THE NEW 110-TON GUN.

The 110-ton gun now undergoing its firing proof at Woolwich must be regarded as a fine specimen of the most recent practical achievement in very heavy guns. It is true that Krupp has supplied four ordnance of 118 tons to the Italians, but the power of guns does not depend entirely upon their weight, and we believe that our piece has already shown itself superior to its German rival, by delivering a heavier blow than any which has yet been given, as far as our information goes, although the heaviest charges have not yet been fired from the English gun.

To lay before our readers the plan on which the power of a heavy armor-piercing gun is estimated, and how it may happen that a comparatively light strong gun of good design may be superior to one of heavier metal, we may compare the gun now under trial with the four 100-ton R.M.L. guns purchased by our government in 1878 from Sir W. Armstrong & Co., when the famous £6,000,000 was hurriedly voted for war stores. These four guns are now mounted on the fortifications of Malta and Gilbraltar; but although only a few years have elapsed, designs have so changed that the new gun is intended to fire double the charge of the older piece, and the energy of its blow is expected to increase in almost the same proportion. We will explain how this has been accomplished. The 100-ton guns were made of coils of wrought iron, the inner tube only being of steel. The latter was made in two parts joined together, the junction being sealed by a so-called gas ring, as, at that date, there was a difficulty in procuring the long tube in one length of steel, and this was an undoubted weakness in the design. The new 110-ton gun is entirely of steel, and the inner tube is made in one piece by the firm of Sir J. Whitworth & Co., on the same principle as the propeller shafts for steamships.

A striking difference between the two designs is the proportion of the weight of projectile to that of the gun. In the 100-ton gun, with a projectile of 1,968 lb., the ratio is 1 to 113·8; while in the 110-ton gun, with a projectile of only 1,800 lb., the ratio is 1 to 137·5. We thus see that in the new system the projectile is lighter by some 17 per cent, in proportion to the weight of the gun, than in the older design. This change has been made in order to attain the present high muzzle velocity of over 2,000 ft. Since the effect of the blow, or the "energy" of a projectile—expressed mathematically by $\frac{Wv^2}{2g}$—depends directly on its weight, but varies with the *square* of the velocity, an increase of velocity is more important than an increase in weight. Thus, for example, suppose a projectile of 100 lb. moves at a velocity of 1,000 ft. per second, it will deliver a certain definite blow. If its weight is doubled the energy will be doubled, but if its velocity is doubled the energy will increase fourfold. Consequent on the reduction of the weight of the projectile, there is a reduction in caliber from 17·72 in. in the 100-ton gun to 16·25 in. in the 110-ton gun. The energy of the 100-ton gun projectile is 32,700 foot-tons. The greatest yet attained by that of the 110-ton gun was 53,895 foot-tons, but as much as 62,000 foot-tons is expected to be reached.

Some idea of the work or energy impressed on the shell may be given from the fact that the ship for which the new gun is intended, the Benbow, of 10,000 tons, could be raised upward 5·39 ft. if the same amount of work (53,895 foot-tons) were employed for that purpose; or we may, perhaps, give a better comparison by stating that the Benbow must steam at a speed of 10·5 miles an hour to inflict a blow with her ram having an energy equal to that attained by the projectile of the new gun. The disastrous and fearful effects of large vessels ramming at speed, when provided with strong bows, are well known. A considerable change has been made in the amount of capacity, on which depends the utilization of the effects of the combustion of the powder charge. In any gun, if the charge is increased, the energy of the projectile will not increase to the same extent, unless the interior capacity of the gun is also increased.

The projectile should not only receive pressure, but the pressure must act over a considerable distance. In other words, the greater number of times the compressed gas produced on explosion is allowed to expand in the bore, while at the same time it presses on the base of the projectile, the greater will be the energy imparted to the projectile. The same principles are involved as in the expansive working of steam. The greater the number of expansions allowed, whether in one, two, or three cylinders, the greater work will be performed by a given amount of steam under a given pressure. The object of the gun designer is, therefore, to increase the interior capacity of the piece as much as possible; but, as we have already seen that it is desirable to reduce the caliber, additional capacity must be obtained by increased length. The bore of the 100-ton gun is 363 in., while that of the 110-ton gun is 487·5 in. in length. An increase of capacity is also given by enlarging the diameter of the chamber or part allotted to the charge. In the 100-ton it is 19·7 in., while the bore is 17·72 in., but in the 110-ton gun this difference is much more pronounced, the figures being respectively 21·12 in. and 16·25 in.

It should be stated, however, that increase in the diameter of the chamber imposes a greater circumferential stress on the metal of the gun, for the same reason that water under pressure in a tube may burst it if the diameter is large, but it will not do so if the diameter is smaller, although the thickness of the metal is the same in each case. The strength of the new steel gun is, however, sufficient for the increased stress imposed by the enlargement of the powder chamber. The total capacities of the old and new gun are respectively 90,700 cub. in. and 112,600 cub. in., and we have dwelt at some length on this point, because of the importance of the principles involved. Four rounds have already been fired from the 110-ton gun, with charges of 600 lb., 700 lb., and 800 lb., on February 10, and 850 lb., on February 16.

Westphalian prism brown powder has been employed up to the present time, and the velocities attained have been satisfactory (from 1,685 ft. to 2,078 ft.). With the highest charge yet employed, the maximum pressure has been as much as 18¾ tons on the square inch. This, however, need cause no surprise. It merely indicates that a slower burning powder should be employed when very large charges are fired. As the volume of the powder chamber is a constant, it follows that when the charge is a small one a certain amount of "air space" is left. This serves to receive the initial expansion of the gases produced on explosion, and lowers the maximum destructive pressure, while, at the same time, some useful effect on the projectile is lost. On the other hand, when a large cartridge is employed, the air space is diminished, and the maximum pressure rises considerably. It is desirable that the pressure should never rise to a very high maximum, but that it should be well sustained. Hence it is possible that one description of powder might give good results when a small charge is used, but a slower burning powder might be employed with advantage when the charges are large.

We give herewith a longitudinal section of the gun, and diagrams in plan and elevation of H. M. S. Benbow, for which the 110-ton guns are intended. These show the method of barbette mounting. The central part only of the vessel is armored, and the ends of the vessel are protected by an armored deck below the water line. The four guns of 118 tons supplied by Krupp to the Italians are of crucible steel, the caliber (15·75 in.) being even smaller than that of our 110-ton guns.

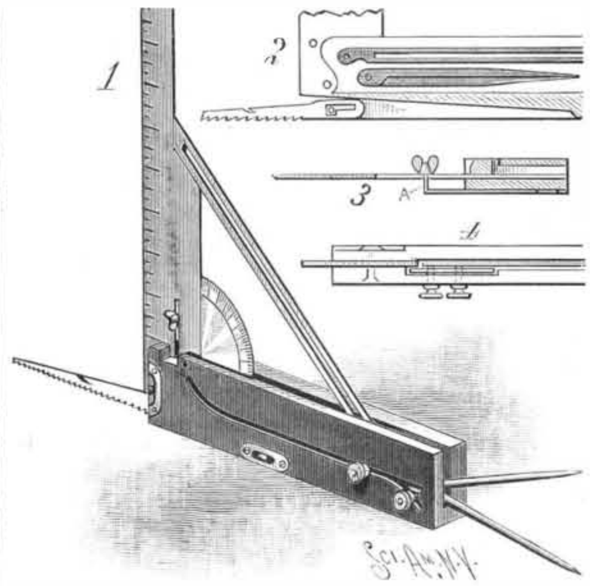
The greatest energy yet attained, of which we have information, is some 50,700 foot-tons, with 864·67 lb. of powder and a projectile of 2,028 lb., with a muzzle velocity of 1,900 ft. per second. It thus appears that although the Krupp gun is heavier than ours, and has employed a slightly larger charge than any yet fired in England, the muzzle energy attained by its projectile is somewhat less than that impressed upon the proof shot of the British gun.—*Industries.*

Carbonic Acid.

The manufacture of liquid carbonic acid is now an important industry in Berlin, where, according to *Industries*, a company established for this purpose are making daily over half a ton of this commodity. The acid is sent out in steel bottles, each containing from 17 pounds to 18 pounds, and the price charged is a little under 1s. per pound. The acid contained in a bottle when expanded into gas occupies over 10,000 cubic feet. It is principally used in the manufacture of mineral waters, and for beer engines. An important use of carbonic acid was suggested as early as 1879, by Dr. Raydt, of Hanover, for the raising of wrecks, who demonstrated the possibility of this application by an experiment at Kiel. The apparatus consisted of a steel bottle containing the liquid acid, and a collapsed canvas bag placed over the neck of the bottle. When the whole is submerged, and attached to the object to be raised, a cock is opened, and the liquid in the bottle is allowed to expand into the bag, inflating the latter, and thus causing it to rise. Another application was introduced by Herr Krupp, of Essen, for compressing liquid steel, and a large plant for the production of liquid carbonic acid has already been at work for some time at the Essen factory.

COMBINATION TOOL FOR SQUARING, LEVELING, ETC.

The engraving represents a tool which has been recently patented by Mr. David W. Warnock, of Lexington, Ky. The tool may be used for squaring, leveling, plumbing, centering cylinders, laying off angles, starting a saw kerf for cutting a keyhole, and for cutting lace leathers for belting. In one edge of the body is a groove, held in one end of which is a square blade which is cut away at an angle of 45° upon its inner edge, to form a beveled shoulder for receiving and supporting the end of a slotted bar, when in the position shown in Fig. 1. This bar is fitted in the slot, and is provided with a pivotal pin projecting through a second slot formed in the side of the body. This pin retains the bar in the body, while admitting of adjusting it in position for use or folding it into the body when not in use. The end of the second slot, near the blade, is curved toward the blade, and the opposite end is branched. In the main groove is placed a thin pair of compasses with a pivotal pin projecting through the side slot. When it is desired to use the slotted bar, the compasses are drawn forward into the branch of the side slot, and the pin of the bar is moved forward to the extremity of the slot beyond the branch, when the compasses may be pushed back entirely within the body. When the bar is folded over upon the shoulder, a left miter can be obtained; and when it is pushed



WARNOCK'S COMBINATION TOOL FOR SQUARING, LEVELING, ETC.

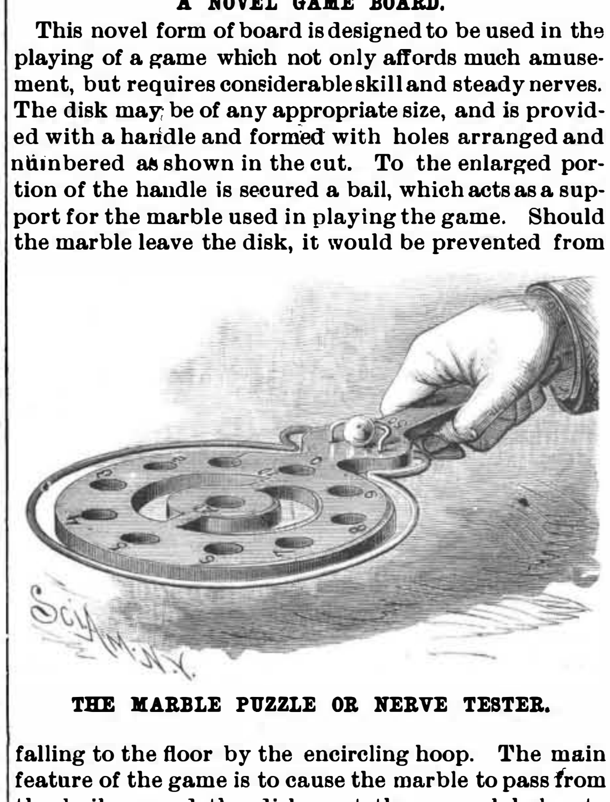
back in the slot to the angle of the body and blade, and then inclined outward at an angle of 45°, a right miter can be obtained.

Both right and left miters can be obtained without reversing or turning the square over. In the body is a cavity, into which the protractor may be turned when not in use. Fitting in a slot in the outer edge of the body is a keyhole saw, the inner end of which is slotted to receive a pin, as shown in Fig. 2. To facilitate the opening of the saw, its back is provided with a nick for receiving the thumb nail for lifting it out of its slot. In one side of the body, near the middle, and at one end, are secured spirit level bulbs, which are used for leveling and plumbing in the usual way.

In a transverse groove in one side of the body is a steel bar, A, Fig. 3, which is bent at right angles at its extremity toward the blade, and is formed into a knife having a shank projecting through a slot in the blade, to receive a nut for clamping the knife in any desired position in the slot. This knife is designed for cutting lace strings for belting, and is made adjustable, to admit of cutting laces of different widths. When not in use, the knife is moved into a notch in the edge of the body.

A NOVEL GAME BOARD.

This novel form of board is designed to be used in the playing of a game which not only affords much amusement, but requires considerable skill and steady nerves. The disk may be of any appropriate size, and is provided with a handle and formed with holes arranged and numbered as shown in the cut. To the enlarged portion of the handle is secured a bail, which acts as a support for the marble used in playing the game. Should the marble leave the disk, it would be prevented from



THE MARBLE PUZZLE OR NERVE TESTER.

falling to the floor by the encircling hoop. The main feature of the game is to cause the marble to pass from the bail around the disk, past the several holes, to and around the central hole, and back again to the bail. The marble should pass the holes marked with the lower numbers first, but if it should fall from the outer edge of the disk, or into either one of the two large inner openings, no count could be made. It is evident that the shape of the disk and the arrangement of the holes may be changed as desired.

This invention has been patented by Mr. C. E. Tranchell, of Willmar, Minn.

Proprietors and Foremen.

A correspondent of *Wood and Iron* asks what he shall do under the following circumstance: He says that he is foreman of a certain shop, but that he is foreman only in name. The proprietor, who, he says, has no mechanical knowledge, continually interferes with the men, giving them orders contrary to his directions. He asks our advice as to whether he had "better quit or kick him out of the shop." We have been, says the editor, in precisely that situation ourselves, and we think on the whole he had better seek "pastures new." Where a proprietor of that kind interferes in the management of the shop at all, he will continue to do it, and the less he knows about mechanics, the more he will interfere.

A little incident in the life of the late President Rutter, of the Lake Shore Railroad, may not be out of place as illustrating the relative positions of proprietor and foreman. When Mr. Rutter first became general baggage agent for the Vanderbilt system, he came upon a very knotty problem, and not knowing what decision to give, he went to Vanderbilt for advice on the subject. When he had stated the case, Mr. Vanderbilt turned to him and asked: "What salary do we pay you?" "Eight thousand dollars a year." "What do we pay it to you for?" "For acting as general baggage agent." "Well, do you want me to earn your salary for you?" Mr. Rutter immediately came to a decision, and never again troubled Mr. Vanderbilt with his conundrums.

SCIENCE IN TOYS.

IX.

THE TOY MICROSCOPE.

The world of the minute existing beyond the range of the unaided vision is little realized by those who never have had an opportunity of using the microscope. The beauty and perfection of the smaller works of nature can never be fully known through the medium of literature or art; the objects themselves must be observed by the student personally.

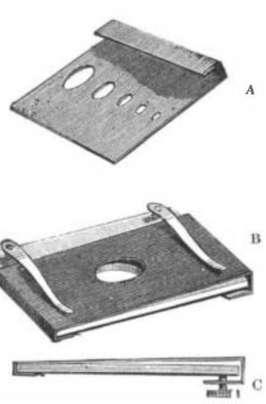


Fig. 2.—DIAPHRAGM AND FINE ADJUSTMENT.

In every pond and stream may be found microscopic forms of life. In every plant and flower, upon leaves and stalks, among the sands and rocks, almost everywhere in all seasons, may be found objects of absorbing interest to the student of microscopy. Animals and insects, food and manufactured articles, yield objects which may be examined microscopically with pleasure and profit. Chemistry and mineralogy afford attractive fields. In fact, one so inclined cannot fail of finding objects of interest with little difficulty.

Some have erroneously supposed an expensive instrument and elaborate accessories necessary to the pursuit of microscopical investigations. These things are, of course, desirable; but when one has learned all that can be learned by the aid of the simple and inexpensive microscope shown in the engravings, he is very far advanced, and may with propriety present his instrument to some one unable to purchase for himself, and proceed to the selection of something better suited to his advanced position in microscopy.

The microscope referred to was devised, at the suggestion of the writer, by one of our leading manufacturers. It costs six dollars and fifty cents, and although not as complete and convenient as more expensive instruments, it is more perfect and satisfactory than its predecessors of the same price.

It is 8 inches high, and has a draw-tube, which permits of extending it to a height of 11 inches. The foot and arm are of japanned iron. The tubes are well finished and lacquered. It has an objective divisible into two powers. The mirror may be swung over the stage for the illumination of opaque objects. The instrument has a neat cherry case, in which it may be placed when not in use

To the instrument as received from the manufacturer is applied a home-made diaphragm, as shown at A, in Fig. 2, and a fine adjustment, as shown at B, C, in the same figure. The diaphragm consists of a piece of perforated thin sheet metal, extending along the under surface of the stage and neatly bent over the outer edge of the stage, so as to be self-supporting—the perforations of the metal being respectively one-sixteenth, one-eighth, three-sixteenths, one-fourth, and five-sixteenths inch diameter, all arranged on a longitudinal line of the metal plate intersecting the axial line of the microscope tube, so that the centers of the holes of the diaphragm may be made to coincide with the center of the hole in the stage.

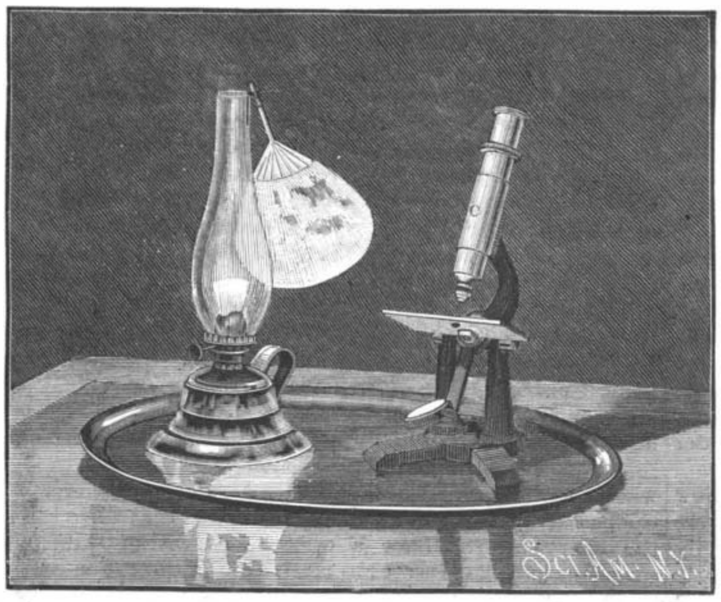


Fig. 3.—SUBSTITUTE FOR REVOLVING TABLE.

The attachment for fine adjustment is made by bending one end of a thin metal plate twice at right angles, so that it will spring on the side of the stage and clamp the stage tightly. The opposite end of the metal plate is bent in a similar manner, but the space between the body of the plate and the bent over end is made wider, to permit of a small amount of movement of this end of the plate. In the portion of this end of the plate extending under the stage is inserted a screw with a milled head, by means of which the free end of the plate may be made to move either up or down through a small distance. The body of the plate is inserted under the stage clips, and the object slide is inserted between the clips and the plate.

The instrument has no rack adjustment, but the main tube slides easily and smoothly in the guide tube, so that little or no difficulty is experienced in focusing. Besides the instrument and accessories, only the following articles will be required to begin in earnest the study of microscopic objects: A small pair of spring forceps, a bottle, a teaspoon, a few concaved glass slides, a few thin cover glasses, a glass drop tube, a small kerosene lamp: and if the investigator desires to entertain his friends microscopically, he will need a Japanese or tin tray, large enough to contain both microscope and lamp, as shown in Fig. 3, so that the relation of both may be preserved while the tray is moved to bring the instrument into position for different observers, by simply sliding the tray on the table.

A little caution as to illumination is necessary, as the beginner is generally unsparing of his eyes, using far too much light. A blue glass screen placed between the mirror and source of light, or between the mirror and the stage, modifies the light so as to greatly relieve the eyes.

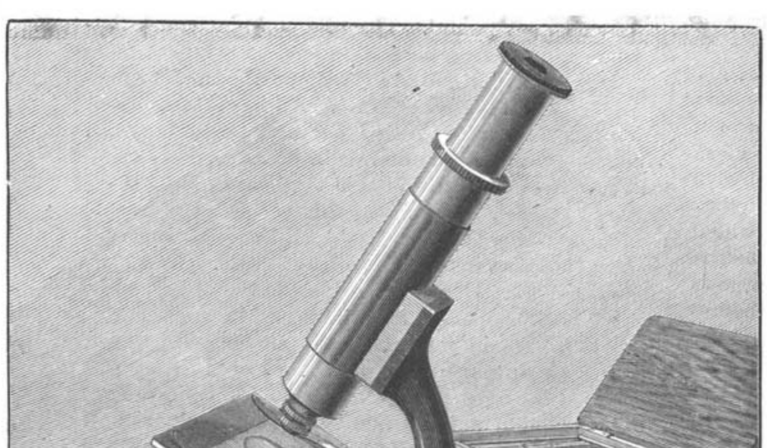


Fig. 1.—THE TOY MICROSCOPE.

The lamp should be provided with a shade of some sort to prevent the light from passing directly from the lamp to the eyes. A small Japanese fan suspended from the chimney by a wire, as shown, forms a very desirable shade.

Most objects viewed by transmitted light in an instrument of this class require an absolutely central light, that is, the light must be reflected straight upward through the object and through the tube.

When opaque objects are examined, the mirror is raised above the stage and made to concentrate the light on the object. Different angles of illumination should be tried, as some objects are greatly relieved by their shadows, while others require illumination as nearly vertical as possible.

Experience will soon indicate the right magnification for different objects. This may be varied by taking off or putting on the lower half of the objective, also by drawing out or pushing in the draw tube.

Various forms of apparatus have been devised for gathering objects from ponds and streams; but much can be done with no other aids than the spoon and bottle above mentioned. The mud at the bottom, scraped up with the spoon and placed in the bottle, will probably be found to contain microscopic life in abundance. The under surface of leaves of aquatic plants and of grasses hanging over into the water may be scraped with the spoon, and more or less of the matter adhering thereto will be secured. Occasionally a long leaf like that of the flag may be lifted from the water and traversed by the spoon with good results. Small twigs and dead leaves floating in the water are often found teeming with life. The thousands of animalcules and forms of minute plant life found in water will afford the most zealous student a life-long supply of subjects for examination.

Fig. 4.—TRANSFERRING OBJECTS TO THE SLIDE.

The objects are transferred from the bottle to the concavity of the slide for examination in the manner shown in Fig. 4. The drop tube, which has a funnel-shaped top, is stopped by the finger at the upper end, while its lower end is inserted in the water in the bottle above the matter to be removed. The finger is then removed and some of the water, together with the objects carried by it, rushes upward into the tube. While the lower end of the tube is still in the water, the finger is again placed on the tube and the tube is withdrawn from the bottle and held over the cavity of the slide, as shown in the engraving, when a drop or so of the water is forced out by pressing down the end of the finger on the top of the tube; the soft end of the finger acting as a sort of diaphragm in forcing out the required amount of water. Care must be taken to avoid getting solid matter upon the slide around the edge of the cavity, as it will prevent the cover glass from seating itself properly. The cover glass is placed over the cavity and pressed down lightly to squeeze out the surplus water, when the slide may be inserted under the clips of the stage and examined.

It would be futile, in a paper like this, to attempt anything more than the mere mention of a few of the interesting objects that may be seen to advantage in a small microscope. In Fig. 5 the engraver has beautifully shown some of the common objects which are easily secured, readily examined, and always interesting. At 1 in this engraving are shown various seeds; the lace-covered one at the top being the seed of the *Nemesia compacta*. The seed in the center is that of heather. That on the right of the lace-covered one is the seed of the poppy. The fringed one below it is that of the climber. At the bottom of the disk the seed of sorrel is shown at the left, and portu-