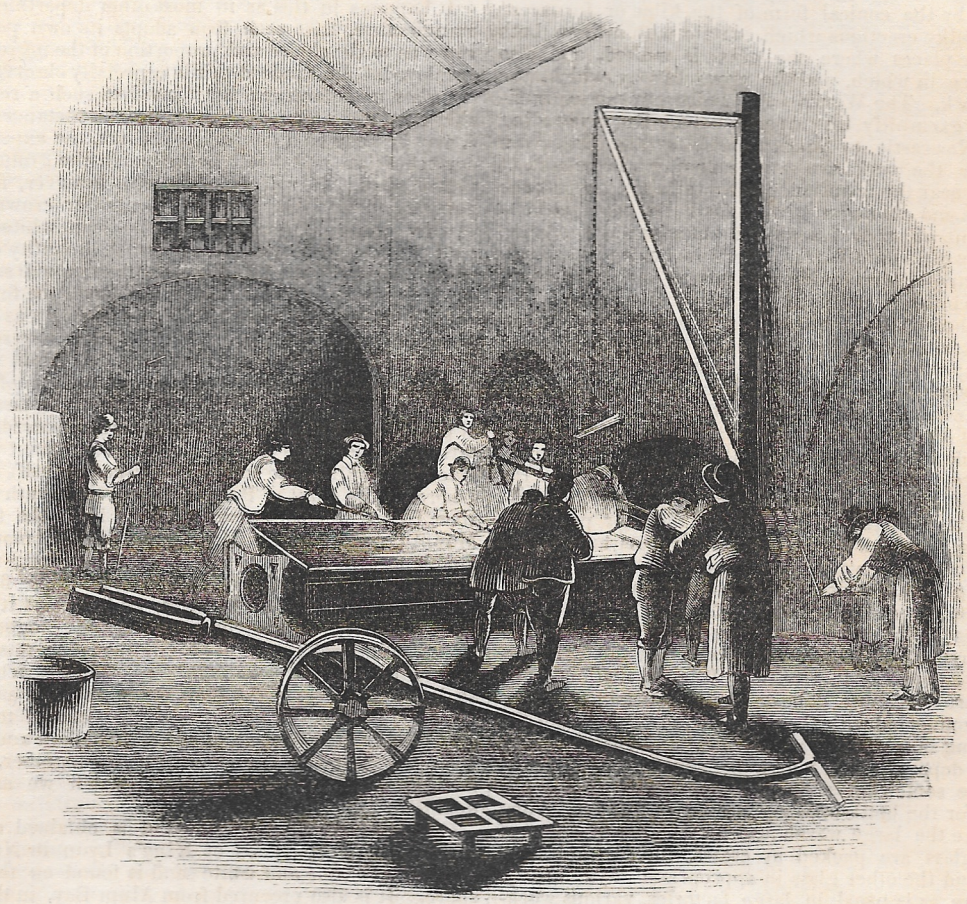
A DAY AT A GLASS-FACTORY.



[Plate-Glass Casting, Messrs. Cookson's, South Shields.]

IN the Supplement for May it was stated that *glass* is one among the staple manufactures of Newcastle and its vicinity. To this subject we shall direct our attention on the present occasion.

The settlement of this important branch of manufacture on the banks of the Tyne may be attributed to the same causes as that of so many other departments, viz., the cheapness of coal and the great facilities for shipping off the produce. Of all the glass made in this country, a very large proportion indeed is produced on the Tyne or the Wear. This, combined with other causes, has given rise to a curious circumstance, which is apt to escape the notice of general observers. The coals, the pottery, the glass, the chemicals, and other produce of the district, employ an extremely large number of vessels for their transport to London and other parts of the kingdom. On the other hand, the produce transported from London and these other ports to the Tyne is comparatively small in quantity; so that the vessels require a large quantity of ballast to place them in sailing order on their return voyage. This ballast is composed of river-sand, obtained at a cheap rate from the dredging of the rivers; and when it has enabled the vessels to reach the Tyne, the purpose of the ballast has been answered. But matters do not end here: the vessels must be emptied, and the ballast must be deposited somewhere. It must not be thrown into the Tyne, and therefore it is deposited on the banks, where huge heaps have in time collected, two or three hundred feet in height. So important is this matter deemed to be, that a district has been purchased within the last few years on the sea-shore, and a railway a mile in length constructed from thence to South Shields, as a means of depositing, in a spot not required for other objects, the ballast taken out of the ships at South Shields. The owners of the vessels pay a certain price per ton for all the ballast thus taken off their hands.

The glass manufacture is a good deal subdivided. There are flint-glass, crown-glass, plate-glass, broad-glass, sheet-glass, and bottle-glass; each one being regarded in some respects as the object of a distinct department of the manufacture, involving its own kind of ingredients and its own routine of processes. There are, of course, certain general principles which pervade them all, without respect to the minor differences among them; and a consequence of this is, that three or four of these are sometimes undertaken by one firm. In the Supplement for February, 1841, a description was given of the operations in a Flint-Glass Factory in London; and we have now an opportunity of glancing at most of the other departments, through

the courtesy of Messrs. Cookson of Newcastle, who carry on, at that town and at South Shields, a very extensive system of manufacture in four of the above-mentioned branches, viz. *crown, plate, sheet,* and *bottle* glass.

A glass-work is generally distinguishable from most others by the conical form of the kilns or furnaces; those bulky erections which contain within them both the fire-places where the glass is melted, and also the space in which, and the apparatus by which, the men work. The Works now under our notice sufficiently exemplify this arrangement. On proceeding from Newcastle to South Shields by the Brandling Railway, the works are seen occupying a large area of ground near the terminus of the railway; the groups of kilns and chimneys giving forth the usual accompaniment of such places—an abundance of smoke. When within the Works, there is evidence enough that many of the buildings are very old; and as we approach the river this is the more observable. The establishment, taken as a whole, is one of the oldest in the district, dating back its origin to so early a period as 1738; and the various clusters of buildings seem as so many marks, to indicate the times when, and the extent to which, the operations have been enlarged. To begin at the beginning: there are the wharfs on the river-side, where the crude materials for the manufacture are landed from the shipping, and where the cases and crates of glass are despatched off per ship. Then there is the large cool building, or part of a building, in which the glass-melting pots are made—those important vessels on which the safety of the melted glass depends; and in connexion with this are the ovens where these pots are baked. Next are the furnaces for the crown-glass manufacture, with the accompanying annealing ovens, and all the arrangements connected therewith. Wholly distinct from these are the more delicate and important arrangements connected with the melting, the casting, and the annealing of plate-glass. The neat and comparatively limited department in which the sheet-glass is made, and the somewhat ruder arrangements which will suffice for the bottle-making, are again distinct. Then there are the large warehouses in which the tables of crown-glass are packed in crates, the plate-glass in cases, and the other glass in appropriate ways. Lastly, there are, as is usual in large factories, various workshops for different kinds of artificers, whose services are necessary to keep the apparatus in working order. The many-storied and many-windowed buildings which are characteristic of the textile manufactures, are not to be looked for at a glass-work—all is necessarily more "in the rough;" and we must be prepared to meet with swarthy workmen, a sooty atmosphere, highly heated buildings, and a labyrinth of scattered erections.

The chief features presented by the various buildings will be best understood by glancing at the operations of which they are the scene; and we will therefore at once proceed to notice the manufacture of

Crown-Glass.

Whatever may be the origin or fitness of this name, the glass so designated is that with which windows are generally glazed in this country, and which is also generally employed for framed prints and drawings. It is always made in a circular form, rather thicker at the circumference than elsewhere, and having a knot or protuberant bulb in the centre. This is certainly a very unfortunate shape for such glass to assume; since, as the central bulb must always be cut away, and as the glass is nearly always used in a quadrangular form, there is a very serious amount of loss in cutting up the glass for use. The other kinds of glass, as we shall see further on, are not exposed to this disadvantage; but, on the other hand, there are counterbalancing advantages which lead to a much larger manufacture of crown-glass than of plate, broad, or sheet glass, and indeed greater than of all these taken together.

It happens in this as in most other departments of manufacture, that each firm adopts its own peculiar views as to the choice and proportion of the ingredients employed. And indeed this is especially observable in the glass manufacture; for it involves such a remarkable chemical union of heterogeneous substances, that it may be deemed an experimental art, the experience derived from past trials being made the ground for future ones. It will be sufficient, however, for our purpose, to say that the ingredients for crown-glass usually comprise the following:—clean white sand, soda or potash, lime, and a very small quantity of one or two other substances. For shortness we will say that the ingredients are sand, alkali, and lime: the first two really constitute the glass, while the lime acts as a flux to enable the others to melt and combine more readily.

This union of sand or flint with an alkali, as the chief circumstance involved in the production of glass, is observable in the legendary account of the discovery of glass as given by the early writers. According to this story, there was on one occasion a merchant vessel, laden with nitre (one form of the alkali potash), driven ashore on the coast of Palestine, near the mouth of the river Belus, a small stream running from the foot of Mount Carmel into the Mediterranean. The mariners, unable to procure stones to rest their cooking-vessels upon, used pieces of the nitre instead. The fire reduced the alkali to a soft state, and enabled it to incorporate with the river-sand, forming together a stream of liquid glass. The circumstance was communicated to the inhabitants of the district, who availed themselves of the hint, and established a manufacture of glass. Whether or not we choose to place credence in this story, certain it is that alkali and sand, wherever found and however melted together, form the bases of all the glass with which we are acquainted.

Of these ingredients, the sand is obtained chiefly from the neighbourhood of King's Lynn in Norfolk, where a very fine and white sand is found on the seashore. It is also procured from Alum Bay, in the Isle of Wight. It was not always usual to employ sand for this purpose, for flints used to be selected instead; as, however, it was found that sand answered the purpose, and saved the trouble of calcining and grinding the flints, the latter gradually became superseded by the former. The term *flint*-glass had its origin from this employment of flints in its manufacture. With regard to the alkali employed, this has been affected by the circumstance alluded to in our notice of Chemical Works, viz., the substitution of salt for kelp as a source of soda. In former times, the glass-makers used to employ large quantities of kelp, which they procured from Scotland; it was an impure carbonate of soda, which gave off its carbonic acid and its impurities by the action of heat, and entered into the composition of glass in the state of soda. But as now obtained from common salt, the carbonate yields a much larger amount of pure soda for a given price, and has thrown into shade the use of kelp for this purpose.

Before the ingredients are actually mixed in the melting-pots, they undergo a preparatory operation called *fritting*, the object of which is to fit them to form a more homogeneous compound. This is effected in a kind of oven, very shallow in proportion to its area. The sand is first washed clean, and exposed for several hours to the action of a strong heat; then, while hot, it is plunged into cold water, which splits the grains of

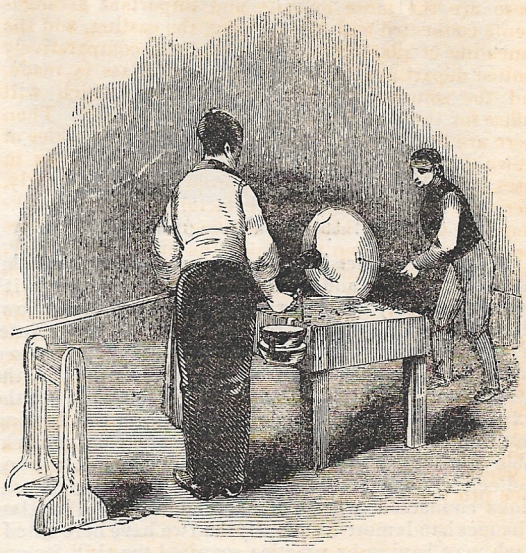
sand to a still smaller size, and enables them to combine more readily with the alkali. The fine sand and alkali being then mixed together, the mixture is placed in the shallow oven, or 'calcining arch,' where it is exposed to a heat which brings it to the liquid state; and by being constantly stirred for some time while in this state, it undergoes considerable change: the moisture is driven off, the carbonic acid is expelled from the alkali, the carbonaceous particles are burned away, and the ingredients are brought into chemical union. The mixture, which now obtains the name of *frit*, is taken from the oven, spread out upon a plate of iron while yet hot, and is divided into large cakes before it becomes quite cold.

It is from this frit, then, that the glass is made. The frit is melted in pots of very large size, and requiring peculiar care in the manufacture. We have on other occasions, such as in relation to the steel manufacture, had to speak of the carefully wrought vessels of Stourbridge clay, which are required to endure a powerful heat; and in the glass manufacture the same is observable, except that the vessels are very much larger and are made wholly by hand. In one of the buildings the potters are always at work producing these vessels —preparing and kneading the clay, making it into oblong pieces, laying these pieces round the vessel one at a time (as a bricklayer might the bricks in a wall), and working each piece so that it shall adhere closely to those which preceded it. The pots are allowed to remain many months slowly drying in the air, and are then gradually exposed to an increasing heat, in appropriate ovens or furnaces, till they are baked and annealed sufficiently to bear the fierce heat of the working furnace.

To this furnace and its busy operations we will next direct our attention. Those who have never been in what is familiarly termed a 'glass-house' may have some difficulty in understanding the mode in which it is arranged. Imagine then a large room or building with a furnace in the centre, having several mouths or openings to the furnace, and the melting-pots just within these mouths, enveloped in a fierce heat. A passage is left open around this furnace, where the workmen take up their stations; and on the other side of this passage are the openings to numerous ovens or furnaces, wholly distinct from the central furnaces. If we therefore picture to ourselves a pathway going round a central furnace, and being itself bounded by other furnaces, we shall form some conception of the kind of place where the glass-makers work. To say that they are "between two fires" is only part of the truth; they are between and adjacent to a dozen fires, and become exposed to the action of one as soon as they leave another. There is very little light in the glass-house except what is derived from the opened or partially opened mouths of the furnaces; and as the men go flitting past these fiery spots—now exposing their brawny figures to the full glare of the light, and now involved temporarily in shade—they form items in a picture replete with striking effects. If each man stood in one spot, and made a piece of glass by his own work, the picture would approach nearer to one of 'still-life;' but they are continually passing to and fro. A piece of glass goes from hand to hand, probably a dozen times in the process of making, travelling along from one furnace to another, and receiving at each spot and from each man some modification in its form. Heat, bustle, and dexterity are, in fact, the three features which attract our attention.

The frit is placed in the pots, together with a portion of 'cullet,' or broken glass; and both together are exposed to an intense heat, whereby they are melted into a liquid glass. The impurities rise to the surface, and are then skimmed off by the aid of an appropriate instrument. The glass (or 'metal,' as it is technically called) is not in a workable state when quite liquid; but by slackening the heat a little, the glass becomes slightly viscid, and is in that state fitted to undergo the remarkable operations which constitute crown-glass making.

As each table or circular piece of glass requires only a few minutes in making, but demands the services of several workmen, all place themselves in readiness to act their parts in the scene. The first man, called the *gatherer*, approaches one of the furnace-mouths, and dips into the melted glass the end of an iron tube six or seven feet in length; he turns the tube gently round, until he has gathered a pound or two of pasty glass on its end; he allows this to cool a little; then dips it again, to increase the quantity; then allows this to cool a little; and so on, until he has gathered a mass of nine or ten pounds of the paste-like and fiery-coloured glass on the end of the tube, turning the tube all the time to prevent the glass from falling off it. He holds this mass perpendicularly downwards, to make it elongate somewhat beyond the end of the tube; and then rolls it to and fro on a smooth iron plate called a *marver*, to give a cylindrical form to the protuberant mass. The man (or an assistant) then blows through the tube, by which the glass is made hollow within, and brought to something like a pear-shape. It is then handed to another man called the blower, who heats it at the mouth of a furnace two or three times, and after each heating blows it and rotates it; till at length he so enlarges the size of the mass of glass and reduces its thickness as to present it in nearly a globular form. The side opposite to the tube is then slightly flattened, by being pressed against an iron plate; and the glass is transferred from the tube to a rod in a remarkably dexterous manner the blower holds the tube horizontal, while another man collects a little melted glass on the end of an iron

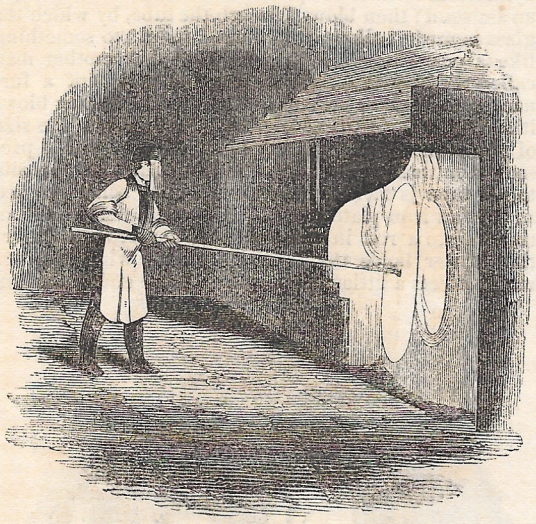


[Transferring from the tube to the pontil.]

rod called the *pontil* or *punty*, and applies this to the middle of the flattened surface of the glass, exactly opposite the tube, which latter is immediately afterwards detached by touching the point of junction with a piece of iron wetted with cold water. This transference from the end of the tube to the end of the rod is effected so quickly and neatly as to form one of the prettiest parts of the operation.

We have, then, up to this point, a flattened globe of glass fixed to an iron rod at the flattened side, and

having a small hole on the opposite side, occasioned by the detachment from the tube. How this is transformed into a flat circular sheet is the next point to notice. The workman holds the pontil so that the glass shall be exposed to the heat of a furnace, at one of the mouths or openings called by the men a 'nose-hole.' He rests the rod at one particular point on a bar which serves as a support or fulcrum; and keeps the glass rotating while exposed to the heat. As the substance of the glass becomes hotter and softer, it yields more readily to the centrifugal force engendered by the rotation: it becomes every moment broader and flatter, deviating more and more from the shape of a globe. The hole which the tube had before formed, and which was at first only about two inches in diameter, gradually enlarges by the same force, until it becomes three inches—six—twelve inches in diameter; and finally, the whirling action so completely masters the previous condition of the glass, that the flattened and misshapen globe suddenly 'flashes' (to use a technical term) out into a circular sheet four or five feet in diameter, nearly equable in thickness in every part, and being still attached to the rod exactly at the centre.



[Flashing-out the Crown Glass.]

This rapid succession of changes is to a bystander at once beautiful and inexplicable. The facility with which the pasty glass is worked into form, the hollowing of the mass by means of the breath, the maintenance of a particular degree of softness while exposed to heat, the transference from the tube to the rod, the steadiness of position maintained by the rotation, the expanding of the small hole in the centre, the flashing out into the flat circular form—all are very remarkable considered even singly, and form when viewed collectively one of the most striking series of operations connected with our manufactures. The glass changes hands more frequently than we have here noted; each man having by practice acquired the skill for one particular operation. It passes also round the central furnace from one opening to another, in order that each man may have a working-spot without interfering with the others. In the last process, that of 'flashing,' the heat and flame given out at the furnace mouth are very fierce, and throw a strong glare on the person of the workman, who stands partially behind a kind of screen, and who shields his face with a handkerchief or cloth.

The manner in which the circular table of glass is detached from the rod is not less neat and dexterous than the other parts of the operation. The rod is rotated for a few seconds after the glass has 'flashed,' at such a distance from the fire as to give the glass sufficient coolness to maintain its shape. The man then carries it a short distance, and places the glass down horizontally on a bed of sand, where the rod is detached from it in a moment by another man. The circular piece (having the 'knot' or 'bull's eye' in the centre) is then lifted up on a wide two-pronged fork, and placed upright in an annealing-oven. Here it is allowed to cool very gradually, whereby it becomes annealed, or loses some of the brittleness which would otherwise characterize it.

It will readily be understood that although a dozen men are thus engaged in making one piece of glass, there are many pieces under operation at the same time, each man taking up a new one as soon as he has handed over the previous one to the man standing next to him. There is thus a kind of endless chain, of which all the links are being made at once.

There is very little more which need engage our attention respecting crown-glass. The circular sheets, when cooled in the annealing-oven, are carried to the warehouse, to be packed in straw in the wooden crates which are familiar to most persons. Sometimes they are packed in the circular form; while in other instances the circle is cut into two unequal pieces, that one which contains the bull's eye or knot being called a *table*, and the smaller piece being called a *slab*. According to the colour, trueness, and flatness of the glass, it is divided into four kinds or qualities, which bring different rates of price in the market. Although some of the circular sheets are five feet in diameter, yet, owing to the curvature of the edge and to the central knot, a rectangular piece measuring three feet by two is nearly the largest that can be obtained from them.

Let us next take a similar glance at the manufacture of

Plate-Glass.

A better name than *plate*-glass would be *cast*-glass, since the former is vague in its acceptation, whereas the latter expresses the mode of manufacture. This kind of glass is *cast* or *founded* while in a liquid state, and is totally independent of the process of blowing. There was formerly, however, a kind of glass which resembled plate-glass in its general qualities, and which was produced by blowing instead of casting; but this has been almost completely superseded by the cast-glass of modern times. Blown plate-glass, like crown-glass, can only be made of small dimensions; but cast-glass has been produced as large as fourteen feet long by eight or nine in width.

The plate-glass, or glass (whether cast or not) which was to serve for mirrors, was originally a very favoured manufacture. Whether this kind of glass was known in early times is still matter of conjecture; but its manufacture was carried on by the Venetians some centuries ago, and so useful were the glass-makers regarded at one time at Venice, and so great was the revenue accruing to the republic from the manufacture, that, to encourage the men engaged in it, the senate made them all burgesses of Venice, and allowed nobles to marry their daughters; whereas, if a nobleman married the daughter of any other tradesman, the issue were not reputed noble. Again, in the early times of glass-making in France, the French government made a concession in favour of this manufacture, by decreeing that not only should no derogation from nobility follow the practice of the art, but that none save gentlemen, or the sons of noblemen, should venture to engage in any of its branches, even as working artisans. This limitation was accompanied by a grant

of a royal charter of incorporation, conveying important privileges, under which the occupation became eventually a source of great wealth to several families of distinction.

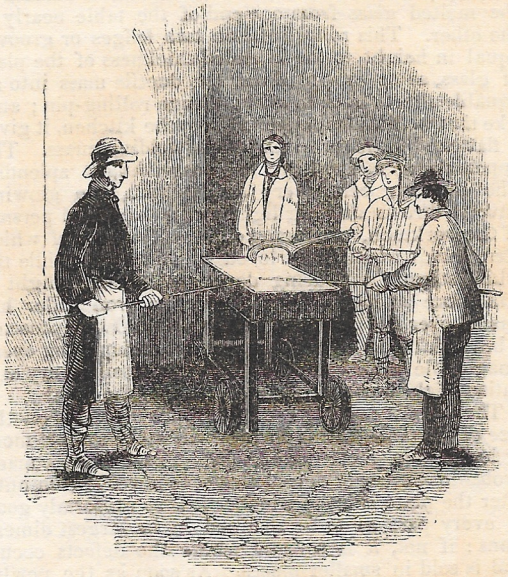
The plate-glass manufacture in our own day is remarkable for the small number of establishments in which it has been centred. There are, we believe, only four firms in England by whom plate-glass is made. It was seventy years ago that the first of these large works was established in Lancashire, and during the whole of the intervening period there have never been at any time more than three or four in operation. Newspaper readers have often remarked that the London daily papers remain the same in number year after year; porter-drinkers find that the great London breweries remain pretty equal as to number year after year; and it may be that the necessity for great capital and great experience will point to the analogous state of the plate-glass manufacture as well as to these. But be this as it may, the fact of the smallness of number is undisputed.

The plate-glass department at these works is a building of remarkable appearance within: very large, quiet, and so dark as to appear gloomy to those unaccustomed to the place, except indeed when a plate of glass is being cast, at which time a vivid and brilliant glow is diffused around. We must remark at once, that here the plates are only *cast;* all the important subsequent operations of grinding and polishing being carried on at other large ranges of buildings in Newcastle belonging to the same firm.

In the large building to which we alluded above there is a central furnace or group of furnaces, with a lofty open area extending three-fourths around it. Exterior to this is a series of annealing-ovens, several in number, the mouths of which are in what may be termed the wall of the room. Everything is on a much larger scale, and is more cleanly in its appearance, than in the crown-glass department. The most conspicuous piece of apparatus is the *casting-table*, a most carefully prepared plate of iron, with various mechanism to place it in any desired position. This iron plate measures seventeen feet by nine feet and a half, and gives a limit to the size of the glass that can be made upon it. Suspended above or near the casting-table is the apparatus by which the melted glass is poured upon the table; and there are other arrangements for working the pasty glass before it solidifies. On the floor of the building a railway is laid, along which the casting-table is wheeled from one annealing-oven to another, since it is necessary that the table should be placed close to the oven into which the plate is removed for annealing after being cast.

In the furnaces which occupy the central part of this great room the glass is brought to a liquid state. In the selection of the ingredients, in the purifying of them for use, in the proportions of mixing, and in the completeness of mixture, more care is bestowed in the plate-glass manufacture than in any other. A large sheet of plate-glass is perhaps one of the most perfect and beautiful of manufactured products, and requires experience and dexterity in every stage of its manufacture: its colour, its freedom from air-bubbles and from coloured specks, its regularity or freedom from veins and wrinkles, its equability of thickness, its freedom from mist or cloudiness—all require the closest attention on the part of the manufacturer. As to the ingredients employed, they so far resemble those used for crown-glass as to comprise sand, alkali, and lime as the three principal ones; but the minute details in respect to proportions and additional ingredients are of great nicety, and concern only the manufacturers themselves. It will suffice for our present purpose to know that the above three ingredients form by far the larger portion of the body of the glass.

The ingredients, then, being *fritted*, or partially combined in small furnaces, are placed in the melting-pots, together with a portion of *cullet*, or broken plate-glass. These pots are, like those for crown-glass, made with great care in respect to their power of bearing heat; but in their shape, and in that of the furnace in which they are placed, there are points of difference corresponding with the difference in the mode of working. When the red-hot liquid lava (if we may so term it) has arrived at a particular state, it undergoes an examination, which may be taken as an instance of the caution observed in the manufacture. Three men take a copper ladle having a long handle, dip the ladle in the melted glass in the furnace, and convey it to a small flat slab or tray, on which the glass is poured out. One man holds the handle, while the other two support the bowl of the ladle by cross-handles. The red-hot mass is so soon affected by the coolness of the air, that it assumes a thick pasty consistence when placed on the tray. A man then examines it, to see



[Examining the liquid glass.]

whether any slight differences of colour indicate defective spots: he knows from experience what are the causes of these spots, and in what way they will affect the purity of the glass when finished; he therefore removes them with the pointed end of a rod or tool, and leaves the rest of the mass in a uniform state. The mass is returned to the ladle, and the three men carry it back to the furnace. It is now put into different pots from those which before contained it, and thus these pots become filled with the successively examined portions. When the quantity has thus accumulated to the required amount for one casting (comprising several cwts.), the pots are exposed to a heat sufficient to bring all the glass to a liquid state.

It may be well supposed that a recognised order is observed in all these preparatory arrangements, so that while one potful of glass is going through the later stages, others are passing through an earlier stage. Thirty or forty hours are required for the melting and proper combination of the materials. It is not exactly a liquid state which is most proper for the casting; but after the perfect melting has taken place, the glowing mass is allowed

to lower its temperature a little, so as to acquire a slight degree of viscidity.

We will suppose, then, that this viscid state has been attained, and that the casting is about to take place. A group of fifteen or twenty men assemble round the casting-table, or between it and the furnace, each one having evidently a definite office to fill, at a particular spot and a particular moment. The *cuvette*, a vessel from which the glass is poured in the casting, remains in the furnace, of the same white-hot temperature as the liquid glass it contains; it having been filled by means of the ladle while in this situation. At the appointed moment, the cuvette is drawn out of the furnace by means of a crane; and the brightly glowing vessel is quickly swung round so as to be brought over the casting-table, very near the end which adjoins the annealing-oven. The foreman or director of the casting places himself in a particular spot; the men also take up their positions; and at a given signal the cuvette is tilted up so as to pour out its broad stream of golden lava on the casting-table beneath. A number of minor adjustments are then quickly made by the men, the principal of which consists in passing a heavy polished iron roller over the whole surface of the melted glass from one end of the table nearly to the other. This roller rests on two ledges or grooves equal in height to the intended thickness of the plate of glass, so as to spread out the ductile mass into an equable sheet: it is, in effect, a huge rolling-pin; and, like that well-known appendage to the kitchen, it gives a flattened form to a shapeless yielding mass. The appearances, meanwhile, are exceedingly splendid. The building being very dark within, the glowing cuvette throws a strong light on the faces and persons of the workmen, producing effects of bold relief which Rembrandt would have loved to paint: and while the white stream is pouring down, the reflected light is still more intense. Then, when the iron roller has passed over the glass, the surface of the latter presents a beautiful play of brilliant colours, comprising every imaginable tint; caused probably by a temporary oxidation of the surface by the coolness of the iron.

The quantity of glass cast at once depends on the size of the table, and is such as will make a plate more or less within those dimensions. There are so many probable sources of defect, that it is never known until after the plate is made whether it is so uniformly good in every part as to be retained in its largest dimensions: if not, it is severed where the defects occur, and is sold in smaller pieces. As soon as the newly-cast plate has solidified, the door of the annealing-oven is opened, and the plate of glass is dexterously thrust from the table into the oven. These ovens are very deep, so as to allow several plates to lie in them edge to edge. The oven is closed up very tightly after the glass is put into it; and there the heat is allowed to decline gradually for many days, so that by this slow cooling the glass may become annealed.

The ponderous iron casting-table will serve to supply all the annealing-ovens. It is wheeled on from one to another by means of the railway; and makes its circuit by the time the annealing is finished.

At this stage we quit the South Shields Works for a time, and follow the plates of glass to Newcastle, where they are ground and polished at two large establishments appropriated to these departments, and belonging to the same firm. Here everything is changed. The men are different, the buildings, the processes, the materials, the machines—all are so totally distinct as to appear like a different subject of manufacture altogether. In these buildings—which are situated in the western part of Newcastle, near the Carlisle Railway—the rough plates of glass are brought to the brilliant state in which we are accustomed to see them. As they leave the casting-table, they are rough and somewhat undulated, and wholly destitute of polish. They are cut to a rectangular form by means of a diamond, and conveyed to the grinding-room. This is an immense room filled with machines in a constant state of rotation; and the sand and water which are dripping around show that the process going on is not by any means a cleanly one. The plates of glass are cemented by means of plaster of Paris to flat beds or frames, and are in this state inverted one over another, so as to have the two plates of glass in contact. The upper one is so connected to machinery moved by a steam-engine as to have a rotatory motion given it; and by introducing between the plates some wetted sand or ground flint, each plate grinds the contiguous surface of the other. The plates are cast very much thicker than they are wanted for use, in order to admit of the surfaces being ground away till no defects appear; and this diminution sometimes extends to one-half the thickness of the plate. From time to time the flint and water are sprinkled on; and from time to time also the plates are removed to see how the process is going on. When one surface of each plate is ground, the plate is separated from the frame, and reversed, so as to expose the opposite side; and these new surfaces are then similarly ground one against the other.

The effect of this grinding is to remove all inequalities and to bring the glass to a perfect level; but it is not only deficient in polish, it is covered with scratches from the fragments of flint, and these scratches must be removed before the glass can be polished. To effect this emery-powder of several degrees of fineness is employed; the coarsest first, and so on to the finest. The smoothing by means of this emery-powder has the effect of removing all the scratches, and of producing a delicate dead-like appearance of surface, but without anything which can be termed a polish. This stage of the work is done by a large number of women, working on stone benches. During these successive stages of progress the two plates are made to grind each other, the upper one moving over and upon the lower; the intervening wetted emery-powder being changed from time to time, until a quality of exquisite fineness is finally used.

The last range of buildings, in which the glass is warehoused and packed in saleable form, contains the shops in which the polishing is effected. In a room of great length there are numerous polishing-machines of remarkable construction. Each plate is laid down on a flat bed, and is rubbed over every part for a long period with a system of rubbers or polishers kept in motion by steam power. These polishers consist of oblong pieces of wood covered with cloth on which a kind of polishing paste is laid; and it is by repeated rubbing with these small pieces of apparatus that the plate receives its final brilliancy.

It would be in vain to attempt to enumerate the examinations which the plates undergo. In every stage of the manufacture the experience of the workman is called for, to determine whether any and what imperfections appear, and how they are to be removed; and as, on the one hand, no manufactured article would betray the existence of defects more readily than a large sheet of plate glass, so, on the other hand, the most sedulous attention is paid to the detection of such defects when they appear in the course of the manufacture. We need hardly wonder at the comparatively high value of plate-glass, when the risk and skill involved in the manufacture are duly estimated.

The *silvering* of looking-glasses is a distinct occupation, with which we have nothing to do here; but a few words of explanation may be offered. In the first place, the designation is a misnomer; there being no

silver used. A sheet of tin-foil is laid down on a flat stone or slate table, and on this is poured some mercury or quicksilver (whence probably the mis-appellation). The plate of glass, being first made perfectly clean, is placed on the liquid mercury, in such a manner as to expel all air-bubbles from between the two; and heavy weights are placed on the glass to force out the superabundant mercury from beneath. The whole is allowed to remain in a slightly inclined position for some days; after which it is found, on the removal of the weights, that the mercury has combined with the tin-foil, and that both together have adhered to the glass, forming what is commonly termed the 'silvered' surface, and giving origin to the brilliant reflection which is the object of the process.

We must now re-conduct the reader to South Shields, to glance at the manufacture of

Sheet-Glass.

This is to a by-stander one of the most inexplicable modes of glass-making. How the workman can possibly obtain a rectangular piece of glass in the way he does, is a sore puzzle at the first glance; and even after it has been witnessed several times, our admiration at the dexterity shown is not one whit lessened. In some of its features the mode of proceeding resembles that adopted in respect to crown-glass; but others are wholly different. Sheet-glass can be made larger in size than crown-glass, and is much employed for glazing large prints and drawings; it being in quality and in value a medium between plate-glass and crown-glass.

We may say of this, as of the former kinds of glass, that sand, alkali, and lime are the three chief ingredients, and that the preparation and melting are brought about in a manner nearly similar. The workman, when the glass is in a proper state of liquidity, gathers on the end of a tube the quantity of glass necessary for one process of making, and which depends on the predetermined size and thickness of the piece to be made. He rests this ductile mass in a horizontal position upon a wooden block, which has a hollow or depression calculated to give a cylindrical form to the mass. A fine stream of water is allowed to flow on the block, as a means of preventing the wood from burning, and of imparting a kind of brilliancy to the glass. The proper balance between the heat of the glass and the coldness of the water is one of the points to which the attention of the workman is directed. The blower raises the other end of the tube to his mouth, and blows the mass of glass into a hollow form, at the same time turning the mass round uninterruptedly in the block of wood. By this means the glass assumes a kind of globular form, eight or ten inches in diameter; and this is made the nucleus of a cylinder three or four feet in length, by a most remarkable train of processes. The workman holds the glass at the mouth of a furnace, to heat it to a certain degree of softness, at the same time keeping it rotating to prevent it from falling off the tube. He then lets the glassy mass hang downwards, and swings it to and fro in a recess or cleft in the floor of the shop. By this movement the globe, yielding to its own weight by the softness and ductility of its substance, elongates into a cylinder with hemispherical ends. Again is the mass heated and rotated, and again is it swung like a pendulum at the end of the tube; until, at length, the workman fairly swings it round in a vertical circle, at the imminent risk (as it seems to a looker-on) of shattering the cylinder into fragments. That the globe will elongate when softened and hung downwards, is what may be reasonably expected, and that it will remain hollow during this elongation is also easy to conceive; but that it should become almost a perfectly true cylinder from end to end, that the thickness should be the same in every part, that the diameter should be equable throughout a length of three or four feet, that the cylinder should solidify in this

[Sheet-glass making.]

form, and that it should remain all this time attached simply to the end of a tube, are results which few persons could anticipate, and which are even more remarkable as exemplifications of the skill of the workman than the 'flashing' of the circles of crown-glass.

The manner in which the two ends of the cylinder are made open and circular is curious. The workman stops the end of the tube, by which a certain quantity of air is enclosed in the cylinder; and by holding the remote end of the cylinder to the fire, the air within becomes so heated and expanded as to burst for itself a means of exit, by forming a small hole at the end of the cylinder. This hole, by heat and rotation, is expanded to the diameter of the cylinder; and thus one of the closed ends is rendered open. The other end is severed from the tube by first heating and then suddenly cooling a line round the circumference of the cylinder.

The quickness with which all this is done is not the least remarkable feature in the process. A few men soon accumulate around them a large assemblage of these finely formed cylinders (which may at an average be taken at forty inches long by nine or ten in diameter); and these are rested upright on the floor for a temporary period. But then, how to transform these into rectangular plates or sheets? In the first place, each cylinder is laid on its side, and a hot iron wire is drawn along the interior from end to end: the glass gives way at this line, and an opening is effected. Another workman next gradually warms the cylinder, and places it on a flat stone in a heated oven, with the crack or fissure uppermost; and in a short time the glass becomes so softened by the heat as to fall down by its own weight, spreading out into a sheet about thirty inches wide. While in this position the workman introduces into the oven an instrument formed of a piece of charred wood at the end of a handle, and with this he rubs the sheet of glass until it is made as flat as possible at the surface. After this, the sheet is placed up edgewise in an annealing-oven, and there kept to cool gradually.

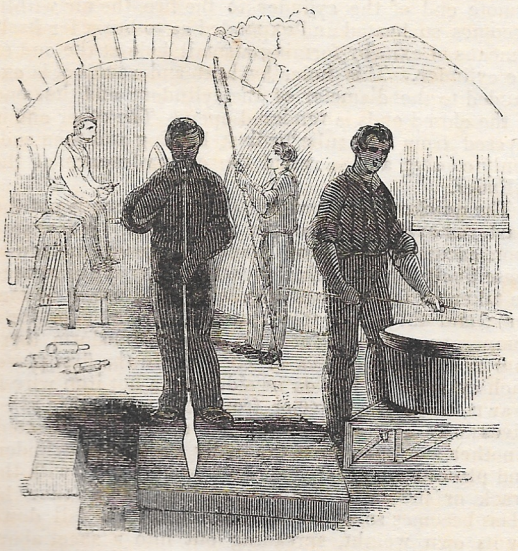
It is worthy of remark that the workmen employed in this department of the works are foreigners. This kind of glass was made in Germany and France before being known in England; and as the quantity of it made is comparatively small, it does not seem yet to have been undertaken by English workmen, but to be still wrought by foreigners who have acquired the requisite tact and judgment by long practice. At all events, the earnings of the men are high, and there is a remarkable cleanness and neatness in their personal appearance: they have blue and white striped dresses, and contrive to maintain a tidiness both of person and of dress which is not a little commendable. In a kind of office or warehouse attached to the Works are a number of little glass instruments, ornaments, and trinkets made by these men, as specimens of delicate manipulation.

There is a kind of glass sometimes made, inferior both to crown and to sheet glass, called *broad-glass*; and this is manufactured in a manner somewhat analogous to that just described. But as no new features are involved in it, we may pass on to say a few words respecting the last sort which we enumerated, and which is designated, from its characteristic use, as

Bottle-Glass.

A greater weight of bottle-glass is made every year in England than of all the other kinds put together. Wine and beer bottles, pickle-bottles, oil-bottles, bottles for chemical liquids, &c. are required in such abundant quantity, that four or five hundred millions of pounds weight are made (and we may suppose broken) annually in England.

The materials for glass bottles are coarser and cheaper than for any other kinds of glass. Neither beauty of colour nor freedom from specks is of much moment for these articles, and consequently the alkali and other ingredients employed are the least costly. The mode of working differs from all the former instances so far as this—that the bottle receives it shape mainly from a mould. The bottle-house is perhaps more bustling than any of the other departments of the Works, since a considerable number of men may work in a small space. There is a kind of central furnace, containing the pots in which the 'metal' is melted; and around this is the vacant place where the men work, together with the moulds and other apparatus for aiding in the production of the bottles.



[Glass-bottle making.]

A workman (the *gatherer*) gathers on the end of a tube as much glass as will make (say) a wine-bottle. This he hands to another workman, the *blower*, who, whilst blowing through the tube, rolls the glass upon a stone, and elongates a portion which is to form the neck of the bottle. He then inserts the bulk of the glass into a brass or cast-iron mould, which gives the exterior form to the bottle; while, by continuing the blowing, he forms the internal cavity. The blower then hands it to the *finisher*, who further fashions the neck by putting on a little ring of glass, then trims the mouth of the bottle and gives shape to the bottom; and, lastly, detaches the bottle from the tube. A boy then lifts up the bottle on a kind of pronged fork, and carries it to the annealing-oven, where it is allowed to cool gradually.

This circle of operations is continued with much quickness, four or five men being able to make a hundred in an hour; and, with a few modifications, according to the size, shape, and purpose of the bottles, may be taken as a general exemplification of the mode of proceeding. The vicinity of the Tyne and the Wear is abundantly supplied with many of the requisites for bottle-making; and hence the manufacture is there largely carried on.

Before concluding this slight notice of the Works which the kindness of the proprietors has enabled us to describe, we must say a word on a sad drawback to which the manufacture is subjected. Glass, as well as soap, is still among the substances over which the Excise officer holds control during the manufacture. As a question of pounds, shillings, and pence, between the leviers of the duty on the one hand, and the payers on the other, or as affecting the relation between home and foreign productions, these pages are scarcely a proper field for its consideration; but the point to which we allude is the injurious tendency which the system exerts on the manufacture itself. So close and binding are the restrictions, that a manufacturer can hardly make any experiments on a large scale, nor can he introduce any improvements except in a few minor details. Glass bottles *must* be made of a coarse kind of sand, whether the maker wishes it or no, on account of certain regulations as to the duty; plate-glass, being charged with duty by weight at a certain stage of the manufacture, is placed without the pale of certain improvements which the manufacturer might attempt, if he were not liable to duty for glass wasted in the experiment; every furnace, pot, oven, and warehouse must be registered; every 'charge,' or filling, must be under the control of the officers; every drawing out from the annealing-oven must be at prescribed hours; all crown or sheet glass must be limited to a certain thickness: in fact, as has been well observed, "from the making of the pots themselves, to the packing up of the glass for sale, everything is done after a certain manner, which is determined by Act of Parliament." It is not easy to see how skill can be developed in the extension of a manufacture so shackled; and indeed there is a homely proverb which might perhaps be brought to bear on this matter, that "Over carefulness sometimes kills."