

A HALF MODEL OF THE "GENERAL SHERMAN," SHOWING THE INTERESTING DETAILS OF A GOVERNMENT TRANSPORT. QUITE TEN THOUSAND PIECES WENT INTO THE MAKE-UP OF THIS MODEL

Ship Building in Miniature

Important Part That Models Have to Play

By Robert G. Skerrett

(Photographs copyrighted by the Keystone View Co.)

SHIPYARDS on the waterfront are matters of commonplace, but a marine construction plant tucked away high above bustling thoroughfares is, indeed, something of a novelty. And yet, in a tall loft building on lower Manhattan, in Greater New York, is an establishment where all kinds of craft that float, from small boats to superdreadnaughts, are turned out complete in every detail.

More than that, there is no other shipyard in the whole country boasting departments enough to supply on the spot, as the concern in question does, the multiplicity of things needed from the time of the laying of the keel until the fluttering colors at masthead and peak indicate readiness for service. True, the vessels produced are not designed to defy storms and to force their way onward against pounding seas, but in their way and field of usefulness they are not dissociated from their water-borne kindred that do battle with the changeful elements. Lest the foregoing mislead, let it be said that we are speaking of nautical models, of the naval architects' creations in miniature.

Popularly, the model of a ship is looked upon more often than otherwise as an expensive toy—a plaything in a measure that may be extremely ornate and decorative but in no wise of practical value. The gentry that count their pennies over carefully are prone to ask, "What's the use of the thing?" And then positively dismiss the matter with the vocal protest, "All a waste of money!" For the sake of those likely to be influenced by this hasty attitude, it might be well to go back two or three centuries for a start and then trace

the evolution and the reason for being of miniature replicas of ocean-going craft of all sorts. We shall see that the utilitarian impulse has played a prime part for a long, long time while in their fabrication.

In the days when the British Admiralty was first busy upbuilding the nation's sea might, in the generations gone when the naval architect boasted no more exalted title than master shipwright, the authorities would have thought they were tempting Fate to start the building of their "oaken bulwarks" without some concrete evidence of how their frigates and their line-of-battleships would look when finished. Indeed, they would hardly have known how to carry on correctly the work of construction unless guided by a model in detail. It was this practice that brought into being the myriad models that now adorn the home of the Admiralty and certain British museums. These miniatures were for a considerable period the basis of such plans as were prepared, and furnished certain information of their own by which the ship carpenters and the shipwrights of those days could visualize just what they were expected to do.

To this end, little was left to the imagination, and a deal of painstaking care was exercised in developing on a much-reduced scale every important structural feature. Therefore, the outside planking on one-half of the hull below the waterline was pretty generally omitted so that the frames, the keel, the keelsons, the floors, the deck beams, etc., could be seen in their true relation to one another, and each with its distinctive shape agreeably to its position in the complex



CHECKING UP THE HULL CONTOURS WITH A TEMPLATE REPRODUCED FROM THE BODY PLAN



FORMING THE MASS OF "BLOCK" FROM WHICH THE HULL OF A MODEL WILL BE WORKED



PUTTING THE FINISHING TOUCHES ON THE MODEL OF A CONVERTED YACHT WHICH PLAYED A PART IN THE WORLD WAR



PAINTING WAR TIME NAVAL MODELS—ONE OF OUR BIGGEST SUBMARINES AND AN UP-TO-DATE DESTROYER

framework. On the other half, the planking would possibly be complete from the keel to the upper limits of the hull. And thus the "lines" or contours essential to flotation and relative ease of propulsion under canvas could be measured and reproduced on the mold-loft floor so that the man with the broad-ax might fashion his timbers for the full-sized vessel.

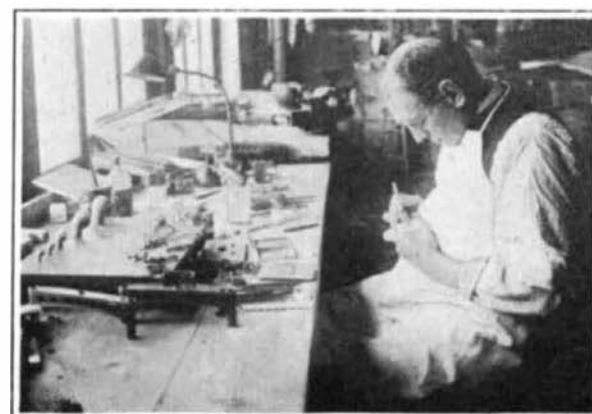
The model maker was a product of the period and, as often as not, was a qualified shipwright who possessed special skill in the handling of refined tools. He would take his block of wood or materials and lovingly and patiently work them into shape—grace of line and accuracy of detail being the result of an experience which made him familiar with the body forms which would give adequate speed and seaworthiness. At a later date, as a knowledge of interpreting drawings grew, the advance model became a simpler product, because the shipworkers were not so dependent upon miniature details. It was then sufficient to supply a solid half model, showing the outer aspect of the bare hull from stern to stern and from the keel up to the exposed decks. From these half models, the men of the mold-loft developed the lines and contours of the craft's body, and, so guided, the woodworkers fashioned templates or patterns for the multiple elements of the structural framework.

These half models were fashioned out of a built-up block composed of successive layers of wood of equal thickness held together by dowels, the meeting surfaces of two contiguous "lifts" representing a waterline at a definite point above the keel. After the block had been cut and chiseled into the desired form, then it was an easy matter to take the model apart, layer by layer, and transfer each waterline to paper. With this done, the ship carpenter could readily check off the dimensions at every point on the hull and make the full-sized part in accordance. With these half models as basic records, and with the knowledge of how the actual craft later performed, the designer of those days was able from time to time to effect improvements despite the fact that his proce-

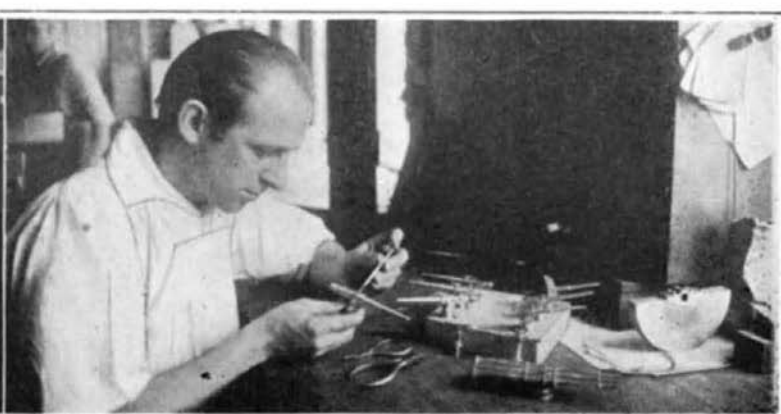
dures was so largely a matter of "rule of thumb." Native cunning and intuition, a cultivated appreciation of "sweetness of line" through feeling, and a keenness of eye made the model then a potent aid in the building of ships.

As the science of naval architecture advanced, the designer was inclined to belittle the value of models, and, because of his wider knowledge of mathematics and the technical development of graphics, he came to rely wellnigh entirely upon paper and pencil. During the prevalence of this attitude many disappointing vessels were put overboard, for somehow either the lines were not faithfully reproduced in the yard or, if they were, they disclosed the fact that the man originally responsible for them could not visualize the consequence of his choice. It is a rare mind that can picture the third dimension from lines that symbolize only length and breadth, for instance. It was inevitable that shipbuilders should come to realize that much might be gained by combining the stories to be told by both drawings and models. This was quickly emphasized when iron, and, later, steel more and more took the place of timber in the fashioning of waterborne craft.

The modern ship, whether naval or commercial, is made up of assembled plates, angle bars, and beams of steel. Knowing as the ship designer does today how much may depend upon a vessel's form in the matter of speed, and the propulsive effort needful to attain it, mere drawings, with all of their elaborateness, are no longer accepted as conclusive. Therefore wooden models are made not only for testing in towing tanks but others, scaled usually to a quarter of an inch to the foot, are produced to facilitate certain essential calculations and to enable the "office" to order the hull plating, etc. Naturally, these models must be fashioned with precision, for any error would be multiplied forty-eight times in every foot of the intended craft. The models also serve to give the designer a three-dimensional appreciation of his problem and aid him in securing that balance of



THE METAL FEATURES OF A MODEL REQUIRE THE SKILL OF AN EXPERT MACHINIST



THE MINIATURE GUNS OF OUR FIGHTING CRAFT MODELS ARE WONDERFULLY COMPLETE IN THEIR OUTWARD DETAILS

mass and features essential to strength, correct functioning and appearance.

As experience has taught us, it is not difficult to draw a circle and to say that it represents the outline of a globe, but it is quite different to decide from that figure just how to proportion and to shape a single piece of material that can be bent or pressed into the form of a sphere. Of course, if you have a ball upon which to fit your pattern a little practice will enable you to do the trick. The external plating of a vessel is the skin that must conform to the changing lines and contours dictated by the underlying steel ribs or frames, and this plating, in multiple units of divers forms, must be ordered in advance of construction.

A properly-scaled wooden model of the hull of the craft to be, with sandpapered unpainted surface, is turned over to some of the drafting force, who indicate on the bare pine every plate from bow to stern and from keel to sheerline. It is then a relatively easy task to take off the "expanded" dimensions of curved surfaces and to give their measurements as flat plates. These figures are then sent to the steel mills where patterns are made and the plates are cut accordingly. Later, when they reach the yard, these parts are heated and hammered or otherwise bent to fit. By means of the wooden model and the advance measurement of materials which it makes possible, the naval architect computes what all of this steel will weigh, and this enables him to determine the ultimate displacement of his craft and to estimate pretty closely some of the costs.

Subsequently this bare model of the hull is carried a stage further and some of the dominating deck features, etc., are put on. If a fighting ship, this procedure is very desirable because it enables the designers to determine quickly the possible angles of fire of guns without inviting interferences with other necessary structural parts. In short, it gives positive information about interrelated characteristics and makes it practicable for the naval architect to avoid mistakes that may later on entail heavy outlays to correct. Similarly, in the cases of merchant and pleasure craft, by following much the same course, vessels can be planned confidently so as to insure a maximum of comfort to passengers and convenience to the personnel operating them.

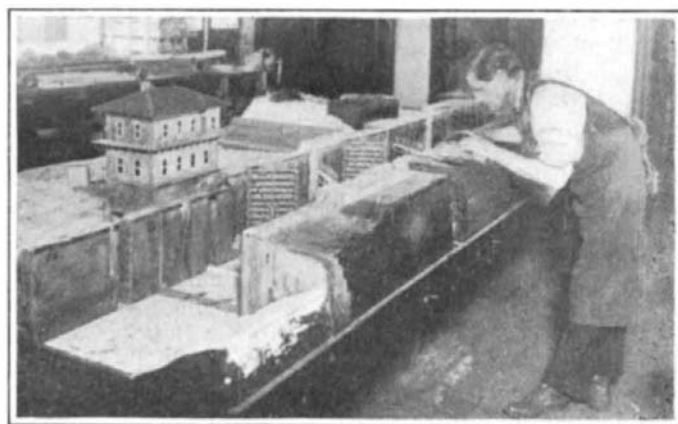
It has been the custom wellnigh since the birth of our modern navy to employ models of the foregoing description and, after they have served the designer's purpose, to complete them and finish them outwardly as miniature replicas of their service kin. The object has been twofold: first to record thus in the most expressive way the development of our battle fleet and the gradual growth of the distinctive types of war craft—the adoption of a uniform scale of a quarter of an inch to the foot facilitating accurate comparison in the matter or sizes. For some years, all of these models were made at the Navy Yard, Washington, D. C., but now some of them are being built at the plant in New York City over which Mr. Horace E. Boucher presides. This expert—one may rightly say of this artist—was for a number of years in charge of the naval model shop in the National Capital; and his establishment in Manhattan is probably the largest and best equipped plant of its kind in the United States.

As the illustrations accompanying this article indicate, Mr. Boucher makes more than marine models, but the purpose of all of these creations is to supply the element of the third dimension and to permit both the technical and the non-technical observer to visualize the relations of things and to get a sense of proportion. The habit is strong with all of us to query, "How does the thing work?" It is the survival of our earlier days when we wanted to pry into a watch or clock to see the wheels go round. The picture of the longitudinal section of the army transport "General Sherman" shows that it is possible to get speedily a comprehensive grasp of the whole interior of that vessel and to see to what purpose the various compartments and sections are devoted.

An examination of the model, itself, gives a still greater wealth of structural data—details that reveal just how much thought must be given to the planning of a ship so that every department may serve its end to the best advantage and that all available space may be put to good account.

But we cannot flatter ourselves that we have been the pioneers in helping the rightfully inquisitive to learn through such mediums about the internal get-up of full-sized vessels. As a matter of fact, we have not carried this educational work anything like as far as wisdom would suggest. Whether we like it or not, the Germans have led by a long way in this realm of enlightenment. Sixteen years ago, our naval attaché at Berlin informed us that all of the Kaiser's warships were furnished with skeleton models for the instruction of their personnels. The German Admiralty recognized that it was very desirable that everybody aboard a fighting ship should be familiar with every phase of its construction and equipment. The Teutons did this because they were aware that drawings and blueprints are not readily understood by the sailors and that even the officers frequently found it hard to grasp their meaning.

Further, the interior of a ship is a complex network of compartment and lesser subdivisions, and many of these are isolated from one another so that a man in one space cannot step readily through a door into a neighboring one and thus



A MODEL OF THE TROY LOCKS OF THE NEW YORK STATE BARGE CANAL

get an understanding of their degree of association. He must travel up a ladder, through a hatch, and possibly around a number of obstructions before he can make his way down into a near-by compartment—confusing the while his sense of relationship. The skeleton model, on the other hand, which permits deck after deck to be lifted off and allows the observer to see successively just how a craft is fashioned and is interdependent, makes it feasible for all but the utterly stupid soon to master every essential detail of his ship. The Germans did not hesitate to promote this knowledge by supplying models costing anywhere from \$500 to \$2,500.00.

The same naval attaché was later ordered to the Asiatic Station to command the U. S. Monitor Monterey; and it was not long before it was impressed upon him that it was very desirable for him to know his ship in the fullest sense of the term—to be familiar with the positions of all watertight compartments, the arrangement of the double bottom, and the leads of a multiplicity of pipes having to do with safeguarding against disastrous leaks, the proper ventilation of out-of-the-way areas, and the distribution of motive steam—not to mention that network of nerves in the form of electric wires and conductors. For \$110 in gold he got three Chinese carpenters to build him a beautiful and exact demountable skeleton model of the Monterey; the ingenious Orientals using the simplest of materials to fashion the miniature—cunningly requisitioning macaroni to serve for piping and valves, and

coloring each of these to indicate the particular system to which it belonged.

At the U. S. Naval Academy, models of vessels have played their part for years in the education of our midshipmen, and by them our embryo admirals have been able to comprehend technical features and operative procedures which otherwise might have puzzled them sorely. The array of full models and the still more numerous half models there tell their own story of how our naval constructors in the decades gone have felt their way before risking the nation's funds in the building of the actual craft. Finally, the so-called handsome display models generally built by the Bureau of Construction and Repair of the Navy Department have proved of the utmost value in bringing vividly home to our inland citizenry an understanding of our fighting fleet—thus serving to promote a necessary interest in our seagoing defenses and to stimulate enlistment.

Big steamship companies are fully alive to the psychological appeal of a miniature replica of their passenger craft, and all of them know that the thousands of dollars expended in this way are richly repaid in patronage. Foreign lines have been especially shrewd in thus reaching first our imagination and next our pocketbooks. A third reason for ship models is a sentimental one; and this is apt to grip strongly the yacht owner. It yields him no end of quiet delight, when the days of cruising are halted and his craft is hibernating in some snug harbor, to look upon the little model and bring to mind vividly every detail of weeks and months of enjoyment and to arouse again the fascination of measuring strength with fickle winds and treacherous seas. A picture would only give a small part of this satisfaction because of the flatness, the two dimensional character of the mediums of expression. The model, on the other hand, he can scan from all angles and revel in an ever-changing point of view.

In building the "block" of a model seasoned white pine of the finest sort is used. The block is formed up of a series of planks so wonderfully smoothed that their surfaces come together throughout, and, under moderate pressure, exclude the air. As a result, the thinnest film of glue is essential to establish a vacuum and to bind the successive layers or lifts into a single mass. Before they are united in this fashion, the contours are traced in pencil upon the planks, and frequently the lifts are sawed approximately to shape. Next, the woodworker cuts away the pine carefully until the penciled contour at each waterline is brought to light, and then he clears away the material between neighboring water lines, checking up the body form from time to time by little templates of the different curves at prescribed positions, usually from keel to deck upon definite frames. When the lines are true in every particular, the skin surface of the hull is smoothed to a nicety by sandpapering.

While the woodworkers are busy at their respective tasks, the metal-workers are engaged in fashioning with amazing fidelity to detail a varied array of fittings and equipment. With infinite cunning they call into being mooring bits, hawse pipes, davits, boat cranes, windlasses, winches, searchlights, guns, ventilator cowls, smokestacks, anchor chains, etc. In many respects their products call for manual skill greater than that of the jeweler. A few of these features can be cast, but many of them have to be wrought by lathe or patiently created by tool, blowpipe, and the smallest of soldering irons. For the most part brass is the basic metal; and if the full-sized replica is of brass, then the fitting is polished and plated with gold to hide the traces of solder. Nickel plating coats the fittings that would be of polished steel or nickel in the full-sized craft; and tinning is the model's substitute for galvanized-iron equipment.

But before the metal features are placed upon the model, the hull, superstructure, deck houses, etc., must be colored in perfect accord with their corresponding portion of the full-sized vessel. Some idea of the painstaking work entailed can be gathered from the fact that the hull may receive anywhere

from five to eight coats of paint, and each coat is rubbed down before the next is applied. Ultimately the miniature is varnished, and this, too, is rubbed and rubbed until it is impossible to detect the slightest trace of brush stroke. With the body of the wee craft ready for its fittings, then these are put in place with precision, and the care exercised must accord with a scale that crowds into only a quarter of an inch the equivalent of twelve inches. A few hairbreadths of error might spoil the interrelation of a number of features. Finally, masts are stepped, stays, signal yards, and running rigging are set or rove. Tiny boats are fixed in their chocks or hung at the davits—the blocks and falls faithful in every particular. No wonder, some models may be composed of 10,000 or more pieces, for neither Mr. Boucher nor a knowing critic would be satisfied if anything were missing or if any fitting seemed lacking an essential working detail.

The layman should not be astonished to learn that it takes the joint efforts of a considerable force of expert craftsmen and weeks and months of continuous work to produce a complete display model. The determining factors are the size of the real vessel and the variety and number of her characteristics and equipment. The so-called miniature may be but a few inches long or, in the case of a dreadnaught or ocean greyhound, may measure from bow to stern from 12 to 20 feet. The cost of these beautiful productions runs from \$300 up to \$12,000 or more.

DEMONSTRATION COAL MINES.

By J. J. RUTLEDGE,¹ McAlester, Okla.

THE United States Bureau of Mines established at Bruceton, Pa., in 1909, an experimental mine for the purpose of testing the means of preventing and limiting mine explosions. During the last ten years, numerous explosions have been caused to originate in this mine for investigative purposes and the rate of propagation of the explosion wave, the pressure developed per unit of area by the explosion, and the general results of the explosions have been carefully recorded and studied. Means of preventing mine explosions or of limiting them to the areas in which they originate have been developed. A great deal of valuable information has been derived from the work in this mine and much more useful and valuable information will be obtained in the future. The writer would plead, not for the opening of experimental mines in all the important coal-producing fields in the United States, but for the opening of demonstration mines, or mines in which experiments could be made with the various details of coal mining.

Owing to competition in the same markets, small capitalization, or low profits, it may be an utter impossibility for any one company to try a new method of mining. Labor conditions may prevent the trial of a new method of working. It may be impossible or inadvisable to disturb existing working conditions for fear of causing trouble among the miners through real or fancied changes in the scale of wages.

If a certain method or plan of working had been shown to be the safest and most efficient, public opinion would force coal operators to adopt the new methods of working, if they did not do so voluntarily, and public opinion would also furnish moral support to the operators in overcoming any opposition that the miner and other employees might manifest toward the installation of the new and better method.

If a new method was found to be safer and more economical than the one in use, the authority of the state could be invoked to support any operator who desired to adopt it. Very few coal-mine operators would dare run counter to public opinion, even were they to ignore the financial benefits to be derived from the adoption of the new plan. Compensation insurance companies, through their mine inspectors, would give credit to those mines that adopted the new methods with the result that their liability insurance would be materially reduced in cost.

¹Mining Engineer, U. S. Bureau of Mines.