surface of the cylinder, and after repeated filing and trial, the chest can be made to fit up closely to the cylinder, and afterward be soldered on.

In soldering this, plenty of solder should be used, especially on the inside edges, to make the chest and cylinder perfectly steam-tight.

The next step is to cut out a little plate of brass just small enough to push in the steam-chest and rest against the flat surface of the cylinder. This little plate is illustrated with large notches cut to correspond with the cylinder-ports, as in Fig. 17 (*a*). The notches are filed out ⅜ inch wide and cut down deep enough to show the edge of the port by about $\frac{1}{16}$ of an inch, as shown in Fig. 17 (*b*).

This little plate is next soldered all around the edges, making them steam-tight too.

The object of cutting the slots in the plate too large is to allow for soldering all around the port, in order to prevent steam from escaping from port to port under the plate.

Having this accomplished the exhaust-chamber is to be made which is illustrated in Fig. 17 (*c*). This is simply filed out from a little block of brass, which should be accurately ¼ inch deep and ⅜ inch wide, and filed out to leave sides a little over $\frac{1}{16}$ inch thick. This should be cut back far enough to have the back of the slot come in a line with the ports, as shown in Fig. 17 (*b*). This must also be carefully soldered in steam-tight by applying plenty of solder all around the edges and up and down the side-seams.

The illustration at (*d*) is a side view, with the port-plate and exhaust-chamber in position.

A ¼-inch hole can now be drilled through the right side of the chest, looking toward the ports, to serve for the exhaust, coming as near the port-plate as possible, in order not to extend above the level of the little exhaust-chamber formed by the little filed-out block. A thread should be cut on the inside of this hole, also one to match should be cut on a short piece of brass tubing of a little larger gauge, and screwed in for the exhaust.

Having the exhaust-tube in position, the port-plate proper can now be made. This is illustrated in Fig. 18 (*a*). A piece of brass ⅛ inch thick is filed truly to the shape of the steam-chest and lines marked across where the ports are to be cut. These must be drilled out first, and afterward filed to shape with a fine flat file tapering to a point. These ports must be just ⅜ inch wide and $\frac{3}{16}$ inch deep, and be separated by a space $\frac{3}{32}$ of an inch in width. The middle port should be exactly in the centre of the plate, and should just cover the exhaust-chamber. This port plate should now be soldered in;

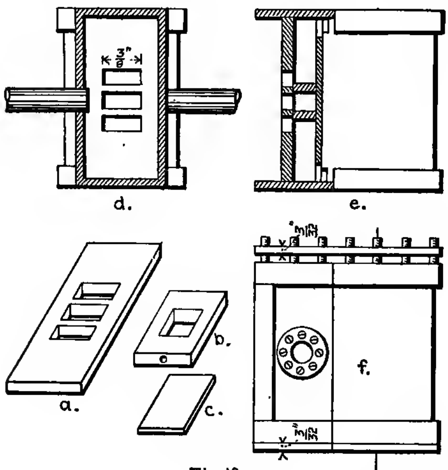

Fig. 18.

and this operation is perhaps the most difficult of any heretofore described.

The under side of this plate, where it touches the upper surface of the exhaust-chamber, must be quite thickly covered with solder, also the surface of the exhaust-chamber, for here a perfect steam-tight joint must be made.

The whole cylinder had better be heated up a little in the flame of the Bunsen burner, as well as the port-plate, and after putting into place, it should be pressed down with a large hot soldering-copper until the solder under the plate melts and makes a steam-tight joint with the exhaust-block. If this joint is not made steam-tight it will be readily seen that steam will escape from one side of the steam-chest to the other between the upper port-plate and the little block which forms the exhaust-chamber.

Having this conscientiously soldered, the edges all around should be soldered as in the case of the first plate, but great care must be taken to confine the solder to the seams and not allow it to get on the plate, where the valve has to slide. Now bore another ¼-inch hole for the supply-pipe on the left of the steam-chest, but make this hole come through on the outside of the port-plate, as shown in Fig. 18 (*d*).

Now comes the slide-valve. This is made from a little piece of brass ⅛ inch thick, with the centre filed out square, as in Fig. 18 (*b*). This little valve is to be filed out so its flat surfaces will just cover the two supply-ports and the hollow-part bridge over the exhaust-port, as shown in Fig. 19 (*a*). Should this little block be so filed that it extends over and beyond the ports, the valve is said to have "lap," and serves for the expansive working of the steam, that is to say, the supply of steam is cut off before the piston has travelled the whole length of the cylinder, allowing the expansive force of the steam to drive the piston the rest of the way. This lap-valve is almost entirely used in practice on large engines because of its economy in

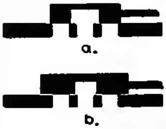

Fig. 19.

steam; that is to say, it enables one to get the maximum horse-power from the steam, but the minimum horse-power from the engine.

On the other hand, with the valve with no laps, which we will choose for our engine, the minimum horse-power of the steam is realized with the maximum horse-power of the engine. We will have plenty of steam from our boiler and can afford to make the steam drive the piston the entire length of the cylinder.

This being understood, carefully copy the scheme of the valve in Fig. 19 (*a*) and file out the valve to just cover the supply-ports.

The valve is now to be ground with fine emery and oil against the port-plate. This can be done by pressing with the finger or thumb and moving the valve back and forth over the port-plate. This should not be slighted; several applications of oil and emery, and prolonged sliding of the valve on its seat, will be necessary to insure the proper surfaces.

A little thin cover soldered on completes the valve, and it is ready to receive its little rod, that extends through the chest and packing-box to the eccentric.

A top and bottom cover for the cylinder must be cut out with a file, and heavy shears used for sheet-iron work.

A lathe cannot very well be used in doing this work, and the cylinder-heads must be first roughly shaped with the shears and then finished off with the flat file. The upper head for the cylinder is to be screwed on after grinding against the cylinder-top with emery and oil until an air-tight fit is secured.

In boring the holes for the little bolts, which are made from brass rod, be sure and bore them through the cylinder cover first, and afterward placing the cover on the cylinder; continue to bore them through the wall of the cylinder, having the cover and cylinder clamped tightly together in a vise. If the holes are bored first in the wall of the cylinder, it will be almost impossible to match them exactly in the cover, and consequently, when the bolts are screwed in the cylinder one will not be able to put the cover on, for some of the holes will not correspond to the bolts in the cylinder.

Paper soaked in linseed-oil should be put under the cylinder-head as a washer, should any trouble be experienced from steam escaping.

The stuffing-box for the cylinder as well as for the steam-chest had better be turned on the lathe and screwed in the bottom cylinder-head. These screw-threads must be cut on the lathe, as in the case of the cylinder-heads on the oscillating cylinder described in the preceding chapter.

The valve-rod is screwed in the valve but is not soldered, in order that it may be taken out if it should be necessary to remove the valve.

A plate of brass about 1/8 inch thick is to be cut to fit the face of the steam-chest, and must be ground on with emery, as in the case of the cylinder-head, on top; the lower cylinder-head, carrying the stuffing-box, being simply soldered on to the cylinder.

Some of the brass strip which was used for the cylinder bands is soldered around the plate, as shown in Fig. 20(*c*), forming an edge or frame, which adds greatly to the finish of the engine. A side view of the cover, with the frame soldered on, is shown at Fig. 20 (*b*), with a flat piece of spring-brass on the back to act as a spring to keep the valve against the ports. This spring is made from a very thin piece of spring-brass about ¾ inch wide and is soldered at one end only, and bent to give sufficient pressure. The holes for the cover and face of the steam-chest are next to be bored. These must not be drilled in the face of the steam-chest until they are put through the cover, as in the case of the cylinder-head.

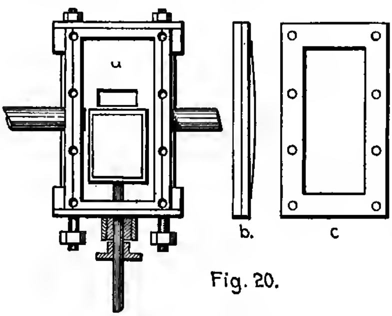

Fig. 20.

The little nuts for the bolts can be made by choosing octagon brass rod and sawing off little sections, which make very pretty nuts after being filed smooth and tapped through the centre. Two large bolts can now be screwed in under the cylinder, as shown in Fig. 20 (*a*), which serve to bolt the cylinder and chest to the frame and bed-plate.

The next and last step is the piston, with its rod, which are readily made after reference to Fig. 21. Both the disks are cut from sheet-brass $\frac{1}{16}$ inch thick, which will be heavy enough for the purpose. They should be turned small enough to leave a clearance all around the cylinder of nearly $\frac{1}{16}$ of an inch. The bottom disk is now screwed down tightly on the rod, which should be about ⅛ inch diameter, and securely soldered to it. The upper disk is left free to screw off and on the rod.

A piece of soft leather, or rubber, should be cut to a perfect fit to the cylinder, and be punched through the centre. If leather is used it should be soaked in linseed-oil, as the steam in the cylinder affects leather in time. The top-plate must be tightly screwed down, clamping the packing between itself and the bottom stationary plate. This practically completes the cylinder.

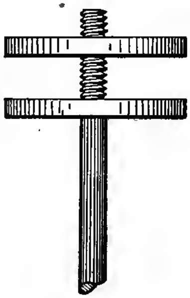

Fig. 21.

A number of little flat pieces of wood should be stained in two shades of color and pressed in the space between the collars, all around the cylinder, alternating the shades. Two very thin bands of brass put around them, top and bottom, and soldered to the steam-chest at the ends, hold them in place. This gives a very real appearance to the engine, as well as preventing excessive heat-radiation, and consequently steam-condensation.

THE MODEL REVERSIBLE-SCREW ENGINE.

In describing the frame and moving parts of the marine engine, the author deems it best to give directions in a little more general manner than in the case of the cylinder.

The builder may care to alter the design of the engine somewhat after the cylinder is completed, and the following description of the frame and fittings is only one of a variety.

The shape of the frame illustrated in Fig. 22 is perhaps the simplest to make, being strong and natural in appearance. This is cut from sheet-brass, after carefully marking out the pattern which appeals most to the builder.

The thickness of the brass can be $\frac{1}{16}$ inch or $\frac{1}{8}$ inch. If brass is used only $\frac{1}{16}$ inch thick the frame can be quickly made by cutting out with large tinners' shears, and will be quite stiff enough for all purposes.

If, on the other hand, brass $\frac{1}{8}$ inch thick is employed, the cutting out will have to be done on a metal-cutting scroll-saw, or else be effected by hand with a large half-round file.

In the latter case the engine will have a more substantial appearance, without really being any better, as it will weigh a little more, which is not altogether desirable.

This frame measures $4\frac{1}{2}$ inches in height, and is the shortest that can be used to advantage with the slide-valve cylinder just described.

The reason for designing the frame as short as possible will be evident, as "head-room" on a model boat is always at a premium.

The frame-braces are made from brass tube and rod in combination, as shown in the figures, which

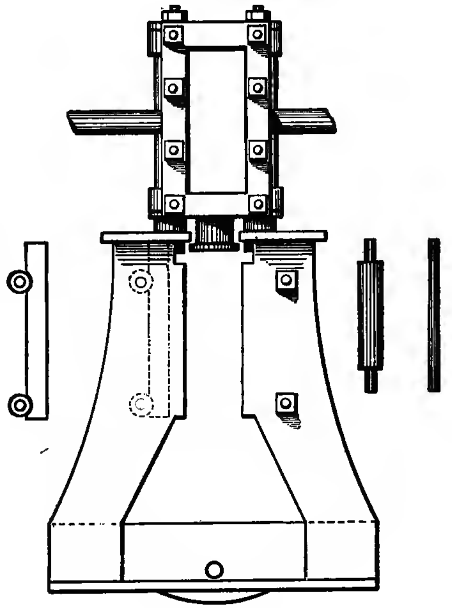

Fig. 22.

answer admirably for the purpose. These braces not only clamp the frame together, but serve to hold the guides for the cross-head, which is carried by the piston-rod. The position of the guides is shown in Figs. 23 and 25, and in dotted lines in Fig. 22.

The guides are made from square brass rod, which may be had of just the cross-section required, namely, about ¼ inch.

The guides are filed out with a rat-tailed file, as illustrated in the figures, and soldered to the horizontal frame-braces. The frame is to be soldered to a heavy bed-plate of brass, made as shown in Fig. 24.

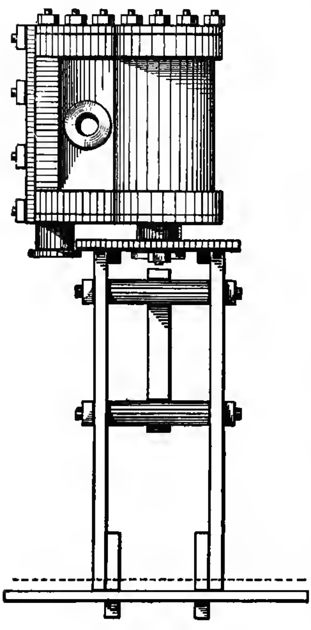

Fig. 23.

These pieces of brass, which constitute the bed-plate, must be at least ⅛ inch thick. By bending little "ears" of brass the frame can, to advantage, be riveted to this base before soldering, although this is not really necessary if good soldered joints are made.

Two little shelves are now soldered on the top of the frame, little pieces of the ¼-inch rod being soldered in the corners, to give strength; or else little "ears" and rivets should be used. Fig. 26 shows the little shelves, which must be at least ⅛ inch thick.

These shelves carry short thick pieces of tubing, two in number, which elevate the cylinder, adding much to the appearance of the engine. About ¼ inch will be found right, but they may be filed down, or longer pieces substituted, should it prove necessary to raise or lower the cylinder, to suit the adjustment of the connecting-rod, crank, etc. The little bolts are made as in the case of the cylinder-bolts, if octagonal ones are fancied, or else from small square pieces.

The cross-head, or piston-guide, is best made from

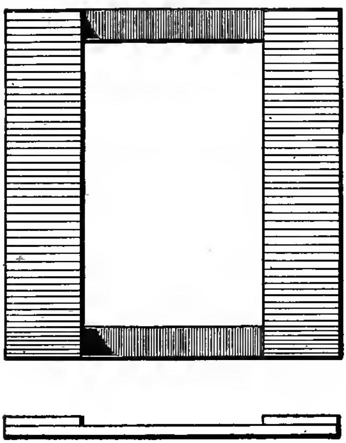

Fig. 24.

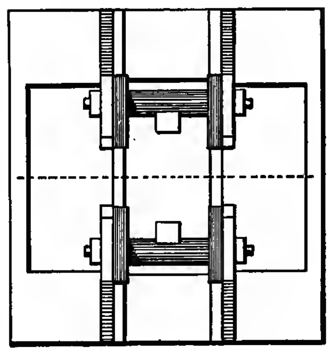

Fig. 25.

three pieces of brass, as illustrated in Fig. 28, together with the connecting-rod.

A cross-head made in this manner is apt to work far better than one sawn or filed from a solid block, as the groove cannot very well be filed perfectly true and straight.

The two side-plates, or cheeks, are neatly soldered to the heavy centre-block by being tinned with solder and pressed together in the flame of the Bunsen burner or spirit-lamp. The groove formed will have to be cleaned out with a very fine file, as some solder is liable to ooze out while in the molten state.

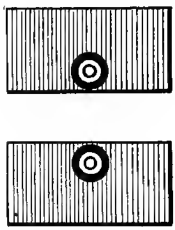

Fig. 26.

Fig. 27 illustrates the complete system of cylinder, guides, cross-head, connecting-rod, and cranks. If this scheme is carefully carried out a smooth-running and high-speed engine will result.

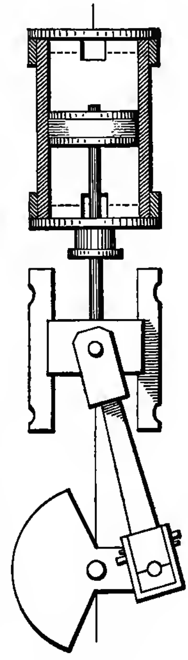

Fig. 27.

A double-balanced crank, as is illustrated in Fig. 29, must be used, also a small leaden fly-wheel, which is not shown in the drawings.

The cranks must be at least $\frac{3}{16}$ inch thick, and can be quickly cut to shape with the large flat file.

The connecting-rod, which is made in a number of pieces, hardly needs detailed description, as the drawings show the different pieces and the method of putting together. The rod is, of course, soldered into the heads, which are filed from little brass blocks.

Soft copper brads are driven in

through the stirrup and head which grasp the crank. This head must be made as illustrated, as the cranks are to be soldered after screwing together, and but for the removable head on the connecting-rod, the engine could not be assembled. Fig. 30 shows the eccentric-strap. This may be filed from heavy brass and be trued up internally on the lathe. The little block is best soldered on the top, where the rod screws in, to add to the appearance of the eccentric and give it strength. Fig. 31 illustrates the eccentric proper, and a simple and efficient reversing-gear.

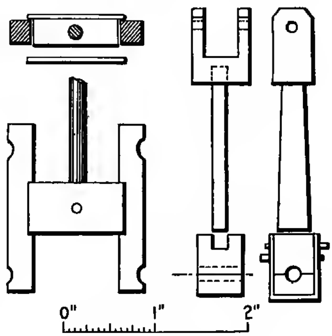

Fig. 28

A circular disk of heavy brass is turned up on the lathe, with the groove, as shown, to keep the eccentric-strap in position. A hole is now drilled in such a position that the disk will be eccentric to the extent of one-half inch; that is to say, the outer edge will travel back and forth through a ½-inch stroke, which is termed, in the case of an eccentric, its throw.

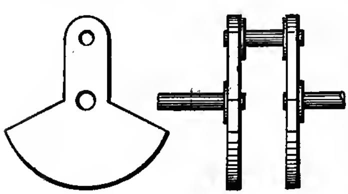

Fig. 29.

The exact position for the hole for the collar and shaft is of the utmost importance, and can be determined by experiment, as follows: Lay the eccentric on a wooden ruler or yard-stick and press the point of a compass as near the edge of the disk as the centre of the shaft is in the drawing, Fig. 31. Press the other point of the compass into the ruler or yard-stick, and revolve the eccentric about the point of the compass, holding the compass as still as possible, and note on the ruler the "throw" of the eccentric.

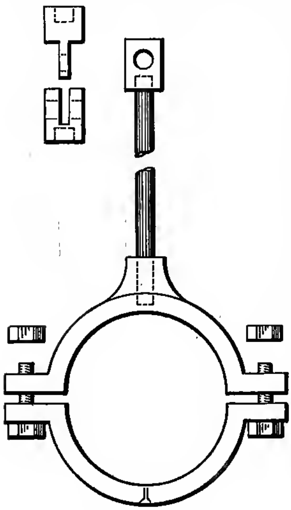

Fig. 30.

By a little trial the disk can be made to move back and forth on the ruler just ½ inch, and this point of the compass will be the place to put the point of the drill which is chosen to put the hole through for the collar and shaft. A collar of brass-tubing goes tightly in the hole and is soldered in place. This collar is now filed out, making a slot, which extends a little over half-way through the tube. The position of this slot is to be exactly as shown in the drawing, namely, fac-

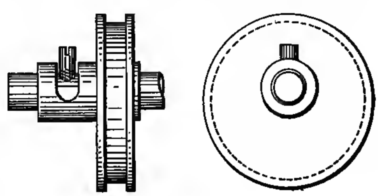

Fig. 31.

ing the top or the smaller portion of the eccentric, and the little pin, or screw, is to be put in the main shaft, pointing up, just when the cranks and piston are at the highest point in the stroke, namely, on the upper dead-centre. One cannot go astray by carefully and faithfully copying the scheme of the drawing.

With this reversing-gear the engine will turn in the direction the pin and end of the slot are put in contact. To reverse the engine, it is only necessary to revolve the shaft in the direction the engine is wished to go, and the slot will turn and arrest the pin in the proper place, to reverse the position of the slide-valve in the steam-chest, and consequently reverse the engine.

The length of the eccentric-rod should be such that the upper port will be just uncovered when the eccentric is at its lowest point, and it will be found, if the directions have been properly carried out, that the lower port will be just uncovered when the eccentric is at its highest point. The engine is now ready for oiling up and testing; and in consideration of its size and small weight, the model will be found a very powerful one for the propulsion of model vessels.

An engine of the same power made from castings will be found to be about a hundred per cent. heavier, consequently far less efficient for use in propelling models with fine lines at a high speed.

Two coats of dark-green paint or bicycle enamel give, perhaps, the most real appearance, and if the trouble is taken to nickel or silver plate the moving parts, one will not only have produced a powerful working-model, but a very pretty and genuine-looking piece of machinery.

The connection to the long screw-shaft and screw had better be made through a flexible coupling. This coupling can be formed from two or three pieces of soft gum tubing, one piece put on over the other, in two or three layers, in order to get the strength to transmit the "torque" or twisting-power of the engine. This rubber connection makes the engine-shaft and the main screw-shaft run with perfect ease, by doing away with any binding or tightness the bearings would cause for a long continuous shaft if the alignment was not perfect. This coupling also affords a ready means of detaching the engine.

Where the rubber tubing goes over the ends of the shafts it is secured with wire by simply twisting a loop together with pliers. This tubing will last much longer if given two or three coats of shellac or oil-paint, as rubber tubing gets hard in time if left in contact with the air.

CHAPTER III.

MODEL BOILERS.

We will call the simplest of steam-boilers the "shell-boiler," and take up its construction first, as it is the easiest to put together and serves admirably for supplying steam to any of the engines described, if made suitable in size and properly supplied with a russia-iron jacket to keep in the heat. The illustrations of the shell boiler are about one-fourth size, and it will be found a simple matter to work from the drawings, if the proportions and dimensions suit the requirements.

If the builder of boiler and engine already has a model vessel he wishes to equip with steam-machinery, it may be necessary to alter the design of engine and boiler, but one must be sure he is installing a boiler large enough to properly run the engine.

There is probably nothing more annoying in connection with small engines than to attempt to run an engine satisfactorily with a boiler that is not capable of supplying enough steam unless forced very much by excessive firing.

The boiler shown in two pieces in Fig. 32 is remarkably strong, if carefully put together. The heads for this boiler consist of two brass disks 4 inches in diameter and about ⅛ inch thick. As each disk, or boiler-head, has a ¼-inch hole through the centre, it is possible to cut out and true up the disk in the lathe.. A ¼-inch brass rod is soldered in place, as shown, plenty of solder being applied on the inside of the heads to make them steam-tight. Heavy brass disks are now screwed on the ends, against the head. Square nuts are possibly quicker to make, but the circular are preferable. The distance

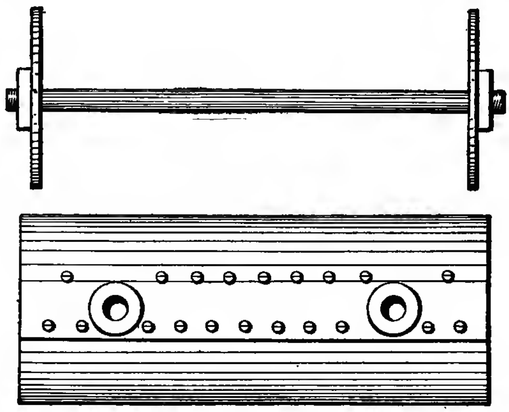

Fig. 32.

between the outside of the heads in this boiler is 10 inches.

Of course, a boiler this size is not necessary for the single-acting oscillating-engines, and may be shortened for them to about 6 inches; giving the double-engine, of double-acting cylinders, about 7 inches, and the slide-valve reversing-engine the full 10 inches in length, which may to advantage be increased to 12 inches, if the vessel is long enough to allow of the extension.

The brass for the shell must be at least $\frac{1}{32}$ of an inch thick for the shorter lengths of this boiler and $\frac{1}{16}$-inch for boilers over 8 inches long. The sheet-brass is now to be bent around the heads, which must be done on tinner's rollers. Two kinds of sheet-brass are on the market, spring brass and soft brass. The soft is the best for our boiler-shells.

The shell should be about ½ inch longer than the boiler-heads, giving ¼ inch overhang on each end. The brass for the shell, if cut about 14 inches long, will, when rolled around to fit the heads, lap over about 1 inch to allow for the joining of the plate. Do not attempt to bend this plate by hand, as it will not be satisfactory.

The rollers used by sheet-metal workers accomplish this in a few seconds, and produce a perfect cylinder, which can be screwed together to a perfect fit.

The boiler is double or lap-welded; only screws instead of rivets are used. If the boiler were riveted it would have to be done before the heads were pushed in place, and, owing to the projections on the inside of the boiler due to the rivets, the heads could not be pushed in at all unless a couple of slots were cut in the boiler-heads to allow the rough rivets to pass through, which would be far from desirable.

The shell is slipped over the bar and disks, and bound with heavy twine in order to close it up tightly around the heads. When bound tightly to the heads, the little holes for the screws are drilled along the top in two rows, as shown. The holes are now tapped for the thread and little brass screws tightly turned in place.

Do not use iron screws, as the rusting will pit the boiler and do damage to the seams. Having secured the shell with the double row of screws, the boiler-heads and rod are pushed out, it of course being understood that the screws just go through the under

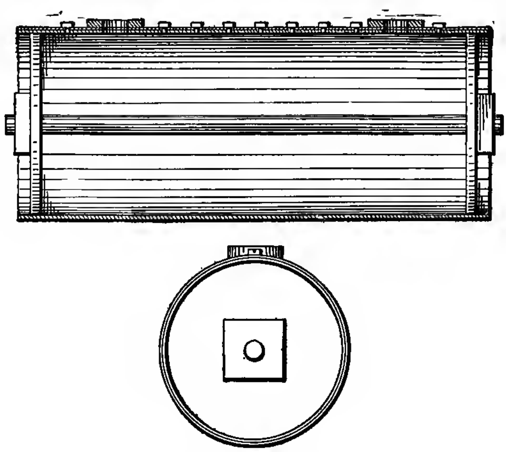

Fig. 33.

plate without projecting, otherwise the heads could not be removed. The seams in the shell are now carefully soldered up by holding the shell in the flame of the Bunsen burner and causing a good flow of solder to run along the seam.

The little screws take up the strain in this boiler and the solder keeps in the steam. The boiler-heads are again pushed in position and soldered all around the edge. With all seams well soldered and the nuts well screwed in place the boiler is a remarkably strong one, the strain being almost all taken up, independent of the solder, although the solder strengthens the whole very much.

Two or three ¼-inch holes are drilled through the top, being bushed with heavy brass disks soldered on. Fig. 33 shows a section through the boiler, and an end view.

Fig. 34 illustrates a plan for supporting the boiler on the ends and the opening for the alcohol-lamp. These end-pieces are cut from russia sheet-iron and carry a russia sheet-iron cover bent to shape, and riveted on by means of little ears and rivets. Fig. 35 represents a side view of the boiler-cover with a portion of it cut away to show the boiler. A series of small holes are drilled or punched along the bottom of the boiler-cover to admit air for the lamp. This boiler-cover adds to the efficiency of the boiler by keeping in the heat and preventing draughts from disturbing the flames under the boiler, which quickly lower the steam-pressure. Fig. 36 illustrates the type of lamp best adapted for firing these boilers for use on board small boats, as they take up very little head-room.

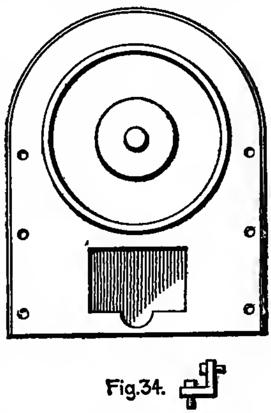

Fig. 34.

Fig. 37 illustrates a simple safety-valve, being a good pattern for small marine boilers, as the weight is not of the hanging or swinging type, which is dis-

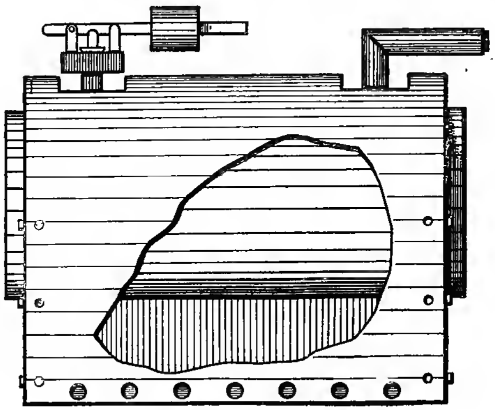

Fig. 35.

placed from position by a jolt or other rough moving. The valve must be ground very thoroughly with emery and oil to its seat, after being turned up true on the lathe. The weight is of lead, cast on a bar a trifle larger than the one it is intended for, or

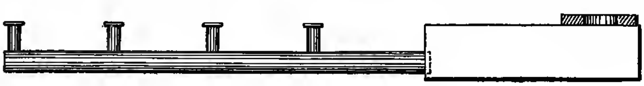

Fig. 36.

else drilled through with two or three small holes in a row and afterward filed smoothly to shape.

The construction of the safety-valve shown is too simple to require detailed description.

As to the adjustment of this valve, the simple rule given here will be easier to carry out than a mathematical calculation, the valve being so small the calculation would not be of the same value as actual experiment: Fill the boiler two-thirds full and light the lamp, after connecting with the engine. If the valve blows off before the engine is able to "turn over," or start up, move the weight a little farther from the valve, until the engine will run without

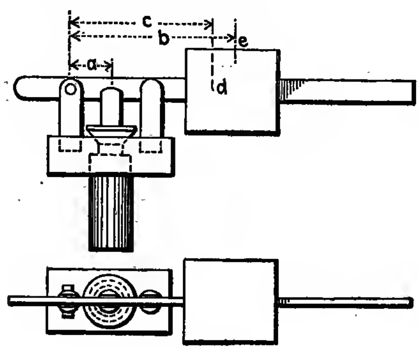

Fig. 37.

having an escapement of steam from the valve. If the valve has been carefully made and adjusted, it will blow off soon after the engine is stopped, if the fire is left under the boiler.

There is very little danger of a boiler built on this plan bursting, even should the valve be carelessly adjusted, if the engine is not stopped and the fire allowed to continue for some time without attention.

The author has made experiments with little boilers of this description, with a view to bursting them, and has always found it a difficult matter, even with the boiler openings plugged up with wooden plugs. In one instance it was not possible to burst the boiler at all, the lamp burning under the boiler, with all ports plugged, until the alcohol gave out. On removing the plugs the demonstration of steam and water which was forced out showed that the boiler had been under a terrific pressure, water from a lower port being forced thirty feet. These experiments are, at best, rather risky, and the author does not advise anyone's making them.

Fusible plugs are used on large boilers, in practice, as a guard against accidents from low water, and may be used to advantage on our models, should carelessness ever reign in the boiler-room. These fusible plugs can easily be made in our boilers by drilling a couple of ¼-inch holes near the bottom of the boiler-shell and soldering them up again with little brass caps and solder. Should the water ever get very low the flame will melt out the plug, and the steam will be discharged into the lamp, putting it out and saving the boiler-shell.

THE WATER-TUBE BOILER.

The water-tube boiler possesses its own peculiar features, both for marine use and stationary duty. For marine use, in practice, it is coming more and more into vogue, which fact speaks largely in its favor. For stationary work it has for some years been the best and most desirable in general practice. The following description is of a small water-tube boiler designed and built by the writer, which has given excellent results and proven a rapid steamer.

Chief among its drawbacks for model boats is the small water-capacity, consequently only being adapted for short-runs; and chief among the points in its favor is its rapid steaming-power, together with safety from explosions.

The reader will have to choose whether or no it is adapted to his needs. It certainly makes an instructive and pretty model when under steam, and a curious one to most persons when at rest. This boiler, if built twice the size of the drawings, is just suited to the oscillating-engines. If built about three times the size, it will furnish enough steam for the model slide-valve engine with reversing-gear.

This boiler is also built from brass disks ⅛ inch thick, which form the ends, only four are required in place of two.

Fig. 38 represents the end view from the elevated portion of the water-tubes and steam-drum.

The water-tubes are ¼ inch internal diameter, and are carefully soldered in the holes drilled for their reception from the front. Sixteen tubes are required in all, which, when soldered between the two inner disks, make an exceptionally strong construction.

Fig. 39 illustrates a side section, which shows clearly the plan of the boiler. Before drilling the holes in the disks to receive the tubes their location should be most carefully marked off on the brass, as irregular drillings for the tubes are extremely unsightly.

The lower tubes must not be nearer the edge than ¼ inch, the reason for which will be seen when the drum-heads are soldered on. Be sure the two disks are parallel to each other before the first tube is

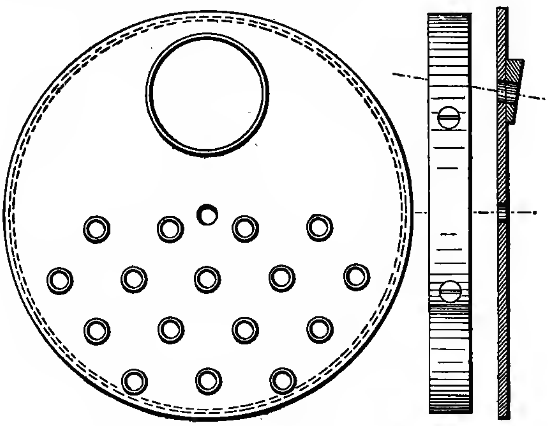

Fig. 38.

soldered in in place, and add the rest as fast as they are cut to length. This will require some little skill in soldering, but can readily be accomplished if the disks and tubes are kept heated in the flame of the Bunsen burner.

The collars, or short shells, are rolled to the proper size, which is about ¼ inch less diameter than the disks, and riveted in two places, as illustrated in Fig. 38.

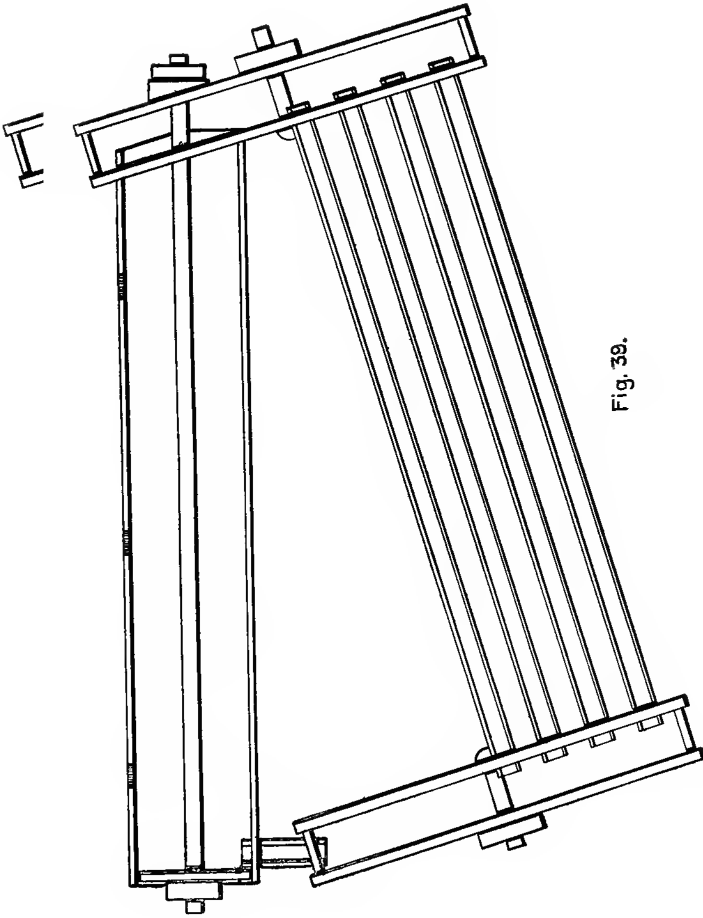

Fig. 39.

To complete the water-tight ends, the outer boiler-head or disk is placed carefully against the collar or short shell, and the two evenly adjusted against the disk with the tubes. The three are now securely clamped together with the wooden-screw vise, and after the most careful and exact adjustment, solder is made to flow all around both edges. This is made very easy by heating up the boiler again in the flame of the burner and "leading" solder around the edges with a large hot soldering-copper. There is little danger of melting the solder on the previously soldered tubes if care is taken in heating the boiler, which should not reach the temperature of molten solder.

The object of heating up the boiler at all, in addition to using the soldering-copper, is to cause the solder to flow more freely and enter all crevices.

Having finished the end, which carries only the small tubes, the end with the steam-drum next takes our attention. This steam-and-water drum is, of course, soldered in first and connected with the back-water drum by a small tube, as shown. This steam-and-water drum is conveniently made from a piece of seamless brass tubing, 1½-inch external diameter. The small tube is soldered securely, as in the case of the other tubes. It will be found necessary to enlarge the large round hole, which must be cut to receive the steam-drum, at its top and bottom, as the drum goes in at an angle, and requires an oval-shaped aperture to receive it. This enlargement can be conveniently made with a large half-round file. When this steam-drum is in position the remaining cover or boiler-head is soldered in place in the same manner as the first. A head is next soldered in the steam-and-water drum at the back, and three holes are drilled along the top, as illustrated in the sectional drawing, to receive the steam-supply pipe, the safety-valve, and the water-supply pipe.

The steam-supply pipe should be screwed in at the back in order to get the dryest steam. The safety-valve is best placed at the front, with the centre hole for the water-supply.

The boiler is now ready to receive its braces. The brace in the steam-drum runs through the entire length, and consists of a brass rod about ¼-inch in diameter, with threads cut on each end to receive circular nuts. A little wedge of brass is necessary under the front nut, because of the angle of the boiler-head. The two other braces are also of brass, but with only one nut each, as there is only room for a rivet-head between the boiler-tubes. These can be turned up on the lathe, or large copper rivets may be used, which take the place of brass very well, but on no account use iron. It will be necessary to flow solder around the rivet-heads to prevent leakage. In order to prevent a slow leak where the nuts go on in front of the drum-heads, it will be necessary to use white-lead, and perhaps a washer made from strong paper treated with oil.

When these three braces are in place with the nuts firmly screwed on, the strain is practically taken off the solder, which merely serves to fill up the crevices and make the boiler water and steam tight.

The boiler must be steamed in the position shown in Fig. 39, after filling with water to the height of the brace-rod in the upper steam-and-water drum. The source of heat is applied under the elevated portion of the tubes, and the action is as follows:

The water in the elevated ends of the tubes ascends, because of expansion due to the heating, and rises in the forward boiler-head to the steam-drum on top. The cold water at the back descends to occupy the place vacated by the warmer water. More water is heated at the front, and rises in the head to the steam-drum, allowing more water, which is less heated and consequently heavier, to descend into the lower boiler-head, where it is in place to be forced through the tubes and become still more heated, when it ascends. In this way a regular flow of water is induced around the boiler, until steam is generated at the front as the boiling water rises.

This boiler, if used on board a model boat, must have a russia-iron jacket or covering to keep in the heat, with slots along the top to allow room for the safety-valve and supply-pipes. A second iron jacket, much smaller in size, can to advantage be made to cover the top of the first, where the pipes and safety valve protrude, and be equipped with opening and funnel.

Without these iron coverings, the flame from the lamps will be far less efficient, owing to intense radiation, and will surely endanger the boat, if built as described in the chapter on ship design and hull-construction.

This concludes the work on steam-machinery, and from the types introduced the reader can surely find a reliable steam motive-power for small boats.

CHAPTER IV.

SHIP DESIGN AND CONSTRUCTION.

SHIP-DESIGN is a very simple and yet a very complex branch of engineering. Let us choose the simplest side of the art, leaving out all calculations of displacement, resistance, etc., and take up designing, with a view to producing models of graceful appearance, and of acquiring such knowledge of design that the reader will become sufficiently interested to consult larger works devoted to boat and ship design. Let us consider the work to be done and sum up the instruments necessary for our elementary designs.

All working-drawings and plans are to be full-size, which makes the use of a large drawing-board necessary. A soft pine-board will answer if the edges are smooth and true, with the ends sawn off perfectly square, for the **T**-square to slide against.

The paper for the designs need not be of the best quality; the buff-colored paper sold to artists and known as "detail-paper" answers admirably. This paper comes in rolls of great length and is about a yard wide.

Designing is largely a question of the eye. No rules can be given for producing a model of graceful appearance, and practice, as in many other things, is the greatest of all instructors. The first thing to decide upon is, of course, the type and size of the vessel, and if the ship is intended for steam-power, the dimensions must be such that the engine and boiler can be accommodated. A vessel with a beam about one-eighth of its length is common practice, but finer lines, and perhaps a more graceful appearance, can be developed together, by designing a vessel about nine times as long as she is broad, especially if the vessel is intended for a fast craft. We will require a long **T**-square, a pair of dividers, a ruling-pen and good black drawing-ink, some thumb-tacks, india-rubber, etc.

We will also need a set of ship-curves, the largest of which must be about 10 inches long. These are used in drawing in cross-sections, or rib plans. The ship-curves sold in sets of ten or twelve will answer every purpose, if selected with a range from a gentle curve to a rather sharp twist. A couple of long thin wooden strips, known as "splines," will be necessary for drawing in the curves in the sheer-plan, the deck-plan, the load water-line in the half-breadth plan, and for very large drawings; the cross-sections in the body-plan are often struck in with the spline. The splines are held in position by leaden weights, which are sold for the purpose. These weights are rather expensive, if intended for a grooved spline, but the author advises their use if the reader decides to do much designing.

Fig. 40 illustrates a fair substitute for the cast leaden weights. This simply consists of a block of wood with a wire-nail driven in one end and bent downward a little. These blocks can either be weighted down by putting flat-irons on top of them,

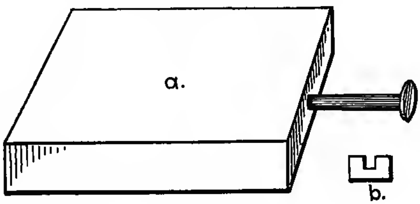

Fig. 40.

or they can be bored out with a large auger and filled in with molten lead. A cross-section of a grooved spline is shown at Fig. 40 (*b*).

The grooved spline is the best for the amateur, and is shown in position with weights in Fig. 41.

It will be observed that the nail-heads go in the groove and leave the edge of the spline unobstructed

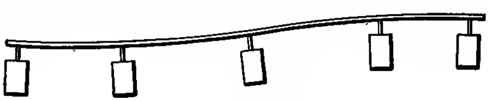

Fig. 41.

for the pencil and ruling-pen. In addition to these implements, a French curve will be found of much use for matching lines that have been sketched in by hand in order that they may be drawn in with ink. It is assumed that the reader has a ruler divided into inches and fractions, and a triangular square of wood or hard rubber.

We are now ready to start a trial design, which had better be full-size. The sheer-plan can be drawn as an original design, or the designer can be helped out very much by first studying the sheer-plans of some already existing models that have a graceful appearance. At first the designer is liable to produce a sheer-plan with too great a height or depth, or perhaps the curve under the stem will not be pretty or graceful, which points are only among the many that give a vessel a clumsy appearance.

Having finished a set of working-drawings, it would be very wise to cut out the ribs from pasteboard and mount them with glue along a pasteboard sheer-plan which is an exact copy of the plan in the working-drawings. This may be called a "trial model" and should be carefully and accurately cut out and put together. In this way one can get an almost perfect idea of the intended vessel, and the designer will run but little risk of carrying out a design that would only lead to a coarse and clumsy-looking craft.

Having mounted the paper truly on the drawing-board with the thumb-tacks, a line should be drawn right across the paper for the load water-line. This line is marked *L. W. L.* in Fig. 42 on all three of the plans. The **T**-square is clapped on the left-hand edge of the drawing-board and the *L. W. L.* drawn across with a pencil.

All lines should be at first drawn in with the pencil, and after the design has been approved the lines can be put in with ink. Determine the length of the

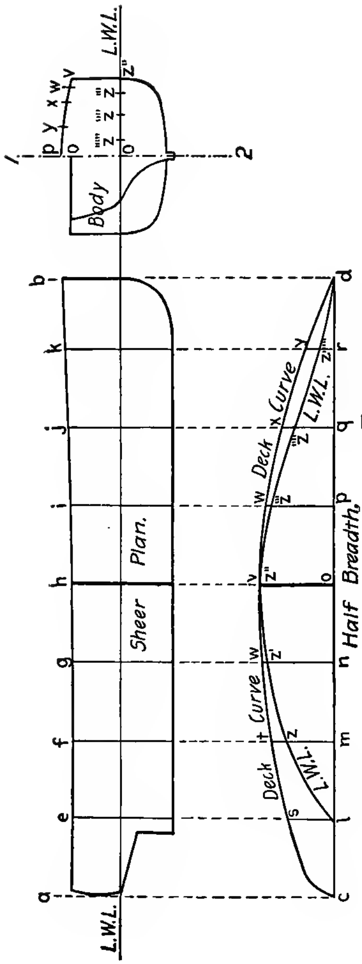

Fig. 42.

boat to be constructed, and prick tiny holes with the compass, surrounding them with a small pencil mark on the *L. W. L.*, which locate the tip of the bow and stern. Next draw in the perpendiculars *a c* and *b d*, drawing them far enough down on the sheet to leave room for the half-breadth plan, which we will take up in a few minutes. Do not change the position of the **T**-square in drawing perpendiculars, but use the triangle-square, sliding it along the upper blade of the **T**-square.

Now decide on the height, or depth, of the sheer-plan, and sketch in the bow and stern, above and below the load water-line. The deck-line should have a graceful curve, which can be struck in with the ship-spline and weights, to suit the taste of the builder. The keel-line is now drawn, which should give some idea of the side view of the vessel.

If the sheer-plan just sketched in does not look well, draw it over again, getting data from some drawings of a finished boat. The designs in this little book are not intended to be copied, but are merely to illustrate steps in the most elementary designing.

If the designer and builder has in view a special engine and boiler for the vessel under consideration he must not overlook the depth of the sheer-plan, remembering that about two inches of the depth of the sheer-plan will be taken up by the depth of the keel and the floor that rests on the upper edges of the ribs.

The beginner is liable to make one or two mistakes in designing a boat for a special engine and boiler, and the author cannot impress too forcibly the importance of cutting out the sheer-plan and rib sections from pasteboard, and mounting them exactly as the wooden ribs and sheer-plan finally go together. It is of course unnecessary to cut out the inside of the ribs or cross-sections, but merely glue the solid pasteboard pattern on a solid sheer-plan, bisecting the cross-sections and gluing them on each side of the sheer-plan with pasteboard "ears."

Having produced a sheer-plan that is satisfactory, the width of the vessel is to be decided on. Here another important choice presents itself. Draw in the line *cd*, which is the base of the half-breadth plan. Bisect this line and draw the perpendicular *ho*, which is the position of the midship section.

Having decided on the width of the vessel to meet the requirements of machinery, appearance, etc., lay off one-half of width from the line *cd* on the perpendicular *ho* and prick the distance off with the dividers, drawing a little circle around the point-mark to make it clear. The curve of the deck must now be struck in with the spline. The spline must be bent and held in position with the weights, so it joins the base of the half-breadth plan at *d*, passes through the point marked off on the perpendicular *ho*, and runs gracefully astern, not approaching very near the end of the line *c*, as this must be rounded in with the French curve to form a graceful stern.

No difficulty at all will be met with in putting in a graceful line with the spline, which of course can be altered, as in the case of the sheer-plan, if the design does not please on first trial.

Do not expect to produce your most graceful model at first, as very few ever produce their masterpiece of work on first trial.

The perpendiculars *el*, *fm*, *gn*, etc., must now be drawn out. Do not copy the plan, or draw only 7 perpendiculars, as represented in the sheer-plan of Fig. 42, as these plans have nothing whatever to do with your design.

The perpendiculars on your full-sized working-drawings must not be over 2½ inches apart. A rib every 2½ inches will be found necessary when the cardboard covering goes on.

Having drawn the perpendiculars, the second curve must be drawn in the half-breadth plan, which represents the load water-line looking down on the vessel. This line had better be struck in independent of rules, as they would be found rather confusing to the beginner.

The author would say that, in general, the curve at the bow in this *L. W. L.* is usually concave, as illustrated. This line never reaches the stern end of the boat, but curves sharply toward the centre line.

In the design of large boats several of these curving lines are used, but the amateur can get along for the present without bothering his head about them. They are fully described in all large books devoted to designing, and are always confusing to the beginner, together with other technical lines purposely left out by the author.

We can now turn our attention to the body-plan. Draw a long perpendicular line at the right of the sheer-plan, or bow of the design, to be the centre of the body-plan. The height of the bow can be laid off on this line on the right, and the height of the stern can be laid off at the left.

Now for the representation of the width of the boat, or midship section. In the half-breadth plan, the heavy line *ov* represents ½ the extreme width of the model at the deck, and the distance *oz''* represents ½ the widest part of the boat on the load water-line. In the illustration the boat is the same width at the load water-line as it is at the deck. The distance *ov* on the half-breadth plan is transferred to the body-plan and marked off with the dividers from the perpendicular 1, 2 to the right, represented in the illustration of the body-plan at *ov*. The distance oz'' on the half-breadth plan, which is on the load water-line, is carried to the body-plan and marked off on the *L. W. L.* there.

The shape or form of the midship section must be sketched in by hand, keeping in mind all the time that the boat is for a boiler and engine of certain depth and width.

Having sketched in a satisfactory midship section it may be drawn in permanently by using one of the ship curves. If you have designed the midship section with sharp twists or turns, it may be necessary to draw the line in two or more pieces, using several ship-curves to complete the line, helping out with the French curves if the turns near the keel are sharp.

The midship section is, of course, only one of many, and the others now demand our attention. The breadth *pw* in the half-breadth plan can now be laid off on the body-plan, measuring, as shown, from the perpendicular. The points *x* and *y* are laid off on the body-plan, carrying their distances, of course, from the base-line in the half-breadth plan. The distances, in the half-breadth plan, to the load water-line are carried in the same way to the body-plan and are laid off on the *L. W. L.*, as shown at z''''', z'''', z'''.

The remaining cross-sections must be drawn in with the ship-curves, the line being made to pass through the points laid off. The cross-sections for the stern end are laid off in just the same manner, the stern-sections having a more and more concave twist as they approach the perpendicular. These must also be sketched in at first, the taste of the designer shaping them as they pass through the points on the deck curve and *L. W. L.*

Having finished the design and made a pasteboard model the amateur will have learned only the first principles of boat-design, and should read additional matter on the subject if he wishes to be a more competent designer. The forms of the cross-sections are best transferred to light paper by tracing, and then to the wood which is to constitute the ribs. The sheer-plan is also traced out and transferred to the board from which the sheer or frame is to be cut. On the whole, the author would advise the beginner to get as many points from drawings as possible, and not be too much disappointed if the first design does not promise a beautiful boat.

The drawing-paper is cheap and the time taken for a design is fortunately not long, so there is very little excuse for not making trials until a really handsome design is produced.

If the reader wishes to copy a boat already in existence, but has not the drawings from which the vessel was designed, the sheer-plan can be pretty accurately obtained by making measurements from the boat itself. The cross-sections can be copied off with reasonable accuracy for small craft, by bending smooth strips of lead around the hull of the vessel and ruling them off on paper. Of course, the curves thus obtained will need some treatment with the ship curves, or in other words, "doctoring."

It is the wish of the author to give enough directions in this chapter to start the beginner in the right way, and enable him, after practice, to design small boats, and get him sufficiently interested in designing to take up more complete works on ship-design devoted solely to the subject.

CONSTRUCTION.

Having produced a design or secured plans worthy of carrying out in actual construction, the selection of the wood is the first important step. Soft white-pine is, on the whole, the most satisfactory to use, and should be selected free from knots. Of course the size of the boat will influence the thickness of the wood. In order to get the requisite stiffness the wood for the "sheer-frame" must be ½ inch thick for a boat 6 feet long. A boat 3 feet long will be stiff enough if ¼-inch wood is put into the sheer-frame and ribs. The wood for the ribs in the larger vessels need not be over ½ inch thick at the most.

The drawings or plans of almost any existing boat can be carried out on the following system, if the reader does not care to take up designing but prefers to confine his work to actual construction. The sheer-plan is laid out on a piece of smooth pine-board, which is neatly sawn out to the pattern. Fig. 43 illustrates a frame cut from a pine-board with the centre sawn out, leaving a keel and upper stiffening-beam. The inside as well as the outside cutting on a frame can be readily done with a small hand-saw with a narrow tapering blade. The thickness of the frame-board at the bow should be reduced, giving the boat a prettier appearance and forming an easier entrance to the water.

Commencing from the bow *d* the board is sand-papered on both sides, using a block with the sand-paper, which thins down the frame to a more perfect taper. The taper should commence about two feet from the stem or bow. A portion of the upper beam can now be cut away to allow room for the engines and boilers. In the figure a section is marked, ready to be cut out at *a* and *b*.

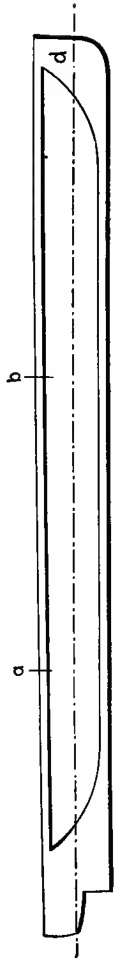

Fig. 43.

The frame must be handled very carefully after cutting away this section, in order to prevent breakage of the keel or remaining pieces of the upper beam. The frame is now ready to be strengthened by the ribs and side-beams. Three types or designs of ribs are necessary for this frame. These are illustrated by Figs. 44, 45, and 46. These ribs are to be cut out by means of a foot-power scroll-saw if possible, or else by a hand-scroll with very fine blade and teeth. They are easily broken, and must be carefully handled after gluing on the frame until covered with the plating. The relation of these differently shaped ribs to the sheer-frame is readily seen by a glance at Figs. 47 and 48. Two side-beams are mortised into the ribs where the upper beam has been cut out, in order to again have the proper stiffness.

Fig. 45 illustrates a midship section cut out nearly square to allow of a roomy compartment for the machinery and boiler. Fig. 44 shows the type of rib,

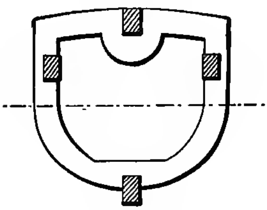

Fig. 44.

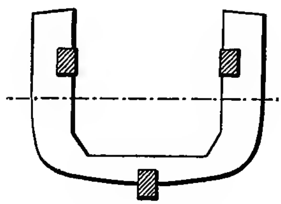

Fig. 45.

forward, where the upper beam leaves off and the side-beams start, and Fig. 46 illustrates a simple rib near the stem, where only the beam and keel are held. Of course the ribs and beams are all glued in place with the strongest furniture-glue and afterward given four or five coats of orange-shellac to protect the glue from moisture. The ribs far astern, as well as the one on the extreme stem, are sawn in half and glued directly to the frame, like two checks, allowance being made for the thickness of the frame-board by cutting a slice off each half-rib on the centre equal to one-half the thickness of the "sheer-board" or frame. The plating is of the best cardboard and is secured to the ribs with tiny upholsterer's tacks and glue.

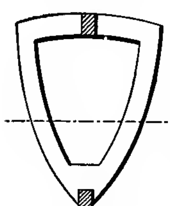

Fig. 46.

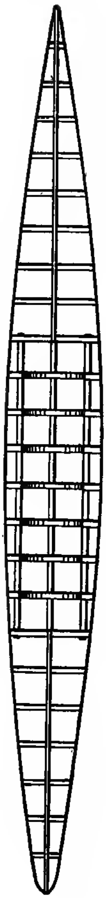

Fig. 47.

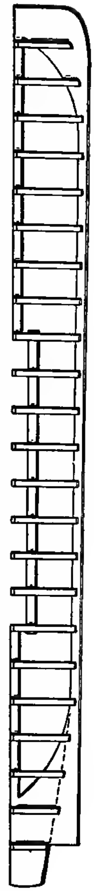

Fig. 48.

If you have designed a boat with violent turns and twists in the hull-lines it will be more difficult to plate than a boat with easy, sharp lines. This plating is by no means the easiest part of the construction and requires practice and care. It is not advisable to put the cardboard on in long strips unless the model has pretty straight lines and no sharp twists.

The easiest way to plate a model with cardboard is by applying vertical plates, as illustrated in Fig. 49. If the twists and turns are violent the plating must be put on in still smaller pieces, starting from the keel and stopping at or near the water-line.

The cardboard in this case must be of lighter weight and be pieced on and carried up to the tips of the ribs. The cardboard used should be about twice the thickness of a stiff visiting-card for the average boat. A combination of short vertical plates from the keel to the water-line, and a long strip from the water-line to the ribs, is good in many cases.

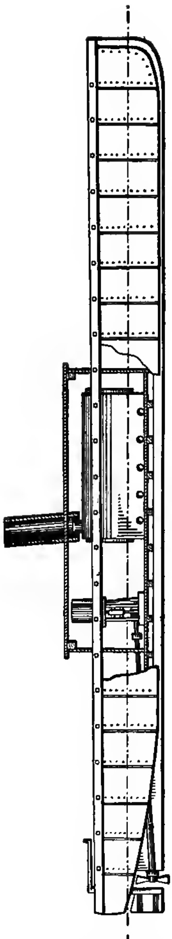

Fig. 49.

It will be found necessary to shave down the edges of the ribs fore and aft to give a surface to the glue, and tack the plating to where the outline of the ribs describe short turns and twists. This of course must be done moderately, and to the same extent on each rib where the plating is to curve rapidly.

The plates should be invariably attached to the lower portion of the ribs first, by the furniture-glue and tacks, and bent upward around the ribs after the glue has thoroughly hardened.

The plates will have a little tendency to bulge out between the ribs at the keel, and should be re-inforced by little blocks of wood on the inside, two between each pair of ribs, one on either side of the keel, securely glued against the keel and to the bottom of the cardboard plating.

The platings are cut off evenly where they meet the top edge of the ribs. The plating cannot very well be made to complete the stern, but a soft pine block, carved to shape and sawn in half, can be glued on either side of the frame to meet the last rib and plating, forming any style of stern. When the block and plating is painted it will be difficult for an outsider to tell how the stern was made. It adds to the appearance of a model steamer to put in tiny upholsterer's tacks (with the round heads) along the edge of each plate, as shown in Fig. 49. A light wooden batten is bent around from stem to stern on the deck-line, over the cardboard plates, and is attached by small screws to every rib. The upper edge of this batten or strip should be at least one-eighth of an inch above the ribs and deck-line, in order to form a projection or angle for the deck to fit against.

The deck-board is cut from very heavy cardboard and carefully fitted to the shape of the deck. The appearance of the deck is made very real looking by ruling a number of deep fine lines with a very hard pencil before applying the orange-shellac.

The plating of the vessel is given six or eight coats of the best orange-shellac, outside and inside, allowing each coat to thoroughly harden before the next coat is applied. With six or eight coats of shellac on the inside, the shipment of a little "sea" will not prove disastrous.

Having applied the coats of shellac and allowed them to harden, the vessel is ready to be painted. A dark reddish paint from the keel to about the water-line, with white sides and buff-colored upperworks and funnel, is sure to appeal to those who are familiar with any of the magnificent vessels of the United States Navy.

The red color under the water-line is made by mixing a quantity of yellow ochre in with the red, and adding a little lead to make a good heavy paint. With the coats of shellac and paint protected by varnish, there is very little chance of much "sea" getting between the cracks.

Hatches can be cut in the deck between any of the ribs, fore and aft, and be provided with covers or sky-lights raised on little wooden frames. A photogravure of a little war-cruiser built on this system, can be seen on one of the front pages. The builder can of course put masts and rigging on his vessel, and is probably well able to design and rig them without assistance. The upper-works can be made from heavy cardboard, shellacked before being painted.

Before installing the boiler and engine, the portion of the ship intended for their reception should be lined with sheet brass or copper of very light weight. This is important, as a small leak or escape of steam would otherwise, in time, soften the plating and shellac, and warp the ribs. This lining is easily made, soldering all seams water-tight, so the engine-room can be nearly flooded without injuring the boat. Of course the propeller-shaft must pass through the lining, and on this account it would not be advisable to fill the engine-room with water purposely.

A vessel built from wood and cardboard requires some care, but if properly treated will not drop behind in a race with models of any construction. A vessel built from such light material will require some shot for ballast poured in between the ribs on both sides of the keel. Fig. 50 shows a form of propeller-shaft and stuffing-box.

The propeller-shaft should be small, not much thicker than a bicycle-spoke, as it is easier to drive and easier to pack water-tight without binding.

The water-tight packing is a very important point in small steamboats, as a leak at the propeller-shaft will soon flood the stern end of the boat.

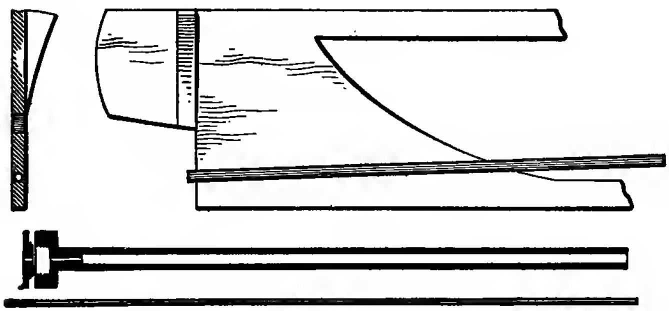

Fig. 50.

A good propeller can be made by turning up a thick disk of brass about ⅝-inch in diameter and sawing three diagonal cuts around the edge to receive three brass blades which are soldered in. Not knowing whether the reader is building a tug-boat or a racing-craft, it is difficult to give rules concerning the propeller's "pitch." While a rule could be given for any one of the engines described in the preceding pages, with a fast or slow model, the adjusting of the blades by experiment as follows will prove far more satisfactory:

Turn up several brass disks or hubs for propellers and saw cuts in each of different angles; in other words, produce one with cuts nearly parallel to the flat surface; in the others, increase the angle—the cuts in any one disk, of course, having the same pitch. Fix in the blades and solder them, and run the boat over a little measured course, timing it, with any one of the propellers. The pitch of the propeller will be found to make but little difference, within certain limits, as the power and speed of the engine will adjust themselves to propellers of different pitches, within a small angle, driving the model at a constant speed. In describing certain steps in boat-construction, the reader will find himself free to carry out his own ideas, and will be able to make them come up to his ideas of satisfaction if he only works carefully and accurately.

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