

EFFECTS OF HEAT ON IRON.

At a recent meeting of the Physical Society, London, the following paper was read:

"The Permanent and Temporary Effects on some of the Physical Properties of Iron, produced by raising the Temperature to 100° C." By Mr. Herbert Tomlinson, B.A.

The paper is divided into three sections: 1st. Internal Friction of Iron. 2d. The Longitudinal and Torsional Elasticities of Iron. And 3d. The Velocity of Sound in Iron.

In his experiments on the internal friction of metals, the author uses a vertically suspended wire, rigidly clamped at its upper extremity, and having its lower end secured to a horizontal bar of metal, attached to which are two cylinders of equal mass and dimensions, placed at equal distances from the wire. When the

and also show that time and temperature have great effect on the internal friction. By repeatedly heating to 100° C. and slowly cooling an annealed wire for six days, the logarithmic decrement due to internal friction was reduced to about one-eighth its original amount, at the same temperature, and when the wire was maintained at 98° C., the decrement was reduced to 1-30.

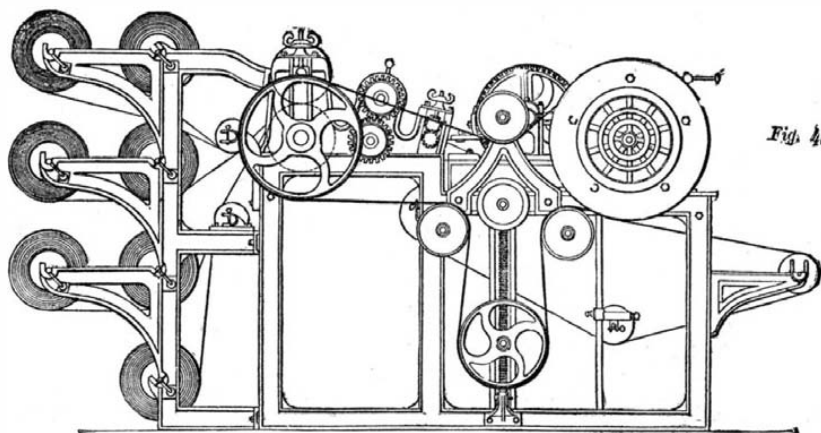
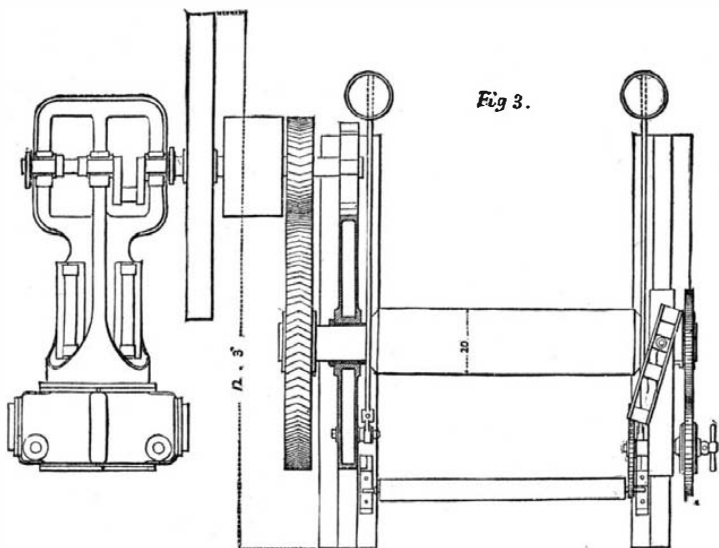
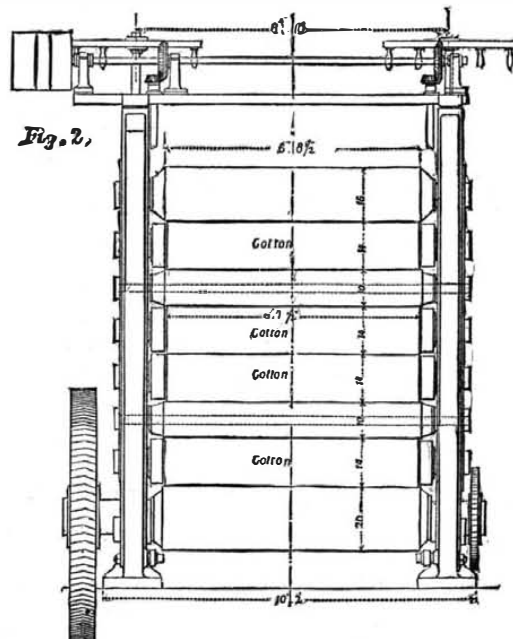
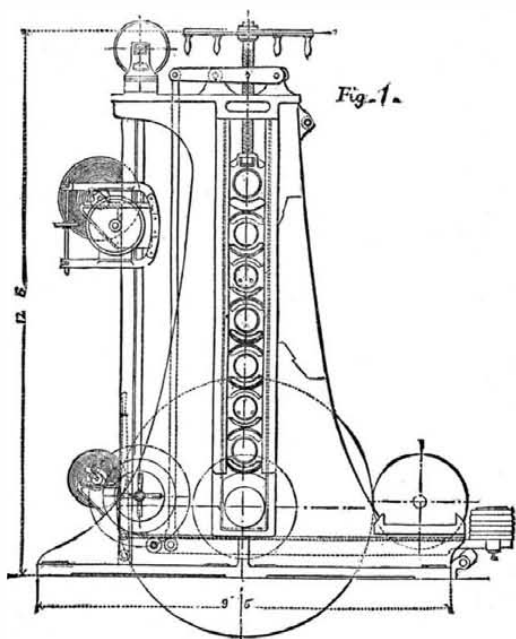
The author considers the permanent diminution produced by heating and cooling to be mainly due to the slow shifting backward and forward of the molecules, induced by that process.

In the second part of the paper, it is shown that the effects of change of temperature on the longitudinal and torsional elasticities of iron and steel are not nearly so great as that produced on the internal friction. Thus, by heating annealed iron wire, its longitudinal and torsional elasticities are slightly decreased, but on cooling there is a permanent increase in both. Time is also an important element, for a long rest after cooling still further increases both elasticities. From the above results it is evident that the velocity of sound in iron and steel must diminish with rise of temperature. This was experimentally proved before the meeting. Attention was particularly directed to this fact because most of the best text-books make the opposite and erroneous statement.

PAPER CALENDERING AND CUTTING.

THE annexed illustrations represent two fine examples of paper calendering and cutting machinery, constructed by Messrs. George and William Bertram, of St. Katherine's Works, Edinburgh. Figs. 1, 2, and 3 show a web calender with eight rolls. The paper from the giving-off reel is passed over the top roll, and then between the various rolls below, until it leaves at the bottom joint, and passes to the winding-up reel. There are four cotton rolls, 79½ in. on the face, and 14 in. in diameter, and four chilled rolls, 80½ in. on the face, and respectively 20 in., 10 in., 10 in., and 16 in. in diameter. The rolls are arranged in the following order: That at the top is of chilled iron, and is 16 in. in diameter, with journals 7 in. in diameter by 8¼ in. long. The second is 16 in. in diameter and covered with cotton. The third is 10 in. in diameter, chilled, and bored to receive steam to heat it. The fourth is covered with cotton, as is also the fifth. The sixth is chilled, 10 in. in diameter. The seventh is covered with cotton, and

45 deg. from seven rolls at one time, and into four widths. The paper from the seven rolls is brought through a pair of leading-in rolls and through a pair of cast iron drawing-in rolls, of which the upper is 9 in. in diameter and the lower 10 in. in diameter. In front of the leading-in rolls are two spindles 4½ in. in diameter, carrying five pairs of circular slitting knives, 6 in. and 7¾ in. in diameter, to cut the paper longitudinally. Next come two small nipping rolls to hold the paper while being cut, and in front of these are the dead and crosscut knives. There is one dead knife fixed to an adjustable frame, and on this frame the revolving drum is carried. Two knives are fixed to the drum, which is driven by an upright shaft and bevel wheels from a shaft under the cutter, and the shaft, in turn, is driven from the expanding pulley shaft by change wheels. The dead knife frame and revolving drum are carried in a circular frame planed on the top, and having a



IMPROVED PAPER CALENDERING AND CUTTING MACHINE.

system is set in torsional oscillation, the amplitude gradually diminishes, due to the internal friction of the metal and the friction of the air. The combined effect is measured by the logarithmic decrement of the oscillations, and the air effect eliminated by Prof. Stokes' formulae and the author's experimental determination of the viscosity of air. When the deformations are sufficiently small, the experiments prove that the logarithmic decrement of air is independent of the amplitude and period of vibration. These results are only true when the wire has been allowed to rest a considerable time after any change has been made in the arrangement, and when there have been a large number of oscillations executed previous to the actual testing.

Reference is made to some experiments by Prof. G. Wiedemann, which show that when a wire is subjected to torsional stress, it does not recover itself when the stress is gradually reduced to zero, but remains permanently twisted through a small angle (say θ). By reversing the twisting couple, there is a permanent set on the other side of the initial position. If the operations be repeated, θ diminishes and attains a minimum. The period during which this diminution takes place is called the "accommodation period."

When a wire is in torsional vibration, the position of equilibrium is continually shifting to and fro, through twice the above minimum angle, and Wiedemann considers the loss of energy to be due to this shifting. The author's experiments verify Wiedemann's results,

the eighth is chilled and 20 in. in diameter. Its bearings measure 10 in. by 10 in., while the bearings of all the intermediate rolls are 6 in. by 8¼ in. At the ingoing side of each pair of rolls there are safety bars, 1½ in. in diameter. At the Edinburgh Exhibition, where this machine was shown, these bars prevented a serious accident, for the attendant's hand was caught, and would have been drawn into the rolls if the safety bar had not been there. Power gear is provided to lift the reel of paper into position. This gear consists of guide bars, 3½ in. by 2 in., with 1½ in. double threaded screws. These screws are driven (Fig. 2) by bevel wheels and a countershaft provided with fast and loose pulleys. The motion of the reel is regulated by a friction brake pulley, 15 in. in diameter by 3 in. broad, tightened by a right and left handed screw. The winding-up reel is driven by a slipping motion with friction plates 14 in. in diameter.

The pressure in the rolls is produced by weights hung from compound levers, constructed on the double plate system. These levers and weights will give a pressure up to 50 tons. The top roll can be lifted by two 2¼ in. square-threaded screws, fitted with 36 in. handwheels having wrought iron handles in the rims. The calender can be driven from any convenient source of power, but the one shown in the engravings has an independent engine with cylinders 10 in. in diameter by 16 in. stroke.

Fig. 4 shows a revolving knife cutting machine. This will cut paper from the square up to an angle of

suitable radius from the center of the upright shaft, so that the paper coming forward to the knives may be cut into sheets having any angle up to 45 deg.

To alter the speed to cut different lengths of sheets an expanding pulley is provided, so that minute adjustments may be made. The machine will cut sheets from 19¾ in. to 98 in. long, the larger variations of length being obtained by the use of change pulleys, which are fixed, as required, on the spindle of one of the drawing-in rolls. The cut sheets are caught on a traveling felt and delivered at the end of the machine. —Engineering.

STUDIES IN PYROTECHNY.

THE ancients knew how to correspond by means of pyrotechnical signals. During the day they lighted great fires, whose smoke could be seen from a distance, and at night it was the flames of these burning piles of wood that served as a signal. This telegraphic fire was called πυρρός; and the art of signaling πυρρεία. The Cestes of Heron form a complete treatise on this art, entitled περί πυρρών. The armies of antiquity did not always burn faggots or brushwood (πυρρόν ἀνάπτειν), but also used torches or firebrands (φρυκτοὶ πόλεμοι).

How did the ancients vary these fires so as to form an alphabet that allowed them to correspond? Simply by varying the number of times at which they lighted them. Modern pyrotechnists use fireworks.

A signal rocket (Fig. 1) consists essentially of a cartridge, pot, and stick. The cartridge, *a*, consists of a cardboard cylinder charged with a composition whose combustion must give the signal the impulsion necessary to make it start. The pot, *b*, is another cardboard cylinder filled with the materials that are to form the signal. This pot is capped with a cone, *d*, for diminishing the resistance of the air. The stick, *c*, fixed along the cartridge, directs the rocket in space.

It is easy to explain the operation of the apparatus. Internally, the cartridge has the form of a very elongated cone. It is in this long conical cavity that combustion takes place (Fig. 2). The gases that are formed make their exit from the bottom, but, at the same time, exert an upward pressure that brings about the rocket's ascent. At the end of the combustion, the composition lights a small charge of powder, which both expels and lights the fireworks contained in the pot.

The cartridge composition consists of 64 parts of saltpeter, 12 of sulphur, and 24 of hardwood charcoal. Mr. Ruggieri varies the proportions thus: 16 parts of saltpeter, 4 of sulphur, and from 4 to 8 of softwood charcoal.

In any case, the charcoal should not be used in the form of powder, but in that of grains of various sizes. The effect of using charcoal in this form is to produce that long train of fire which everybody has observed on the ascent of a rocket.

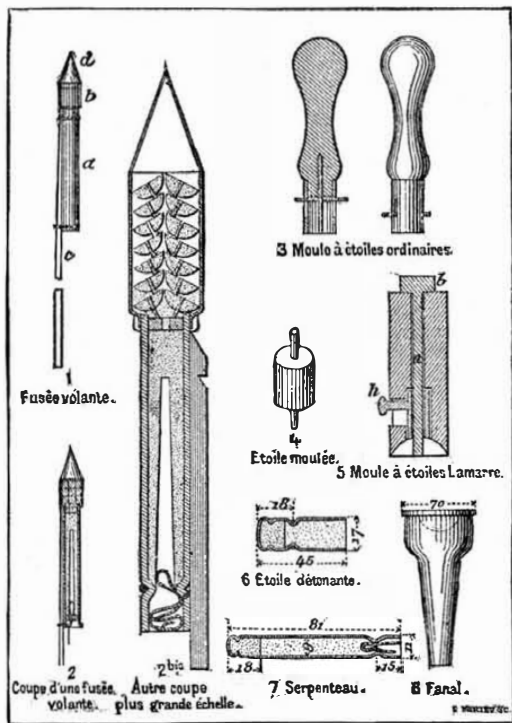
The amount of composition used must be calculated in such a way that the rocket shall not expel its contents until it has reached the end of its travel. Priming is effected by means of a quick-match inserted in the bottom of the cartridges.

The contents of the pot are arranged thus: The primer beneath; the serpents standing in one row; the petards and the detonating stars and crackers in two layers, separated by pieces of quick-match.

It is well to enter here into some detail concerning these fireworks, the most commonly used of which are stars, golden rain, serpents, crackers, saucissons, flames, and parachutes.

STARS.

White Stars are made of a composition formed of 32 parts of saltpeter, 16 of sulphur, 14 of priming powder, and 3 of antimony. These materials, after being first powdered and sifted, are moistened with a liquid composed of 1,000 parts of pure water, 1,000 of brandy, and 160 of gum arabic. The paste thus obtained serves for making cubical or moulded stars. The cubical stars are made, like brick, by means of a wooden frame and a roller. The moulded ones are formed



DETAILS OF FIREWORKS.

in a mould (Fig. 3). These fireworks are primed with a piece of quick-match placed in a channel formed in the axis. They are dusted with priming powder on every side (Fig. 4).

Another recipe for white stars is the following: 72 parts, by weight, of saltpeter, 25 of sulphur of antimony, and 3 of tallow.

Azure White.—Take 75 parts of saltpeter, 25 of sulphur, and 48 of regulus of antimony.

Green.—Mix 60 parts of chlorate of potash, 120 of nitrate of baryta, and 39 of protochloride of mercury.

Bright Yellow.—Take 48 parts of chlorate of potash, 12 of oxalate of soda, 24 of sulphide of copper, and 12 of gum lac.

Ordinary Yellow.—Take 12 parts of chlorate of potash, 8 of oxalate of soda, and 3 of gum lac.

LAMARRE STARS.

The Lamarre star has the form of a plano-convex lens $1\frac{1}{4}$ in. in diameter and $\frac{1}{2}$ in. in thickness. It is made in a bronze mould (Fig. 5). The composition is compressed in the bottom of the mould, and a hole is afterward punched in it by the rod, *a b*, for the insertion of the quick-match.

White.—Take by weight 373.98 parts of chlorate of potash, 373.98 of nitrate of baryta, 162.6 of priming powder, and 89.44 of boiled oil.*

Red.—Take 564.55 parts of chlorate of potash, 94.1 of carbonate of strontia, 15.05 of lightwood charcoal, 75.27 of boiled oil, 150.54 of priming powder, 4.51 of gum lac, and 1.88 of oil.

DETONATING STARS.

These consist of cartridges containing about 36 grains of rifle powder, above which has been rammed down

some star paste. This latter, in ceasing to burn, sets fire to the powder (Fig. 6).

GOLDEN RAIN.

This is formed of small cubes cut out of a composition made of 5 parts of priming powder, 1 of saltpeter, 1 of sulphur, 1 of oxide of zinc, 1 of gum arabic, and 1 of German black. This mixture is moistened with a brandy containing 128 grains of gum arabic to the pint, so as to obtain a paste having nearly the consistency of glazier's putty.

SERPENTS.

These consist of small cartridges charged with 15 grains of powder, and above this a composition formed of 6 parts of priming powder and $1\frac{1}{4}$ part of sifted and slightly moist charcoal.

CRACKERS.

These consist of cartridges similar to those of the detonating stars. These cartridges are filled with compressed rifle powder, and are primed with a quick-match. **Marrons** are simply cubes of cardboard filled with powder. **Saucissons** consist of cartridges filled with compressed powder, and capped at the ends. They are primed with a quick-match.

A dynamite rocket contains a charge of nine ounces of dynamite, designed to explode in the air and be heard at a great distance. The explosive is primed with a detonator or a capsule of fulminate of mercury. Thus formed, this rocket makes an excellent acoustic signal.

Every rocket is set off from a picket 6 feet in height planted in the ground. This picket is provided at the top with a small horizontal iron fork.

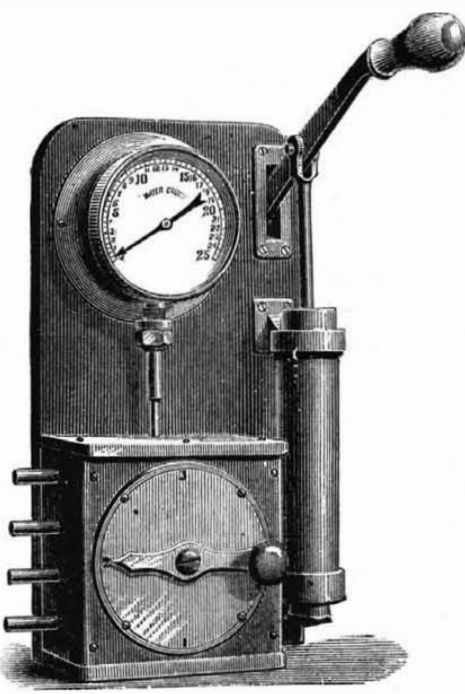
Beacons serve for signaling to a great distance. To this effect, we can use, in the day time the "smoke ball," consisting of 12 parts of saltpeter, 4 of sulphur, 2 of charcoal, 10 of pitch, and $1\frac{1}{2}$ of resin. At night we can use "Bengal fire," casks filled with tar, straw smeared with pitch and tar and then dusted with powder, and, finally, the beacon properly so called.

This apparatus consists of a piece of hard wood hollowed out at the wide end, and filled with a composition consisting of 2 parts of saltpeter, $1\frac{1}{2}$ of sulphur, and $\frac{1}{2}$ of priming powder. This mixture will burn from 7 to 8 minutes.

These fire signals are arranged upon points of great altitude. They are suspended from the top of a pole stuck into the ground, or from the trunk of a tree.

THE PNEUMATIC HYDROMETER.

SMILES' pneumatic hydrometer is a handy instrument for measuring the depths of fluids. It is capable



of being applied in many different situations. For instance, it may be used in a ship to ascertain the amount of water in the different compartments, and for this purpose it is fixed in the chart room or in the engineer's cabin, and enables the officer to sound each part of the vessel in succession without leaving his post. In a brewery it will indicate to the manager the amount of water in the well, in the cistern at the top of the building, and in the various tuns throughout the building. In the latter case, the dial may be marked in gallons if it be preferred. Many other situations, says *Engineering*, will suggest themselves to the reader in which an instrument which will measure the depth of liquids at a distance, without involving the trouble of a visit to the spot, would be most convenient and economical of labor.

The principle on which the hydrometer acts is exceedingly simple. A pipe, open at the lower end, is placed in each tank or compartment to be measured. The other end of this pipe is led to an air-compressing pump provided with a pressure gauge. The pump is worked and air forced into the pipe until the whole of the liquid is ejected from it, and the air escapes at the lower end. A reference to the gauge shows the pressure required to effect this, and this amount may be readily converted from pounds per square inch into the equivalent head of water. Or better still, the gauge may be marked in feet of the liquid which is to be measured.

The illustration on the present page shows the instrument as constructed for sounding four vessels or compartments. The four pipes lead to a four-way cock, by which any one may be placed in connection with the pump and the pressure gauge. The manufacturers are W. Reid & Co., 45 Fenchurch street, London.

THE articles in this week's SUPPLEMENT "On Kites," "Studies in Pyrotechny," "Magnetic Carriages," "Driving a Needle through a Coin," are from our excellent cotemporary, *La Nature*.

MODERN WAR SHIPS.

AN important paper on this subject was read on January 21 at the Mansion House, London, by Mr. W. H. White, Director of Naval Construction, the lecture being one of a series delivered under the auspices of the Shipwrights' Company. Lord Charles Beresford presided, and introduced the lecturer. Mr. White commenced by stating that, while his official position imposed limitations and restrictions upon his public discussion of many important matters affecting our naval forces, he was glad to comply with the request of the Master of the Cutlers' Company, hoping to succeed in some degree in the attempt to place before them facts and figures illustrating the progress of war ship building in recent years, and the most characteristic features of modern war ships. At the outset it was necessary to lay down some definition of modern war ships. Progress in war material had been so rapid during recent years that it was not uncommon to find ships defined as obsolete before they were ready for their first commission. He should not follow that method of classification, or treat a ship as unworthy of consideration because she was not in every respect "up to date," or possessed of the latest improvements. He would include in his review all the vessels that had been constructed since 1859, when he first became connected with shipbuilding, which happened to be the date when the ironclad reconstruction of the Royal Navy began. The period 1859-87, of which he would speak almost entirely, had witnessed greater changes than had taken place in the whole preceding history of war ship building, and it was possible for him to speak of these remarkable events in the light of intimate personal knowledge and observation.

When he entered the Admiralty service, twenty-eight years ago, the dockyards were the scene of feverish activity, the too long deferred steam reconstruction of the navy being in full swing. Forced on by the action of Napoleon III. and his able naval architect, M. Dupuy de Lome, the Admiralty had at last frankly faced the necessity for fitting screw propellers and steam machinery to the largest class of war ships. Full sail power was to be retained, and wood hulls (built on the old methods) were to be adopted on all these vessels, structure and armament being practically identical with those of the sailing ships of earlier date. Many of these sailing ships were being converted into screw steamships in 1859, and he had assisted at the cutting down of sailing three-deckers and their conversion into screw two-deckers, as well as at cutting asunder, lengthening, and alterations of other kinds carried out in various classes of ships.

While that might sound like ancient history, it was of comparatively recent date, and was treated as of paramount importance at the time. Some idea of that might be gathered from the statement that in 1859 no less than seventeen line-of-battle ships and ten frigates were launched or converted, while twelve line-of-battle ships and thirteen frigates remained in hand. It was a supreme and costly effort to retrieve lost ground, but it came too late. While money was being lavished on wood hulled steamships, a further reconstruction was recognized as inevitable by those who watched the progress of events in France, where the *Gloire*, an ironclad seagoing frigate, was already far advanced, and others of the class were being pressed forward.

As a contrast to subsequent changes, Mr. White glanced at a few of the leading particulars of first class British war ships, from the *Great Harry* down to the last of the complete screw three-deckers, remarking that from 1600 to 1850 changes were few and gradual, and ships remained effective for long periods, and that, in default of more important subjects, discussions arose over what now appeared to be trivial details. Could it be possible that our successors would think similarly of what we now treated as burning questions? It must be frankly admitted that the lead taken by the French on both the steam and the ironclad reconstructions was the primary cause of most subsequent activity in war ship building. Throughout the period under review, the ceaseless competition between rival designers of different nationalities had been productive of great and material advantages.

English naval authorities in 1858-59 would, no doubt, have gladly postponed action in the building of armor-clads had they been free to decide, but the *Gloire* and her consorts made action imperative, and in May, 1859, the first English seagoing armored ship, the *Warrior*, was ordered. She was followed by several other ironclads within the next two years; but in 1861 something very like a panic set in, caused by the great lead which the French had obtained in armored ships. The new departure made by the Admiralty in the design of the *Warrior* class, and later on in the design of the *Minotaur* class, was remarkable for its boldness and success, even when regarded from our present standpoint.

The *Gloire* and *Warrior*, and all their successors, owed their existence to the terribly destructive effects of shell fire on unarmored wood built ships. The primary use of armor plating was to keep common shell with large bursting charges out of the batteries of ships, and for a long period the struggle between the attack and the defense in war ships was chiefly one between guns and armor. The $4\frac{1}{2}$ inch armor and thick wood backing on the *Warrior*'s sides were practically proof against the heaviest shot, as well as the shell, of the armaments carried when she was designed. In the first stage of the contest, therefore, the defense scored a victory, but it was not a lasting one. Gun manufacture rapidly developed, and had continued to advance; improved kinds of powder had been devised; the science of explosives had been thoroughly investigated; projectiles had been produced of a vastly superior kind; and so step by step the power of this form of attack had been increased to an astounding extent.

Guns had been increased in weight from $4\frac{3}{4}$ tons to 110 tons, in powder charge from 16 lb. to 900 lb., in weight of projectile from 68 lb. to 1,800 lb., in energy (measuring the force of the blow struck on impact) from 450 foot tons to 50,000 foot tons, at a range of 1,000 yards. The 68 pounder failed to penetrate the *Warrior* target with $4\frac{1}{2}$ inches of wrought iron armor at close range; the 110 ton gun can penetrate 35 inches of iron at 1,000 yards. In range and accuracy, as well as in the efficiency of arrangements for mounting and loading guns, the progress made was of inestimable value. There could be no question but that the power of the heaviest guns now carried in war ships as com-

* Obtained by boiling linseed oil in a pot until the liquid takes fire in contact with a body in flames. It is allowed to burn for 8 or 10 minutes, and then the fire is smothered by putting the cover on the pot. The oil is allowed to thoroughly cool before the cover is removed.

pared with the resistance of the strongest armored defense in existing ships was greater than it had been at any time since the ironclad reconstruction began. Nor was the end yet reached, for new projectiles and explosives were being produced which might reasonably be expected to place the attack in an even superior position in relation to the defense.

His sympathy was, of course, on the side of the ship, but it was folly to shut one's eyes to facts and probabilities, and from the very nature of the case the attack must have greater flexibility and capability of variation or development than the defense. On the other hand, it was but right to note that the defense showed to least advantage under the conditions of peace experiment. These conditions were altogether favorable to the attack, and in actual warfare the gun did not show the same power as at Shoeburyness, Garves, or Spezia.

For the first half of the period under review ramming was the only rival attack to gun fire; but while the newly revived, yet ancient, form of attack exercised but little influence upon ship designs, the contrary was true of gun armament. Strengthened and suitably shaped bows and great handiness were essentials to success in ramming, which were easily provided; good internal subdivision into water tight compartments and great handiness were the best means to prevent injury from ram attacks, and were easily arranged for. With the gun armament the case was altogether different. Upon the nature and number of guns to be carried, their disposition and range of command, their height above water, and the means of working and loading them, as well as upon the protection to be afforded to guns and gunners, the design of each war ship must be principally based. Hence it happened, speaking broadly, that from 1859 to 1873, the most notable changes in warships might be said to have resulted from the desire, on the one hand, to carry fewer, but heavier, guns under armor protection, giving to these guns great horizontal command, and, on the other hand, to increase the defense by thickening armor over the protected portions of ships, obtaining this result by carrying larger relative weights of armor and diminishing the ratio of armored surface to the total surface of the ship's side.

The lecturer then entered upon examination of the principles of construction of several ships, including the Warrior, Minotaur, Bellerophon, Hercules, Devastation, Dreadnought, Inflexible, Admiral, Collingwood, Trafalgar, and the Nile, and contended that that hasty glance over the influence which progress in naval gunnery had had upon armored defenses and types of ships would confirm the justice of the generalization that the gun was the most influential factor in modern warship design. The artilleryist was fond of speaking of ships as gun carriages. That was true, but not all the truth. A ship was that and much besides. The gun was the principal weapon no doubt, but the ram and torpedo were also important. There was one view, however, of this popular description which the artilleryist often overlooked when he gloried in the progress of gunnery. Every increase in the weight and power of guns added to the difficulty of the shipbuilder, for in the final result every strain incidental to carrying and fighting the guns had to be borne by the structure of the ship. Only those who had to be responsible for the structural arrangements realized fully what had been involved in the adoption of the modern types of guns, and it was a marvel that such complete success had been attained.

It would be improper not to give due acknowledgment of the great assistance which the mechanical engineer had given in the device of suitable mountings and appliances for loading and working these monster guns. It was no exaggeration to say that with these aids the largest guns are now under more complete control than were the much smaller guns formerly worked by manual power. There were not wanting advocates of the view that the risks of failure incidental to these mechanical appliances were too serious to be accepted, and that guns had outgrown the necessities of the naval service. Mr. White stated both sides of the debate on this point, and said that, having done so, he would leave the matter, only adding that in the latest ships, both English and foreign, while heavy guns were to be carried, they were not the heaviest available. In concluding the gun question, he must allude to the remarkable movement now in its early stages, but undoubtedly destined to great development, in the construction of quick-firing guns and mountings for them.

A quick-firing gun was capable of delivering from eight to ten well aimed shots per minute, or possibly more. Beginning with a six pounder, to which a three pounder was soon added, this class of gun had already reached a 40 pounder, and promised to embrace still larger calibers. Such rapidity of firing, combined with accuracy, range, penetrative power, and shell fire, would undoubtedly prove of enormous value, and could not fail to have an effect on both the armaments and the protection of ships. In some cases attempts had been made to give protection against the 6 pounder, which could perforate $2\frac{1}{4}$ inch steel plates at 500 yards. This protection was, however, quite inadequate to resist the fire of the 40 pounder, and so there seemed to be a possibility that another chapter might be opened in the duel between guns and armor.

Leaving the gun, Mr. White passed on to direct attention to the influence exerted upon modern warships by the introduction of the locomotive torpedo. In the course of his remarks he pointed out that a moderately rough sea, that scarcely troubled the ironclad or the cruiser of considerable size, sufficed to render inevitable a reduction in speed of the small vessels, and a serious loss of power in the accurate use of their torpedoes and guns. As adjuncts to fleets, the small, swift vessels and boats were undoubtedly of immense value under many circumstances; for the defense or attack of ports and coasts they were well fitted; but as substitutes for all other types, and as the successful rivals of large war ships in sea service, their claim was not, and probably would not be, established. The discovery of the minimum size of swift torpedo vessels or torpedo boat destroyers really capable of independent sea service with a fleet was now engaging attention in all navies. Messrs. Thomson, of Clydebank, had just completed another example of the class intermediate in size between the Bourke and Grasshopper, and said to have attained the very high speed of $22\frac{1}{2}$ knots on trial in smooth water. Experience at sea with these

vessels would be of immense value to future designs. Having alluded to the torpedo cruisers of 1,300 to 1,700 tons which had been built during the last four or five years, and to the Polyphemus, he referred to the great development which had taken place during the last four or five years in the construction of swift protected cruisers. Passing from these descriptions of types and armaments of war ships, he directed attention to certain important matters common to all types, and largely affecting their efficiency as well as their cost. A war ship was minutely subdivided into a very great number of water tight compartments, in order to gain increased safety against under water attacks. Another noticeable feature in modern war ships was the extended use of mechanical appliances as substitutes for manual labor. It would be obvious that the task of designing and building modern war ships would be one of great difficulty, even if it were possible to fix beforehand all the conditions to be fulfilled in armament and equipment. Since the ironclad reconstruction began, however, no such fixity in design, especially for the larger classes of ships, had been obtained.

The progress in guns, torpedoes, equipment, materials of construction, propelling apparatus, etc., had been rapid and continuous, and there is a great desire to embody these improvements in vessels still incomplete at the date of their introduction. Of course, these additions and alterations meant greater first cost, and generally greater weight. Changes, additions, rearmament, were the rule during the whole period of a war ship's career. Wide differences of opinion existed on many, if not most, of the features of war ship design; but there was almost absolute agreement that high speed was of primary importance in all classes. The increase in speed had been obtained by improvements in two directions—first, in the forms of the ship; and, secondly, in the design and construction of the propelling apparatus.

The progress made in the machinery of the grand steamers of the mercantile marine had been of the utmost advantage to war ships. In the latter, the introduction of both the compound and the triple expansion engine had been the result of mercantile experience, and the inverted cylinder engine had found its way into war navies from merchant ships, adding to its reputation, and finding general favor where it could possibly be adopted. The war fleet had not only derived benefit from the mercantile marine; it had also given it the benefit of special experience. Twin screws, for example, had been first applied and proved efficient in deep draught war ships; "forced draught" had been developed, and in the construction of the engines many improvements both in design and materials had been worked out which would help the future association of strength with lightness in marine engines generally.

Before the abandonment of sail in the Devastation class was decided upon in 1869, there were anxious discussions. Subsequent experience had proved how wise the decision was. All the changes made since that date had favored reliance upon steam. Twin screws gave an assurance of safety against the breakdowns so troublesome with single screws; higher steam pressures and triple expansion engines had greatly reduced the rate of coal consumption. Ships were now built capable of steaming continuously for five or six weeks 8,000 to 10,000 knots, at speeds of ten knots an hour, before their coal supply was exhausted, and for still longer distances and periods at lower speeds. Sail was still continued, however, in many classes of war ships, and was absolutely necessary for certain services and stations.

After what had been said respecting the size, armor, armament, and complex fitting of war ships, no one would be surprised to find that their first cost had been greatly increased. Large as had been the sums actually spent on shipbuilding during the last quarter of a century, they had not been large enough in proportion to the number and cost of the new ships in hand to permit of rapid construction. That financial limitation or want of funds in relation to work incomplete had sadly hampered and hindered progress and completion, lengthening out the time over which a ship had been on hand, it had indirectly added to the cost, and had given time for the numerous alterations and additions which he had described. Even when funds were ample, and all conditions favorable, the time required to complete a first class modern battle ship for sea could not be put at less than three or four years, for a cruiser one and a half to two years, and for the smaller vessels one to one and a half years. These figures compared badly with what was done in merchant ship construction, but the reasons for the difference were obvious enough.

For many reasons the development of the swift cruiser class was to be welcomed. The British navy must always be in a position to meet every class of ship which an enemy could bring into the line of battle or send on detached service. If what was being done abroad was observed, and the necessary provision made in proper time, our shipbuilding resources were such that the lead could always be secured. With respect to the possible use of mercantile auxiliaries in time of war, he fully recognized the splendid performances and unrivaled capabilities of our swift modern steamships. He heartily sympathized with all that had been done in the last ten years to encourage methods of construction and subdivision which would better fit these vessels to receive an armament of guns, and to be capable of fighting. And he believed that in many ways these armed vessels would be of immense value to the country in the time of war. But he did not concur in the opinion that they were to be treated as substitutes for regular war ships, and that the navy could be reduced in numbers because these auxiliaries were or might be available.

There were radical and unavoidable differences in structure, protection, machinery, and steering gear, as well as handiness and capability of using their armaments, between such vessels and regular built fighting ships. The officers and men who had to navigate and fight the war ships of these days had great demands made upon their intelligence, skill, and courage. In concluding, Mr. White said he had purposely avoided anything of a controversial nature, and refrained almost entirely from all attempts to assign individual credit for many and great improvements which had marked the ironclad period. His wish had been to indicate in general terms the character and scope of

recent changes, and to illustrate the difficulties that had been overcome, as well as the results attained.

Lord Charles Beresford, in proposing a vote of thanks to the lecturer, said it had been shown that our naval expenditure, heavy as it was, had not been thrown away, for it had been incurred in order to keep pace with foreign countries. In regard to the relative position between attack and defense, people, when they heard of guns firing at armor, forgot that the gun was then placed in the most favorable position. The shot struck at right angles, whereas, if the target was placed obliquely, the shot would probably strike and ricochet off. That was what generally occurred in action. He had always been an advocate of having small guns as well as large ones on our big fighting ships, as you could find the range better, and the moral effect on the men was bad of not having a shot for a long time from their own ship when shot was striking them. In regard to the citadel and belted type of ships, there were advantages in both. He, however, inclined to the belted type, armored fore and aft. The citadel type had their vitals well protected as strongly as they could be; but he thought if they were to ram another vessel, the enormous weight in the center would cause the light fore end to collapse, and that the armored deck would be shoved out through the ship's sides.

The constructors did not agree with him; they said the horizontal armor and deck armor would support the ship, and keep her bow intact. In any case he would be very glad to command one of them in action, and he should not anticipate the danger suggested by Sir E. J. Reed that shell fire would so cut up the ends that buoyancy would be lost and the ship would turn turtle. He would, however, take care to see his enemy in a very advantageous position before he rammed. Referring to the Nile and the Trafalgar, he said they would probably be the last of the heavy ironclads, unless other nations continued to build that type of ship, when we should have to do so too. We could not afford to allow any nation to build vessels of any kind superior to ours. He believed the determination to build these two vessels had had a great effect on France, as they saw we were determined to keep the lead, and knowing that we had most money, they came to the conclusion it was useless to keep up the struggle.

He was rather borne out in that theory by the recent report of the French minister of marine, who for years had held that the French ought to build small ships with enough coal to run out from French ports to the foci of our trade across the Atlantic and round the Cape, and prey on our commerce, and no doubt they would do it if we did not look out, instead of devoting their money to building large ironclads, in which we were sure to beat them. He deprecated the plan of taking so many years to complete a ship, declaring that a vessel would be a far superior fighting machine if she was finished quickly as she was first designed, instead of delaying and introducing changes which altered her speed and draught. The mechanical engineers had made fighting a science, and through their invaluable aid the 110 ton gun, the 80 ton gun, and the 68 ton gun were worked by one man with vastly more ease than five men could work a 68 pounder in 1859. He did not anticipate that torpedoes were going to revolutionize warfare. They were neither to be underrated nor overrated.

In his opinion, the energy, dash, and audacity which would be required to handle the torpedo boat would tell for Englishmen rather than against them. Those little craft were yet in their infancy, and it was not quite certain what class would be most useful for our fighting fleets and squadrons, but we should not, in his opinion, want anything between 400 tons, or thereabouts, and the small boats of 70 to 80 feet, which could be hoisted in and out. The boats from 135 feet to 70 feet would never be able to keep the sea, as instanced recently by the French torpedo squadron, where out of seventeen only six reached the rendezvous and were able to do what was expected of them. Submarine boats were another novelty; but he did not think they would revolutionize warfare. If they could be made safe to get into a position to fight, they might be very useful. As to big ships running away from pygmy torpedo boats, the explanation was that in order to demolish the pygmies the best thing to be done was to go as hard as you could in an opposite direction. He did not like the expression running away, for then you would get them altogether in pursuit of you, and your quick firing could be used with most effect. As to the measured mile trials, he would much prefer to have ships tested under exactly the same conditions as they would be in fighting an action, and then they would know the worst of her at first instead of at last. As to the cost of ships, they must look, not to that, but to what our ships had to do; and one of ours had to do sixty-six times more than a French ship in protecting our floating wealth and our food supply. We must not be satisfied with a small numerical superiority over the French. In conclusion, Lord Charles Beresford dealt with swift passenger steamers, thirty of which are on the Admiralty list for use as cruisers to protect commerce in case of war. Of these, he said, sixteen would probably be at home when war broke out, and our organization should admit of their being armed, manned, and dispatched to sea in three days, in which case we should probably prevent the departure of a few French rovers, who otherwise might step out of port to play the role of Alabamas, and do incalculable mischief to our commerce.

THE SPANISH CRUISER DESTROYER.

The torpedo cruiser Destroyer, built by Messrs. James and George Thomson, Clydebank, for the Spanish government, has arrived in Spain, her sea voyage having justified the expectations of her builders. She crossed the Bay of Biscay from Falmouth to Finisterre in twenty-four hours, her mean speed being twenty-one knots, or a little over 24 miles, per hour. She was launched in July last. Her particular function is to catch and destroy torpedo boats, and every other feature is almost entirely subservient to those qualities which secure high speed. The vessel is of 450 tons displacement, and is propelled by two sets of three cylinder engines, each in separate compartments. These are protected by steel plates, $1\frac{1}{4}$ inches to $\frac{3}{4}$ inch thick. She carries several guns, and has five torpedo tubes. Two rudders, one fore and one aft, have been fitted to enable her to maneuver quickly.

WEIGHT AND POWER OF MODERN GUNS.
TABLE OF ARMSTRONG GUNS.

Gun.	Caliber.	Weight.	Total Length of Gun.		Length of Bore.		Weight.		Muzzle Velocity.	Total Energy.	Energy per Ton Weight of Gun.	Energy per Inch of Shot's Circumference.	Thickness of Wrought Iron Plate the Shot is Capable of Perforating.
							Charge.	Projectile.					
in.	in.	tons.	calibers.	in.	calibers.	in.	lb.	lb.	ft. per sec.	ft. tons.	ft. tons.	ft. tons.	in.
4.724	4.724	2.5	24	112.7	22	104.0	12	40	1,680	783	522.0	53.1	7.0
4.724	4.724	2.2	35	165.3	33	156.6	16	40	2,078	1,198	532.4	81.3	9.1
6.0	6.0	4.0	28	166.4	26	156.2	42	80	2,060	2,354	588.5	125.7	11.6
6.0	6.0	4.5	32	192.0	30	180.0	45	100	1,940	2,610	580.0	139.4	12.2
6.0	6.0	5.5	37	222.0	35	210.0	60	100	2,146	3,193	580.5	170.5	13.5
7.0	7.0	7.0	28	196.0	26	182.0	60	120	2,050	3,497	466.3	160.2	13.0
7.0	7.0	8.0	32	224.0	30	210.0	75	145	2,020	4,075	479.4	186.6	14.1
7.0	7.0	9.0	37	259.0	35	245.0	80	145	2,140	4,604	511.5	210.9	14.9
8.0	8.0	11.5	28	222.5	26	208.0	120	180	2,177	5,915	514.3	236.9	15.8
8.0	8.0	12.5	32	256.0	30	240.0	120	200	2,157	6,452	537.6	258.4	16.5
8.0	8.0	14.0	37	296.0	35	280.0	130	210	2,236	7,280	520.0	291.5	17.5
9.2	9.2	19.0	28	257.6	26	238.7	175	320	2,060	9,412	495.3	327.5	18.5
9.2	9.2	21.5	32	287.3	30	267.8	200	380	2,035	10,923	508.0	380.1	20.0
9.2	9.2	24.0	37	340.4	35	322.0	230	380	2,375	14,800	618.6	515.0	23.2
10.0	10.0	25.0	28	274.0	26	254.5	200	450	1,910	11,383	455.3	364.2	19.5
10.0	10.0	27.0	32	320.0	30	300.0	270	470	2,185	15,560	578.3	497.9	22.8
10.0	10.0	30.0	37	370.0	35	350.0	270	500	2,213	16,979	566.0	545.3	23.8
12.0	12.0	43.0	28	331.0	26	307.5	330	700	2,087	21,141	491.6	563.1	24.2
12.0	12.0	46.0	32	384.0	30	360.0	400	800	2,117	24,861	540.4	662.2	26.2
12.0	12.0	51.0	37	444.0	35	420.0	450	850	2,205	28,665	562.0	763.8	28.1
16.25	16.25	98.0	28	455.0	26	422.5	850	1,800	2,106	55,377	595.4	1,088.7	33.5
16.25	16.25	110.0	32	520.0	30	487.5	900	1,800	2,216	61,200	556.4	1,203.2	35.2
16.25	16.25	127.0	37	601.3	35	568.75	900	1,800	2,295	65,745	517.6	1,292.6	36.5
17.0	17.0	100.0	28	468.0	26	442.0	827	2,000	1,932	51,730	517.9	973.1	31.7
17.0	17.0	116.0	32	544.0	30	510.0	1,000	2,000	2,190	66,512	573.3	1,249.7	35.8
17.0	17.0	137.0	37	629.0	35	595.0	1,000	2,000	2,255	70,520	514.7	1,325.0	37.0

THE HUDSON RIVER BRIDGE AT POUGH-KEEPSIE.

A GLANCE at any map of the Eastern and Middle States will show the need of a bridge over the Hudson River at a point midway between New York and Albany. All traffic between the New England States and the West and South over either of the lines having a terminus at Jersey City is subjected to more or less delay, caused by crossing the Hudson at that point. The Poughkeepsie bridge, together with about twelve miles of road to be built between Poughkeepsie

and Gardiner, will obviate this difficulty by making an almost direct route from Boston and Springfield to Scranton and the anthracite coal fields and Harrisburg. The advantages to be derived by the transportation of coal over this route, and by the passenger and freight traffic between New England and the West and South, are apparent.

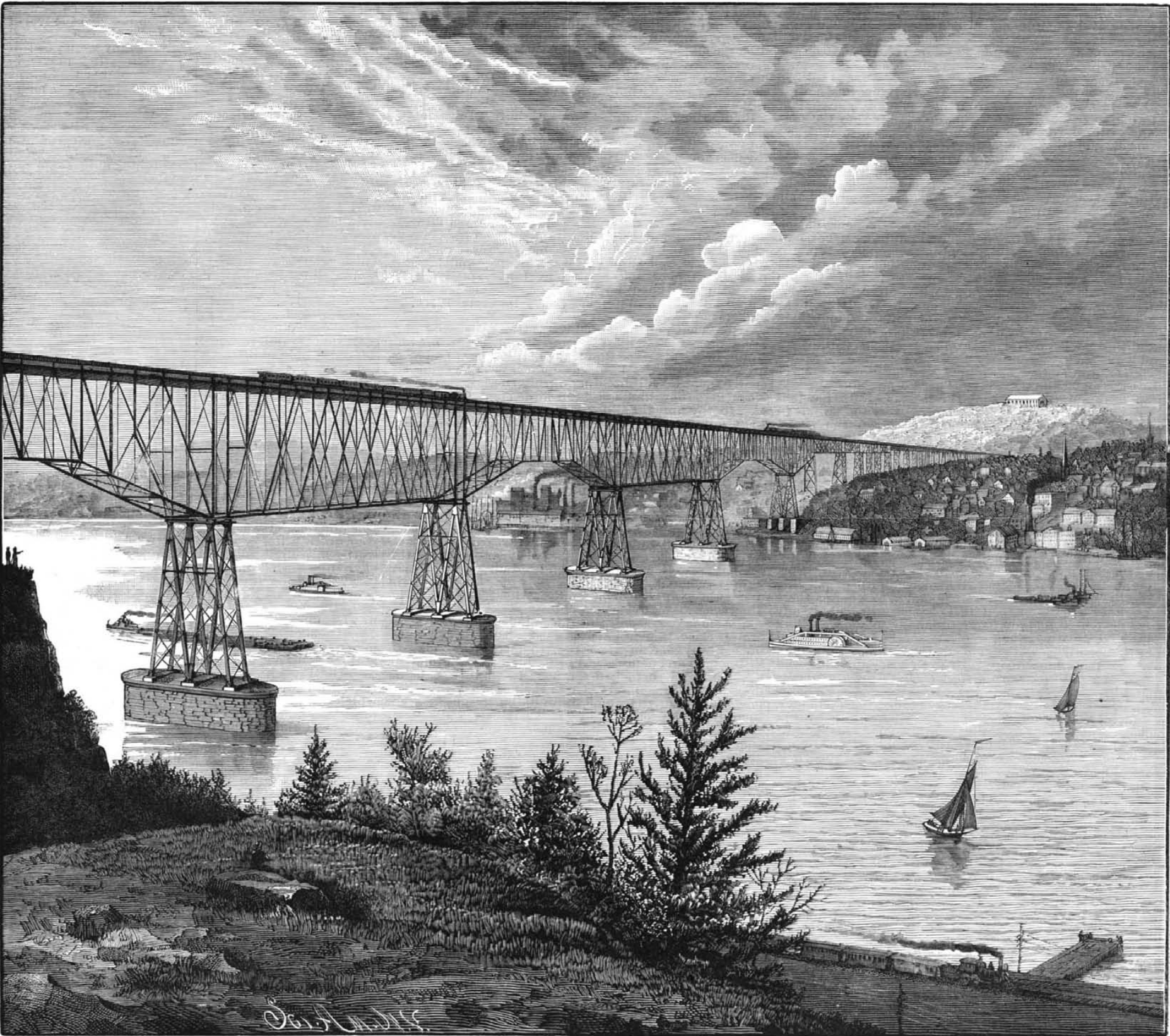
The Poughkeepsie bridge has four piers in the river. These are of masonry resting upon timber caissons, which are dredged down to about 125 ft. below high water. These caissons are 60 ft. by 100 ft., with twelve pockets left open for dredging, and which

will be filled with concrete after the caissons are sunk.

The masonry will be built on grillages, 46 ft. by 100 ft. by 10 ft. deep, with temporary sides. These will be sunk to rest on the top of the caissons, which will be 20 ft. below high water. The masonry piers are 24 ft. thick and 86 ft. long, and their tops will be 30 ft. above high water. From that level to the lowest point of the superstructure—100 ft.—will be steel towers, 16 ft. by 60 ft. on the base and 16 ft. by 30 ft. on top, made of eight columns well braced together in all directions. The wind pressure provided against is 30 lb. per square foot upon the exposed surface of the spans and towers and the area of the trains. The spans are provided to carry a train load of 3,060 lb. on each track, headed by two consolidation locomotives of 85 tons each, with factor of safety of 5. The pressure on the caisson bases is about 3 tons per square foot, and the material upon which they rest is hard gravel. The principal changes from the original plan of this bridge, as designed some fifteen years ago, are, substitution of steel towers for masonry, which diminishes the pressure on foundations very much; substitution of three cantilever spans of 548 ft. each, and two connection spans of 525 ft. each, for five disconnected spans of 525 ft. each. This change enables the Union Bridge Company to erect the three cantilever spans without staging in the river. It also gives more waterway between the piers, and a clear height of 160 ft. instead of 130 ft. in three spans.

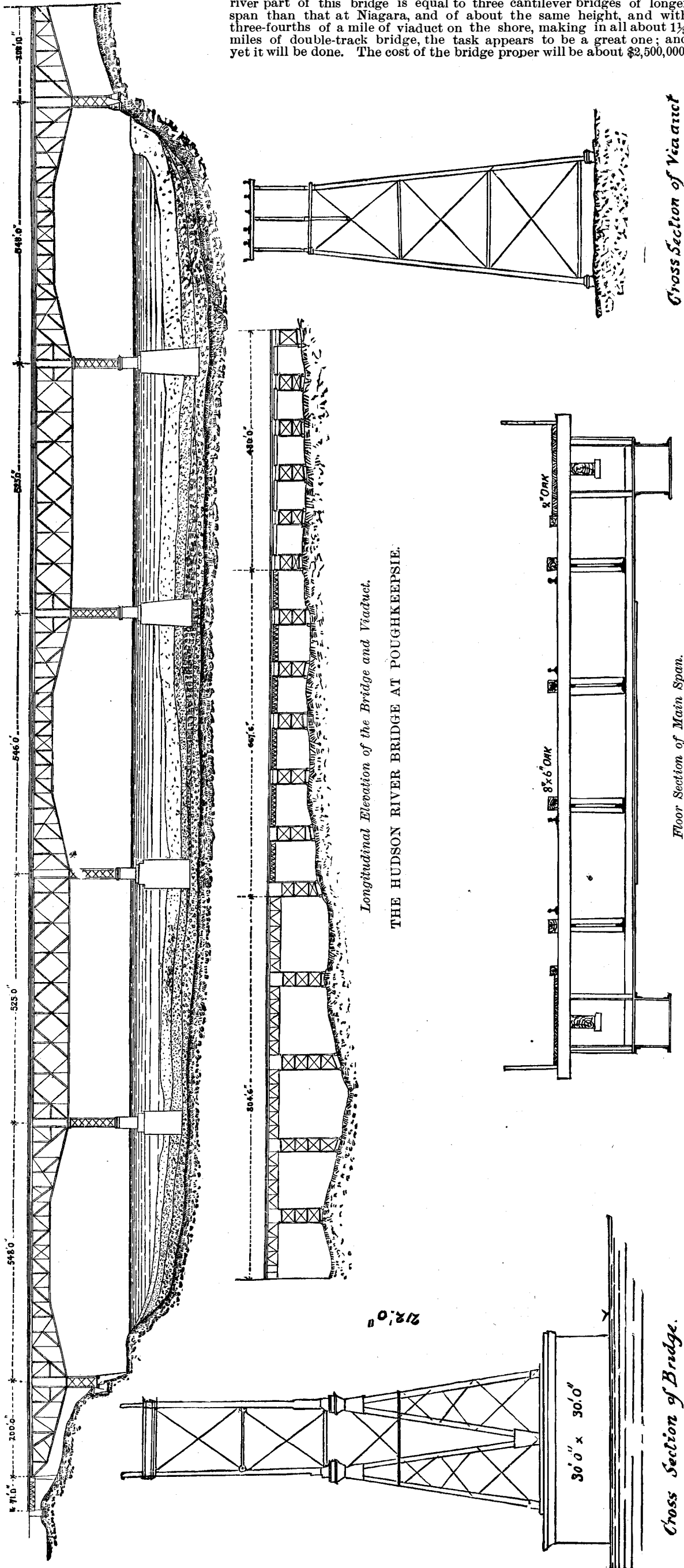
The superstructure will embody all the results of the latest and best practice. The following is a record of the test of an eyebar similar to those to be used in this bridge:

- Ultimate strength, 66,445 lb. per square inch.
- Elastic limit, 36,063 lb. per square inch.
- Elongation in 8 ft., 21 per cent.
- Elongation in 12 in. at point of fracture, 37½ per cent.
- Reduction of area at point of fracture, 51 per cent.
- All broke in the body of the bar.
- These were tested on the Union Bridge Co.'s 600 ton testing machine at Athens, Pa., at present the most powerful testing machine in the world.
- It is expected to pass trains over this bridge before December 31, 1887. When it is considered that the



THE HUDSON RIVER BRIDGE AT POUGHKEEPSIE.

river part of this bridge is equal to three cantilever bridges of longer span than that at Niagara, and of about the same height, and with three-fourths of a mile of viaduct on the shore, making in all about 1 1/4 miles of double-track bridge, the task appears to be a great one; and yet it will be done. The cost of the bridge proper will be about \$2,500,000.



Longitudinal Elevation of the Bridge and Viaduct.
THE HUDSON RIVER BRIDGE AT POUGHKEEPSIE.

Cross Section of Viaduct

Floor Section of Main Span.

Cross Section of Bridge.

THE DIAMOND MINE OF WISCONSIN.

In 1883, some little excitement was occasioned by the discovery of diamonds in Wisconsin, the little village of Eagle, which is situated on the line of the Chicago, Milwaukee, and St. Paul Railroad, about thirty-six miles west of Milwaukee, being the place of discovery. The mine is owned by Mr. S. B. Boynton, a Milwaukee jeweler, and I will give Mr. Boynton's own words in way of description and the incidents that led to the discovery of the diamonds:

"Eagle is surrounded by a beautiful and romantic country, abounding in springs, brooks, lakes, and hills. On the north of the town, not more than a stone's throw from the depot, lay a long range of high hills, known as the Kettle Range. This range of high hills seems to be the terminus of a large body of float which undoubtedly was thrown down from the northeast corner of the State, during the glacial periods, long ages ago. The hills are forty or fifty feet above the general level of the country, and are formed of beautiful gravel. All along the top of these hills are great sink holes, or pot holes, as they are more generally called.

"On the top of one of these hills, not far from the depot, some twenty years ago a man by the name of Bovee built a house, and dug a well to supply his household with water. The well was dug about thirty feet deep at that time, going through the first stratum of gravel and striking a bed of hardpan below. Thinking they had sufficient amount of water, they ceased digging. In a few years after, the property was sold to a Dr. Tucker, and the doctor concluded to sink the well still deeper, as the water was scant and insufficient to supply the wants of his family. They dug through the hardpan, which was thirty-five feet thick, at the bottom of which they found a bed of cement, or crust, about four inches in thickness. This crust was as hard as a solid rock. With crowbar and pick they broke a hole through it, when the water spouted up twenty feet high, so great was the pressure from below. In a short time the force of the water was spent, and the workmen went to work again. They dug out this crust and came to a beautiful bed of gravel below, in which they found a vast variety of very beautiful stones. They found one stone that attracted their special attention from its shape and brilliancy. One of the workmen picked it up and gave it to Mrs. Dr. Tucker; at the same time he said, 'Mrs. Tucker, here is a diamond, and I will give it to you.' She took the stone and showed it to several of her friends, who now live in Eagle.

After a few years Mr. Tucker sold the place to Devereux, who built another house on one part of the lot and rented this house to Mr. Wood. The well became filled up at the bottom, and it was necessary to clean it out. Workmen were set to work to do the job. They cleaned out all of the debris and dug about one foot into the lower bed of gravel, all of which was put into a pile at the top of the ground, near the well. One morning, after a hard rain, Mrs. Wood went out to feed her chickens, and saw something shining in the sunlight. She picked it up, and found it to be a very bright stone. She sent it to Milwaukee by a friend, who took it to a jeweler, who pronounced it a topaz, of no great value. It was taken back to Mrs. Wood, who laid it aside. After a few years, Mrs. Wood moved to Milwaukee. She brought the stone to me, to have it made into a ring. I looked at the stone, and told her that it was a very pretty one, and would make her a beautiful ring, and to do the job in a good shape would cost her twelve or fourteen dollars. She said she did not feel like paying so much money for a ring, and thought she would not have the work done. Then I told her I would buy the stone of her if she wished to sell it. 'What will you give me for it?' she asked. I told her I did not regard it of any great value, although it was very pretty. 'Yes, I think it is pretty. I am told that it is a topaz,' she said. I offered her one dollar for it. She said she would not sell it for that, and she went away. This was in November, 1883. I saw no more of her until a few days before Christmas, last, when she came into the store again, and said to me, 'I guess I will sell you that stone, Mr. Boynton, if you want it.' As she spoke she handed me the stone. I took it, and asked her how much I had offered her for it, for I had really forgotten. She said one dollar. 'All right,' I said, and handed her the money. I then asked her where she found it, and she told me as I have related her story. She then went away. I sat down to my bench, took up my eyeglass, and took a look at the stone with a glass for the first time. After looking it over carefully for a few moments, I became convinced that it was a diamond. I tried to cut it with a file, but could not make the least impression upon it. I then spoke to my son, and told him that I had a diamond. He came to my side and we both examined the stone, and came to the conclusion that I was right about it. My son took the stone to a manufacturer of jewelry, and showed it to him and asked him what he thought it was. He looked it over carefully, and said he could not tell, but thought it might be a sapphire. My son brought it back to the store, and I took it to one of our leading jewelers, and showed it to him, and told him I thought it was a diamond. He smiled a sort of sickly smile and said, 'Yes, that is a diamond, in a horn.' I brought it home, and in a day or two I took it to Chicago to have it tested.

"I took the stone to Messrs. Giles Bros., of Chicago, and showed it to C. K. Giles, who said, as soon as he saw it, 'That is a diamond.' He then showed it to his diamond cutter, who said, 'Why, that is a diamond.' He then tested it, weighed it, and said it was a very fine stone, and weighed 15 3/4 carats.

"I then went to my brother's store, who is a jeweler on State Street, in Chicago, and we talked the matter over, and came to the conclusion that it would be a good plan to prospect the old well, and see if there was not some more diamonds there. I told him I did not know where the old well was, nor did I know the lady's name from whom I bought the stone, or where she lived. I knew she said she found the stone in Eagle, and that it came out of a well, but whether in the village of Eagle or in the township of Eagle I could not tell.

"I came home, and began hunting for the woman. I walked the streets daily for some time, looking into the faces of all the ladies I chanced to meet, until I became ashamed of myself, so I concluded to change base; suffice it to say that after a trip to Eagle and

back, and much inquiry, I finally struck the trail, and found the lady.

"She called at my store to get a clock repaired. I at once recognized her, and asked her what her name was. She said it was Wood. I asked her if she was not the lady from whom I bought the stone, and she said she was. I then asked her again all about the finding of the stone, and where the well was, who now owned the place, etc. I got all the information I desired, and she went away. In a day or two, I took a friend with me, and we went to Eagle to purchase the land where the old well was.

"On our way to Eagle, we arranged a story that we thought would look reasonable to tell the parties, giving a reason why we desired to purchase the land on which the old well was located. We arrived at the depot, went to the post office, called upon Mr. Parks. I told him that the gentleman with me was a man who desired to purchase a small piece of land, suitable to raise some fancy chickens on; that he wanted from four to ten acres, and would pay what it was worth if it suited him. Mr. Parks gave us the names of several parties who had land for sale, but in doing so he did not name the name of Devereux, the man who owned the land we wanted, so we told him we had been told that a Mr. Devereux had a piece of land that might be bought. He said, 'Yes, he has a piece of land, but I hardly think it is what you want, but however you can take a look at it and see.' We thanked him for his information, and went to look at the land. We called upon several parties, and finally called on Devereux. We found him chopping wood. We told him what we wanted, he thought his place was just the place for us, and he would sell it to us for \$800, not a cent less. We looked the land over; there was the old well, and he said that at one time Mr. Wood's folks had lived upon the place, etc. We became convinced that that was the place, and we bought the property for the \$800.

"When Mr. Parks found out that we had bought the Devereux property he was much surprised, as it was up on top of a high hill, and poor land. But we told him that there was a point in the chicken business that he undoubtedly did not understand. We told him one very great advantage in that place was that it was so well located, being on high ground and so near the town, that if the hens knew their business they could lay their eggs in such a way that they would roll right into market. We returned home and waited for warm weather to come, so that we could begin work on the claim, and prospect it. We endeavored to keep the matter quiet, and succeeded in doing so for more than a month.

"After we had got the land secured and all safe, I sent word to Mrs. Wood by Mr. Wood to call at my store when she came by, I wanted to have a talk with her. She came in next morning, and I told her that the stone I bought of her proved to be of much more value than I supposed it was, and that I proposed to make her a good present, not in jewelry, but in cash. She said I did not owe her a cent, that I had paid her for the stone, and that it was all right. She said she had tried to sell it to other jewelers, and that all she could get for it was fifty cents, and I gave her one dollar, and that was all right.

"In a day or two the reporters of the *Evening Wisconsin* came to me to find out how much truth there was in the story. I tried to throw them off the track, but no go. I told them that it was all bosh, but they said they knew better, so the next evening the paper came out with a flaming heading, and gave the thing a most wonderful send off, setting the value of the stone at \$850, etc.

"As soon as Mrs. Wood saw this account of the diamond, its value, etc., it broke her all up, and now she made haste to call upon me, and demanded the stone. Said if it was a topaz it was mine, but if a diamond it was hers. I did not give her the stone. She went away, and sued me for \$10,000.

"On the 23d of April last, we began work at the claim. We sunk a shaft seventy feet deep, passed through thirty feet of gravel, then thirty feet of hardpan, then came to a stratum of cement about four inches thick, and as hard as solid rock. We broke through this and struck a bed of gravel below, in which we found such a body of water that we are compelled to put up an engine and pump. In digging through the upper stratum of gravel, we found several nice small diamonds and a multitude of other very fine stones. We have now demonstrated the fact that there are diamonds in those hills.

"Several old African diamond miners have visited the mines, and all of them say we have the very best of indications, and if we do not find diamonds in good paying quantities, they are greatly mistaken."

The above is an extract from a letter written to the editor by Mr. Boynton, July, 1885.—*Amer. Jeweler*.

MAGNETIC CARRIAGES IN CHINA AND JAPAN.

In the *Bibliothèque Electro-technique* of Hartleben, of Vienna, we find a very interesting little volume, by Dr. A. De Urbanitzky, on electricity and magnetism in ancient times. We extract from it a few passages relating to the applications of the magnetic needle. The invention of the compass dates back to the year 2634 before our era. In fact, we find the following lines in a great historical work, the *Thung Kian Kang mou*:

"Tschu-yu loved war, which permitted him to raise disorder and confusion. He had manufactured for him sabers, spears, and machines for throwing projectiles, in order to subjugate his neighbors and plunder them at his ease. Hoang-ti, not being able to tolerate such conduct any longer, forbade him to leave his dwelling, Choa-hao. But Tschu-yu still persisted in his misdoings. He crossed the river Yang-chui, ascended the Kieu-nao, and attacked the imperial army. The emperor, forced to beat a retreat, succeeded in getting in shape again through the aid of subsidies from his vessels, and forced Tschu-yu to give battle in the plain of Tschu-lu. The rebel governor then caused clouds of dust to be raised, in order to hide the disorder of his army from the enemy. But Hoang-ti, having had a carriage constructed that pointed out the south, was enabled to pursue the insurgents and seize Tschu-yu."

This carriage is thus described by Tschu-yu: "It carried a small pavilion supported by four wooden dragons. Upon this pavilion stood a carved wooden image representing a genius. Whatever was the direc-

tion of the carriage, the hand of the genius always pointed toward the south."

On another hand, according to the historic memoirs of Szu-mathsian, written in the first half of the second century before Christ, the invention of the magnetic carriage dates back only to the year 1100 B. C. Tschu-Kung (uncle and prime minister of the emperor Tsching-wang) made a present, to some ambassadors from distant lands, of five carriages constructed in such a way as to constantly point out the south. Thanks to these vehicles, the ambassadors found it possible to reach the coast and embark for their own country.

The Chinese employed the magnetic needle, not only to get their bearing upon land, in their travels, or in military expeditions, but also to determine the principal lines of their structures, and to guide their ships by.

According to Tsui-pao, the art of constructing magnetic carriages was lost, and not discovered again until

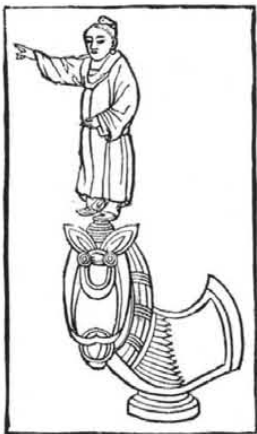


FIG. 1.—MAGNETIZED IMAGE BELONGING TO A CHINESE MAGNETIC CARRIAGE.

A. D. 235, by the learned Ma-Kiun. The following description is borrowed from a code of ceremonies inserted in the history of the Sung:

"To whichever side it turned, the hand constantly pointed south. One of the commanders of the imperial escort, charged with the guarding of this valuable car, always led it at the head of the cortege, when the prince attended a ceremony."

We find the most recent description in the encyclopedia *San tshai thu hoei* (A. D. 1609). Fig. 1 is a facsimile of the sketch that accompanies the text.

"The ornament of the carriage has the following dimensions: One foot, four inches and two lines in height, and seven inches and four lines wide at the base. At the extremity of the wooden shafts there is a circular aperture of a diameter of three inches and seven lines. A pivot of same diameter turns in this orifice, and is surmounted with a statuette representing a man with his arm always stretched out toward the south. This statuette moves in the aperture. . . ." (Here the text is effaced.)

The sovereigns of China, who always had to lead their armies over steppes of great extent, never were sure of the direction to take except through the aid of these compasses, which, moreover, were combined with apparatus that permitted of measuring the distance traversed.

According to Hai-bara Tok-sin, the author of *Wa zi si* (the origin of things in Japan), magnetic carriages were not known in Japan until the second part of the seventh century after Christ.

"In the fourth year (A. D. 658) of the great pontiff



FIG. 2.—MAGNETIZED IMAGE BELONGING TO A JAPANESE MAGNETIC CARRIAGE.

Sai-meit-yo, the Chamen (priest of Buddha) Tsehi-yu constructed a magnetic carriage," and he adds that this was the origin of these apparatus in Japan.

Fig. 2 is a reproduction of a picture taken from vol. xxxiii. of the great Japanese encyclopedia.

SOME CURIOUS FLAMES.

By THOMAS FLETCHER.

FLAMES and their peculiarities have not, up to the present time, received the amount of study which is necessary to understand them from a scientific point of view, or to utilize them commercially to the best advantage. Flame is really nothing but a sign of an incomplete or transition state of chemical combination. Its presence during combustion is not always necessary, and I think I am within the actual facts when I say that its presence under practical conditions in

commercial use indicates always a loss of work. Many of the experiments I shall show you have been adopted as regular demonstrations at scientific lectures, and the details of these will be found scattered among different lectures of my own. But they have never been collected and classified so as to be utilized for a systematic study of the laws of flame and combustion, and enable a broad and general view to be obtained on this most important subject. The appearance of flame is misleading, and the greater the flame the smaller the work done, other things being equal. I was recently asked by a well-known engineer if I could explain why certain boilers gave such an exceedingly small duty for the fuel consumed when the flues were, as he said, "filled from end to end with magnificent flame." The fact was that his so-called magnificent flame was a delusion, hollow and cold inside, and not coming into contact with his boiler at all. When the fuel was burnt with a very small flame, hardly visible over the bridge, the duty increased some 30 per cent. (The lecturer then gave some practical demonstrations of the various characters of flames, and their delusive appearances.) A cotton handkerchief, as you no doubt are aware, will burn readily to ashes, and I will prove this to you by burning one. I have here another, precisely the same, which we will saturate with proof spirit, and, as you see, the flame, although apparently a fierce one, is not hot enough to ignite the handkerchief, which comes out of the fiery test without a singe or mark. The fact is that the flame is not only comparatively a cold one, but it is also hollow, and does not come in contact with the handkerchief at all, the space between the handkerchief and the flame being filled with cold vapor, which only burns when it comes in contact with the surrounding air. To make this internal space in a flame visible to you, I must experiment in a different way. I now take a burner 8 in. in diameter, supplied with a mixture of coal gas and air, the air being supplied in a quantity sufficient to increase the bulk of the flame, but not enough to enable the gas to burn, except on the outer surface, where the mixture comes in contact with the surrounding air, with which it combines. This great flame is formed by the combustion of coal gas at the rate of 2 cu. ft. and about 20 cu. ft. of air per minute. It is of very little use for any purpose, and we now proceed to prove how great a delusion it is, by placing a ball of paper inside it, then some loose gunpowder on an open paper, and again a ball of gun-cotton, all of which remain untouched. The outer film of flame is hot enough to burn my hand if left in it. But if the body of my hand is protected with a damp cloth, I can put my naked fingers inside the flame without discomfort, and pick the paper of gun-cotton out of the center of the flame. By an alteration of the burner, admitting sufficient air with the gas to form an explosive mixture, which will burn without assistance from the external air, the flame instantly becomes solid, much smaller, less visible, and at once explodes the gunpowder. If not the first to discover the peculiarities and value of a solid flame without a cold center, the first application of this discovery to practical use was made in Manchester by Mr. Wallace, and any mention of this valuable improvement would be incomplete without a mention of the name of so worthy a pioneer in the study of combustion. To reduce the flame to a still smaller size, a different form of burner is necessary, with a supply of air under pressure, and the same quantity of gas and air burning, but the space taken up by the combustion, instead of being, as at first, 8 in. wide and 18 in. high, is less than one hundredth part the size. And instead of being able to put my bare hand in, it will fuse wrought iron almost instantly. It is well known that the available duty of any source of heat is, other things being equal, in direct proportion to the difference of temperature between this source and the object to be heated, and, therefore, we shall get a much larger amount of work from our small high temperature flame than from the large and colder one. I will now dispense with flame altogether, and show you the same quantity of gas and air burning as before, but in the most perfect form, the combination taking place on the surface of the substance to be heated without any flame. To show this, the mixture of gas and air is directed on a large ball of iron wire, flame being used at first to heat the wire to the necessary temperature to continue the combustion. By stopping the gas supply for an instant, the flame is extinguished, and the combustion is now continued without any flame, but with an enormous increase in the heat obtained. This invisible or flameless combustion is only possible under certain conditions, and one essential point is that the combustible mixture shall come in absolute contact with a substance at a high temperature which is capable of absorbing the heat as it is generated. We will now heat this small furnace to a temperature sufficient to cause combustion without flame, and will then remove the side, showing you the interior of the furnace, with a crucible being kept at a white heat, by blowing a cold mixture of gas and air into it. In the absence of a solid substance at a high temperature, it is impossible to cause combustion without flame. And when a flame is used, it is also impossible to make it touch a cold surface. Some may imagine that if a solid body is surrounded by a flame, the flame touches it. This is altogether a mistake; there is a space between the two which it is impossible to pass, a cold and flameless zone which surrounds the cold surface, and which is quite impassable to flame under any conditions, and which most seriously obstructs the work of heating. To prove that this impassable cold zone exists beyond any doubt, I take a copper vessel containing water, and on the side of this vessel I paste a thin paper label. On this I will direct the powerful flame, which you have seen will fuse wrought iron instantly, and the paper remains untouched, without a trace of singeing. The full force of the flame, urged by a heavy blast of air, may be directed on this paper for any length of time without the slightest effect, so long as the vessel contains any water. Some will imagine that the heat is absorbed so quickly that the paper has not time to get hot. But it is very easy to prove that this is not the case, by heating a wire in the same flame and touching the paper with it, causing instant charring. The cause of this extraordinary result has never yet been fully explained, but I believe it to be that all substances have an adherent film of air which resists the passage of any flame, but which is, of course, instantly removed by the application of any solid substance. This theory has one weak point, that the

cold zone is impassable also to radiant heat. And in the face of this fact, I must say that a really satisfactory explanation is yet to be found, which will agree with the present accepted theories of heat. The action of flame or heated matter on moist surfaces is much more easily explained. It is known that a moist hand or stick can be passed through molten iron without burning, owing to the film of steam evolved, which prevents contact with the metal. The same reason accounts for the fact that we can burn gun-cotton on the palm of our hands without feeling any heat, the moisture present absorbing the heat as fast as it is evolved. In the case of the paper label on the metal vessel, there is no moisture, the label having been carefully dried to prevent the sudden formation of steam lifting it away from the metal surface. And I think that the peculiar resistance to flame contact with a cold surface requires some further explanation than the present theories can account for. In connection with the subject of flames, I may refer, as a curiosity, to the enormous volume of sound of different tones which is produced by placing various sizes of chimneys on a gauze burner consuming a mixture of gas and air. The sound is as powerful, but certainly not so pleasing, as that of a fog horn. In all the experiments ordinary air has been used to combine with the combustible materials, air being composed of four parts of nitrogen and one of oxygen. The nitrogen is quite inert, having no power to combine. In fact, it does nothing except to dilute the oxygen and reduce the temperature obtained. If we remove the nitrogen, and use oxygen alone, the combustion is far more rapid and intense. So powerful is oxygen alone, that substances which are supposed to be incombustible, such as iron wire, burn readily in it. If we take a glass vessel full of oxygen, which is ordinary air with the useless nitrogen removed from it, I can show that iron, which is not usually considered a fuel, burns brilliantly in oxygen gas. In the combustion of iron, magnesium, and other substances of which the product is a solid, and not a vapor or gas, flame proper never exists, although in the combustion of magnesium and zinc it is apparently present. The brilliant incandescence of the particles thrown off causes a deceptive appearance. Flame never exists except as the result of combination of two or more gases or vapors. As a familiar instance of both forms of combustion, there is no more striking example than coke or charcoal, which, if burnt at once to carbonic acid, burn entirely without flame. If the supply of air is deficient, carbonic oxide is formed, which, being a combustible gas, burns with a flame. When speaking of the properties of flame, I am on the borders of the unknown, and my experiments and knowledge of this subject are very incomplete. The study is, to myself, one of both business and pleasure combined, and I am still studying experimentally the cold zone or space which exists between all flames and cold substances to which they are applied. If this cold zone can be passed in practice, and the flames can be applied in direct contact with the vessels to be heated, we shall then obtain something approaching the full theoretical duty of the fuel consumed, and our waste of fuel will drop to a very small fraction. In a paper which I had the honor of reading before the Iron and Steel Institute, I referred to one problem in heating which, if solved, would reduce our waste of fuel to zero, *i. e.*, the conversion of a large bulk of heat of low intensity to a smaller bulk of heat of high intensity. This conversion is possible with all other natural forces, such as light, electricity, etc., and I believe it to be possible with heat also, the only objection being, so far as I can see, that we do not know how to do it at present. But I have no doubt that the time will come when this problem will be solved by some one, who will be rewarded by both fame and fortune.*

PURIFICATION OF THE WATER SUPPLIES OF CITIES.†

By ALBERT R. LEEDS, Ph.D.

ACTING under instructions from the Aqueduct Boards of Newark and Jersey City, I spent the past summer in examining the water supplies of the large cities in England and Scotland. Many of these cities have already passed through crises in the history of their water supplies, similar to those at present agitating American communities. It is of the remedies which they have adopted, and of the pressing needs of Philadelphia, Albany, Newark, Jersey City, Wilmington, Washington, and other places, that I propose to speak this evening.

Our modern manufacturing towns increase in population with such rapidity that they soon find their local sources of water supply insufficient in quantity, and dangerous to health from pollution by sewage and factory waste. Then follows a more or less prolonged period of bitter controversy. It matters not how plain the fact of gross pollution may be; the fact is denied. In case the chemical testimony agrees with that of the senses, and water which is dirty, foul smelling, and bad tasting is found by the chemist to be impure, his honesty and ability are assailed. Either his results are declared false, or it is asserted that they mean just the reverse of what he himself says. Other experts are employed, and the local water supply, though it may contain the sewage of 10,000 or 100,000 people, is joyfully discovered to be extremely pure, and second in purity to none in the country. But at last, after years of denial, during which the public health has severely suffered, the fact of pollution is admitted, and the community resorts to one or more of the three following remedies:

1. It abandons local for remote sources, such as springs, lakes, rivers, or areas of upland drainage.
2. It sinks artesian wells, or deep wells, or subterranean galleries.
3. It purifies the polluted local supply.

In the study of this subject, there is no source of information more valuable than the blue books containing the minutes of inquiry before the Royal Commissions of 1851 and 1868 upon the supply of London. It is there stated that at first London drew its supply directly from the Thames, where it flowed through the town, at London Bridge. This was in 1581, and a century later (1691) the Thames was again drawn upon at Charing Cross, and this intake remained in use as late as 1829. Again, in 1723, the Chelsea Water Works were estab-

lished, and in 1785 those at Lambeth. While some part of the water supply was derived from springs in the chalk formation at Chadwell (brought in through a canal called the New River, in 1613), and another part from the river Lea (introduced by the East London Water Works Company, in 1806), yet as late as the year 1829 the metropolis was principally supplied by water taken from the Thames within the reach of the tidal flow. But in 1829, a Royal Commission, consisting of Telford, Brande, and Roget, was appointed to inquire into "the description, the quality, and salubrity" of the water. They reported that "the Thames water, when free from extraneous substances, was in a state of considerable purity; but as it approached the metropolis it became loaded with a quantity of filth which rendered it disgusting. It appeared, however, that a very considerable part, if not the whole, of this extraneous matter might be removed by filtration through sand, and the commission decided that it was perfectly possible to filter the whole supply with the requisite rapidity and within reasonable limits of expense."

Stimulated by this report, and alarmed, probably, at the prospect of a sweeping change of the sources of supply, the companies directed their attention to the purification of the water by filtration. It was soon found that the only appropriate material for mechanical filtration on a large scale was fine sand; but the great practical difficulty was to prevent the sand from becoming clogged, and to find an easy, practical, and cheap method for its renewal. After long experimentation, a means was discovered of getting over these difficulties. It was found that by far the greater quantity of the impurities was held in suspension by the agitation and motion of the water, and that if it was allowed to stand for some time at perfect rest, in a reservoir, the heavier and grosser particles were deposited by simple subsidence, leaving only a small proportion of lighter and finer matters to be dealt with by filtration. It was also found that when the water was allowed to filter downward through a porous bed of sand, held up in its place by underlying layers of coarse gravel, the dirt did not penetrate into its mass, but was stopped at its upper surface, so that the whole cleaning operation necessary was to scrape this surface off to a slight thickness, and when it had become too much diminished, to put on fresh sand.

In accordance with these suggestions, the first large filter, which had an area of one acre, was put into use by the Chelsea Company, in 1829.* It worked well, so well, indeed, that it led to the well-nigh universal practice of filtration in England. Our failure to do the same in this country shows that in this respect we are behind the age.

But about the time of this first use of filters in England, the disturbing ideas of modern sanitary science took their rise; that unspeakable abomination, the domestic cesspool attached to a city house, began to be abolished; drainage and sewerage works were established, and the amount of impurities carried to and fro under London Bridge was increased enormously.

This agitation kept on growing, until, in the year 1834, the engineer, Mr. Telford, recommended that the Thames should be abandoned. This was not done, but in 1851 a Royal Commission, consisting of Profs. Graham, Miller, and Hofmann, recommended that while the supply should still be drawn from the Thames, the points of intake should be removed above the influence of tidal flow (*i. e.*, above Teddington Lock). They made other recommendations, which were incorporated into an act, passed in 1852, regulating the water supply of the metropolis. In this act, the two clauses of greatest significance to us are, 1, that every storage reservoir within five miles of St. Paul's should be covered; and 2, that all water supplied for domestic use should be *effectually filtered, unless it is pumped from wells direct into covered reservoirs*.

A mere statement of the law which was passed after a quarter of a century of discussion by the most eminent engineers, chemists, and law makers of England, is a more emphatic testimony to the fundamental importance of the provisions therein contained than any argument I am able to make.

This law led to certain results throughout England, which I trust will become universal. These are:

1. The education of public opinion to such a point as to demand sources of city water supply actually and visibly free from pollution. The wealthiest communities, like Glasgow, Manchester, and Liverpool, have deemed it a wise investment of great sums of money to obtain sources absolutely free from suspicion and reproach.

2. The construction of large, and in some cases vast, reservoirs, with the object, not merely of safety, but also of allowing opportunity for the dissolved organic matters to oxidize, or to be carried by subsidence along with the suspended mineral matters to the bottom.

3. Effectual filtration. And it should be noted that when the act of 1851 required the London companies to filter the water, under very heavy penalties, the water referred to was that taken from the Thames above Teddington Lock, which water the Commission had previously found to be "perfectly wholesome, palatable, and agreeable." Still more striking instances of the estimate put upon filtration as a process indispensable to the excellence of city water supply were frequently brought under my personal observation, and some I shall mention later.

4. The preservation of the water, after it has been filtered, in covered storage reservoirs.

The good effects of the act of 1851 speedily became apparent. The water companies expended £2,500,000, with the result, according to the examinations of Professor Hofmann and Mr. Blyth, made in 1856, of bringing about "a very positive and considerable diminution in the amount of organic matter. This, though doubtless due chiefly to the removal of the intake to a point above the tidalway of the Thames, was also attributed in great degree to the considerable improvement which had taken place in the collection, filtration, and general management of the supply of water."

But, fortunately, the public was not satisfied. In pursuance of the recommendations of the Royal Commission of 1865 on the pollution of rivers, the admission of sewage or any other offensive or injurious matter into the Thames, or into any tributary stream

or water course within three miles of its junction with the Thames, was declared illegal, with heavy penalties.

In 1866, 5,596 lives were destroyed in London by cholera; and although this visitation was subsequently attributed to the polluted water of the Ravensbourne and the foul unfiltered water from the reservoirs at Old Ford on the River Lea, yet it so alarmed the community that the Commission of 1866 was appointed to make a far more extended inquiry than ever before, and to ascertain what supply of unpolluted and wholesome water could be obtained, by collecting and storing water in the high grounds of England and Wales, either by the aid of natural lakes or by artificial reservoirs, at a sufficient elevation for the supply of London and the principal towns of England. Now, it is a well-known fact that the recommendations of the very distinguished engineers came to naught, so far as London was concerned, though they are at present bearing fruit in connection with Manchester and Liverpool.

It is well worth our while to inquire why such was the case. Mr. Bateman's plan was to bring the waters collected from the drainage areas at the head of the River Severn in Wales (including the drainage area of the Vyrnwy) by gravitation through an aqueduct 180 miles in length, and capable of conveying 230,000,000 gallons per diem. Messrs. Hemans and Hassard proposed to bring the waters of Lakes Thirlmere, Ullswater, and Haweswater through conduits, tunnels, and pipes equivalent in their carrying capacity to a river 30 ft. wide and 10 ft. deep, over a length of 270 miles. These plans, which were considered the best, were reported upon unfavorably, principally on account of the cost, the estimated expense of Mr. Bateman's scheme being £55,000,000, and that of the Cumberland Lake scheme still greater.

This report decided the future supply of the metropolis, and confined it to local sources. The supply from Lake Thirlmere has already been appropriated by the city of Manchester. The water will be brought in a tunnel 9 ft. square to the reservoirs at Prestwich, on one side of Manchester, a distance of 95 miles, and continued thence to reservoirs on the other side of Manchester, a distance of 110 miles. Mr. Hill, the engineer of the new supply, informed me that the first 10,000,000 gallons are estimated to cost £2,000,000, inasmuch as the tunnels of full size are to be constructed at once, and connected by a 40 in. iron pipe where siphons are necessary. The second ten million gallons are estimated to cost only £400,000. The land damages to persons living around the lake and along the tunnel are £225,000.

The supply from Vyrnwy Lake has been appropriated by Liverpool. This artificial lake is to be created by a dam, which, at its top, will have a length of 1,173 ft., and will rise to a height of 144 ft. above the bed rock and 84 ft. above the bed of the existing river. Its length will be $4\frac{1}{2}$ miles, its area 1,165 acres, and its greatest depth of water about 84 ft. The aqueduct from the lake to the existing Prescot Reservoir, nine miles east of the Liverpool Town Hall, is 68 miles. It will consist mainly of tunnels, through which the ultimate supply of 40,000,000 gallons a day may be passed without filling them, and of three lines of pipes, each having an internal diameter varying according to the fall of the sections from 39 in. to 42 in. All this water from the Welsh mountains will be subjected to filtration through sand filters, the Oswestry reservoir and the three reservoirs for filtered water having an aggregate storage capacity of 54,549,500 gallons.

In one very important particular, the Commission of 1866 was certainly in error. It thought a probable increase of population to 4,500,000 or 5,000,000 would have to be provided for, and a maximum daily supply of 200,000,000 gallons, though the time for such an extended provision would be very remote. As a matter of fact, the population supplied by the companies in May of this year was 5,274,542, and the average daily supply during the month was 160,388,316 gallons. Of this, more than half, or 82,366,466 gallons, came from the Thames, and the balance from the River Lea, and from certain chalk springs in the valleys of the Lea and Thames, and from twenty-one deep wells sunk into the chalk formation to the north and south of London. There are fifty-four *subsiding reservoirs for unfiltered water*, with an area of 465 acres, and an available capacity of 1,290,100,000 gallons, and fifty-three *covered reservoirs for storage of the water after filtration*, with a capacity of 160,002,000 gallons. The number of filter beds is ninety-nine, with an area of 98 acres. Of this surface, 92 acres were cleansed during the month of May, some of the filter beds being cleansed once and partly gone over again during the month. The maximum permissible rate of filtration is 2 ft. per hour and per square foot of surface, but, as a matter of fact, the actual rate in the month of May last was generally much smaller than this, some filters passing only $1\frac{1}{2}$ ft. The construction of the filters varies greatly, the top layer, however, being in all cases fine sand, in depth from 2 ft. to $4\frac{1}{2}$ ft.

From the published analyses, it appears that the quality of the water supplied to London is usually satisfactory, though at times results are obtained adverse to that portion of it which is derived from the Thames. The population of the drainage area of the Thames is very large, and although the towns located therein are compelled to purify their sewage, yet much polluting material from them and from the floating population on the river finds its way into the river.

Leaving, for the present, the history of the largest experiments hitherto made in the way of purification of a polluted water supply, I shall ask your attention more particularly to the methods by which such purification may be effected.

Artificial Aeration.—One of the easiest and most inexpensive methods of improving the quality of water is by means of artificial aeration. The importance of natural aeration has been recognized from time immemorial, and the effect of tumbling down natural falls and rapids, passing over artificial dams, and of agitation by winds and storms, in keeping water lively and sweet, is too well known to need more than passing mention. It is of especial interest to us that this mode of improving water was first applied to city water supply in consequence of the extremely offensive taste and odor of the Schuylkill water in January and February, 1883. The fact that the analyses revealed the presence of a large amount of sewage in the Fairmount water did not explain its peculiar offensiveness at that

* From a recent lecture before the Manchester Technical School.

† A lecture delivered before the Franklin Institute, Thursday, December 23, 1886.

* Royal Comm. Water Supply, 1868.

season, for there have been times, before and since, when it contained even more sewage and was not so unpalatable. But it appeared to me very noteworthy that the oxygen which ought to be present in a state of solution was largely deficient. Much of it had been used up in the oxidation of the sewage, and the river, being ice bound from its source to Fairmount Dam, had no opportunity of taking from the atmosphere sufficient oxygen to replace that which had been lost.

Reflecting upon these facts, I thought it worth while to try the effect of submitting the disgusting samples from Fairmount Pool to artificial aeration. I found that they not only took up from the air forced through them the oxygen they lacked, but also that much of the sewage to which their offensiveness was due was destroyed. These experiments suggested to me the idea of pumping air into the lower ends of the mains at the pumping stations. This way of introducing the air was not only the easiest and simplest, but it also afforded an opportunity of placing the mixture of air and water under a maximum pressure. Air, as is well known, consists of twenty-one parts by volume of oxygen and seventy-nine parts of nitrogen; but the oxygen is more soluble in water than the nitrogen, and, therefore, the greater the pressure to which a mixture of air and water is subjected, the larger is the relative amount of oxygen made to enter into solution.

The study of the subject received fresh impetus from the condition of the water supply of Hoboken in the latter part of July, 1884. At that time, the oxygen in a number of samples from the Hackensack River, whence the supply of Hoboken is derived, fell to 3.87 c. c. per liter, and the total dissolved gases to 14.93 c. c. Contemporaneously, the same waters, when impounded in the reservoir, became covered with a scum several inches in thickness, consisting largely of *Oscillaria*. These quickly died, and yielded up a dark blue coloring matter (the *Phococyan* of Cohn). Finally, this great accumulation of vegetable growth passed into a state of active decomposition, attended with the formation of white foam and the liberation of large volumes of carbonic acid and other gases. The water for ten days previous had been too nauseous to drink, but the whole succession of phenomena above described took place within twenty-four hours, the vast development of algae, their breaking up with evolution of green and blue coloring matter, and their final decomposition occurring with astonishing rapidity. The entire reservoir had the appearance of an enormous dyeing vat, covered with dark green and blue dyestuffs.

A repetition of the same disastrous sequence of events was threatened on September 14, when the percentage of dissolved oxygen fell to four cubic centimeters, and at the same time a growth of algae began in the reservoir. But meanwhile arrangements had been perfected in anticipation of this catastrophe, and by pumping air under pressure into the mains, the percentage of total dissolved gases was raised from 15.9 cubic centimeters to 21.2 cubic centimeters. The green scum on the reservoir disappeared, and the taste and smell of the drinking water became satisfactory.

In November, 1884, a preliminary experiment was instituted at the Fairmount Pumping Station, an air pump being attached to the main at that point. The aerated water was pumped into the Corinthian Basin through the forty-eight inch main, a distance of 3,000 ft. The results of this experiment were so encouraging that the Chief Engineer, Col. Ludlow, obtained air compressors for all the pumping stations. At only one of them, however, has the process been applied, namely, at Belmont, the other mains being too leaky to permit of its being used.

At this station, the water has been charged with twenty per cent. of its volume of air, and the change in composition thereby effected is strikingly illustrated in the following results, which give the composition of the water before it enters the pumping main, and as it is discharged therefrom:

	PARTS PER 100,000.	
	Non-aerated.	Aerated.
Free ammonia.....	0.017	0.004
Albuminoid ammonia.....	0.011	0.007
Oxygen required to oxidize organic substances.....	0.133	0.117
Nitrous acid.....	0.0008	none
Nitric acid.....	0.45	0.54
Total solids.....	9.00	8.70

It will be seen that the albuminoid ammonia has diminished nearly forty per cent.; and, what is the most noteworthy feature of all, the nitrous acid has undergone complete oxidation, none being present in the aerated sample. At the same time, by oxidation of the nitrogenous portions of the organic matter, the nitric acid has been increased twenty per cent.; and by oxidation of the organic constituents in general, the total solids have been diminished from nine parts per 100,000 to 8.7 parts.

The process has now been applied to the entire water supply of Hoboken, amounting to 4,000,000 gallons per diem, for more than two years, and during this time the unpleasant taste which caused its first application has never reappeared.

Similar experience in Brooklyn has caused the process to be used in connection with the water obtained from driven wells. This driven well water has been used in the Greenwood Cemetery to feed a number of artificial lakes arranged to beautify the grounds. Last summer, I was asked to examine the water in the reservoir into which the driven well water is first pumped and to devise a means if possible for preventing the enormous growth of plants therein. The growth, on examination, proved to be diatomaceæ, particularly of the species *Navicula viridis*, and the green vegetable substance which by its decay rendered the water offensive was the slime secreted by these diatoms. Two facts were prominent. The one was that the diatoms could be made to grow very rapidly when exposed in open jars to sunlight; the other, that the water of the reservoir was very deficient in dissolved oxygen. It contained only 2.32 cubic centimeters of oxygen in the liter, and the enormous amount of 4.97 cubic centimeters of carbonic acid. I advised the covering of the reservoirs to exclude sunlight. The authorities were opposed to so doing, because it destroyed the very result aimed at in providing the reservoir and ponds, which was to beautify the park. Then I advised the use of an air compressor. This was installed, and the result is given in the following letter from the consulting engineer:

November 27, 1886.

DR. ALBERT R. LEEDS:

Dear Sir: In answer to your inquiry concerning the trouble at the Greenwood Cemetery reservoir, I would state that the water, fresh from driven wells when delivered into the reservoir, began to develop decaying vegetation, which in a short time rendered the water offensive to taste and smell; that immediately on receipt of your report and recommendation, last June, I set up an ordinary compressor, and pumped air into the mains under a pressure of about eighty pounds to the square inch, allowing it to escape through the reservoir, with this result: At first there was no perceptible effect, but upon increasing the amount of air supplied to the water to the extent of about ten per cent. of the free air to an equal volume of water, the trouble in the reservoir disappeared. Since that time air has been freely supplied whenever there appeared to be any recurrence of the growth of vegetation in the reservoir, and there has been no return of the offensive taste and smell.

Respectfully submitted,

CHAS. B. BRUSH,
Con. Eng. Greenwood Cemetery.

Covered Reservoirs.—In May of this year, the water from the driven wells supplying the city of Jamestown, in Western New York, was similarly affected, the reservoir containing several species of diatomaceæ, among which the *Cocconeis lanceolata* was the most abundant. Certain of the protococceæ, especially various species of *Scenedesmus* and certain genera of *Zygnemaceæ*, including different species of *Spirogyra*, were also present. The water in the driven wells (May 22) had a temperature of only 48°, but that in the reservoir was over 80°, and the development of the spores in the deep well water was correspondingly rapid. The suggestion to cover the reservoir was carried out in this case, and the aquatic plants disappeared. Similar troubles, and the development of a variety of odors chronicled as "fishy," "pig-pen," "cucumber," and the like, have been reported as affecting, at one time or another, the water supplies of most of our towns.

There is good reason to suppose that these complaints will continue as long as water, which on standing has lost much of its dissolved oxygen and has become stagnant, is exposed to our burning suns and allowed to rise to a temperature of 70° and upward, in uncovered reservoirs. Either it should be covered, so as to exclude light, and kept cool, or, if its temperature is allowed to rise above 70° and it is exposed to the sun, it should be charged with air and kept moving.

Storage and Subsiding Reservoirs.—The development of aquatic growth, and the nauseous tastes and smells arising from its decay, have probably had a discouraging influence upon the construction of large subsiding reservoirs in our own country. In many cities, as in New York and Philadelphia, the small storage capacity has been for years the cause of most serious apprehension. The new works now in progress in connection with the Croton Aqueduct will, it is hoped, overcome this danger so far as New York is concerned. I noted, however, with great interest, that Mr. Worthen, in the course of his examination before the commission charged with providing a more abundant supply for the metropolis, made the significant remark, in relation to the great new reservoir at Quaker Dam, which will hold 3,600,000,000 gallons, that *stagnant water would not keep*. In England, this difficulty is sometimes, though rarely, encountered. I asked Mr. Wood, the City Engineer of Leeds, whether the English reservoirs are injuriously affected by vegetation. He said that trouble from this source seldom occurred, but when it did occur it was owing to the growth of the American weed. The particular kind of weed he referred to was not so common as its name would appear to indicate, and I never saw it. The great benefit due to storage and subsidence was strikingly exemplified in the case of the city above referred to. Its watersupply is taken from the drainage area of the small river Washburn, at a distance of about ten miles from the city. On this stream are located three impounding reservoirs, and their waters are carried by gravity into the Eccup Reservoir, an artificial lake a mile long and holding 1,400,000,000 gallons. This supply, without addition, is adequate for the consumption of 10,000,000 gallons per diem for nearly five months. But this safeguard is only a part of the advantage due to the large size of the reservoir. For the water is made to enter at the bottom near the great dam forming one end of this artificial lake, and fifty-two feet below the surface. It then travels the entire length of the lake and is taken out by a bell supported on masonry piers, the lip of the bell being 15 feet below the surface and 23 feet above the bottom. During its months of passage, not only nearly perfect sedimentation of earthy particles occurs, but by a process of natural oxidation the peaty color is bleached out. Though such is the case, all the water is subsequently filtered, seven filter beds being adequate, and finally stored in covered reservoirs. These reservoirs are made with inverts of masonry, upon which walls are built, capped by arches, the latter being covered with earth and handsome lawns.

It is not improbable that the difficulties which we encounter in America from the long-continued heat of summer may lead to remedies appropriate to our peculiar needs. I have already alluded to the advantage derived from first bringing the percentage of oxygen to the highest possible point in delaying or preventing that condition of oxygen-poverty, with its resultant growths, which we recognize as stagnation. During the warmer months, reservoirs could be provided with such a covering as might be thrown out of use when winter came on, with the accompaniment of crushing weights of snow. I saw at Manchester, Bradford, Buxton, and many other towns in England, subsiding reservoirs arranged to effect a subsidence of the sludge or coagulum which is produced when town sewage is treated with lime. These reservoirs are built with vertical partitions, so that the water flows over the top of the first and under the bottom of the second, and over the top of the third, and so on through sometimes as many as twelve compartments. Where the town sewage does not contain dye-stuffs, as at Buxton, the water coming out of the last compartment is frequently as sparkling as spring water. The construction of subsiding reservoirs for water storage in a similar manner would facilitate cleansing, inasmuch as the greater part of the silt would be deposited in the first

and second compartments, and a constant onward movement of the water without a disturbing current would be obtained, permitting of subsidence, while at the same time preventing stagnation.

Filtration.—Up to the present time, no material has been found which is practically available for filtration on a large scale, except fine sand. Sponge, coke, animal and wood charcoal, porous brick, carbide of iron, spongy iron, and many other materials have been tried, but with the result as above stated. When metallic iron is used, excellent results are obtained, through its chemical action as a carrier of oxygen to the organic matters, which are thereby oxidized and destroyed, but the water even then must be subsequently filtered through sand.

Until quite recently, it has been supposed that the main benefit of sand filtration is in the removal of suspended mud and dirt, the amount of organic impurities thereby removed being small. But since Pasteur discovered that the micro-organisms, which are supposed by some to be the specific germs of disease, may be completely arrested by filtration through a thin porous plate, a great revolution of opinion has been effected. In his report for the month of May last, Dr. Frankland states that the unfiltered Thames water yielded by the method of gelatine-peptone culture 4,800 colonies of microbes per cubic centimeter of water. After passage through sand filters at Chelsea, it yielded only fifty-nine colonies, and through those of West Middlesex only nineteen colonies. This is indeed astonishing, and the more so when the remarkably pure water in the deep chalk-wells of Kent yielded eight colonies, and the same water by the time it reached its point of supply had increased in its number of micro-organisms until 101 colonies were obtained in the culture liquid.

At the present time, American engineers regard it impracticable to introduce the English system of sand filters, on account of the great expense of operating them. This has been variously estimated at from \$2.50 to \$5 per day for each million gallons filtered, exclusive of first cost and interest. Such being the case, I need not go into a statement of the reasons why the few which have been actually brought into use in this country have been so little successful. The conviction appears to be generally entertained that American ingenuity must discover some method by which mechanical arrangements may take the place of the cumbersome English system, and dispense with the very considerable manual labor required in cleansing. Many contrivances have been brought forward, but they are crude, or have complicated systems of pipes for reversals of the current, or are wasteful in the use of filtered water for cleansing. Recently, however, an extremely simple device has been proposed, which is yielding excellent results. As is well known, the efficient part of a filter bed is the top layer of sand, which need not be more than two feet in thickness. At Poughkeepsie, on the Hudson River, this two feet of sand rests on four feet of gravel and stone, which are provided merely to support the sand and to afford channels for the filtered water to drain away. This gravel and stone are replaced in the device I have alluded to, the National filter, by a system of double pipes which are perforated and the annular space between the perforated pipes filled in with fine quartz gravel. The filtered water runs out through these double pipes, while the sand is arrested. By another simple arrangement, the manual labor requisite to clean the deposit of dirt from the upper surface is dispensed with. A system of perforated pipes is laid at a distance of six inches below the surface. When it is necessary to cleanse the filter, a reverse current of filtered water is sent upward under pressure through these pipes, and the impurities are washed off and floated away.

Damage by Waste.—The statistics of water distribution in our American cities show that from one-third to one-half of the water is wasted, not used. Less importance seems to be attached to dirty and unwholesome water, provided there is enough of it, than to controlling dishonest waste and expending the money thus saved in improving the quality of the supply. Until such waste is stopped by metering and fines, there will be little popular sympathy or support for movements intended either to purify and filter the water at present used, or to go ninety miles to get water, one-half of which will subsequently be thrown away.—J. F. I.

THE SYMPATHETIC NERVOUS SYSTEM.*

By WALTER H. GASKELL, M.D.

THE lecturer commenced by giving a short sketch of Bichat's views of the division of life into organic and animal life, and pointed out how that division naturally led to the conception of two separate central nervous systems, the one, the sympathetic, to which all the organic functions are to be referred, the other, the cerebro-spinal, regulating the animal functions. He then pointed out how Remak's discovery of a special kind of nerve fiber—the non-medullated nerves—associated only with the ganglia of the sympathetic system, tended strongly to confirm Bichat's teaching of the existence of two separate central nervous systems in the human body, each of which communicated with the other by means of its own special kind of nerve fibers; the cerebro-spinal supplying the sympathetic system with white medullated fibers, and the sympathetic supplying the cerebro-spinal with gray or gelatinous non-medullated fibers. He then continued as follows:

Even at the present day the teaching of Bichat still very largely holds its ground. It is true that the tendency of modern physiology is to increase the number of centers of action for the organic nerves, which exist in the cerebro-spinal central axis, and therefore to do away with the necessity for a separate independent sympathetic nervous system, yet the automatic actions of isolated organs such as the heart, and the existence of special nerve fibers in connection with this system, still induce the neurologists of the present day to place the sympathetic nervous system on an equality with the brain or spinal cord. In this lecture to-night I hope to give the death blow to Bichat's teaching, and to prove to you that the whole sympathetic system is nothing more than an outflow of visceral nerves from

* Abstract of lecture at the Royal Institution, on June 4, 1886, by Walter H. Gaskell, M.D., M.A., F.R.S.—*Nature*.

certain nerve centers in the cerebro-spinal system, the ganglia of which are not confined to one fixed position, as is the case with the ganglia of the posterior roots, but have traveled further away from the central axis.

I do not propose to-night to deal with the argument for the independence of the sympathetic nervous system, which is based upon the automatism of such isolated organs as the heart. I have already in various papers given the reasons and arguments why I look upon such automatic movements as due to the automatism of the cardiac muscular tissue rather than to any action of nerve cells comparable to the nerve centers of the spinal cord. I shall deal entirely with the anatomical argument, and show you step by step how the nerve fibers which constitute the sympathetic system can be traced to their origin in the central cerebro-spinal axis.

Evidently, in endeavoring to determine by anatomical means whether the sympathetic and cerebro-spinal systems are in reality independent of one another, our attention must necessarily be especially concentrated upon the nature of the connecting link between the two systems, *i. e.*, upon the nature of the rami communicantes. Largely owing to the preconceived notions of anatomists, you will find that the rami communicantes are arranged symmetrically in connection with all the spinal nerves of the body. In reality this is far from being the case. The rami communicantes of the thoracic nerves differ from those above them, *i. e.*, of the cervical nerves, and from those below them, *i. e.*, of the lumbar nerves, in two important particulars. In the first place, the corresponding sympathetic ganglion is connected with each thoracic nerve by two rami communicantes; and secondly, these two rami differ in color, one being gray, *i. e.*, composed almost entirely of non-medullated nerves, and the other white, *i. e.*, composed essentially of medullated nerve fibers.

This double nature of the rami communicantes is confined to the region lying between the two large plexuses which supply the anterior and posterior extremities, *viz.*, the brachial, lumbar, and sciatic plexuses; the rami communicantes to the lower cervical and first thoracic nerves, as well as those to the nerves forming the anterior crural and the sciatic, are, on the other hand, single, and are composed only of gray rami. In other words, the sympathetic chain is connected with the central nervous system by means of white rami communicantes only between the second thoracic and second lumbar nerves.

Further, I have been able to trace both the white and gray rami in their journey to the spinal cord by means of consecutive sections of osmic acid preparations, and have found that the gray rami pass out of the sympathetic ganglion as a single nerve, and then ramify in the connective tissue about the vertebral foramina, a portion only reaching the spinal nerve trunk; the gray fibers of this portion pass mainly along the nerve peripherally; the few which pass centrally never reach the spinal cord, but pass out with the connective tissue which lies in between the medullated nerve fibers of the anterior and posterior roots, to ramify over and to supply the blood vessels of the various membranes which inclose the spinal cord.

In fact, the gray rami communicantes are peripheral nerves, which partly supply the vertebræ and the membranes of the cord, and partly pass to their destination in the same direction as the efferent fibers of the spinal nerve itself.

So far then I come to these conclusions:

(1) The sympathetic does not send non-medullated fibers into the cerebro-spinal system, because these fibers all pass out of the nerve roots before they reach the spinal cord.

(2) White or medullated nerve fibers constitute the only link between the sympathetic and cerebro-spinal systems, constituting the white rami communicantes.

(3) Consequently the connection between these two nervous systems is limited to the region of white rami communicantes, *i. e.*, to the region between the second thoracic and second lumbar nerves.

Further, these conclusions are borne out when we attempt to follow the white rami communicantes into the central spinal axis by means of their structural peculiarities; sections of osmic preparations show that each white ramus is composed chiefly of very small medullated nerve fibers, varying in size from 1.8μ to 3.6μ , very much smaller, therefore, than the large medullated nerves which form the bulk of the anterior roots of the spinal nerves, these latter varying between 14μ to 20μ or even larger. Clearly then the fibers of the white rami communicantes ought to show very conspicuously among the large fibers of the anterior roots whenever they are present in those roots. I have cut sections of the anterior roots of all the spinal nerves in the dog, and have found, as I show you on this screen, that these very fine medullated nerve fibers make their appearance for the first time in the anterior roots of the second thoracic nerve; they are found in large quantities in all the anterior roots between the second thoracic and second lumbar, and then again the anterior roots immediately below the second lumbar are free from such groups of very fine fibers. We see then that exactly corresponding to the presence of white rami communicantes in the thoracic region we find groups of characteristic fine medullated fibers existing in the anterior roots, fibers which clearly form part of the white rami communicantes, and confirm by their presence the conclusion already arrived at, *viz.*, that the nerves which pass from the spinal cord into the sympathetic system are limited to the thoracic region of the cord.

We can now go a step further, and argue in the reverse direction that the presence of groups of these very fine medullated fibers in the anterior roots of any nerve implies the existence of nerve fibers belonging to the same system as the white rami communicantes or rami viscerales, as we may now call them. Examination shows how just is this argument, for I find that the same groups of fine nerve fibers suddenly appear again in the anterior roots of the second and third sacral nerves, and can be traced into that well known nerve which passes from the second and third sacral nerves into the hypogastric plexus to supply the rectum, bladder, and reproductive organs; a nerve, therefore, which may be looked upon as the white rami communicantes of the sympathetic ganglia which form the hypogastric plexus.

Again, in the cervical region, although such groups of fine fibers are absent from the anterior roots of all the cervical nerves, yet they form a conspicuous part

of the upper roots of the spinal accessory nerve, and upon tracing them outward I find that they separate entirely from the large fibers of the accessory which forms its external branch to pass as the internal branch into the ganglion trunci vagi (Fig. 2). Here, then, we see in the upper cervical region that the internal branch of the spinal accessory nerve is formed on the same plan as a white ramus communicans, the ganglion belonging to which is the ganglion trunci vagi.

Among the cranial nerves we find, especially in the vagus, glosso-pharyngeal, and chorda tympani, groups of fine nerve fibers belonging to the same system. We can therefore say that the communication between the so-called sympathetic and cerebro-spinal systems is not symmetrical throughout, but consists of three distinct outflows of characteristic visceral nerves, *viz.*: (1) cervico-cranial; (2) thoracic; (3) sacral; the break of continuity corresponding to the exit of the nerve plexuses which supply the upper and lower extremities.

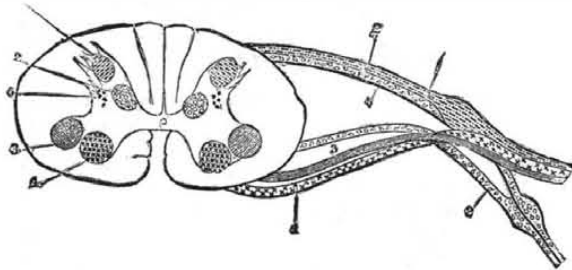


FIG. 1.—Diagram of section of spinal cord to show the various groups of nerve cells in the gray matter, and the formation of a spinal nerve with its sympathetic ganglion. 1. Cells of posterior horn and somatic sensory nerves. 2. Cells of Clarke's column and ganglionated splanchnic nerves. 3. Cells of lateral horn and non-ganglionated splanchnic nerves. 4. Cells of anterior horn and somatic motor nerves. 5. Solitary cells of posterior horn and splanchnic sensory nerves.

These medullated visceral nerves then pass out from the central nervous system into the various ganglia of the sympathetic, and it is possible that these latter ganglia bear the same kind of relation to them as the ganglia on the posterior roots bear to the sensory nerves. Before, however, we can accept this view, it is absolutely necessary to account for the non-medullated nerves which arise from the sympathetic ganglia. Now it is hopeless to follow, by anatomical means, any special nerve fiber through the confusion of a ganglion. What we cannot effect by anatomical methods we can by physiological. If we find two nerves, one of which enters a ganglion and the other leaves it, and we find their function absolutely the same on both sides of the ganglion, we have a perfect right to conclude that we are dealing with the same nerve in different parts of its course. Thus, in the case of the posterior root ganglion, the same sensory nerves are found on each side of the ganglion, although they are in connection with nerve cells of the ganglion itself.

So also with the sympathetic ganglia: we know, for instance, that the nerves which increase the rate and strength of the heart's beat pass to the ganglion stellatum along the rami communicantes of the second and

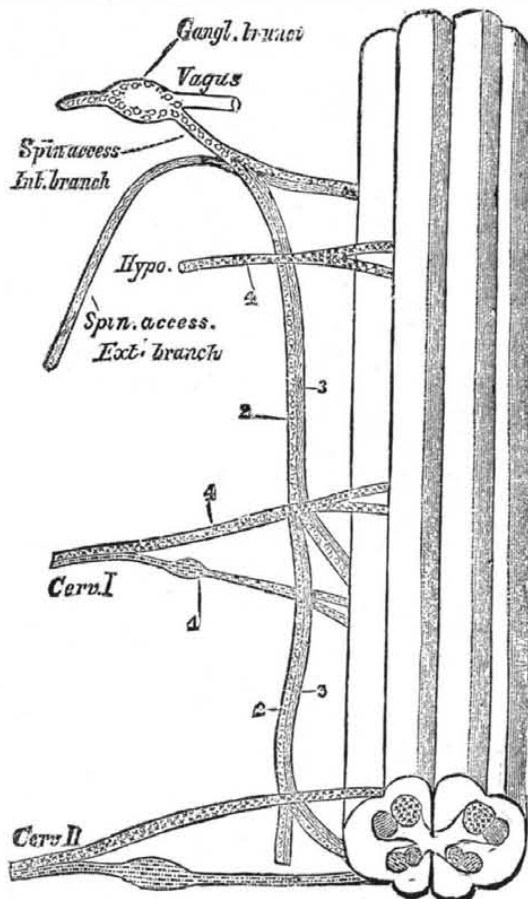


FIG. 2.

following thoracic nerves, and we know also that the same nerves pass to the heart from the ganglion stellatum, from the annulus of Vieussens, and from the inferior cervical ganglion. Now, seeing that these nerves are known to pass out of the cord in anterior roots, and from thence into the white rami communicantes of the upper thoracic nerves, it follows that they are medullated in this part of their course, and are to be found among the bundles of very fine medullated nerves which we have seen are characteristic of the anterior roots of this region and of the white rami communicantes.

We can then say with certainty that the accelerator nerves enter the ganglia stellata as fine white medullated nerves. I am also able to say with absolute cer-

tainty that the accelerator nerves in that part of their course which lies between the chain of sympathetic ganglia and the heart are entirely composed of non-medullated fibers. I know no other bundle of nerve fibers which is so absolutely free from medullated nerves; in other words, nerve fibers of the same function enter a sympathetic ganglion as white medullated fibers, and leave it in increased numbers as gray non-medullated nerves.

Throughout we find the same fact—all the vasomotor nerves behave in exactly the same manner as the accelerators of the heart. In all cases the non-medullated fibers of the sympathetic are simply the fine medullated visceral nerves which have passed from the spinal cord in one or other of the three visceral outflows and lost their medullary sheath in their passage through the ganglia of the sympathetic system; together with that loss of medulla they have increased in number by division.

Seeing, then, that the non-medullated (so-called sympathetic) nerve fibers are throughout modified medullated (so-called cerebro-spinal) fibers, and do not, therefore, arise in the sympathetic ganglia, we may fairly look upon the sympathetic ganglia as bearing the same kind of relation to the visceral nerves that the ganglia of the posterior roots bear to the ordinary sensory nerves. This conception is remarkably confirmed by the observations of Onodi, who has shown that the ganglia of the sympathetic are developed in close connection with the posterior root ganglia, and travel further away from the central axis as the animal grows.

Finally, the meaning of the sympathetic as a simple outflow of ganglionated visceral nerves from certain portions of the spinal cord and medulla oblongata is, to my mind, conclusively settled by the intimate relationship which exists between the structure of the spinal cord and the presence or absence of rami viscerales. In the gray matter of the spinal cord we find, as shown in the accompanying diagram, certain well defined groups of nerve cells, *viz.*, a, a group of large nerve cells in the anterior horn (4 in Fig. 1); these are known to be the origin of ordinary motor fibers (4); b, a group of nerve cells (3) split off from this and forming the lateral horn; c, a group (2) known as Clarke's column; and d and e, two sets of nerve cells (4) and (5), in the posterior horn connected with sensory nerves. All these groups of nerve cells are found along the whole length of the spinal cord, except those of Clarke's column. Their connection with nerve fibers of different functions is known, except those of Clarke's column. Thus both sets in the anterior horn are connected with ordinary motor nerves; both sets in the posterior horn with ordinary sensory nerves. Now, Clarke's column is limited to certain definite regions of the cord, being conspicuous: first, between the second thoracic and second lumbar nerves; secondly, at the top of the cervical region and extending into the cranial region; and, thirdly, an isolated patch in the sacral region. In other words, its cells correspond exactly in position to the distribution of the white rami communicantes, so that, corresponding to the variation of this cell group, we find variations of the number of very fine medullated fibers in the anterior roots, and we find corresponding variations in the white rami communicantes, which latter, as I have told you, are the only true connections of the cerebro-spinal nerve center with the sympathetic. In other words, we have driven home to their origin these visceral nerve fibers, and we find that they do not arise from any nerve cells outside the brain and spinal cord, but from a definite nerve group within the spinal cord.

We can, I think, go further than this, and say, with Bichat, that two nerve systems do exist—the one for organic, and the other for animal life. These two, however, are not separate and distinct, but form parts of the same central nervous system. Looking at this diagram of the upper cervical region of the cord, we see that the voluntary striped muscles may be divided into two groups, according to their nerve supply, *viz.*, a group supplied by the anterior (4), and one by the lateral horn of nerve cells (3), and we know also that these two groups of nerve cells separate from one another more and more as we pass into the brain region. So that we find for the muscles of the face a distinct separation of two groups, *viz.*, (1) those which move the eyes and the tongue—these are supplied by nerves which arise from the continuation of the anterior horns; and (2) the muscles of expression and mastication, the nerves of which arise from the continuation of the lateral horn; and remembering how the smile, the laugh, and the snarl, as well as the action of swallowing, are at the bottom only modified respiratory movements, we see that Charles Bell was not so far wrong when he inserted a lateral or respiratory system of nerves in between the anterior and posterior roots. This insertion is actually to be seen at the upper part of the cervical cord (Fig. 2), where a separate nerve is formed by elements which arise laterally, known as the spinal accessory; and what is most striking is this fact, that in this region the fine medullated fibers (2 in Fig.) are found only in connection with these lateral motor nerves, and not with the anterior motor, so that not only do these lateral or respiratory tracts supply special muscles with motor nerves, but these motor nerves have a closer relationship to the visceral nerves than other motor nerves. What is true of the upper cervical region is true also of the medulla oblongata. Here, again, the visceral fine medullated nerves are closely connected with the motor fibers which arise from the lateral horn, *e. g.*, the chorda tympani and the facial. Undoubtedly this particular group of muscles has some closer relationship to the viscera than other trunk muscles, and that relationship is explained immediately if we can accept and extend Van Wijhe's investigations, *viz.*, that in the cranial region the muscles which are supplied by the third, fourth, sixth, and twelfth cranial nerves are derived from the myotomes, while the muscles supplied by the seventh and fifth cranial nerves are derived from the lateral plates of mesoblast.

In fact, we may look upon the body as composed of two parts—an outside or somatic part, and an inside or splanchnic part. Each part has its own system of voluntary muscles; each part is supplied by nerves arranged on the same plan, *viz.*, a ganglionated and non-ganglionated portion; and each part has its own individual centers of action, the inside portion of the gray matter of the spinal cord containing the centers for the splanchnic roots (2, 3, 5, in Fig. 1), *i. e.*, the centers of

organic life; the outlying horns the centers for the somatic roots (1 and 4), *i. e.*, centers for the animal life. It is a strange and suggestive fact that these two sets of centers are not arranged symmetrically along the spinal axis, but that two great breaks occur in which the centers of organic life fall into the background in comparison to those of animal life. These two great breaks correspond to the origin of the nerves for the legs and arms, and suggest that the formation of the limbs in the originally symmetrical ancestor of the vertebrata—*i. e.*, the large outgrowth of somatic elements in two definite portions of the body—caused of necessity a corresponding increase in the centers for animal life, while there was no necessity for a corresponding increase in the centers for organic life. The oldest part of us is undoubtedly the vital part; those organs and their nervous system by which the mere act of existence is carried on. With these two there may have been originally a symmetrically segmental arrangement of locomotor organs. Such symmetry, however, went for good when it was found more convenient to concentrate the locomotor machinery into the anterior and posterior extremities, and with the asymmetrical arrangement of the locomotor organs disappeared also the symmetry of the central nervous system. This correspondence between the plan of the central nervous system and the development of the extremities is, to my mind, strongly in favor of the view which I have put before you to-night. In conclusion, I thank you for the kindness with which you have listened to me, and hope that I have succeeded in convincing you that Bichat's teaching of an independent sympathetic system is finally dead.

[Continued from SUPPLEMENT, No. 582, page 9299.]

ASTRONOMICAL TELESCOPES: THEIR OBJECT GLASSES AND REFLECTORS.

By G. D. HISCOX.

III.

REFLECTING TELESCOPES.

THE silver on glass reflectors of the Newtonian form are considered the best for amateur practice.

The glass for such telescopes may be good clear plate of $\frac{3}{4}$ in. in thickness for a five inch reflector and under and 1 inch in thickness for 6 in. 7 in. and 8 in. reflectors.

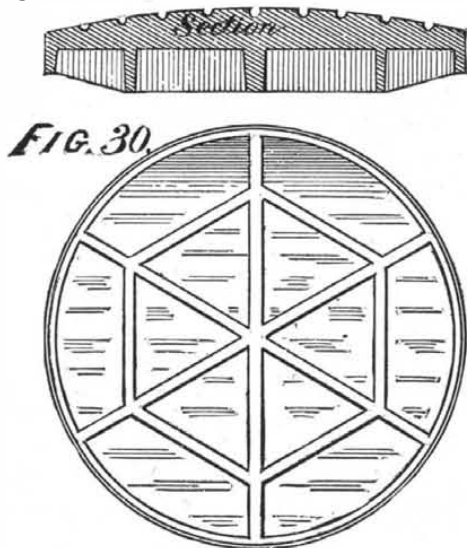
These may be obtained from the dealers in plate glass in squares, and in some establishments cut with a diamond into disks. There is no necessity for grinding the edge and back, but the front edge should be beveled to a circle, when, with a lap for roughing and a pair of laps for finishing, made as described for object glasses, the grinding can be proceeded with.

The radius templates for reflectors or specula are simply twice the required focal length.

The manipulation of grinding and polishing requires all the care in the adjustment of the strokes as described for objective lenses, but with increased solicitude in regard to flexure and errors of surface, from unequal pressure of the hand upon the handle or lap, which tends to spring the speculum, and thereby produce an irregular surface during the last finish with the washed flour of emery, as well as in polishing.

Remember that all errors of surface are doubled in the focal image of specula.

The laps for the larger sizes should be grooved in squares of about 1 inch in diameter, the grooves being $\frac{1}{8}$ inch wide and $\frac{1}{4}$ inch deep, rounded at the bottom as in Fig. 30.



The bracing upon the back is designed to give the greatest stability with lightness, and well pays for making a good pattern.

This lap should be slightly smaller than the speculum if the speculum is bedded and the lap moved over it; whereas, if the lap is bedded, it should be slightly larger than the speculum. For glass, we prefer to work the speculum on a bedded lap.

For rough grinding, a lap without grooves, about one third larger than the speculum, will save much tedious work.

Use the finishing lap for the layer of polishing cement with the same management as before described for lenses, using a wooden template for laying out the grooves, as shown in Fig. 23.

The block or handle for holding an 8 to 12 inch glass should not be liable to change form by moisture or the heat of the hand, and should therefore be made of some light, tough wood, that is free from cracks, and of the form as shown in Fig. 31. It should be dipped

prevent a partial vacuum from springing the disk. The pitch should not be hard enough to splinter.

The air space under the handle will be found to equalize the reciprocating pressure of the hand upon the handle, and thereby avoid polishing in zones, which has heretofore been a fruitful source of disappointment with amateurs.

The polishing cement should be the same as described for lenses, and the stroke manipulation the same as in Figs. 19, 20, and 21. Supposing that you have followed the directions in regard to lens polishing, and obtained a clear, bright surface, the next step is to make a preliminary test of its figure without taking off the handle.

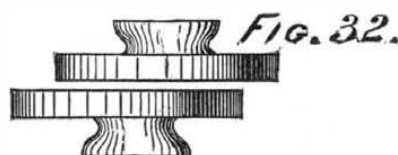
For this purpose you may make or obtain a Huyghenian eye piece of low power, an illustrated description of which may be found in SCIENTIFIC AMERICAN SUPPLEMENT, No. 399.

The small plane mirror is the next in order, and in the hands of experts may be ground and polished in its elliptic form; but for amateurs we advise to grind and polish as a disk of the size of the long diameter of the ellipse, and then cut and grind the edge to the proper form.

The proportions and size of the plane mirror may be quickly obtained by making a cylinder of wood, one-quarter larger than the field glass of the lowest power, and cutting it at an angle of 45°. Otherwise project the form of the ellipse as 1 to 1.41 by any of the geometrical methods at hand.

Use clear plate glass $\frac{1}{4}$ inch thick, rough ground on the back, and fine ground and polished on the face as described for lenses.

For this purpose three flat disk laps of brass will be required, of a size one-third larger than the mirror, with a handle as in Fig. 32. These should be made as flat as



possible with a file, or by turning, and ground alternately with each other until they all match and are equally flat, which may be ascertained by cleaning the laps and slightly rubbing one and the other alternately together, looking at the laps at an angle to catch the reflected light from their surfaces, when if true they will all show an equal burnish over their whole surface.

The finish of the lap surfaces should be made with the same washed flour emery that is to be used in finishing the mirror.

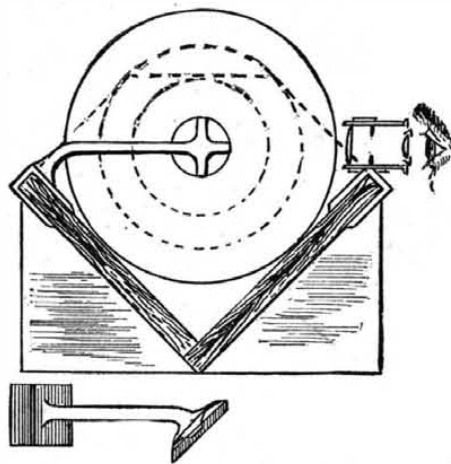
Then the mirror, already having a fair flat and polished surface, with a wooden handle cemented to its back with pitch, is to be ground on the three laps alternately also, alternating the laps with each other to retain their flat surface. Use only the finest emery to save time of finishing from the coarser emery.

The strokes to be made small and as directed in Figs. 19, 20, and 21, following the method before described for polishing.

To test the flatness of the small mirror, look at a sharp dark shadow, or a bright line that is perfectly straight, in the mirror, at as small an angle as possible. Notice if the line of shadow is perfectly straight at the lowest angle that it is possible to see the line.

In a perfectly flat mirror, the line and its reflected image will appear close together, and parallel in every position of the mirror around its plane. A confused line denotes a defective surface; and no line, that the surface is either concave or convex.

A temporary mounting may be made with two dressed boards of a width equal to the diameter of the speculum, with a board nailed across the end, as shown in Fig. 33, against which the speculum may be set



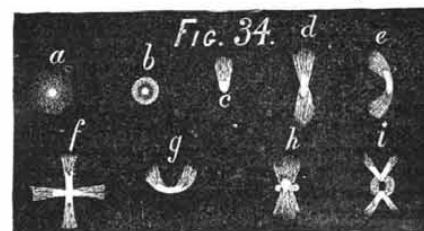
square with the trough and held in position by a clamp or soft wax. The small mirror can be grooved at the side and a clip of sheet brass made to slide in the grooves, to which may be soldered a brass bar reaching to a clip on the board. The eye piece can be arranged upon the opposite side, and attached to a clip on the board, both clips sliding for adjustment. The back of the small mirror should be blackened with black shellac varnish. Adjust the small mirror and eye piece as nearly as possible opposite to each other, and as near the proper focal position as possible when viewing some distant object. Point the telescope to a white wall or the sky; draw the eye piece out of its tube and look at the speculum reflected in the small mirror. If the image of the small mirror is not central as reflected from the speculum, the speculum must be slightly moved to bring it into the optical axis. When the adjustment is complete and the small mirror set at 45°, the telescope is ready for a trial.

An artificial star is probably the best and most satisfactory method of testing; as the following of a star with a crude and temporary mounting, together with the uncertain condition of the atmosphere, is very tedious and perplexing.

For this purpose, place a strong light at the greatest distance available, say 10 to 20 times the focal length of the telescope. Set up close to and before the lamp a cardboard, with a hole about one inch in diameter, covered with a piece of tinfoil, in which make a few

holes as small as possible, with a cambric needle, just pricked through.

Set the holes in line between the light and the telescope. If, upon focalizing the artificial stars, you find that their images are sharp and compact, showing slight diffraction rings as the eye piece is moved out or in from the focal point, which are round and evenly dispersed, you may congratulate yourself with success. The probabilities are that you may have some of the phenomena as illustrated in Fig. 34, where *a* represents



the normal image of a parabolic speculum; *b*, the normal image of a spherical speculum; *c, d, e, f, g, h,* and *i*, the distorted images caused by flexure or defective grinding and polishing.

The distorted images caused by flexure may be easily distinguished by turning the speculum and noticing whether the images revolve with the speculum. If they do, the surface is defective from the grinding or polishing; and if strongly marked, the speculum should be reground, as with the last emery finish, and repolished. If but slight, they may vanish by repolishing only.

If the distorted images remain in the same position upon revolving the speculum, they are due to compression by the weight of the speculum. The extent of these flexures is very small, and may be scarcely discernible in specula of 6 in. and under in diameter; but in the larger sizes, of from 12 in. to 20 in., they begin to be of serious consideration—merely the heat of the hand on the back or edge often producing strong images of the form of *f, g, h,* and *i*, Fig. 34.

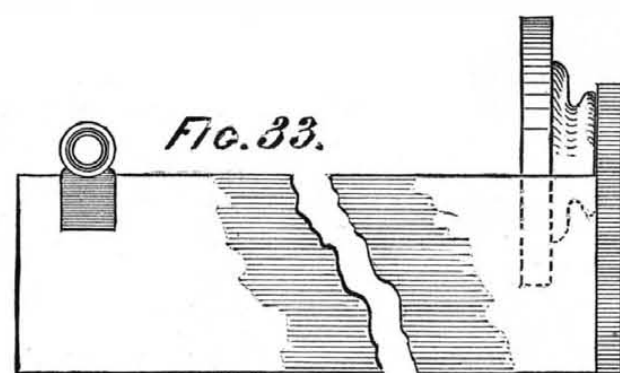
When you have been enabled to produce a true spherical surface, it will be proper to attempt the working of a parabola, which should always be generated after a perfectly spherical polished surface has been obtained.

For this purpose, it is necessary that the polishing lap should have a tendency, by the form of the strokes, to lengthen its radius.

The amount of the correction for longitudinal spherical aberration in specula of medium size, with a focal length of 13 diameters, is but about five one-thousandths of an inch, and the depth to be polished away at the margin is about one twenty-thousandth of an inch, it being for a speculum 4 ft. in diameter but one ten-thousandth of an inch. So that it may be easily comprehended that it is not quantity that is to be cut away, but rather the minute and gradual change of curvature from the spherical form, beginning near the center and finishing at the edge.

Amateurs are more often led to overwork than to underwork a parabola, from a magnified conception of its amount. Those used to microscopic work better understand this minute quantity.

There are two methods principally in use for accomplishing the parabolic form. First, to use the outside swing, Fig. 21, examining at the commencement if every part of the lap has an even touch, shown by an even gloss, which may be done by sliding off the mirror gently and looking at its surface at an angle, so as to receive reflected light. If found even, change to the inside swing (Fig. 20) for a few minutes, then changing to straight strokes (Fig. 19), at the same time move around the post so as to give any uneven motion of



the hand its effect in every direction. No fresh rouge should be put on the lap at this stage of the work. A drop of water or the spatter from a brush occasionally, to keep the lap moist, is all that is required.

The delicacy of touch in the fingers must now be depended upon to reveal the condition of the work. The motion around the center will be felt to stiffen from the greater friction toward and upon the outer zone of the mirror. Keep an even pressure and slow motion, thirty to forty strokes per minute, for a few minutes. Then alternate with short, straight strokes (Fig. 19) for a few minutes longer, and at last very short, straight strokes, at the same time moving around the post and turning the mirror slowly to shift its position on the lap.

The time for parabolizing a 5 in. or 6 in. mirror should not exceed one hour. Much, of course, depends upon the temper of the lap. If hard, or so that the thumb nail slightly chips it by pressure, the operation will be hastened.

A soft lap for glass is not recommended. Another method for parabolizing has been made effective, consisting of cutting away or widening the grooves in the lap toward the center, as in Fig. 35. This may be done with a sharp knife after the spherical polish is finished, by cutting away the sides of the original grooves slanting, so as not to chip the face. Use the same motions as last described. Supposing, by testing as before described, that you now have a fairly

in boiling pitch for a few minutes to make it impervious to moisture, then heat the disk and set the handle upon its back, preserving the open hole and space to

perfect mirror, the next operation is to silver the faces and polish the silver surface of both mirrors. The handles having been left on, the mirrors must now be made perfectly clean by first washing free from rouge and finger marks with soap and water, rinsing and drying. Then wipe the surfaces with a piece of old cotton or linen cloth, dipped in a mixture of aqua ammonia or alcohol and prepared chalk. Let the surfaces dry with traces of chalk upon them. Then wipe with a fresh, clean cloth until the surfaces look bright and clear. Then make a swab with a wad of clean cotton wool, fastened to the end of a piece of glass tubing, which can be done by pushing the wad partial-

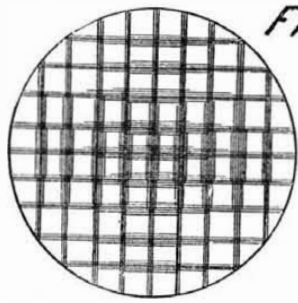


FIG. 35.

ly within the tube. Dip it in strong nitric acid, and carefully swab the surfaces of the mirrors with the acid, and thoroughly rinse in clear water. The mirrors are now supposed to be chemically clean. Using care that nothing touches their faces, they are now ready for the silver bath, which may be prepared as follows:

For a square foot of surface, or in proportion for smaller surfaces, dissolve $1\frac{1}{2}$ oz. Rochelle salts in 3 fluid oz. of clear water, and filter through cotton wool packed in the bottom of a glass or porcelain funnel. Also dissolve $1\frac{1}{4}$ oz. nitrate of silver in 4 fluid oz. clear water. Provide 1 fluid oz. strong aqua ammonia in a glass jar or open mouth bottle large enough to hold three pints. Also 2 fluid oz. aqua ammonia in a separate bottle.

To the 1 oz. of strong aqua ammonia gradually add the nitrate solution until a brown precipitate remains undissolved. Then alternately add ammonia and the nitrate solution until all the nitrate solution is in, gently stirring the solution with a glass rod while mixing, when, if properly done, some of the brown precipitate should remain in suspension. Here some judgment, and probably a little experience by trial, may be required to know, at sight, just how little of the brown precipitate may remain, as on this depends the hardness and brightness of the silver deposit on the mirrors. Filter this mixture, as described, for the Rochelle salt solution.

When ready to use, add the Rochelle salt solution to the ammonia nitrate solution. Then add clear water, enough to make 3 pints of the combined mixture. The silvering vessel may be a flat glass dish, a soup plate, or a pie plate, a little larger than the mirror, covered on the inside with a coat of paraffin. On the bottom, at each side, fasten, with paraffin, a narrow slip of glass, or piece of glass tubing, slanting downward toward the center of the dish, and so placed that the edge of the mirror only will touch the glass, and high enough ($\frac{1}{4}$ in. to $\frac{3}{8}$ in.) to keep the mirror from touching the bottom of the vessel while the mirror is gently rocked to stir the solution. Warmth, from 80 degrees to 100 degrees, facilitates the deposit, and makes a hard, close grain. This may be done just before the operation of the silver bath by putting the bottle of solution in warm water, and also holding the face of the mirror in clean warm water, not over 100 degrees Fahrenheit.

Pour the solution into the vessel, say to the depth of one inch or less, take the mirror from the warm bath and dip one edge first, to prevent air bubbles being caught under the concave surface. Then bring it to a horizontal position, resting its edges upon the glass supports, and slowly rock the mirror to produce circulation in the solution and loosen any air bubbles that may have adhered to the face of the mirror at the first dip.

The solution soon turns brown, and in two or three minutes a film begins to appear. In from fifteen to twenty minutes the mirror may be lifted from the bath without in any way touching the face. Look through it at a bright light or the sun. If the light or sun is ill defined, or only exhibits a faint light, it is right. If, on the contrary, it is semi-transparent, immediately immerse it for a few minutes longer, when it may be taken out and rinsed in clear water and immersed in a vessel of water for several hours to draw from the silver film any chemicals that might favor oxidation after the mirror is finished. Then set it on blotting paper to dry.

Its surface should now have a bright yellow color. If, on the contrary, it should be of a dull gray color and entirely opaque in sunlight, the deposit has gone too far, the film being over-thick.

We recommend a trial, as the amateur's first, and even second, effort, on a piece of plate glass, as the silver film has to be dissolved from the mirror with nitric acid in case of failure to perfect the deposit the first time.

The handle may now be taken off by carefully inserting the edge of a thin knife between the handle and glass and cracking the pitch, while the mirror lies upon its face upon a table covered with cloth or paper, to prevent scratching the silver. Clean off the pitch and dirt from the back by scraping, and wipe with a rag wet with turpentine or alcohol. Avoid touching the face of the silvering with the hands or fingers, as they have a corroding influence upon the surface that may afterward show.

With a piece of the softest buckskin, or kid leather, make a rubber or pad filled loosely with cotton. Then proceed to rub the pad over the entire surface of the mirror in small circular strokes, made in such a way as to insure all parts being rubbed alike. This seems to partially burnish down the surface and remove the yellow film. Then rub some of the finest jeweler's rouge upon a piece of buckskin laid in a clean plate, and dab the rubber upon the rouged buckskin.

Commence the polishing (dry) by moving the rubber lightly in small circles, so as to successively and equally cover every part of the mirror alike, occasionally dabbing the rubber upon the rouged buckskin. Continue these motions, varying them as in Fig. 36, until a bright

black surface is obtained, which may require from a half to one hour, according to size of mirror. When the polishing process is finished, place the mirror between your eye and the sun, observing the evenness of light by transmitted light all over the surface. If the glimmer has an even shade, the work has been well done.

The silvering of the small mirror or flat may be done in the same bath immediately following the large

ber around the crucible with charcoal. Urge the fire, and charge the crucible with all the copper. Use a moderate, even blast, throw a little powdered charcoal on top of the copper and cover the crucible with a large piece of charcoal or a plumbago cover. Keep the space around the crucible filled with charcoal, then urge the fire to its greatest heat.

When the copper appears at a white heat, drop into the crucible small pieces of the charge of tin to facili-

FIG. 36.



mirror, and polished under the same conditions in every respect, save the size of the pad, which may be reduced to about one-half the size of the small mirror.

The testing of the finished mirrors should correspond with the previous testing of the glass surface. If it should be found deficient in sharpness of image on a star, or hazy, the trouble will be found in the unequal polishing of the silver film, although, if the film be as thin as claimed, $\frac{1}{200,000}$ of an inch, any unequal polishing should show by its partial opalescence in spots by transmitted sunlight.

METALLIC SPECULA.

The casting, mounting, grinding, and polishing of metallic specula for telescopes require some special considerations which we will endeavor to bring within the scope of the amateur's resources.

The best composition for these specula, after years of fruitless experiment, has resolved itself into the atomic proportions of copper and tin, with a little arsenic added, acting as a bleaching agent, as perfected in the experiments of Lord Rosse, Mr. Lassell, and others. The atomic weights of copper and tin being 126.4 and 58.9 respectively, the proportions of each will be equal to copper 100, tin 46.6 by weight; white arsenic, $\frac{1}{100}$ of the combined weight of the metals.

The metals should be as pure as possible to obtain the best results. The copper obtained from chemical precipitates, or crystallization, as from the mint or assay office, is the best.

Lake copper that has a clear red color from the ingot mould is good. Avoid copper ingots that have been dipped in acid to make the red color. They contain iron or other base metals.

Banca tin is best, and may be known by the brand on the ingot, or recognized on it guarantee by its sharp, crackling tones when small bars are bent in the hands. Any tin that is pure also shows the sharp crackling tones, and may be equal to Banca.

The mould for specula of 12 in. or under in diameter may be made of a cast iron disk with the face turned, or otherwise finished to the exact curve of the proposed radius, which is twice the focal length of the specula, with a recessed projection all around the edge.

A ring of soapstone to fit the recess, of a thickness suitable for the specula, with a taper on its inner edge to allow of its being drawn off from the casting. The back may also be of soapstone a little thicker than the proposed casting, the whole as shown in section, Fig. 37.

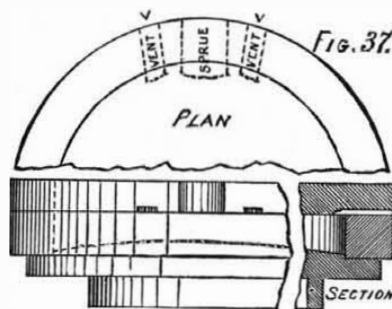


FIG. 37.

The sprue should be cut out of the back piece, as well also the two vents, which should be scooped out broad and flat as shown in plan and section at V.

When ready for casting, the whole mould should be heated to about 300° Fah., to free it from moisture, cleared of dust on the inside, put together and fastened with wood or iron clamps lightly at four places around the edge. Set the mould at an angle of 30° from the level. Provide a charcoal fire of sufficient size to cover the whole speculum with live coals, as directed after casting.

A 12 in. speculum, 1 in. thick in the center, will weigh about 37 lb., and will require about 45 lb. of metal to be melted. For any size divide the cubic contents of the mould and sprue in inches by three for the weight in pounds of metal to be melted.

The mould for the small mirror or flat may be carved out of a small slab of soapstone, with a sprue and vent. Clamp a flat piece of iron to the slab, and heat to free the mould from moisture.

Having everything in readiness for casting and annealing the specula, the melting may be proceeded with. For a speculum requiring 15 pounds of metal and upward, we recommend a brass foundry furnace and the services of a brass founder, who better understands the handling of large masses of melted metal.

For the lesser work a common forge may be utilized as a furnace by building of brick, preferably fire brick, as closely as possible without mortar, a chamber over the tuyere, the inside to be $2\frac{1}{2}$ times the diameter of the plumbago crucible to be used, and from 12 to 15 in. high. Use charcoal as fuel, and place the crucible on top of the fire to dry and heat before charging with the metal, then set the crucible in the fire with its top even with the top of the chamber, and fill up the cham-

tate the melting of the copper, so that by the time the copper is melted fully one-half of the tin has been added. Now shut the blast nearly off and add by degrees the balance of the tin, then shut off the blast entirely to keep the heat down to the flowing point of the mixture, which is much less than the melting point of the copper.

Divide the arsenic into three small packages in thick paper, and slip each into the end of a split stick, by which means you can push the arsenic to the bottom of the crucible. The bubbling of the gases will thoroughly mix it with the metal. The sticks should be dry, putting in one at a time.

The metal should now be at a proper temperature for pouring off, which may be known by its shining surface when it is slightly stirred or skimmed with a rod. In no case should it be hot enough to boil or throw off bubbles from its surface. Blow all charcoal dust and ashes from the surface of the metal with a small hand bellows or mouth tube, and take the crucible in a suitable tongs and pour into the moulds as quickly as possible. Open the small mould as quickly as possible; place the mirror on some hot ashes and cover with red hot charcoal, then quickly turn the large mould upon its back; unclamp and take off the iron face and ring, lift the speculum and its soapstone back into the annealing fire with a three part hook tongs and cover with the red hot coals; set some of the red hot bricks of the furnace around it, and bank the whole with the fire and ashes from the furnace, where let it remain until cold enough to remove with the hands.

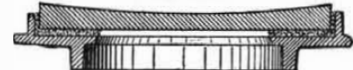
If, upon removing the casting after annealing, it should be found to have shrinkages or air spots that are not more than one-sixteenth inch in depth upon its face, it may be called a good casting, and suitable for finishing.

In casting the larger specula in a brass foundry, the directions for mixing and annealing should be strictly followed, with the added experience of the founder, in preventing the boiling of the metal by too great heat, which is the basis of a sound casting. A boiled metal makes a porous casting.

The mounting of the casting in a permanent setting for handling and fixing in the telescope tube should be done before grinding.

For this purpose a pattern, of which Fig. 38 is a sec-

FIG. 38.



tion, may be made with the rim that surrounds the speculum, at least $\frac{1}{4}$ inch larger on its inner diameter than the speculum.

The casting should be made with a composition of copper 2.75 parts, zinc 1 part by weight, which expands or contracts by changes of temperature exactly coincident with speculum metal. The ordinary 6 oz. brass is within a fraction of this proportion, and may be used for specula of 10 inches diameter and under.

The outside of the ring may be finished to suit the taste, but preferably the back of both setting and speculum should have two coats black varnish.

The speculum may be cemented into the setting with a cement made of shellac, resin, and beeswax, equal parts, melted and thoroughly incorporated. Then mix enough Venetian red to make the mass a soft putty while hot. Warm the setting and bed the warm putty all around the recess, and set the speculum, previously warmed in a stove oven, into the recess, allowing it to melt its way to a bearing. In putting the speculum into an oven to warm, caution should be used against cracking, by placing it upon pieces of wood and not allow it to touch the hot iron. The oven need be no hotter than to melt the cement.

When the speculum has cooled and the superfluous cement removed, it is ready to place upon the grinding post, or barrel, as illustrated for lenses (Fig. 18), only with care that the rim on the back of the setting has a fair bearing all around in the groove of the block, and to touch it at no other points. A little beeswax or shoemaker wax in the groove will hold it steady.

When the lap is to be the rider, it should be made $2\frac{1}{2}$ percent. smaller in diameter than the speculum, which prevents the lengthening of the radius by the overriding of the lap. It may be made of cast iron from a pattern, as in Fig. 24, and, as shown in section in Fig. 39, of a radius twice the focal length of the pro-

FIG. 39.



posed telescope, with a raised ring on the back, to which the wooden handle may be screwed; not put on with pitch, because the same lap should be used for polishing, when any pitch on the back would give

trouble in charging the face with the polishing cement. Make the grooves, as represented in Figs. 24 and 39, one-sixteenth inch deep, one-eighth inch wide for laps of 8 inch and less, and somewhat wider for larger laps. This relieves the surfaces from binding in the last or finish grinding, and also answers for the necessary grooves when used for polishing.

The method of procedure in grinding is the same as described for lenses, and with the same care in selecting the fineness of the emery. The only difference in the manipulation of a convex or concave surface of a lens or a speculum will be found in their disposition to change the radius of their curves. When the fixed piece is concave, the radius tends to lengthen, whether it be a lap, a lens, or a speculum, while the opposite effect takes place when the fixed piece is convex.

Use care in making the strokes, so as to avoid error as to a true spherical surface when ready for the polishing operation.

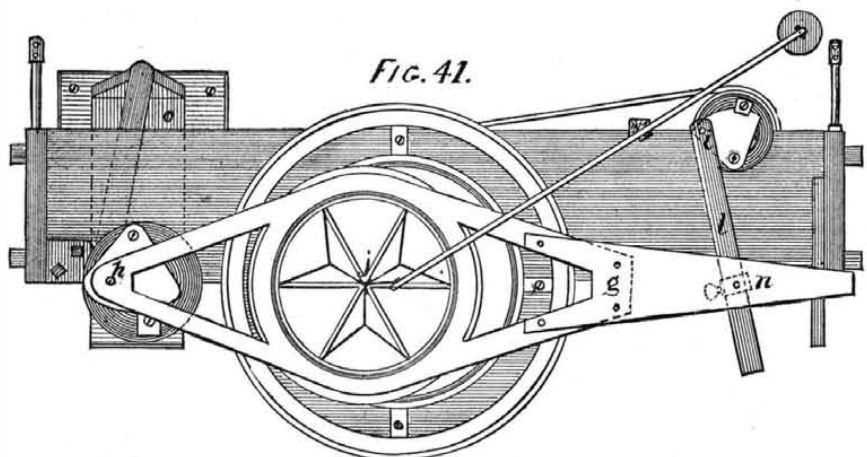
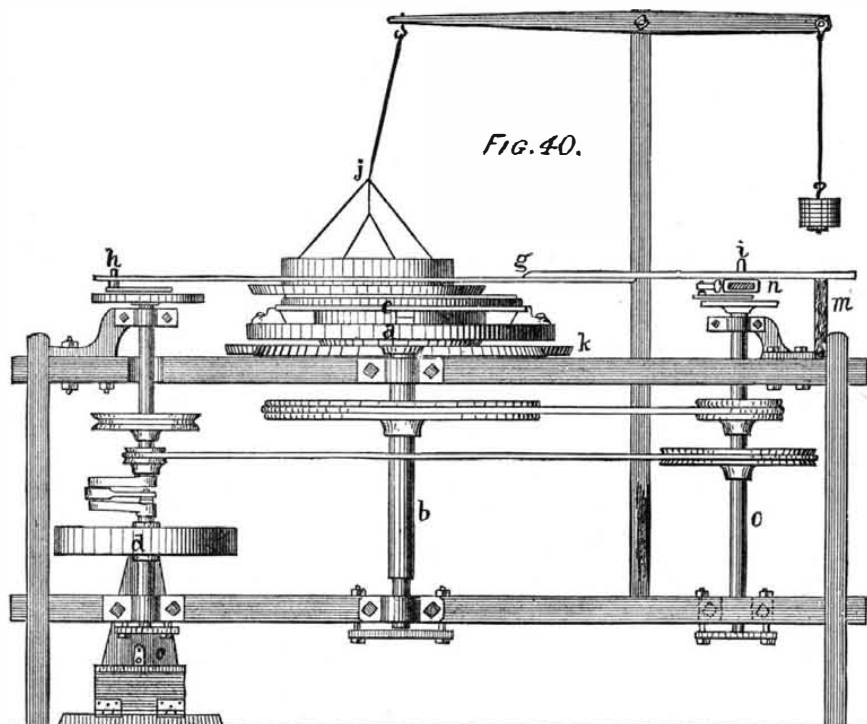
Any irregularity in alternating the different kinds of stroke as illustrated in Figs. 19, 20, and 21, or an over-reaching of the strokes, so as to throw the weight of the lap heavily upon the outer edge of the speculum, will produce distortion from the true sphere, that will only become apparent when the polishing is commenced, by showing an unpolished or but partially polished zone at the edge of the speculum. This should not be allowed to pass, but return to the fine grinding with small strokes as in Fig. 20. Here the

speculum should show where the surfaces are in contact by inequality of brightness on the speculum, or the smooth bronze color on the polisher. If the bronze color is on the outer zone only, it is evident that the radius of the lap is lengthening, and the strokes (Fig. 20) are required with a preponderance of pressure by the fingers on the side of the lap that is over the central portion of the speculum, and the reverse when the central zone only is bronzed. A little observation and the touch of the fingers on the lap will tell you more than pages of description.

When a perfect spherical figure is obtained, the strokes for the parabolic form may be started and followed exactly as described for a silver on glass speculum. Here also a little practice and experience by trial, and perhaps failure, is necessary to success. If you fail the first time, do not resort to regrinding, but try and bring back the curve to a sphere by short circular strokes (Fig. 20), and make a test trial for regularity of curve, and repeat the operation for parabolizing.

For the instruction of those who may desire to build a telescope of larger dimensions, we give an illustration of a machine made and used by the writer in grinding and polishing 10 in. specula, that has the means of controlling the motions required for the delicate operation of perfecting the parabolic figure.

The frame may be made of 2 in. pine plank framed together and braced to the floor as shown in Figs. 40 and 41, where *a* is a vertical shaft, that by its variable



action of the hands in counteracting the tendency of the lap to lengthen its radius by the weight of its overhanging part becomes very apparent, and if used with judgment, will lead to a perfect spherical surface. These points are also true as to glass surfaces.

The lap used for grinding is in the best form for polishing, and only the same precautions described for lenses as to cleanliness are needed at the change from grinding to polishing.

In making the polishing cement for metallic specula, follow the instructions and precautions as before given for lenses, with the exception of the rouge mixture, instead of which, incorporate with each half pint of the melted resin and turpentine a teaspoonful of fine flour.

This will be lumpy at first, but thorough stirring at a lower temperature, which makes the cement a little waxy, will make the mass homogeneous; after which, by additional heat it will become transparent. Test as before described for hardness, so that an impression by the thumb nail will not make the cement flake at the temperature of the room in which the polishing is to be done. Warm the lap so that the cement will stick, smear over the surface, and divide into squares exactly as described for lenses. Wet the speculum with rouge and water, place the lap on it lightly, instantly moving it in circular strokes to bring the cement to a bearing: the only difference from the instructions for lenses is that with the lenses the lap is stationary, while with metallic specula the speculum is stationary. This is necessary for safety, as the metallic specula are brittle and difficult to handle.

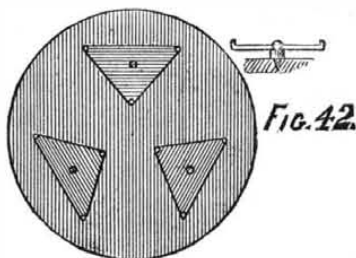
After a few minutes' polishing, the squares will run together, when the grooves must be opened as before described by cutting.

Observe at all times during the polishing whether there is froth or abraded matter running apparently loose upon the lap. The feel of the fingers upon the lap should tell what is the trouble by the uneven or jerky movement of the lap, the cause being a change of figure in the lap or imperfection of figure in the speculum. Inspection of the face of the lap and

crank pin, *h*, gives the required elliptic stroke to the lap through the carrier, *g*, which fits loosely around the rim of the lap, *f*. The shaft, *a*, being the driver, through its small band pulley or treadle, *o*, gives a slower motion (1 to 4½) to the eccentric shaft, *c*, also having a variable crank pin, *i*, to which is attached the connecting rod, *l*, which in turn controls the eccentricity of the carrier by a movable slot clamp at *n*.

The carrier, *g*, may be made of cast iron, and does not rest on the lap, but on the pin shoulder at *h* and the slide rest, *m*. The main shaft, *b*, supporting the speculum, *e*, receives its motion from the small band pulley on eccentric shaft, *c* (1 to 3½). Its face plate, *d*, may be made of hard wood, well oiled, and fastened to a lesser flange cast upon the shaft.

The speculum, if not otherwise mounted, may rest on three triangular pieces of iron, Fig. 42, so arranged as to

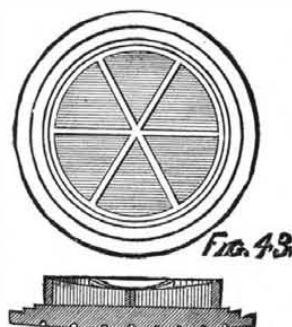


give a free bearing at nine points on the back of the speculum. Its lateral motion may be stayed by small chocks of pine wood screwed to the face plate around its edge. The lap to be of cast iron, with an outer groove for catching dirt, and an inner rim and web bracing as illustrated in plan and section, Fig. 43.

The harness, *j*, may be made of strong twine, and attached by hooks to the outer rim at six points, gathered to a single suspender passing over a small grooved pulley or attached to a lever on the ceiling or frame, with a counterweight to relieve the pressure of the lap upon the speculum.

The edge of the back of the lap should have a groove all around the outer edge (Fig. 43), to keep dirt from working over the edge and falling upon the face of the speculum.

The looseness between the carrier and the rim of the lap allows the lap to gradually turn within the carrier, but not as fast as the speculum turns, so that in this machine there are four variable motions, each of which is controllable at will, independently of each other.



The machine may be driven by power to the supplementary pulley on shaft, *a*, or by a treadle attached to the crank as shown in the cut.

In thus laying before the amateur the partial details of one of the most difficult of all the arts, and the one associated with the noblest of the sciences, we trust that his anxiety for haste, and failure from want of experience, will not deter him from continuous effort to accomplish his aim, and master an art that has taken an age to approximate to perfection.

ON THE CUTTING OF POLARIZING PRISMS.*

THE author showed the manner of cutting two new polarizing prisms, designed by Ahrens and by himself, and described and figured in the *Phil. Mag.* for June, 1886. The Ahrens polarizer is a rectangular parallelepipedon of calc spar, having square end faces, and having its long sides in the proportion of about 1.6:1 relatively to the short sides. The square end faces are principal planes of section of the crystal. Two oblique sections are cut in the prism, being carried through the top and bottom edges of one end face, and meeting in the horizontal middle line of the others. The dihedral angle between these planes of section is about 32°. The faces are polished and reunited with Canada balsam in the usual way. The advantages claimed for the new prism are: (1) decrease in length, (2) increase in angular aperture, (3) saving of light consequent on non-obliquity of end faces, (4) minimum of distortion, (5) less spar required than in Hartnack, Glan, or Thompson prisms of same section. Against this are the slight disadvantages of (1) the line of section across end face, and (2) the use of more spar than a Nicol of equal section. But Mr. Ahrens has recently added a thin covering glass at the end face crossed by the line of section, thereby making this line almost imperceptible; and he has also succeeded in finding a new method of cutting the prism, in which there is extremely little waste of spar. The other prism designed by the author is a simple modification of the Nicol, giving a wider angle of field. A wedge is cut off each end of the calc crystal so as to make the new end faces almost co-planar with a principal plane of section, and the crystal is cut through along the other diagonal of the sides. The results may be tabulated thus:

	Ordinary Nicol.	Reversed shortened Nicol.
Obliquity of end face.....	71°	69°
Angle between end face and crystallographic axis.....	45°	5°
Angle between balsam film and crystallographic axis..	45°	94°

The effect is to throw the blue iris limit right back, to shorten the prism, and to widen the field. In the discussion that followed, Prof. Stokes remarked that there was no dearth of Iceland spar in Iceland, but that the supply had been limited through ignorance of the extent of the demand. The mine had, however, been bought by the Icelandic Government, and a plentiful supply might therefore be expected.

THE MANUFACTURE OF LENSES.

THERE is scarcely anything more desirable than a bright, well finished lens. To the art that produces these beautiful objects we are heavily indebted, for it has enabled us to peer into other worlds. It gives us the means of seeing objects so minute that without some visual aid their existence would be unknown. It has prolonged the usefulness of our failing eyesight, and has, in many other ways, contributed to our comfort and pleasure, and to the advancement of knowledge.

The process of making a lens is extremely simple, so much so, indeed, that a person observing the manipulations of an optician might conclude that almost any one could make a passable, if not a perfect, lens. But this is not so. It requires a great amount of practice, and a peculiar adaptability to fine mechanical work. The glass used for fine lenses is mostly imported from Europe. That used for achromatic lenses is made by the celebrated firm of Chance & Co., of Birmingham, England. It comes in pairs of disks, one of flint and one of crown glass. These disks are tested as to their refractive power, and classed according to the use to which they are applied. The flint glass for telescope objectives is more dense than that used for the achromatic lenses of photographic cameras.

The disks are cut to the required size, either by means of a diamond or by a revolving iron hoop supplied with sharp sand and water. They are then roughened into shape in the machine shown in one of the upper views in the large engraving on opposite page. The hopper suspended from the ceiling contains sharp sand and water, which are allowed to flow out upon the form or tool on the upper end of the vertical spindle. This form, or tool, as it is called, has the same curvature as the lens to be made. It is convex for a concave lens, and concave for a convex lens. A disk of glass

* Abstract of a paper read at the Birmingham meeting, 1886, of the British Association, by Prof. Silvanus P. Thompson.

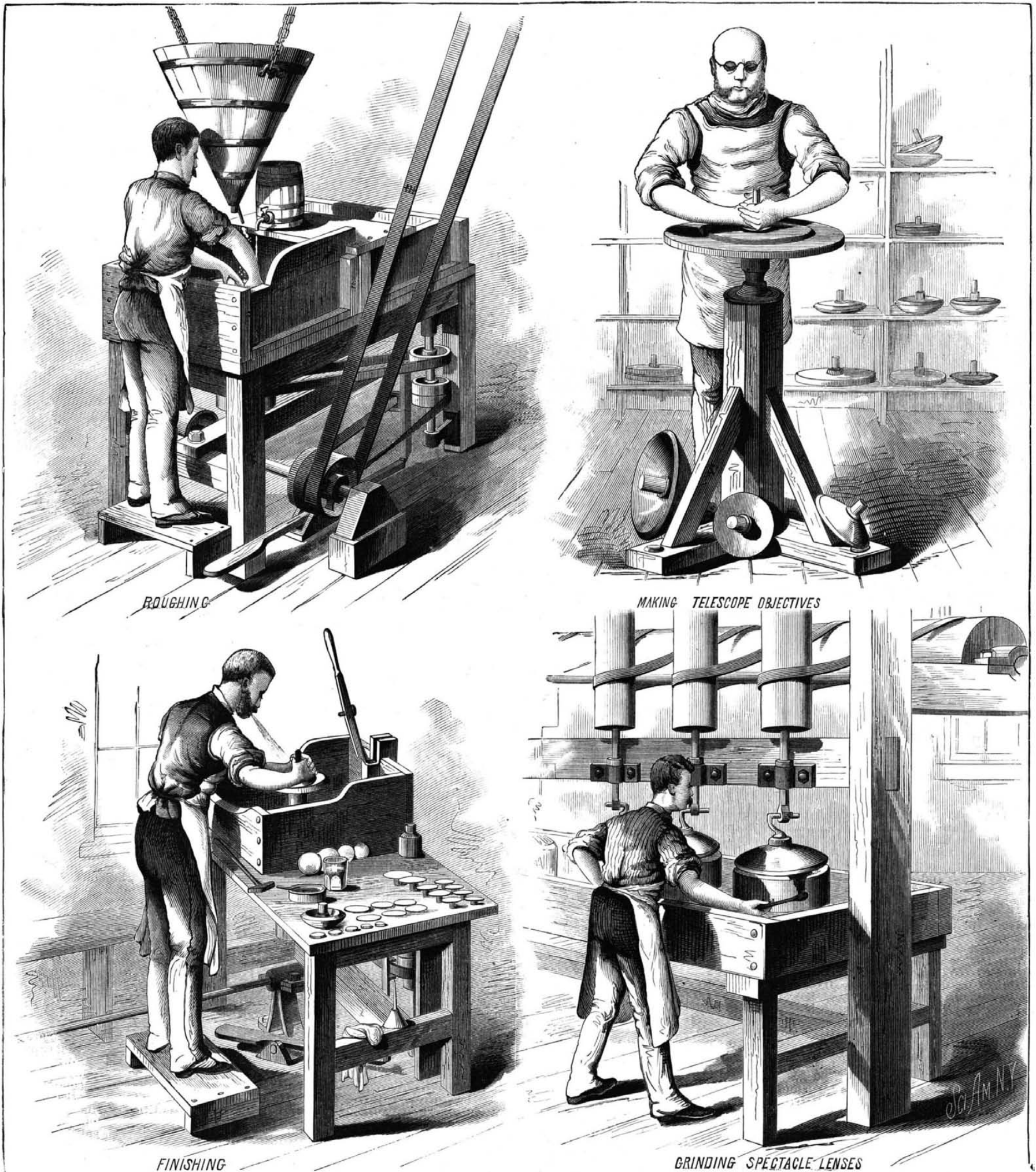
held upon this tool, charged with wet sharp sand and water, soon assumes the desired curvature, and is ready for the next step, which consists in grinding the lens in another machine with three different grades of emery, on as many different tools.

The emery ranges from No. 90 to No. 150, the last grade leaving a surface sufficiently fine to be at once polished with rouge. To the back of each disk of glass a hub is cemented with pitch. In the center of this hub there is a conical hole of sufficient depth and size to receive the point that projects from the lever by which the disk is held down upon the finishing tool.

washed, and the face of the tool is covered with fine woolen cloth similar to broadcloth, which is made to adhere by a thin coating of melted pitch applied to the face of the tool before putting on the cloth. The tool thus prepared is wet by blowing on water from the mouth in a thin spray, as represented in the engraving, and the workman applies to the cloth surface a ball of fine rouge, forming on the face of the cloth a thick paste of rouge and water. The lens, if large, is held upon the tool with the lever in the same manner as in grinding. If small, it is held by the steel-pointed handle. A gentle pressure is applied, and, should the

cemented to the end of a stick. The roughing is done upon a common grindstone. The grinding is done in much the same way as already described. The polishing, however, is somewhat different; the tool being covered with a mixture of rouge and beeswax, the amount of rouge being sufficient to render the beeswax quite hard. The form is given to the wax surface by pressing the unpolished lens into it. A thin paste of rouge and water is applied to the tool occasionally.

Ordinary spectacle lenses are ground in quantities in the manner represented in the lower right hand view in the large engraving. Here a great number of pieces of



THE MANUFACTURE OF LENSES.

When small lenses are ground, an ordinary handle, having a steel point, is used, instead of the lever, as shown in the lower left hand view. When lenses are ground in this way the tool is much larger in diameter than the disk, and the latter is held eccentrically in relation to the axial line of the tool, so that as the tool revolves the disk is also made to revolve, thus continually changing the relation of the surfaces in contact, thereby insuring greater accuracy in the form of the lens.

Between the applications of the several grades of emery the disk is thoroughly washed, and great care is exercised to prevent any particles of the coarser emery from becoming mixed with the finer.

After the application of the finest grade of emery, the glass disk and the tool are both thoroughly

tool become too dry before the required polish is secured, water is blown over it with the mouth, as before described. After having finished one side of the lens, the other is proceeded with in precisely the same way. The treatment is the same for both convex and concave lenses. In grinding the best quality of telescopic objectives the operation is wholly performed by hand. This is done in the manner shown in the upper right hand figure of the engraving. The tool is supported by the post, and the disk is moved in a series of small circles, and at the same time turned as the operator moves slowly around the post. In the case of telescope lenses, the final finish is secured by a pitch surface formed on the tool, and traversed by grooves running across it in different directions.

Very small lenses are formed from pieces of glass

glass are cemented to a form with pitch, and the tool is moved over it by a short crank on the lower end of the vertical spindle. The workman dashes emery and water or rouge and water over the form; and the upper tool, in addition to receiving an oscillatory movement, is slowly rotated by the action of the crank in the socket at the back of the tool. Generally a series of forms are operated in a single bench and attended by one man. The steps in the operation of grinding spectacle lenses are about the same as when single lenses are ground. After they are ground and polished upon one side, they are removed from the form and turned over, cemented to the form, and ground and polished upon the other side.

For many purposes it makes little or no difference whether the axis of a lens corresponds with its geo-

metrical center; but for telescopes, opera glasses, photographic cameras, and other instruments of accuracy, their optical and geometrical centers must correspond. The manner of testing lenses to ascertain if the optical center and the geometrical center coincide is illustrated below. The lens is cemented to a chuck upon one end of a hollow lathe mandrel; near the opposite end there is a ground glass surface, and in front of the lens being tested there is another lens supported on a standard, beyond which there is a small vertical rod and a lamp. These different pieces are all in line with the axial line of the mandrel, and an image of the rod is cast upon the ground glass screen. If the image remains stationary while the lathe revolves, the optical center of the lens coincides with the center of rotation; but if the image moves, the optical center is out, and the lens must be centered while the cement which supports it is still warm and soft. This is easily done by holding the hands against the edge and sides of the lens as it revolves. When the lens is optically centered, if its periphery is out it must be ground down. This is readily done by placing under it a piece of sheet iron bent into semicircular shape, and forced upward against the edge of the lens by means of a screw passing through a board that supports it. The sheet iron is charged with sand or emery and water, and as the lathe revolves, the lens rapidly assumes a circular form.

The matter of testing the different qualities of glass used in the manufacture of fine achromatic lenses has

the animals which inhabit them. As the poor creatures die, the shell is freed from their hold, and falls to the ground. Were the creature to die in his house, it would greatly deteriorate the value of the shell for cameo work.

Messrs. Francati & Santa Maria, of Hatton Garden, are the largest and almost the only dealers in shells for cameo work the metropolis possesses. This firm, which has branches in Rome, Florence, and other cities of Italy, is famous for its stores of cameos and gems, and for every variety of mosaic work which is produced, as well as for its collection of vases and other art productions of Italy. They are always represented at the exhibitions held in London, Liverpool, Folkestone, Dublin, and at Edinburgh their goods were shown, and they have frequently been awarded medals. I have seen in their cellars many thousands of conch shells, brought from foreign seas for the purpose of being cut into pieces, for export to Italy or Paris. Mr. Santa Maria, upon one occasion, showed me a magnificent Black Helmet shell, which he said was the only one that had been discovered out of about ten thousand. A shell of ordinary size only produces, on being sawn, three or four large workable pieces, and these are worth from 3s. to 5s. each. But the Bull Mouth, of small size, may be purchased for a shilling. A face or figure cut upon a whole shell looks well, and one such specimen is here for examination. The experienced workman will often employ his leisure in covering a large shell with work. In the center is the

tion to Mr. Konig, mineralogist of the British Museum, and by Lord Fife was introduced to Sir Joseph Banks. The latter introduced him to Mr. Payne Knight, who produced at the interview what he called the finest Greek cameo in existence, a most choice gem, a fragment of the head of Flora, for which he had paid Bonelli 500 guineas. Pistrucci did not even take the stone from the extended palm of Mr. Knight. A glance disclosed the fact that it was that head of Flora in whose hair he had cut two Greek letters, and for which Bonelli had paid him £5. An unpleasant scene resulted. The letters were plainly visible. But Bonelli, realizing that his trade was at an end, boldly denounced Pistrucci. He pointed to the wreath of flowers about the head in proof of his conceit that it was an antique, asserting that no such flowers were then in existence, but Sir Joseph Banks, examining them with a microscope, exclaimed: "The flowers are roses, as I am a botanist." Pistrucci offered to carve another Flora exactly similar without looking again at the "antique." This challenge was not accepted. Then it was agreed that he should cut a head of Flora in a different position, and this was accepted as a test of his truth. The story soon spread through London society. Noblemen, scientific men, ladies of rank, watched the growth of the new Flora under the hands of Pistrucci, and when it was completed the dispute raged with increased bitterness, so that Payne Knight's antique Flora became the question of the day. The controversy at length ended with universal expressions of sympathy for Mr. Payne Knight.

This stone may be seen in the Gold Ornament Room at the British Museum. It is placed in the case of "Modern Engraved Gems," upon which stands the alabaster vase engraved with the name of Xerxes, and is in the bottom row of the case. The face is exquisitely beautiful, and the roses which are cut in the upper colored layer of the stone are perfect. An attendant will point out this Flora to any one who asks.

The dispute about the Flora indirectly brought about Pistrucci's appointment to the Mint as chief engraver, and he designed and executed the George and Dragon among other works. Afterward a considerable amount of jealousy was created by his employment among the officers of the Mint, and the members of the Royal Academy were divided about his appointment, one portion insisting that native talent should be encouraged, the other division holding that he was the best living engraver. To restore peace, his appointment was subsequently styled that of "chief medalist." He cut two portraits of the Queen in onyx, one as Princess and the other with the diadem. On retiring from the Mint, he took a cottage at Old Windsor, where he died in his seventy-first year, in 1855, only thirty-one years ago, and recently enough for him to be well remembered by living men. His connection with our own day, and the distinction to which one of his pupils has risen, justify the introduction of his name into this paper. His daughters, before their father's death, returned to Rome, where they practiced cameo cutting with great success.

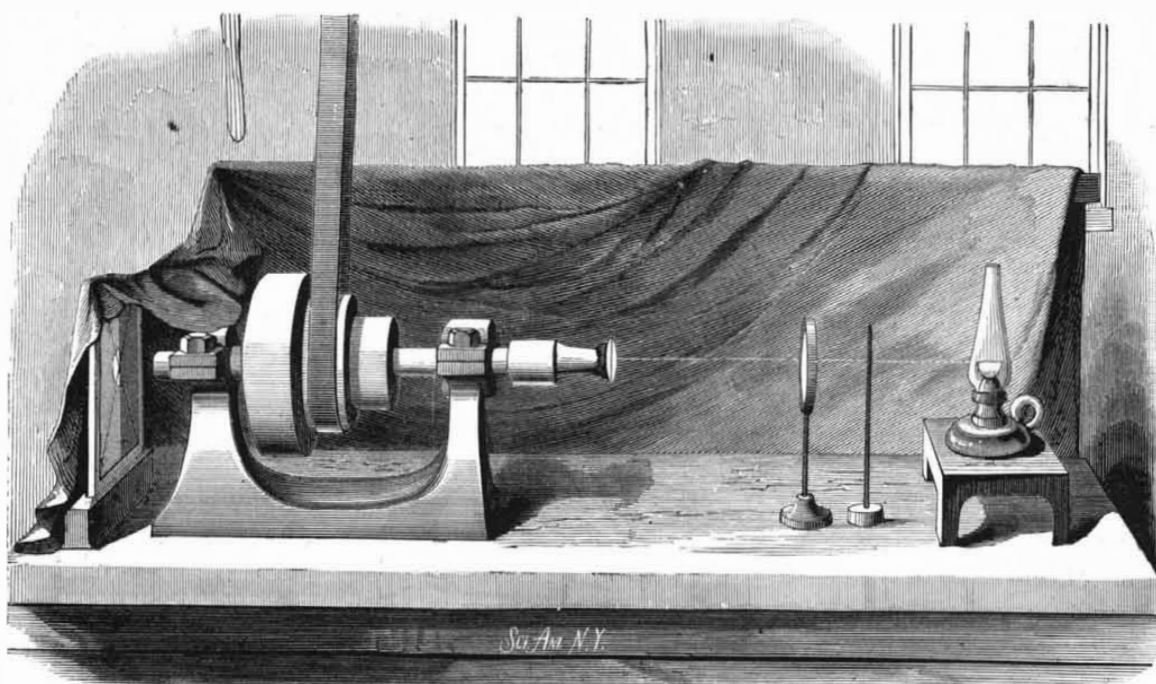
A brother of Pistrucci, the one who was a painter, followed him to England, and gave lessons in drawing. Among his pupils was James Ronca, now one of the best cameo engravers in Europe. After being grounded in the art of drawing, Ronca was put to an Italian named Chelli, to learn the art of cutting cameos, and he had for a fellow apprentice a youth named Ford.

Mr. James Ronca has frequently exhibited gems at the Academy, and he now has the honor of carving the portraits of the Queen and the late Prince Consort for all the orders of Victoria and Albert which are bestowed by her Majesty. At one time the question of teaching the process at the South Kensington School of Art was discussed by the authorities, and arrangements so far progressed that Mr. Ronca was selected as the teacher. But the scheme was abandoned, owing, as Mr. Ronca believes, to the fact that upon being asked what probability there was for the future employment of skilled workers, he had the candor to say that he did not know of any. This was at a time when the fashion of wearing cameos had almost passed away, and the class was never formed. But the Council of the Society of Arts having had their attention drawn to the subject, a few years ago offered a prize for cameo work, and this was awarded to a young lady who had been taught by Mr. Ronca.

Mr. Ford, after learning to cut under Chelli, went to Rome, and there perfected himself in the work. He was afterward employed in Paris, and executed some beautiful cameos in England. He is now the head of the firm of Ford & Wright, Clerkenwell Green, diamond polishers, and it was at his stand in the late Colonial and Indian Exhibition that her Majesty, watching the process of washing African gravel for diamonds, picked one out of the soil, and directed that it should be polished for her use. Mr. James Ronca, Mr. Ford, and Mr. William King, in the employ of Messrs. Francati & Santa Maria, are the only three I know who are practically acquainted with the work of cutting cameos.

Mrs. Henry Mackarness, the well-known authoress of "A Trap to Catch a Sunbeam," a lady of acknowledged taste and judgment, strongly recommended the art of cameo cutting in shell to the notice of ladies. In an admirable work entitled "The Young Lady's Book," published by Mr. George Routledge in 1876, she thus speaks of the work: "It is sufficiently simple to be within the scope of many who possess taste, patience, and deft fingers. . . . It cannot be acquired without some instruction and considerable perseverance. But the instruction is within reach, and the perseverance will be amply repaid by the results." This cameo cutting will "give young ladies a new and elegant pursuit." It will "raise their thoughts from knitting and netting, and cultivate a taste for higher pursuits. . . . It can be practiced with half a dozen small tools that take up scarcely any room. And, with a little care and instruction, the art can be readily acquired. Some knowledge of figure drawing is necessary, and a correct eye. And it is needless to say that the more skillful the artist in this respect, the better her cameo work is likely to be."

There are in the collections shown in the mediæval room of the British Museum several fine specimens of shell cameos which date from mediæval times, but these shells were found in the Mediterranean; and at South Kensington are a few specimens of shell cameos worked in Rome. The only illustrations of the art of progressive working in the conch shell in any museum in London are to be seen in the south court of South



CENTERING LENSES.

been omitted on account of the abstruseness of the subject and the amount of space required to properly treat it.

For many of the points given above we are indebted to Mr. Chas. F. Usner, a practical optician of this city, from whose factory, at 128 and 130 Fulton Street, we have taken the majority of our sketches.

CAMEO CUTTING AS AN OCCUPATION.*

By JOHN B. MARSH.

THE adaptation of the conch shell to the art of the cameo cutter has no history. It was discovered, as years are reckoned in the progress of art, only yesterday, and to-morrow, if we do not awake to the benefits which the art is capable of realizing, the industry may be snatched from our hands. The working of cameos in precious stones goes back beyond the earliest records. History contains no reference to the beginning or the progress of its development. Tradition affirms the Asiatic origin of the art, that it was practiced by the Babylonians, from whom the Phenicians carried it into Egypt. Thence the progress of the art is clearly traced to Greece and Italy, and in our own time to France and England. Those who have practiced it in England may be numbered on the fingers of one hand. It is not, however, with the carving of precious stones that this paper is intended to deal, but with the youngest of all the processes discovered in connection with the production of the cameo, that of working the beautiful conch shell.

The use of this shell (specimens of which are on the table) for the purpose of cameo cutting was first practiced in Italy, about the year 1820, and is believed to be of Sicilian origin. For many years all the shells used were exported from England, and the number averaged about 300 per annum. These were valued at thirty shillings each. They soon became a favorite medium in Rome for workmen, and the art was taken thence to Paris, where it flourished. In 1847 the sale of shells was reported to have reached 100,500, and their declared value was £8,900, while the cameos which were produced were estimated to be worth at least £40,000.

The color of the ground in these shells varies from pink and orange to an absolute black, which is the most valuable of all. This is called the Black Helmet (*Cassius tuberosa*), and comes from the West Indian seas. The shell with a pink ground is called the Queen Conch (*Strombus gigas*), and is also brought from the West Indies. A favorite variety is the Bull's Mouth (*Cassius rufa*), found in the East Indian seas, which has a sard-like ground. Another class is the Horned Helmet (*Cassius cornuta*), which is brought from Madagascar. Occasionally shells are made use of having three layers, the upper, always dark colored, serving for the hair, or a wreath, or for armor; the second layer, which is always white, is used for carving the figure, and the third layer is the ground.

When the shells are first taken, they are hung up by

principal design, always a classic figure or group of figures, and around such ornamentation as his taste approves. One of these, cut in Hatton Garden, was sold recently for a hundred guineas, and another, almost entirely cut by a young Englishman, realized £80.

The most celebrated cameo engraver of modern times was Benedetto Pistrucci, who designed the "George and Dragon" of our coinage, which is acknowledged to be the finest work that has ever appeared in modern currency. And his association with a living worker in cameos, Mr. James Ronca, whom he taught, and the fact that his daughters became accomplished cameo cutters, justify a reference to the leading incidents of his life. Of himself he says that he was in a manner born to the work he took up from choice, and he mentions in proof of this that he had square thumbs, and the palm of his right hand was covered with horny skin. This had been a characteristic with certain of the males in the family for several generations. He was the son of a judge, and was born at Rome, in May, 1784. His eldest brother was a painter, and every member of the family was endowed with artistic tastes. Italy, in his youth, was overrun by the French, which caused his parents to make frequent changes of residence. At fourteen years of age, being then proficient in drawing, he was first put to a master, one Signor Mango, who, perceiving his genius, employed him to make designs for his cameos. This provoked much jealousy among the other workmen, one of whom stabbed Benedetto with a dagger. During his illness he amused himself by modeling the figures he drew, and so perfected himself in the stages necessary for becoming an artist in this work. Less than this in training will only make a workman. Upon his recovery, he was sent to two masters in succession, the second of whom, noticing the superiority of his designs, exclaimed: "With one who has genius there is very little for a master to teach." At sixteen years of age he began work on his own account. And, after a brief courtship, at eighteen years of age, married a girl of sixteen, of gentle family. He had two daughters, Victoria and Elisa, and one son, Vincenzo. Elisa and her brother were born with the paternal characteristic, a horny palm, and became celebrated as workers in cameo. At twenty-four years of age Benedetto had made a reputation as an engraver of precious stones, having taught himself the process, and constructed with his own hands the wheel with which he worked. For several years he had sold cameos worked in stones to one Angelo Bonelli, a traveling dealer in gems. And discovering one day that a specimen of his work had been stained to represent an antique, and sold for a high price, he resolved for the future to place a secret mark upon those he sold. On one of these, the head of Flora, he cut two Greek letters in the hair. The troubled condition of Italy induced him to consider the advantage of proceeding to England. But, before emigrating, he executed several orders for one of Napoleon's sisters, one portrait being cut in stone, much smaller than a fly. Pistrucci brought to London a letter of introduc-

* A paper recently read before the Society of Arts, London.

Kensington, where the portrait of Millais is shown in the several stages of progress, together with the shell from which the piece worked was originally cut. This interesting specimen was presented by Mr. Ronca. There are of course many separate specimens of carved conch shells, in whole and in pieces, at both the British and South Kensington Museums.

There were two principal causes for the decline of fashion in the wearing of cameos. The first arose from the paucity of designs, and the second from the bad workmanship engendered by overwhelming orders being thrust upon a market in which only a limited number of operatives were engaged. With regard to the first cause, modern cameo cutters found no other models than those which had been handed down from the times of the ancient workers in gems. The cutters were copyists merely, not true artists, and modern taste was not satisfied with the representation of classic deities, however daintily wrought. There was no variety in the pose of figure, and the minutest detail was settled one or two thousand years before. Thus Apollo, Diana, Jupiter, Mercury, Sappho, and Venus were represented in precisely the same manner they have been a thousand times before, and the cameo worn by a noble lady only differed in the quality of execution from that worn by a greengrocer's daughter.

How the sudden demand for cameos arose it is difficult to say, but orders were poured into Paris houses, and the little colony of Italian and French workers found themselves unexpectedly flooded with wealth. They were men possessed of most skillful hands, but very ignorant, and untutored economists, and they worked hard for a portion of the week only, then shut themselves up in low wine houses, and with cards and dominoes whiled away their time. Their wages were soon exhausted by drink and gambling; and when masters wanted workmen they had first to settle scores they had run up, for the payment of which the landlords detained them. The natural result soon followed, the quality of work deteriorated, and prices fell considerably; then houses undersold each other, and cameos were cut at per dozen instead of per piece. When the Franco-German war began, the cameo occupation was at its lowest point, and the outbreak of hostilities dispersed the major number of workers.

There are only two kinds of tools made use of by workmen, the scawper and the spit-sticker. The scawper is of two kinds, one having a flat side, and the other a round side. With the round scawper, the white of the shell is scooped out, and the face or design modeled; with the spit sticker the finer cuts are made; and with the flat scawper the work is smoothed and finished.

When at work, the cutter sits at a bench or table which has what is called a peg or a pin screwed into it. This projects a few inches from the table, and is hollowed to allow of the stick resting within. But an equally good peg is furnished by the fret-cutter's grip, which may be placed at the edge of the table, and, by means of a wooden screw below, fixed tightly in its place. This may be fastened without injury of any kind to the table. One of the advantages which cameo working in shell possesses is that it occasions no dust or dirt, and does not involve the use of any machinery, such as the gem cameo worker requires. If the work is done at night, an engraver's glass is requisite in order to concentrate the light without glare upon the shell. There are two kinds of these glasses; one is filled with water in which sulphate of copper is dissolved, and clarified with oil of vitriol; the other consists of a large green glass eye, which moves up and down an iron rod, and is screwed to the required height. This is the better glass to use, as the oil of vitriol, however much diluted, would, by the accidental breakage of the globe, cause the destruction of any carpet over which it ran. But no glass is required during the day time, and no artificial light is equal to the natural light of day. Work should, therefore, be confined to hours before dark.

The first thing to be done is to select a suitable piece of shell for the subject to be cut. Small bits, of the size of the little finger nail, may be bought for 3d.; and oval pieces, from 45 to 48 millimeters in circumference, may be had at from 2s. to 3s. each; and whole shells from 5s. to 20s. each, according to the rarity. In selecting an oval piece, care should be taken to get one without flaw. This is a difficult matter, and requires a great deal of experience. Beginners should select pieces tolerably smooth; but practiced workers prefer those which are irregular in their surface, because they furnish more scope for the exercise of their skill. In cutting these, the design follows the convolution of the shell. It is dangerous to lower any one portion, because the white surface does not preserve the same relative thickness all over the piece; and unless care is taken, the ground will show through. This is not a disadvantage in the ear or the neck, but would be serious if it was apparent on the forehead or in the cheek. A skillful cameo cutter will, however, so arrange his design as to produce the blush of the ground in such portions as to enhance the value of his work. Having selected the piece, it is fixed with setters' cement on a stick. The best are made out of a broom handle; cut off five inches, run some cement on the top, and press the ground of the shell into it while warm. The shell adheres firmly, and is now ready to be worked. In drawing the face, avoid, if possible, the rough, rotten-looking patches. These are signs of decay which may only be superficial, and disappear at the first cut; but, on the contrary, they are more likely to penetrate deeply, and may necessitate the lowering of the whole face before they can be got rid of altogether. Sometimes when the face has been modeled, and nothing remains but the finishing, a crooked line appears, which cameo cutters believe is caused by the presence of a worm in the early development of the shell. This is very difficult to get rid of. Hence extreme care is necessary in selecting the piece for working. A third fault is "flaking," when, by a single cut, the whole of the forehead chips off, or half the nose disappears. There is no remedy then; the whole face must be cut in low relief, or the piece be thrown aside altogether; the latter is often the preferable course. But all these risks are minimized by experience. Having got a satisfactory piece mounted, the stick is held in the left hand, and the face drawn upon it in lead pencil, a little larger than the size actually required. A skillful man will not use a pencil, but cut away at once, and rough out the head and face very quickly. A workman can cut a portrait from a

photograph in a few hours; the beginner should not spend more than two hours at a single sitting. Having drawn the face, take up a scawper, and cut the outline almost down to the ground; then separate the hair from the forehead, outline the ear, divide the mouth and nose from the cheek by a single upward cut to the eyebrow; from the corner of the nose cut a triangle—that will form the eye; make two cuts for the nostril and chin, and midway another cut will mark the mouth; sink the neck, outline the collar and coat; then the face is what is technically known as "roughed." At this point it is an interesting study to watch the cameo worker's method. With a scawper in his hand, he makes cuts all over the face, indents the cheek, smooths the ear, fashions the nostrils, lowers the nose, works at the mouth, forms the lips, cuts the chin, rounds the little triangle which contains the eye, marks the arrangement of the hair, with a cut here and there trims the beard; and so passes over the whole face again and again, bringing every portion into harmony before finishing any one feature. When the triangle has been duly rounded, and the eyebrow formed, a single cut separates the two lids of the eye, and lowers the eyeball at the same moment. When the eye is open, the likeness is complete; a portrait becomes apparent when the nose and mouth are cut, but the fashion of the eye is necessary to make it perfect. The ear and the hair play important parts in completing the face. To fashion the hair requires a great amount of skill, and the beginner is timid in making his cuts, but he is aided in forming the curved tresses by turning the stick to meet the scawper he is using. A fine scawper is necessary to cut the whiskers and beard, and the cuts should be short and curved. When the whole face has been modeled to the satisfaction of the eye, the third process begins—that of finishing. In this operation the spit sticker plays an important part. The upper eyelid is under-cut, which adds very much to the appearance of the eye; the hair is also traversed by the spit sticker, as well as the beard, and the tool smooths where it cuts. Finally, a flat graver is used to smooth forehead, cheeks, nose, and chin, taking out all marks of cuts, and softening the appearance of the whole.

In beginning, the learner should cut a few simple outlines, such as are furnished by the rose, the lily, or the fuchsia; the hand soon becomes accustomed to the use of the tools, and the timid cut becomes exchanged for the vigorous and graceful stroke of the artist. When progress has been made so far as to justify the cutting of a face, the learner should begin with separate features—the ear, the mouth, the nose, or eye; the hair will require a considerable amount of practice, but by perseverance all difficulties vanish, and when the features can be cut to the satisfaction of the teacher, then a whole face should be tried where no likeness is necessary. To produce a portrait, take a tracing and draw a star across it, then transfer the face to a star upon the shell. Make free use of a pair of compasses. The variations of eye, nose, mouth, and hair are quickly caught, and the likeness is complete. A portrait is not obtained by a series of bold sweeping cuts, but rather by a multitude of light touches, in which the surface is gradually shaved into the requisite form.

Great care is necessary in working the shell so as not to cut into the ground, on account of the extreme difficulty of removing any mark. When the work is finished, the first thing to do is to remove all marks from the ground. This is effected by the use of powdered pumice stone and water, applied on a piece of pointed wood. The next process is to smooth the surface with pumice stone and oil. Wash with a soft brush and warm water, then polish with the dust of the rotten stone and sulphuric acid mixed to a paste, and applied on the point of a piece of wood.

With respect to the articles required for commencing work, the following list embraces all that are necessary: Four round-sided and one flat scawper, one spit sticker, one file; seven tools, 1s. 9d.; one fret worker's grip, 1s.; a dozen pieces of shell of various sizes, 5s.; one broom handle, 2d.; cake of cement, 1d.; one oil-stone, 5s.; total, 13s. With such an outlay one can begin work at once. All these articles may be purchased at the shop of Messrs. Gray & Son, dealers in jewelers' materials, Clerkenwell Green, or at the shop of Mr. G. Schultz, cutler, 27 Sloane Square, Chelsea, S. W.

If the cost of these tools is compared with the expenditure necessary on many occupations to which ladies and gentlemen devote their talents in spare hours, it will be admitted that cameo cutting carries the palm for cheapness. When it is further considered that this may be resorted to for an hour, at any time, and does not involve the use of any machinery for its pursuit, nor the exclusive possession of any special table, while it is absolutely free from dirt or dust injurious to furniture, to the carpet, or to the dress, that it is not trying to the sight, and not attended with risk to the hands, it must be apparent that in cameo cutting an occupation is presented which has undoubted claims to consideration. All who engage in it become fascinated by the results which are obtained.

Children of tender years quickly become absorbed in the work, which not only trains the eye and the hand, but elevates and corrects the taste. To what more pleasant use could a child put the knowledge of drawing which it has gained at school? But it is not solely as an occupation for children that cameo cutting should be considered. Between the simple forms which a child may cut and the classic groups of finished artists such as abound, there is scope for the exercise of every degree of talent. There are artists in cameo now in Rome and Paris whose touches are readily identified whatever they treat, in the same way that the touches of a first-class sculptor are recognized. This society has already revived in England the practice of wood carving. Is not that of cameo cutting a kindred pursuit equally deserving of cultivation? Wood carving is an ancient industry revived, cameo cutting is an entirely fresh one, and its practice would add a new source of enjoyment and of wealth.

French taste, German industry, Italian art, meet us in the markets of the world, and strive for complete ascendancy, to the exclusion of British productions; but with an improved education, a more elevated taste, and indomitable industry, we may become formidable rivals even in departments from which we have hitherto been thrust out. As a very unassuming worker

of cameos, I desire to recommend the art to your consideration.

Mr. Marsh further said in reply to questions, that he thought it was in portraiture that those who took up this art would mainly succeed. You could not at present go into any shop or warehouse in London and get a portrait cut upon a cameo without the photograph being sent to Paris or Rome. But the few specimens on the table would show that it was quite possible for any one with a fair artistic ability, and a little training of the hand, to acquire the power of cutting portraits successfully.

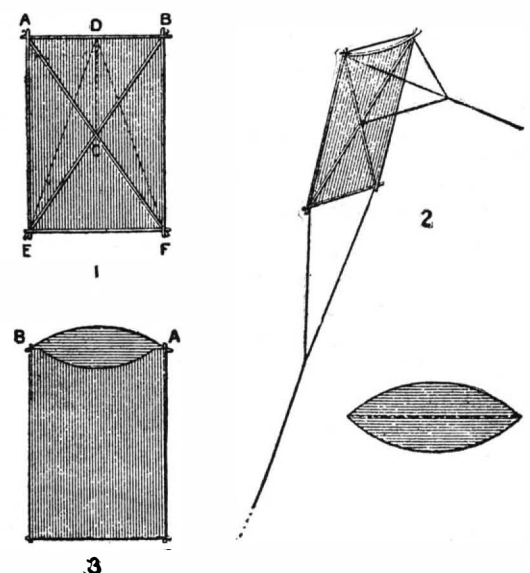
With regard to the use of the cameo when cut, it was eminently adapted for the ornamentation of furniture in the way suggested, but the ornamentation need not be confined to portraits. Flowers, groups of figures, and other designs suitable to such purposes were innumerable. He might mention that there was present a young Englishman who would be prepared to give instruction in this art, and he was the only one in London who could cut portraits. It was a curious fact that until he went to him about a twelvemonth ago, and asked him for a little help out of a difficulty in cutting a face, he had never attempted to cut a portrait, but he could now do it with a facility and finish equal to any artist in Rome.

He was pleased to hear Mr. Simmonds suggest that some better use should be found for these beautiful shells than grinding them up for lime. He should have much pleasure in communicating with the City and Guilds Institute, as Mr. Roberts suggested, and pointing out to them that the services of a teacher could be secured. Of course, before a teacher was engaged, pupils must be found, but he thought, with the publicity given to the matter in the *Journal*, pupils would be making inquiries, and by communicating with the City and Guilds Institute, pupils and teacher might be brought together.

Having drawn attention to the specimens of shells sent by Mr. Santa Maria, he thought it best to use the name commonly applied to them, the conch, rather than the Latin names for the different varieties, but these would be found in the printed paper. He had had innumerable applications to cut portraits, but as he only practiced the art as an amusement, he could not go into it as a business. He had not the smallest doubt, however, that in portraiture there was a large and remunerative field to those who would acquire the art.

ON KITES.

THE mode of constructing kites is very different in various countries. The following is the mode in Russia:



FIGS. 1 TO 4.—THE RUSSIAN KITE.

Selection is made of quite a tough paper of rectangular form, whose length is from $1\frac{1}{4}$ to $1\frac{1}{2}$ times its width. To the edges of this are glued four light strips of wood and two diagonals (Fig. 1). For greater strength, the ends of the three strips that cross each other at the corners are connected by strings. The cord is divided into three branches, one of which holds the kite by the center C; the two others by the corners A and B. To this effect the center of the kite is punctured by making a hole through the two diagonal strips which cross at that point. A string is passed through this hole, and fixed by means of a large knot formed in the end of it. The length of this string should be equal to the distance from the center to the upper edge. Another string is attached by one end to the corner A, and by the other end to the corner B. The length of this string should be equal to AC+CB, C being the center. After this, the middle of the string is connected with the middle of the one starting from the center. In this way we have a skeleton prism whose edges are represented by the strings united as has been explained, and the base by the portion ABC of the kite. The cord is affixed to the point where the three strings meet (Fig. 2). We now proceed to affix the tail. Taking quite a long string, we fix one end to the corner E, and the other to the corner F. The length of this string is usually made equal to ED+DF. The tail of the kite is attached to the middle of this string, and usually consists of a long string to which pieces of paper are fixed at intervals, and at the end of which is attached a heavier piece of paper or a rag. The weight to be given these tail appendages is to be found by experiment. If it is too great, the kite will not rise, and if it is too little, the kite will have no stability in the air and will be apt to dive. One important thing to see to is that the tail be not too short. It might almost be said that the longer it is, the better. In order that the kite may have more stability and more resistance to the wind, it is made convex at its upper part.

To this effect, the two upper corners, A and B (Fig. 2), are drawn slightly backward by means of a string that is a little shorter than the upper edge, AB. If to this string there be attached a piece of stiff paper in the shape of a double crescent (Fig. 4), folded in two,

this paper, when agitated by the wind, and striking the kite, will make quite a loud humming noise.

Kites constructed according to this method have great ascensional force. A kite about a yard in length is capable of easily lifting a Chinese paper lantern. If a lighted candle be put into this latter, and the kite be sent up at night, the effect will appear very curious to those who, from a distance, observe this species of moving star in the heavens.

An artillery captain at Toulouse sends us the following information in regard to the musical kites used in Tonkin by the Annamites:

"I have the honor of sending you some sketches of a kite (Fig. 5) that I have seen operating in the vicinity of Haiphong, in Tonkin. A large number of Annamites, children and men, amuse themselves in sending up this kite, which, when once in the air, is fixed to the ground by the cord, and left to itself. It is not rare to see an urchin seated upon the back of a buffalo (to whose horns the kite is attached), and moving about to the sound of the reed pipe fixed to the kite."

The annexed sketches (Fig. 5) render our correspond-

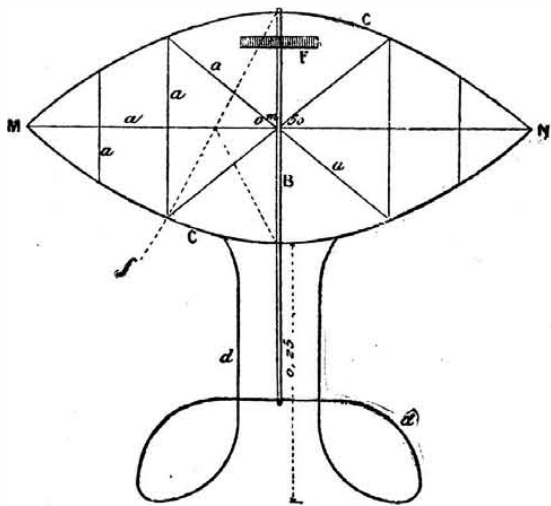
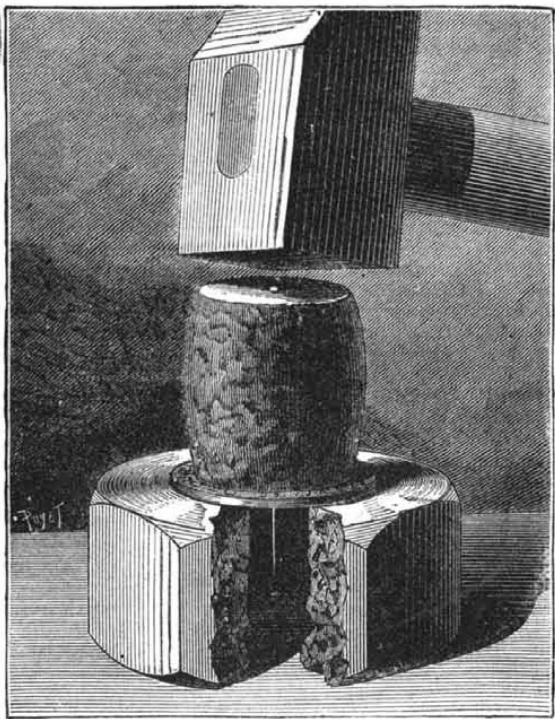


FIG. 5.—MUSICAL KITE.

ent's information complete. From M and N, the kite has a course of about from 2 to 4 inches radius. This curve is obtained by tautening the string extending from M to N. A reed pipe, E, is fixed on the opposite side, above the kite. The air rushes into the two apertures of this, and produces a sound that can be heard from afar. The reed is fixed to the kite with a small piece of bamboo that traverses it in the center like the principal piece, B, and is about 2 inches distant from the body of the kite. Sometimes the Annamites use two reeds, one placed above the other, the upper one being smaller than the under.

DRIVING A NEEDLE THROUGH A COIN.

WE know that one body is harder than another when it is capable of scratching the latter. A piece of glass scratches marble, a bit of diamond scratches glass; so glass is harder than marble, and the diamond is harder than glass. The steel blade of a knife scratches copper; so steel is harder than copper, and it is not impossible to pierce a copper coin with a needle that is much harder than it. The problem at first sight appears insoluble, because if we endeavor to drive a needle into a cent, just as we would drive a nail into a board, we never fail to break the needle at every at-



METHOD OF DRIVING A NEEDLE THROUGH A COIN.

tempt, since steel, although very hard, is very brittle. But if, through some artifice, we succeed in holding the needle straight and rigid over the cent, we can drive it into the copper with a hammer. To do this, it is only necessary to introduce the needle into a cork of the same length, when, being held in a true sheath, it will be unable to bend in any direction, and can be given a hard blow in the direction of its axis without being broken.

Under such circumstances, place the needle and its cork over a cent laid upon a bolt nut, or even upon a table that you do not fear to injure, and then take a somewhat heavy locksmith's hammer and strike the

cork a hard blow, as shown in the figure. If the blow be true and a very hard one, the needle will pass through the cent, and it will be impossible to remove it. The experiment may be tried with any other piece of money. We should add that success may not attend the first blow, and it will be necessary to make several trials; but the fact is real, and we have on hand a cent thus traversed by a slender needle.

IS BOTANY A SUITABLE STUDY FOR YOUNG MEN?

By J. F. A. ADAMS, M.D.

AN idea seems to exist in the minds of some young men that botany is not a manly study; that it is merely one of the ornamental branches, suitable enough for young ladies and effeminate youths, but not adapted for able bodied and vigorous brained young men, who wish to make the best use of their powers. I wish to show that this idea is wholly unfounded, but that, on the contrary, botany ought to be ranked as one of the most useful and most manly of studies, and an important, if not an indispensable, part of a well rounded education. In support of this view, these four good and cogent reasons can be adduced:

1. *The study of botany is an admirable mental discipline.* Any education is defective which includes no training in the scientific method of study; that is, in developing the powers of careful, minute observation and comparison in some department of nature. By this means is acquired the habit of investigation, or the seeking out of nature's mysteries by the use of one's own senses, instead of trusting wholly to the observations of others. This method of study may be learned through any branch of science; but botany presents this advantage, that it can be pursued with less inconvenience and less expense than any other. The mental training which botany affords is very thorough. The details of plant structure are infinite, and essential peculiarities are often so hidden as to be recognized only by the most minute investigation. This involves the use of the microscope, which every educated man ought to understand, since it reveals to the eye a newly discovered and wonderful world,—a world of which our grandfathers had but the faintest glimpses, but which is scarcely inferior in interest to that larger world which the unaided eye can see. After this training of the powers of perception and comparison comes the process of generalization, whereby the laws of vegetable life are determined from the study of plant forms and modes of growth. Thus is acquired the habit of inductive reasoning, or the supporting of every general proposition upon a solid foundation of positive, indisputable fact.

Learning the names of plants is but the beginning of the study of botany. It is like learning the names of our companions or schoolmates before we become really acquainted with them. After we have learned to tell plants apart and to call them by name, we have presented for study such problems as the laws governing their distribution, the relation between the floras of different continents, and the relation of variety to species, which introduces the subject of Darwinism. The study of botany also includes the fossil plants, and by enabling us to trace the vegetable kingdom from its first appearance upon the earth through all the varying conditions of the geologic ages, opens those tremendous scientific questions as to the birth and infancy of this world of ours which we now see in its maturity, and as to what it will become in its old age. These researches afford not only the amplest mental training, but abundant occupation for the longest life.

2. *The study of botany promotes physical development.* The botanical student must be a walker; and his frequent tramps harden his muscles and strengthen his frame. He must strike off across the fields, penetrate the woods to their secret depths, scramble through swamps, and climb the hills. The fact that he walks with an earnest purpose gives a zest to these rambles; and he comes home proud and happy from his successful search for botanical treasures, with a keen appetite and an invigorated body and mind. He has enjoyed himself more thoroughly, and gained more substantial benefit, than those who have devoted the same time to the bat, the racket, or the bicycle. In his vacations the young botanist can toughen himself by making long and delightful excursions, living all summer in the open air, and may even have opportunities for joining government exploring parties, and enjoying the active out of door life, full of adventure and useful experience.

3. *The study of botany is of great practical utility.* It is an essential preparation for several important pursuits. The physician and pharmacist need to have a practical knowledge of those plants which are used as medicines; and, if this knowledge is not acquired in early life, the opportunity never afterward presents itself. For the protection of our rapidly dwindling forests, the services of many skilled foresters will soon be required; and the forester must be a practical botanist. So must also the horticulturist, whether professional or amateur. For the most accomplished botanists, who desire to make this their life work, there will always be places as instructors in our many colleges.

4. *The study of botany is a source of life-long happiness.* Whatever may be one's station or pursuit in life, it is a great thing to have an intellectual hobby, which will afford agreeable and elevating occupation in all leisure hours. Botany is one of the best of hobbies. It can be studied out of doors from early spring till the snow falls; and even in winter there is plenty to be done in the analysis of dried specimens and the care of the herbarium. The botanist lives in the fresh air and sunshine; and when he leaves the world behind, and seeks, amid the solitudes of nature, to penetrate her wondrous mysteries, he feels the quickenings of a higher life. A taste for botany wonderfully enhances the pleasures of travel, and also gives happiness and content to him who stays at home. It is equally efficacious in preventing the ennui of wealth and the anxieties of poverty. If one's surroundings are uncongenial, and life proves full of cares and disappointments, it is a great solace to be able to say with Aurora Leigh,

"I was not therefore sad,
My soul was singing at a work apart."

For these reasons it is obvious that the study of botany is peculiarly rich in those elements which con-

duce to a vigorous mind and body and a robust character. It is therefore pre eminently a manly study, and an invaluable part of a young man's education. The student may rest assured that the time and effort devoted to it are well spent; for the result will be to make him a wiser, stronger, more useful, and happier man.—*Swiss Cross.*

MEDICATED GAS.

THE treatment of pulmonary phthisis with rectal injections of medicated gases has been reported upon favorably by Dr. Bergeron (*Brit. Med. Journ.*, Oct. 2, p. 651). About four or five liters of carbonic acid gas is passed through one-quarter to half a liter of a mineral water containing sulphur, and then introduced into the rectum, two injections being made in the course of twenty-four hours. After two days of this treatment cough is reported to have been cured, expectoration modified in quantity and character, profuse perspiration stopped, and the general condition improved, even in cases in the confirmed stages of phthisis.

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