weakened now that such high velocities have been attained with a trifling shock to the internal mechanism of the gun, and we rejoice to think that the success may lead to the adoption of breech-loading guns for siege trains. This we have always advocated, not because of any intrinsic superiority in the weapon, but because the gunners working it can be more easily protected from the rifle fire of the enemies' sharpshooters. But, so far as the gun itself is concerned, a muzzle-loader made on the same principles would have the same power—that is to say, a gun constructed on the new principles will be at least as powerful for penetration as one of the old pattern double the weight. Thus, if the conditions are that a certain effect is to be produced, the gun need only be of half the weight formerly necessary; or if the conditions—say the strength of a merchant ship's deck—prevent the use of a gun above a certain weight, then the piece supplied may be twice as powerful as was formerly possible. In saying this we are far within the mark, for not only has the 6-inch gun shown itself superior to the 8-inch of more than double its weight, but pieces of higher caliber are now almost completed which will carry out the proportion and even raise it. The new 8-inch guns, weighing about 11 tons, will be much more powerful for penetration than the old 11-inch pieces of 25 tons, and the 35 and 38 tons will be far surpassed by the new 10-inch gun. We are, therefore, in presence of an extraordinary advance suddenly disclosed in the power of artillery. It is entirely an English development, and should we be unhappily called upon to vindicate our title to the command of the sea for trading purposes, it will have an extremely practical effect. English ships thus armed may not only double their artillery power against ironclads, but sometimes gain a power which they had previously no chance of possessing, for vessels may now be well armed which could not until now be armed at all, while those which might have carried weak guns can now bear an armament of powerful pieces. A high initial velocity given to a projectile means more than a heavy blow upon the adversary; it means longer effective range and better shooting at all ranges. For instance, when we say that the range of the new 6-inch, fired with an elevation of 3°, is 2,713 yards, or, with 5°, 3,795 yards, while that of the old 8-inch—double the weight—is only 1,715 and 2,605 yards respectively with the same elevations, it means more than that the shells range about 1,000 yards further. It means that at any range whatever the new gun will be much more likely to strike an adversary because the path of its projectile through the air is less curved, and, therefore, less likely to pass over the mark. We do not set much store by the ranges of 6,000 yards given by the new gun with 10° of elevation, because the use of such long ranges would be only occasional. Yet there are situations in war when accurate shooting at long range is of the highest value, and no pains should be spared to render such long range shooting more reliable by the use of finer sights and telescopes. For harbor defense and river work the new guns will again give increased power and that in a high degree. The little boats carrying a gun each which were sent by the Elswick firm to China some years ago will now step upward in efficiency, for the very smallest of them can now carry guns as powerful as those formerly carried by the largest. It is worthy of passing remark that the Russian guns have, for the most part, a low velocity, and are in all cases far behind those now produced by England. There is nothing of the kind to be bought in America, and we may hope that the utter futility of finding cruisers armed so as to match merchant steamers which can carry light, far-reaching guns, such as can now be given to them, may be another and a potent argument in favor of peace. All such developments as those we have explained—the largest guns for smashing exceptional ironclad defenses, and the lightest guns to produce any given effect—are fortunate acquisitions at a moment when the peace of the world may depend on England's readiness for war.—*London Times.*

ROCKET FIRING.

A SUGGESTION for the better employment of rockets has been made to the Royal Artillery Institution at Woolwich, by Lieut. E. N. Henriques, Royal Artillery, who proposes a rocket shell to be fired from a rifled gun. He hopes by that means to secure all the moral advantages attributed to the employment of rockets in the field, and to obviate their special defects, which are—difficulty of laying, irregularities in flight, uncertainty of range, height of trajectory, low velocity at long ranges, small momentum after bursting, great weight of each round, and considerable deflections after graze. The proposed rocket shell, when fired from the gun, would be ignited by a fuse in front of the enemy's line, and carry a bursting charge of gun-cotton in its head.

NEW TORPEDO BOATS.

Two new torpedo boats, in which some special features have been introduced by the builders, Messrs. Yarrow & Co., of Poplar, England, were lately tried by the Admiralty officials. These vessels are each 85 feet long with 11 feet beam, and draw, when fully equipped for service, an average of 3 feet of water. They are strongly constructed of steel, and are fitted with compound surface-condensing engines capable of indicating 420 horse power. The high-pressure steam cylinder of these engines is $12\frac{1}{2}$ inches in diameter, and the low-pressure $21\frac{1}{2}$ inches, both having a 12-inch stroke. These boats are at present known by their builders' numbers, one being No. 419 and the other No. 420. The former is propelled by a three-bladed screw, 5 feet 6 inches diameter and 5 feet pitch; and the latter by a two-bladed screw of similar proportions. Messrs. Yarrow adopt supplementary engines for driving the air-pump, circulating pump and feed pumps; they consider this plan preferable to that of working these pumps direct off the main engine, as is sometimes done. One advantage in having separate pumping engines is that, whether the vessel is in motion or stationary, a powerful means is available for pumping her out, should the necessity arise. It is estimated by her builders that if the air-pump and circulating pump were both utilized for this purpose the water could be pumped out as fast as it could enter either of these vessels through one hundred holes made in the skin by Martini-Henry rifle bullets. If this is the case, these craft may be deemed safe from sinking so long as their machinery is working efficiently. The boiler is of the locomotive type, is placed in the forward part of each vessel, and has a closed stoke-hole. In connection with the boiler a very important improvement has been introduced by Messrs. Yarrow. This consists in a means of rendering the closed stoke-hole safe for the men in the event of the collapse of a boiler tube—a contingency which cannot be absolutely guarded against. The arrangement was explained to us, but, although patented, we are asked not to publish the details. From what we have seen the plan appears very simple, while its efficiency was proved beyond all question upon a previous trial of one of these boats. This was No. 419, which was tried on the 24th May last, under the supervision of the Admiralty officials. Upon that occasion an accidental rupture of one of the boiler tubes occurred nearly at the close of the runs over the measured mile, which so far had been very successful. When the boiler tube gave way the steam rushed out of the foremost hatchway from the compartment in which the smoke-box end of the boiler is situated, and soon after from the two funnels. The men in the stoke-hole, however, being shut off from the boiler, were uninjured, and remained at their post several minutes after the first outburst of steam. The accident, although an untoward event, was considered by the Admiralty officials as affording a highly satisfactory proof of the efficiency of Mr. Yarrow's invention. The engines are placed amidships, and each vessel has spacious cabin accommodation aft, as it is intended that they may be used either as dispatch or torpedo boats. For the latter purpose the cabin framings above deck are removed and replaced by steel plating. These vessels are, in fact, now fitted one for one purpose and one for the other. They are steered from the cabin, there being a lookout for the steersman just above deck-level. The deck is clear of all obstructions, the two funnels being placed one on either side. They are fitted with balanced rudders, and steer well, answering their helms very quickly. These vessels would probably have now been on their way to the Neva but for the Government proclamation which prohibited torpedo boats leaving this country, and which led to their purchase by the English Government.

The above trials were conducted under the supervision of Mr. Neil M'Dougall, on behalf of the Admiralty, the runs being made over the measured mile—or, rather, two miles—at Long Reach. No 420 was first tried, and made the down run over the two-mile course in 5 minutes 19 seconds, which is equal to a speed of 22·59 knots per hour. In other terms, this vessel attained the remarkable speed of 26 miles an hour. She had 6 tons of ballast on board, and her draught forward was 2 feet eight and a half inches, and aft 2 feet 7 inches. Her mean revolutions were 460 per minute; maximum, 475; steam pressure, 120 lbs.; vacuum, 23 to 25 inches, and blast 4 inches. The tide had just turned and was running out, being, therefore, with the vessel on the run down. On the run up it was, of course, against her. This run was made in 6 minutes 47 seconds, or equal to a speed of 17·69 knots per hour. The mean of the two runs was 20·14 knots, or 23·2 miles per hour. On the up run the mean revolutions were 460 per minute, the steam-pressure 120 lbs., the vacuum 24 inches, and the blast 4 inches. The vessel was under way just an hour, during which time she burned 10 cwt. of coal, a portion of which was used in getting up steam. No. 419 was then tried. She was run light, without any ballast, her draught forward being 2 feet 5 inches, and aft 2 feet 4 inches. The first run was made up the river, and, consequently, against the tide. The two miles were run in 6 minutes 38 seconds, giving a speed of 18·09 knots per hour. The mean revolutions were 459, the steam-pressure 110 lbs., the vacuum 22 inches, and the blast 4 and a half inches. The second run was made down the river, and, consequently, with the tide. Here the two miles were accomplished in 5 minutes 1 second, giving a speed of 23·92 knots, or 27·56 miles per hour. The mean of the two runs was a speed of 21 knots, or 24·2 miles per hour. On the last run the mean revolutions were 459, the steam-pressure 110 lbs., the vacuum 22 inches, and the blast 4 and three-quarter inches. This boat was then put through the circle, and in this trial she described a circle half a knot in circumference, or rather more than 1,000 feet in diameter, in 2 minutes 31 seconds. There were no heated bearings or any other drawbacks during these trials, which were highly satisfactory in every respect.

COMPRESSED AIR IN MINES.

By M. G. JOHNSON, of the Kingswood Collieries, Bristol.

AMONG the collieries visited by Mr. Cossham were included Ryhope and Shireoaks, and at each of these collieries compressed air is being used with excellent results. The same may be said of all the places I visited in South Wales—in one colliery no less than 40 horses had been dispensed with through the application of this power. Great credit is due to Sir George Elliot for the persistent efforts he has made and the money he has spent in order to bring as near perfection as possible the methods for obtaining this power. In the Powell's Duffryn Collieries, in South Wales, the proprietors are so convinced of the benefits to be derived from its use that they are dispensing altogether with animal power, and substituting air engines for their underground haulage; and the testimony of these collieries (Mr. Wilkinson, manager, and Mr. Snape, engineer) was to the effect that after ten years' experience in the use of compressed air they are fully convinced that there is no power equal to it for winning coal back to the shaft where steam cannot be conveniently employed, and where the coal lies to the dip. At New Tredegar Collieries, belonging to the same firm, this motor is, I am told, extensively employed. They have no coal works but what lie below 1,500 yards to the dip, and from that distance down to 2,000 yards, the lowest point reached at that time (two years ago), they were hauling 800 tons per day.

When the Mont Cenis Tunnel had to be driven, the engineers, Messrs. Sommellier and Grattoni, at once recognized this power, and availed themselves of it, and but for this I have no doubt the completion of that grand engineering feat would have been retarded for at least five years. It not only served as the power for driving their rock drills, but it cleared away the smoke after blasting almost immediately, and enabled the men to resume work at the face of the heading without any unnecessary loss of time, and to get the debris at once cleared away. Every miner knows that the hanging of the smoke in the ordinary method very often keeps him away from the place of his work quite one-fifth of his time, so that this power not only permits much more work to be done, but admits of its being done in a healthy atmosphere instead of in a vitiated one. At Mont Cenis Tunnel, too, they got this power very cheaply at merely the cost of the machinery; a mountain stream running down near the mouth of the tunnel was utilized, and supplied the power for compressing the air. M. Derilley has published an elaborate and most valuable report on the work done at this tunnel, and much information is given therein respecting their method of compressing the air. Mr. Taylor, of Ryhope Colliery, in a paper read before the North of England Institute of Engineers some few years ago, enumerates some of the advantages resulting from the use of this power:—1. It is obviously of great importance to have a large power which can be applied to any purpose, and at any moment, to any part of the mine. 2. Possessing this power is a mere question of detail to use means for working the coal and bringing it to the point from which it is to be led by the air engine, thus dispensing in a great measure with manual labor, both as regards hewing and putting the coals. 3. Compressed air at 40 lbs. pressure has been successfully tried at Ryhope for airing a stone drift, and he sums up the results as follows: 1. Economy as regards its application to any part of the mine. 2. Additional safety to the mine, inasmuch as there is more direct communication with and control over all parts. 3. Having a power so easy of application to any part of the mine, its use for all purposes where labor is concerned must necessarily follow.

M. Trasenter, Professor of Mining at the University of Liége, considers that great advantages must ensue from the use of this power for driving engines at high speed in the galleries or working places underground, through the freedom from heating and condensation, slight friction in the pipes, and the ventilation in the works; but while enumerating its advantages we must not fail to look fairly in the face what are considered to be the drawbacks to its general adoption. Mr. Trasenter says compressed air necessitates costly works, and if used without expansion it leads to a great loss of power owing to the necessity for conducting the air at the required pressure. In calculating the ratio of the energy expended in compressing the air to the useful work theoretically given out, Mr. Trasenter has laid down a simple and interesting formula. The work given out soon reaches a limit which cannot be exceeded, whatever may be the pressure of the air or the energy expended. The maximum of work given out (increasing the compression indefinitely, and without taking into consideration the elevation of temperature due to this compression) cannot exceed the energy given out by the volume of air caused by the piston of the blowing cylinder working with an effective pressure of one atmosphere, and he demonstrates the law, and goes on to say that the power which a cubic meter of air, compressed to a million atmospheres, is capable of yielding, without taking the rise of temperature into consideration, can never become double that which the same quantity of air, compressed to two atmospheres, is capable of yielding. Air compressed to four atmospheres will give out a power proportional to $1-\frac{1}{4}$, or $\frac{3}{4}$, whereas to obtain a power equal to 1 a compression infinitely great is necessary. He gives a formula which expresses the ratio of the work done to the power expended. This power is not a new discovery; Hero, of Alexandria, was in some measure acquainted with it, as well as with the knowledge of steam as a motive power. Hero's tutor, Clestibuis, is said to have discovered that air was compressible, and the pupil is credited with having written a book on pneumatics, showing that when air was compressed it decreased in volume, and expanded itself again when the pressure was removed. Experiments proving its "ponderability" were made in the 17th century by Galileo and Torricelli; about the same time, too, Guericke invented the air pump. Its chemical properties, however, did not engage much attention until another century had elapsed, when Black, Priestley, Lavoisier, and others took up the subject, and great discoveries resulted from their labors. Papin, about the beginning of last century, had an idea of working an engine with air, generated by a water-wheel and compressing pump at a distance, but it was not brought into practice; and just 100 years before the Mont Cenis Tunnel was commenced one Isaac Wilkinson obtained a patent for a machine for compressing air very similar to the one employed at those works. It is generally known that when air or other elastic fluid is compressed, there is generated an amount of heat which is the exact equivalent of the force employed in the compression.

It may not be out of place here to give an extract from Professor Tyndall's valuable work, "Heat a Mode of Motion." He says:

"Whenever friction is overcome (by compression or otherwise) heat is produced, and the heat produced is the exact measure of the force expended in overcoming the friction. The heat is simply the primitive force in another form, and if we wish to avoid this conversion we must abolish the friction. We put oil upon the surface of a bone, we grease a saw, and are careful to lubricate the axles of our railway carriages. What is the real meaning of these acts? Let us obtain general motions first, and aim at strict accuracy afterward. It is the object of a railway engine driver to urge his train from one place to another; he wishes to employ the force of his steam; it is not his object or interest to allow any portion of that force to be converted into another form of force which would not promote the attainment of his object; he does not want his axles heated, and hence he avoids as much as possible expending his power in heating them—in fact, he obtained his power from heat, and it is not his object to reconvert by friction the force thus obtained into its primitive form. For every degree of temperature generated in his axles a definite amount would be withdrawn from the urging force of his engine. There is no absolute loss. Could we gather up all the heat generated by the friction, and could we apply it mechanically, we should by it be able to impart to the train the precise amount of speed which it had lost by the friction. Thus every one of those railway porters whom you see moving about with his can of yellow grease, and opening the little boxes which surround the carriage axles, is, without knowing it, illustrating a principle which forms the solder of nature; he is unconsciously affirming both the convertibility and the indestructibility of force. All the force of our locomotives is derived from heat. When a station is approached—say at the rate of 30 miles an hour—a brake is applied, and smoke and sparks issue from the wheels on which it presses. The train is brought to rest. How? Simply by converting the entire moving force which it possessed at the moment the brake was applied into heat."

The heat in actual practice is to a very considerable extent lost by radiation from the receiver and pipes in use; and further, when this compressed air has fallen to the temperature it possessed prior to its being compressed, it has lost in cooling an exact equivalent of the power expended in compressing it. Where, then, is the power to perform work? This remains in the stored-up air in the reservoir, where it is held under considerable pressure, and when allowed to expand in a working cylinder its temperature then falls below that of the atmosphere, and thus develops the work demanded from it. In accomplishing this, however, there is a loss of about 30 to 40 per cent. in consequence of the temperature of expansion not being depressed in an equal proportion to the increase obtained during its compression; and hence when the air has done its work in the cylinder, and issues forth from the exhaust passage, it is exceedingly cold, being about $28\frac{1}{2}°$ Fahr., or $3\frac{1}{2}°$ below freezing point. This intense cold formed for a considerable time very serious objections in its practical use as an engine

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motor, through the formation of ice at the exhaust. Various methods have been resorted to to remedy this defect, but this is effectually accomplished by casting the cylinder so as to have the exhaust openings connected with the exhaust port vertically, and open across the cylinder, so as to discharge the air downward as well as upward, and admit of a bar being passed through, if necessary, to chip off the ice. It would appear from the foregoing that the higher the air was pressed the greater would be the loss in the economic result; but in this there is a great difference of opinion, one party going in for slow speed and low pressures, not above three atmospheres, and another for high speed and high pressures. It is a very common expression, and true, that circumstances alter cases, and so, in my opinion, it is in this, the "battle of pressures."

I do not wish to be dogmatic in this matter. Douglas Jerrold once said that dogmatism was grown-up puppyism; and I know, too, there is a proverb which says that a certain class of people, the opposite to wise, rush in where angels fear to tread. Where the work, however, to be accomplished is of a temporary nature, such as tunneling, deep well sinking or boring, high speeds and high pressures may be adopted with advantage, as they admit of smaller machines being used to do the desired amount of work; but where the power is required for the running of a colliery to extend over 20, 30, or 40 years, and the air to be carried to long distances for hauling, pumping, rock drilling, and coal cutting purposes, then I say put down a good compressing plant, with moderate speed, ordinary pressure of (say) three atmospheres, and plenty of margin. This is my view of the matter, and must be taken for what it is worth. An athlete, in running a hundred yard race, starts away at a very different speed to what the one does who is in for a mile race; it is the old fable of the hare and the tortoise.

Looking at the matter in this light, the Kingswood Coal and Iron Company ordered a pair of air compressors from Messrs. J. Fowler & Co., of Leeds, of the following dimensions: The steam cylinders are 36 in. diameter, the air cylinders being 40 in. diameter, with a 5-ft. stroke. The air cylinders are immediately behind the steam cylinders, and fixed to the same bed plate; the piston is continuous, but so arranged that no part of the rod that works in the steam cylinder shall enter the air cylinders or even the stuffing box. The air cylinders are cast with square ends and flanges to attach flat plates vertically at the sides, thus forming a tank or receptacle for a complete jacketing of cold water, the object of the cold water being to keep the temperature of the air as low as possible during compression, the top left open to allow of evaporation and radiation. The supply of cold water is kept up by a pipe at the under side, getting its supply from a reservoir at a higher level than the tops of the cylinders, and the heated water is passed off at an overflow pipe at the top, the inlet and outlet being regulated by taps. The air is forced into a receiver, which is nothing more than an ordinary egg-end boiler, 25 ft. long and 5 ft. in diameter, fitted with stop valve and safety valves, the latter weighted to 45 lbs. per square inch. Steam is supplied at 40 lbs. per square inch, and the pressure of air stands at 45 lbs. per square inch; the steam is cut off at ¾ in. of the stroke; the fly wheel is 21 ft. diameter, and weighs about 24 tons. From the receiver toward the shaft an old boiler tube, 28 ft. long, 2 ft. 10 in. diameter, is utilized, and from this cast iron pipes 8 in. diameter are carried down the shaft for 225 yards; at this depth, and in an opening in the side of the shaft, a pumping engine is fixed and driven by the compressed air. This engine consists of a pair of air cylinders, 10 in. diameter and 2 ft. stroke, which drives a pair of rams 6 in. diameter, geared 5 to 1, with air pressure at 40 lbs., and delivers 160 gallons of water per minute 700 ft. high. The out and out dimensions of this pump are 15 ft. long, 7 ft. 6 in. wide, and 6 ft. 3 in. high. These compressors and pump, made by Messrs. Fowler & Co., of Leeds, have given the most unqualified satisfaction. The air pressure at this point, more than 250 yards from compressors, stands at 2 lbs. higher than it does in the receiver at surface, and my experience is that the pressure increases about 1 lb. for every 100 yards of depth. We have tested this by changing gauges; the same has also been observed by Mr. Snape, engineer, and Sir George Elliot, who has had more than 11 years' experience with compressing machinery. I do not intend here to account for this, but merely state the fact. We have 7 in. pipes continued for the remaining 270 yards down to the bottom of the shaft, and for the present have a dead flange screwed on the end of the pipes, but we have already two pairs of hauling engines on order, and hope to have them at work in a few months—one pair for level haulage, the other for dip haulage. I anticipate, therefore, when we come to put the pressure gauge on at the pit bottom, that the pressure there will register about 5 lbs. higher than at the surface receiver.

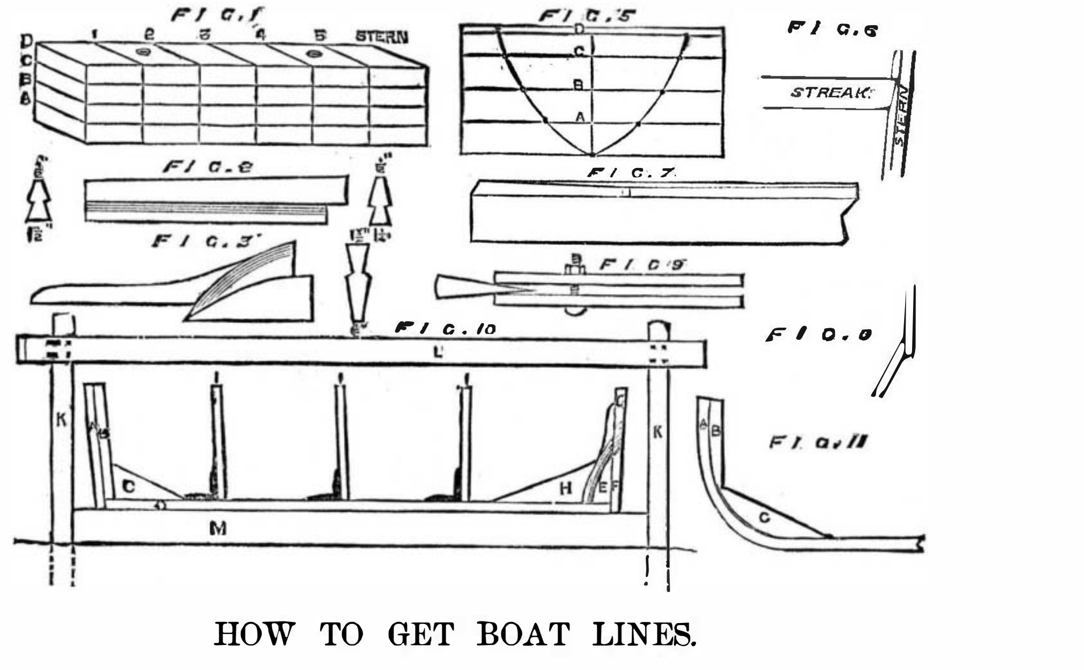
HOW TO GET BOAT LINES.

By R. COOPER, Parry Sound, Canada.

I WILL describe the method I adopted in building a clincher-built boat, 17 ft. long, 4 ft. beam, 2 ft. deep at head and stern, and 1 ft. 1½ in. at midship. Take four pieces of pine, 17 in. long, 2 in. wide, and ½ in. thick, dressed up quite true, glue them together, and put two screws through them to hold them together; divide the length into six equal parts, and draw a line square across the top at each division. Then with a square draw a line down the side from the end of each line on the top, take out the screws, and cut the model of half the boat on the side not marked. Then place it in water to soften the glue, and take it to pieces and dry it, then draw a line across the top of each piece from the lines on the sides, number the divisions, beginning at the stem,

1, 2, 3, 4, 5, and stern,
1⅜ 1⅞ 2 1⅞ 1⅝ 1⅛ in.,

as Fig. 1. My model was the respective breadths given under each number of divisions. The joints where the pieces come together and the top may be marked A, B, C, D. The model is made upon the scale of ½ in. to the foot. The first thing to make is the keel. This may be made in different ways; it may be made of a board any breadth required, and tapered off from midship to both ends, in which case the edges are worked up so as to nail the strakes to. The keel proper is nailed on this board when the boat is finished, or it may be made out of a piece of wood placed edgeways, in which case a groove or rabbet is worked out on each side to nail the first strake to. The stem is made from a piece of wood, 3 in. by 2 in. at top, and 4 in. by 1½ in. at bottom (Fig. 2), with a rabbet on each side for the ends of the strakes to fit into, and a piece taken out at bottom to fit on keel. The stern-post is made from a piece of wood, 2 in. thick and 5 in. wide at bottom, and 2 in. wide at top (Fig. 3). A rabbet is taken out at each side for the ends of strakes to fit into from the bottom to the part where the stern-piece fits on to the stern-post. The stern-piece is cut out and nailed to the stern-post, the shape being taken from the model. A piece is taken out of the bottom of stern-post, and stem and stern are nailed to keel. A 1 in. or 1½ in. board is firmly fixed edgeways on the ground, and the keel firmly fixed on the top edge with screws, the stem and stern being firmly fixed in a perpendicular position. Divide the keel into as many parts as you have in the length of the model, and make a mark square across. To make the shapes or templates to give shape to the boat take a piece of board for each template, and lay off three parallel lines, the first 6 in. from the bottom edge of the board, and the others 6 in. apart; mark the lines A, B, C. Draw a line in the center of the board perpendicular to the bottom edge. Take the model apart, and measure with a pair of fine compasses and scale the width of the model at line No. 1, at joint marked A; transfer this distance in inches to line A on the board on each side of perpendicular line, and make a mark; then measure the width of second piece, marked B, and transfer this to line B, and mark as before; then measure the top side of third piece, marked C, and transfer it to line C, and mark. Repeat this with each of the other sections and stern, then put the model together and measure the flat side opposite each division and set it off in inches on the perpendicular line of each template, and mark; draw a line parallel through this mark and mark it D; set off on this line the widths at 1, 2, 3, 4, 5, and stern, and mark these places on the line; draw a curved line through the marks of the lines on each template, and cut by these lines; a piece of whalebone, a thin lath, or a piece of stout crinoline wire is convenient to draw the curves with. The templates are numbered to correspond with the divisions on the model, and are fixed with an iron angle or otherwise to the keel on the line corresponding with their numbers, and are firmly fixed with stays. It is very important that the center of stem, stern, and center line of the templates should be in a line; it is obvious that the model may be divided into any number of divisions that is convenient, or if a carvel-built boat is required a division may be made for each rib. If greater accuracy is required the model may be made with 6¼ in. pieces instead of 3½ in. pieces for the three lower pieces, and the lines 3 in. apart on the templates. The midship section or template may be divided into a number of unequal parts on the outer edge, according to the number of strakes. Where the section is flat they may be wider, where round narrower. The stem and stern may be similarly divided. Now take a lath and fix it on the marks at stem, stern and midship, and mark the edges of the other sections. This will give you an idea of the width and shape of the strakes. To get the shape of the strakes get a thin board about 3-16 in. thick, 6 in. wide, and 12 or 14 ft. long. This is called the curve board. Also a piece of wood 1 in. square and 12 or 14 ft. long. Chalk the curve board and rub it down with a cloth; lay it on the boat where you require the strake; being light it will easily bend and fit. Fasten it with clamps, then mark with a pencil along the edge of the keel or strake, as the case may be, inside. Take off the curve board, lay it on the board from which you intend to cut the strake, pencil mark on top; provide a number of bradawls, and put them through the center of the 1 in. lath, about 15 in. apart. Lay the lath on the curve board close to the low side of the pencil mark, and stick the bradawl through the curve board into the wood to form the strake, bend the lath to the line, and stick the other bradawls through until it is so fixed the full length, then pull out the bradawls from the wood and curve board, but leave them in the lath, place the curve board on one side, and stick the bradawls into the holes made in the wood; then, with a pencil, mark the opposite side of the lath to the line on the curve-board. This will give you the shape of the strake with one inch lap for nailing. Cut the other edge of strake according to judgment, cut out another piece the same size and shape for opposite side, and dress up. It is easier to put the strakes on in two pieces than all in one piece; if done in this way the piece at stern must be put on first, say two-thirds the length of the boat. The end of the strake must be fitted into the recess formed in the sternpost, then cut the other end square off with a fine saw, lay on a try square and mark with a pencil the width of the blade on the outside of the board, with a broad firmer chisel cut off from this mark to an edge on the opposite side of the wood, thus forming a wedge-shaped splice. Make a pencil mark 1 in. from the top edge on the outside, and another 1 in. from the bottom edge inside; with a spokeshave dress off the top outside edge at stern from the line to the opposite edge, coming off to nothing about 18 in. from the end of the board (Fig. 5). The next strake will have to be dressed off in a similar way at the bottom to fit on this. These two pieces may now be steeped in water, steamed, or put on as they are—it is best to steam them; if not convenient, steep them in water as long as you can, then fix and nail them in their places; get the forward part of the strake in the same way, making them a little longer than required; fit the front end to the stern. In fitting the end of the strake bevel to fit the stern rabbet make the bevel greater than apparently necessary, as it is reduced in bending (Fig. 6). Fix the strake in its place with clamps, and make a mark across where the other piece of the strake joins it; take off the strake and lay the blade of the square close up to the line, and draw a line on the other side of the blade. Cut off by this line, and with a broad chisel cut off the wood from this line to the opposite edge of the board. If carefully done this will make a good splice; it may be nailed with 1 in. nails. Make lines 1 in. from the edges, as in the first place, and dress off top edge same as for stern. In making the next strake let the splice be one-third from the stern, so that the splices cross each other; proceed thus until all the strakes are put on. In the parts where the mould of the boat is nearly straight nothing will be required to be done, but where it is round the outside of the lower strake is to be dressed off (Fig. 7) with a spokeshave, to get the necessary shape, how much or how little may be judged from the edge of the template. Nothing is to be taken off the top strake at bottom edge, but at the ends where the two boards are fixed to stem and stern. A useful kind of cramp for boat building may be made of two pieces of hard wood, 1 in. thick, 2 in. wide, and 14 in. long; a ½ in. hole is bored through 6 in. from the end, and a ½ in. bolt put through long enough to give a little play, 3½ in. or 4 in. long, and a wedge to drive in between them to tighten them up (Fig. 9). Having got all the strakes on, take out the templates, and fit in the ribs, which may be made of oak, ¾ in. wide and ½ in. thick. These may be steamed and bent into their places and nailed fast, putting the nail-heads outside. Take two strips of wood, 1½ in. or 2 in. wide and ½ in. thick, nail one outside the top strake along the gunwale, the other outside upon the top of the ribs. On each side of the boat a solid block must be inserted where the rowlocks come, and an iron plate put on with a hole in it for the rowlock to drop into. This hole may be 12 in. abaft the after edge of the thwart. Next, the rising, which is a piece of wood 1½ in. wide and ½ in. thick, nearly the length of the boat, is fixed inside and following the gunwale of the boat, and about 5 in. below it for the thwarts to be fixed to. It is nailed to each rib, and the thwarts are laid upon this, and are long enough to butt against the strake on each side. A knee is put in at each end of the thwart, butting against the strake and coming 6 in. on the thwart. It is now ready for the ceiling or floor, which consists of one board down the middle, 6 or 8 in. wide in the middle, and tapered off at each end to fit the boat. To make it lie level and firm cleats are nailed on the underside, across it, and aboard, sometimes two boards, nailed on each side of it. They are 3 or 4 in. wide, and ½ in. thick. The center one is left loose. I have used cut clout nails 1, 1¼ and 1½ in. long, heads outside, and clinched inside, 2 to 2½ in. apart. If found brittle they may be softened by putting in the fire and left till the fire goes out. A convenient steaming box may be made of four boards, 1½ in. thick; two may be 12 in. wide, and the others 4 in. wide. The narrow ones may be firmly nailed between the others, forming a box, any length required, 4 in. by 9 in. One end may be nailed in, the other fit loose, or, when steaming, a tuft of hay may be put in to close the end. Get a kettle and fit a wooden lid to it tight. Make a hole in the center, and fit a wood pipe in it. The other end of pipe must be fitted to the underside of box. Bore a hole in the lid and fit a plug, place the boiler under the box a little way from the ground, put in water and insert the plug. Make a fire under, and when steam is up put in the article and close the end until steamed sufficiently.



HOW TO GET BOAT LINES.

The stem is sometimes made of two pieces. That part to which the ends of the strakes are nailed is called the apron, and is sometimes made separately, and nailed to the stem proper. There are two blocks fitted into the angle of the stem and keel, and stern and keel. These are called respectively the stem dead wood and the stern dead wood (Fig. 10). When the apron is made separately the dead wood is fitted up to the stem, and the bottom of the apron fitted upon that; but if the stem and apron are made from one piece the dead wood is fitted to the apron. It will be easier for an amateur to fit the dead wood in after one or two strakes are on. The stem can be made curved, if required, instead of straight, in which case it is better to make the apron separately, as shown in Fig. 11.

I have lately seen a very light canoe, 14½ ft. long, 30 in. beam, 12 in. deep, stem and stern, carvel built, with a very flat bottom, no keel except about 2½ ft. or 3 ft. from stem and stern, the sides cambered in at midships. The ribs were 6 in. apart, the strakes were ⅜ in. or ¼ in. thick, as near as I could tell, and were put on in three strakes on each side, nailed to the ribs where the strakes joined. A piece of wood, 1 in. wide and ⅜ in. thick, was fitted in between the ribs along the joint, and nailed along the edge of each strake. The stem and stern were made like a wedge, and the strakes were carried beyond the edge and nailed together. A narrow iron strut was carried along the joint, and 2 ft. under the keel a good block was put in at bow and stern about 2 ft. long, and four stays fixed across from gunwale to gunwale. A 1 in. half round bead was fitted round the gunwale.

References to letters in Figs. 10 and 11. A, the stem; B, the apron; C, bow dead wood; D, keel; E and F, sternpost; G, sternpiece; H, stern dead wood; I, templates; K K, posts; L, scantling to stay to; M, the stocks. The dark lines in Fig. 10 are angle-irons to fix template to keel.—*English Mechanic.*

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