A handbook of chemical manipulation

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London, 1857

Section XXIV. Glass-Working

urn:nbn:at:at-ubi:2-3808

SECTION XXIV.

GLASS-WORKING.

633. There are few acquirements of more use to the chemist than a moderate proficiency in the construction of glass apparatus: the mere fact of being to a certain extent independent of the instrument-maker is at once a great object gained. It frequently, nay constantly happens that an experiment is dependent for success upon the use of an instrument of a shape different to that kept in the laboratory; the operator who can readily supply any deficiency of this kind is far more likely to make progress in his researches than one who has to wait until it can be obtained from the glass-blower.

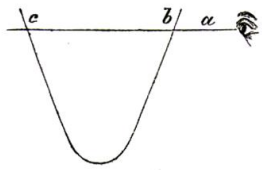
634. Small retorts, tube-funnels, siphons, test-tubes, pipettes, &c. are always in requisition; no pains should therefore be spared to acquire facility in the use of the table or other blowpipes for purposes of this kind. But it must not be forgotten that some persons are liable to fall into the other extreme, and spend valuable time in the construction of apparatus which might be better obtained from the instrument-maker; for instance, it would be a waste of time for any one, unless singularly skilful at such practices, to attempt the construction of Liebig's potash-tubes, fig. 67, § 107, while, on the other hand, it would be very useful and highly advantageous to be able to repair one if broken. The advantage of possessing a certain amount of practical skill in mechanical operations should not therefore be overlooked, for it may be said to constitute an important element in the qualifications of a chemist. Even in so simple an affair as the construction of a combustion-tube, p. 357, much is gained by doing it in a neat and proper manner, without regarding the annoyance which most persons cannot help feeling at the sight, much less the use of one that is ill-made and clumsy.

635. The most common operation with glass in the laboratory is the bending of tubes, and it is also the simplest. They should

be selected for this purpose of tolerable thickness, and not too large in diameter; very thin ones are troublesome to bend, and are seldom useful when done. Supposing a tube to be required for the washing-bottle (§ 200), or for delivering gas in small experiments, a piece should be selected about the size and thickness depicted in the margin. It will not be necessary to use the blowpipe, the flame of a gas- or spirit-lamp being sufficient. About an inch should be heated, until it is perceived by a slight motion of the hands that it begins to yield; it is constantly turned round on its axis, in order that all parts may be equally heated, and when found to be sufficiently soft, removed from the flame, and being held by the ends, they are inclined gently towards each other, care being taken that the movement is in the same plane, *i. e.* so that if it were continued long enough, the two portions would at last meet throughout their whole length, without having any tendency to one side. This is accomplished by holding the tube in such a manner that a line from the eye would pass through both portions of the tube, fig. 322, where the eye being at *a*, any tendency to one side of either limb would be readily seen and corrected.

Fig. 321.

Fig. 322.



In all operations of glass-working, the state of the glass with regard to its temperature is judged of as much or more by the feel than by the sight, for glass requires a much higher temperature to show a red heat than metal. It is necessary also to learn to distinguish between the appearance caused by the ignition of reduced lead in the glass, or ignited charcoal deposited from the flame, and that shown by red-hot glass. It is a great object in all operations at the glass-working table to acquire that lightness of hand, combined with steadiness, which enables a tube to be held without distortion although very soft.

636. Very thin tubes are liable to become malformed on bending, especially if large, the outer or convex portion flattening,

and the inner angle having wrinkles; this may be avoided either by closing one end and gently blowing into the tube while bending, or by filling it with sand and making the curve at the lowest possible temperature over a charcoal fire.

This method of bending tubes by means of sand will be found of the greatest utility in the construction of U- and V-tubes for drying gases, condensing volatile fluids, &c. By means of a small quantity of ignited charcoal, supported on a piece of wire-netting elevated on bricks, so as to allow of free combustion, I have always found that tubes from $\frac{1}{2}$ to $\frac{5}{8}$ths of an inch in diameter, and of the hardest glass, may be bent with perfect ease. It is of course imperative that the sand should be dry. It is necessary also to avoid too high a temperature, or the sand would have a tendency to adhere to the glass.

637. The Herapath's jet, fig. 48 (§ 60), is so convenient and manageable, either with or without a blowpipe-bellows attached, that where there is a supply of gas it will render almost any other description of instrument of this class unnecessary. By carefully regulating the supply, any description of flame may be obtained, either oxidating or reducing. It is to be remembered that the gas should never be turned on too fully, as in that case the combustion is less complete, and the oxidating and reducing portions of the flame scarcely to be distinguished from each other, and very often the former not obtained at all. In fact, the temperature may be raised to a greater degree by regulating the amount of gas than by increasing the blast. In working with soft glass containing lead, it is to be carefully kept away from the reducing-flame, films of lead becoming visible which may be difficult to remove by exposure to the oxidating flame. The latter may always be known by its peculiar nebulous appearance, and from being beyond the luminous and reducing portion. Before introducing thick glass into the flame, it is to be carefully heated to prevent cracking from sudden and unequal expansion, and on removing it, every precaution is to be taken to prevent too rapid cooling. It is to be held at the very extremity of the visible flame, being continually rotated and gradually removed

further and further from the jet; after this it should be held in the current of hot air ascending from the lamp, and finally it is to be put in a warm place, such as the sand-heat, to cool gradually. A hot piece of glass, even if so thin as to render very slow cooling unnecessary, is never to be placed upon the bench or working-table, as a film of carbon, difficult entirely to remove, adheres to it. Sometimes it is better to bend tubes in successive small portions, so as to avoid too sudden a curve.

Cutting Glass.

638. (1) *By files.*—Glass tubes are cut into lengths by filing a notch on them with a sharp three-square file, and breaking the tube at the point marked, in the manner that a twig is snapped, the hands being held in precisely the same position.

639. If the tube is thin, great care must be taken to avoid too much pressure with the file, as the glass would then be crushed. If the tube is large in diameter, the file-mark must be carried half round. The notch should be deeper on the side furthest from the operator when being broken.

640. (2) *By the diamond.*—Cutting-diamonds usually have one part that acts more readily than the others; this position should be ascertained by trial on a piece of flat glass, and marked on the handle in such a manner that it may be easily found when required. When a piece of glass is to be cut, it should be laid upon a perfectly flat surface, because, if a hollow exists underneath the plate, it is liable to cause fracture when pressure is applied to the upper surface.

641. (3) *By spring-coals or pastilles.*—One of the most convenient methods imaginable of separating glass into various forms, is by the use of spring-coals. The following formulæ are given for their preparation, the first by Gahn, the second by Mohr. 1. Two and a half ounces of gum-arabic, and half an ounce of gum-tragacanth, are dissolved in five and a half ounces of water. Then one quarter of an ounce of storax, and the same quantity of gum-benzoin, are dissolved in one and a half ounce of spirit of wine; the two mixtures are to be worked,

with three and a half ounces of powdered charcoal, into a stiff paste. 2. Half an ounce of gum-tragacanth in powder is to be dissolved in water to an elastic mucilage, allowing it to macerate for about one hour. Then add one quarter of an ounce of benzoin, dissolved in sufficient spirit. Rub the two fluids in a mortar, with as much powdered charcoal as will form a tenacious paste. The pastes formed by either of these processes are to be formed into sticks about the size of ordinary quills, and slowly dried in the water-bath.

The benzoin is merely for the purpose of adding a pleasing odour during the burning, and if finely powdered charcoal is worked up with a thick mucilage of gum-tragacanth and a little gum-arabic, it answers equally well. I form the sticks by taking a mass of the mixture and rolling it on a stone slab with a piece of smooth hard wood until the mass is about the length and thickness of a black lead pencil. The sticks thus formed are to be laid out upon a tray dusted with charcoal-powder to prevent them adhering; the tray and contents are then placed on a moderately warm part of the sand-bath for half a day, to dry. I have also found that the addition of a very small quantity of linseed-meal (that which has been prepared from expressed cake) has a remarkable tendency to strengthen the spring-coals, and prevent the red-hot ends from dropping about.

642. To use them, one is to be ignited, and suffered to burn to a point, the combustion being aided during the whole time by gentle blowing. A crack being made in the edge of the tube or other vessel to be cut, the ignited point is to be placed about a tenth of an inch from it, and in the direction in which the crack is wished to extend; the latter will almost immediately run to the ignited point, which is then to be removed about the tenth of an inch further; in this manner the crack may be led in the desired direction, so as to enable a flask or other vessel to be cut to any shape. If a spring-coal is not at hand, a substitute may be found in a small stick of well-dried deal, which is to be burnt until a charcoal point is obtained, but it soon goes out, and has to be repeatedly ignited. A red-hot iron may also be used to

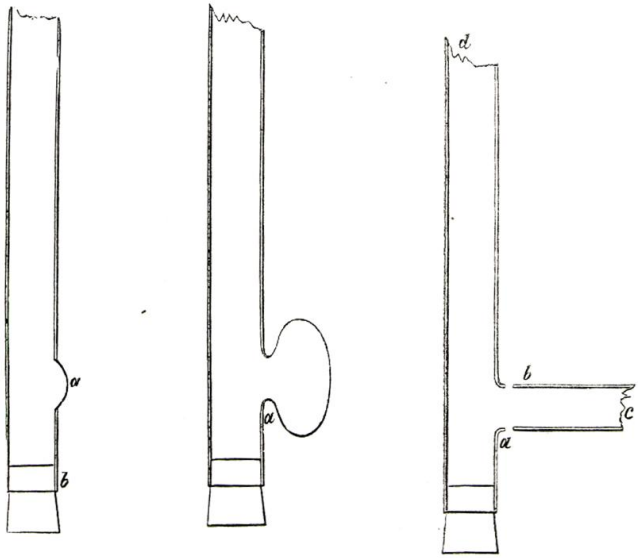
lead a crack. It is strange, that, from some molecular peculiarity, probably caused by the heat, it is impossible, as a general rule, to make the crack extend entirely round a tube, a small portion, about an eighth of an inch, remaining intact; this is, however, too small to be of importance, and after the parts are separated, forms a point which may be easily removed by the file. A flask, retort-neck, &c. is sometimes divided by tying a thread saturated with turpentine round, and setting fire to it, at the same time rotating the vessel to enable the flame to extend equally. As soon as the spirit is consumed, the vessel is suddenly dipped into cold water, when it generally separates into two portions; the fissure corresponding to the line marked by the thread. This method is, however, less to be relied on than the process by the spring-coal. The latter remark also applies to the use of red-hot iron rings, which were much used by the older chemists for dividing glass vessels; they were applied red-hot to the flask, which was then dipped into water, when it usually parted at the line marked by the heated ring.

Piercing Holes in Glass.

643. *By heat.*—A hole may be very conveniently made in tubes and other thin glass apparatus, by directing a pointed flame from the blowpipe upon the spot where the aperture is to be, until it is red-hot; the mouth is then applied to one end of the tube, the other being closed by the finger or a cork; the glass is by this means blown into a thin bubble and bursts; if not, it is reheated, and on blowing a second time, the object is attained. This is, perhaps, the best method of obtaining an aperture in the side of a tube where it is intended to insert another. Figs. 323, 324 and 325 illustrate the method of proceeding; the flame being directed for a few seconds strongly at *a*, fig. 323, the tube which is closed at *b* by a cork, is blown into strongly; the glass is by this means forced into a thin bubble, fig. 324, *a*, and on repeating the process, bursts. On removing the thin glass, it presents the appearance of *a*, fig. 325. The flame is directed upon the aperture for a few seconds, and while the edges are red-hot, the tube, *b*, fig.

325, is approached, and having its edges also made red-hot, is applied to the aperture and pressed rather strongly to make it adhere, and is immediately slightly pulled away to render the glass at the juncture thinner; the end, *c*, of the tube, *b*, fig. 325, is then to be closed, and the flame directed all round the juncture of the two; the mouth being then applied to *d*, air is thrown in, which, by expanding the edges of the join, will make it still

Fig. 323. Fig. 324. Fig. 325.



thinner and less liable to crack on cooling. When, by a few repetitions of this, it is seen that the joint is tight and not wrinkled, it is to be very slowly cooled. If it is wished to construct a siphon, the tube, *b*, which is much longer than could be conveniently represented in the figure, and for this purpose of smaller calibre, is to be turned up as at *b*, fig. 326, and bent again at *c*. A long tube, a little smaller in calibre than the one to which *b* is soldered, is then bent into a siphon, and inserted in

the other, the lower end of its longer leg penetrating to *a*; a caoutchouc-tube is previously slipped over the end of the longer tube at *d*, and serves to enable the two to be united by tying with silk.

644. It will be seen that by this means a convenient and easily-constructed siphon is formed, one of its chief advantages

Fig. 326.

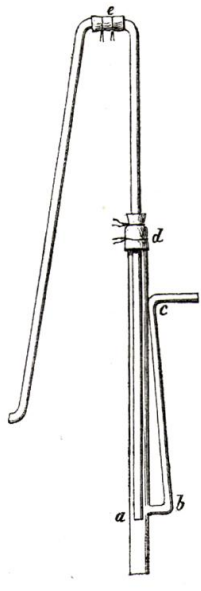
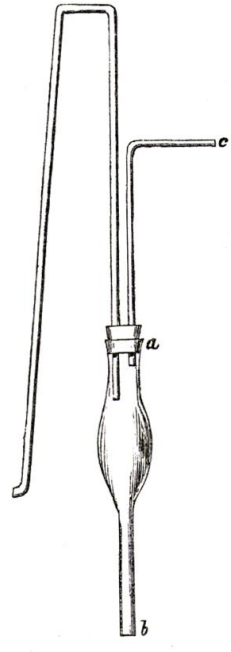


Fig. 327.



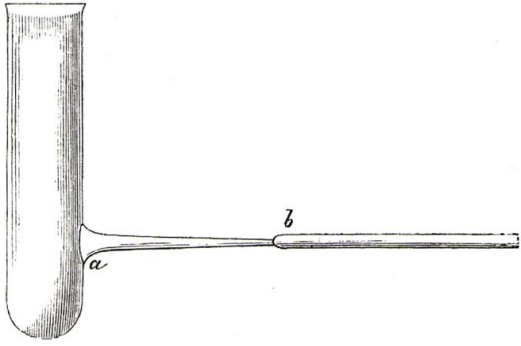
being, that as the caoutchouc junction allows a certain amount of motion, the chances of fracture are much diminished; and, moreover, if the instrument be broken at the bend which unites the longer and shorter leg, another tube has merely to be bent and inserted into the tube, *d a*. In many cases the two limbs

of the siphon may be connected by a caoutchouc-tube (as at *e*), and by this means all danger of fracture is removed.

The same object may be attained, perhaps still more easily, by taking the end of a broken chloride-of-calcium-tube and inserting a cork at *a*, fig. 327. Holes are made in this cork, through which two tubes are passed, one forming the siphon, and the other intended to enable the air to be drawn through in the usual manner. It is to be observed that in all siphons the aperture corresponding to *b*, fig. 327, is to be closed before applying the lips to *c*.

645. A very convenient, and in many instances extremely useful method of piercing an aperture into tubes, bulbs, &c., and at the same time of forming a tube, is in the manner seen in fig. 328. A strong and pointed flame is directed at *a* until the glass

Fig. 328.



is perfectly melted and very soft; a piece of rather infusible glass rod, *b*, is introduced into the flame until the end is red hot; it is then pressed rather forcibly upon the melted spot at *a*, and immediately withdrawn; by this means a small tube of about an inch or an inch and a half long will be formed. Retorts to which this has been applied for the purpose of introducing a fluid without soiling their necks, are seen in §§ 382 and 653.

646. Holes may be drilled with ease through thick plates of glass, stoppers, &c., by means of a common brad-awl dipped in

turpentine, the instrument being used precisely in the same manner that it would if the hole was being bored in wood. I have made a neat aperture through a glass stopper half an inch thick in less than ten minutes, by this means. This is a convenient method of making the hole in a glass plate, by which to suspend the watch-glass or capsule over the surface of sulphuric acid contained in a beaker, as in fig. 60, p. 66. When a glass stopper has become fixed in the neck of a bottle and broken off, this is a good method of extraction, for the glass may thus be crumbled away, and finally removed altogether.

647. *Closing of tubes.*—This is an operation of constant occurrence in all laboratories, either for the purpose of making test-tubes, or little bottles to contain specimens.

Fig. 329.

Fig. 330.

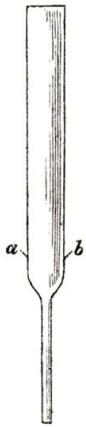


Fig. 331.

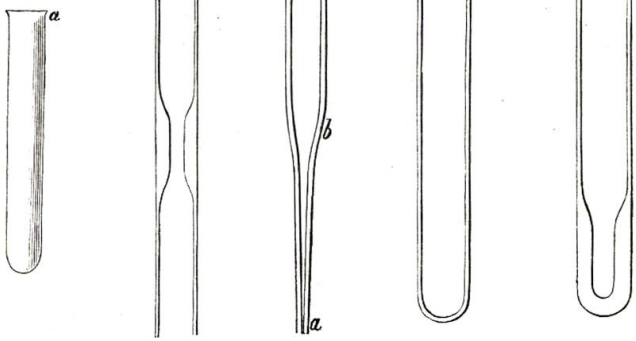
Fig. 332.

Fig. 333.

The tube is to be strongly heated at one end, from *a* to *b*, fig. 329. Another piece being then attached, the heat is to be directed at *a b*, fig. 330, the tube being continually rotated, in order to equalize the heat; it is then drawn out, as at fig. 331, and the flame being strongly directed at *a*, fig. 332, the superfluous glass is to be drawn off. The tube, after a little turning in the flame, then appears like fig. 333. The mouth is then

applied to *a*, fig. 334, and air cautiously thrown in until the end becomes rounded and free from the point seen in fig. 333. It should now resemble fig. 334. The mouth should then be heated until the sharp edge is fused, or if it is desired to expand it as at *a*, fig. 334, the end should be ignited for the tenth of an inch, and a piece of charcoal, previously filed or rasped to a proper shape, inserted and turned round in such a manner as to enlarge

Fig. 334. Fig. 335. Fig. 336. Fig. 337. Fig. 338.



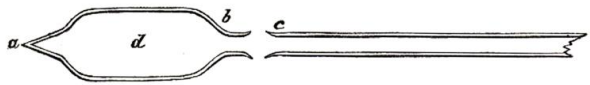
the aperture; this will cause the cork to fit more completely, and at the same time strengthen the tube.

648. It is very frequently required to draw out tubes to a capillary termination, either for pipettes or otherwise. It is generally better to thicken them before drawing out, by rotating them for some time in the flame, and rather pressing up than otherwise, but not sufficiently to cause a fold or wrinkle; by this means they will take the form seen in fig. 335; and if it is then drawn out, as in fig. 336, and cut off at *a*, a strong but extremely fine aperture may be obtained. The calibre will of course be regulated by the degree to which the tube is pulled.

If it is wished to form a small pipette, it may be done by closing *a*, heating strongly at *b*, and thickening and pressing up the glass so as to obtain sufficient to form a stout bulb. On

blowing strongly but steadily, still rotating the tube, a globe will be formed sufficiently large for most purposes. The formation of pipettes leads to a consideration of the methods of blowing bulbs. The simplest method of doing this to a beginner, will be, to take a piece of tube about the size and stoutness of fig. 337, and close it at one end; it is then to be thickened by rotation in the flame, and pressing the glass carefully up with a piece of metal until sufficient has been accumulated at the end; by this means a section of the tube will resemble fig. 338. The thick portion is then to be strongly heated, and air thrown in by blowing steadily as soon as the tube is removed from the flame. A bright cherry-red is the best heat for this purpose. The tube is to be turned not only while in the flame, but also while the bulb is being blown. If too much pressure is exerted, a kidney-shaped bulb of extreme thinness, and perfectly useless, will be obtained. The eye should be steadily kept upon the expanding glass the whole time the air is being thrown in, so that the pressure may be arrested at the proper moment. If the bulb obtained is not sufficiently large, it may be reheated and blown into again. When it is required so large that sufficient glass cannot be accumulated at the end to form it, a large piece of tube may be joined to a smaller. For this purpose the larger piece is drawn out at both ends until of the diameter of the smaller one, fig. 339. The end, *a*, is then thickened and drawn out small, but

Fig. 339.



not closed; *b* is then introduced into the flame of the blowpipe, and closed; it is then to be heated, and on blowing strongly at *a*, the end, *b*, forms into a small but excessively thin globe, which is broken off, so as only to present an enlarged edge, as seen in the figure: the same is done at *c*. The aperture, *a*, is then to be closed by fusion. If, now, the edges of *b* and *c* are held in the flame, and both are equally heated, they may be

perfectly united by pressing together; they are then to be slightly drawn in an opposite direction, to reduce the thickness of the join, and then reheated and blown into until the thickened portion disappears and becomes equally distributed; a little more careful drawing out will then make the tube of the same size at the join as elsewhere. The portion, *d*, is then to be heated in the flame, and expanded into a bulb, by careful blowing. If another piece is connected at the end, *a*, in the same manner, a large pipette is at once formed.

649. An excellent pipette for delivering small quantities of fluids in delicate experiments may be made as follows:—A small but thick tube is to be thickened at one end, and then drawn out; by this means a tube of very small bore, but of considerable strength, is obtained. The extremity of the drawn-out portion is to be closed, and the glass at that part where the capillary portion joins to the rest of the tube is to be thickened considerably, by turning it in a good flame, and pressing up the glass, using the capillary tube as a handle. The heat is then to be raised, and a bulb blown, so that the instrument has the form of fig. 340. I am in the habit of using pipettes made in this manner from ordinary quill-tubing, in adjusting the quantities of fluids to be weighed for analysis.

650. The funnels so much used in distillations on the small scale, and in the preparation of hydrogen, hydrosulphuric and carbonic acid gases, are readily made in the following manner:—A piece of wide and tolerably stout tube is drawn out and cut off, of the width of the smaller one to be attached to it, as in fig. 341. The end, *a*, is then to be corked, and the two may be joined, as previously directed. Or if what is termed a thistle-funnel is preferred, a globe of tolerable stoutness is to be formed at the end of a tube, by soldering a wide to a narrow one, and expanding the wide portion into a bulb. The end opposite to the narrow tube is then to be strongly heated and blown into until a large thin bubble is formed, fig. 342; this is to be broken off, the aperture made smooth by fusion, and opened with an iron wire or piece of charcoal.

By bending the tube-funnel, fig. 341, at *b* so as to form a right angle, and bordering the wide portion, excellent suction-

Fig. 340.

Fig. 341.

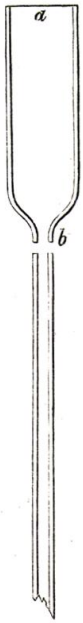


Fig. 342.

Fig. 343.

tubes for combustions are made*. Bent tubes of this latter kind are also very convenient for connecting many pieces of apparatus. By much thickening a piece of rather wide tube, and then

* See also § 564.

drawing it out until of the relative proportions of fig. 343, I make the small caustic potash-tubes for attaching to the potash-bulbs for organic analysis, as in fig. 298, p. 376. The aperture, *a*, fits the cork of the suction-tube used to draw the carbonic acid through the potash solution after the analysis. The mode of attaching and using these instruments is seen at §§ 562, 564, and 607.

Fig. 344.

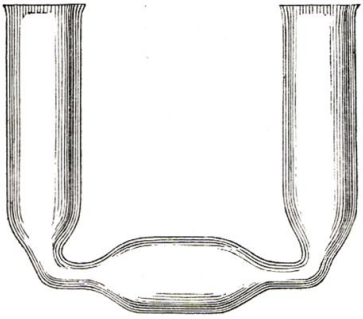


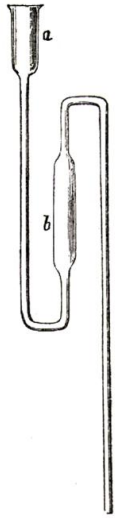
Fig. 345.

651. Where it is wished to construct U-tubes, but, from the largeness of the diameter and thinness of the glass, difficulty is found in bending without distortion, and the process with sand is not convenient, I frequently make them of the form seen in fig. 344. This is very easily done by thickening in two places, and then drawing out, fig. 345. This thickening enables us to bend the tube neatly at *a a*, fig. 345, with great ease, and when done in this manner, the bend is exceedingly strong.

652. Safety-tubes of the form of fig. 346 are easily constructed out of pieces of glass tube. Two sizes are selected, the larger of sufficient diameter to form the funnel, *a*, and the elongated bulb, *b*. At about 2 inches from the end of the tube, the flame of the blow-pipe is made to play strongly until the glass is very soft; it

is kept constantly turned until it has very much thickened. and become about a third less than its original diameter; it is then removed from the flame, and drawn out until of the same size as the small tube, as at *a*, fig. 347. It is again drawn out about 2 inches further down, as at *c*, and cut off at *a*, *b*, and *c*. The first portion is joined, by the method given at p. 411, to about 6 inches of the smaller tube; the other end of the latter is then soldered to the end, *b*, of the bulb, fig. 347, and about 10 inches more of the small tube is affixed to the end, *c*; the whole is then bent into the form of fig. 346. This is the method I always adopt for the construction of these useful pieces of apparatus; and I find that, if proper care is taken to reduce the thickness of the welds by the method described at p. 411, they are no more liable to fracture at those places than at the portions of the tube where there is no join.

Fig. 346.

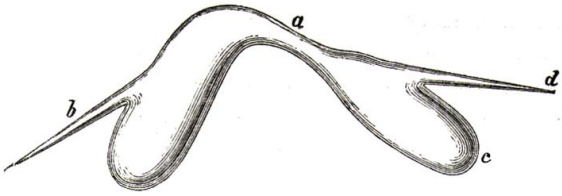


653. I have sometimes had occasion to construct a retort and

Fig. 347.

receiver out of one piece of tube, as in the figure. It has many

Fig. 348.



advantages where the presence of cork or caoutchouc is inad-

missible, and is extremely easy to make. A piece of glass tube, $\frac{1}{2}$ or $\frac{5}{8}$ths of an inch in diameter, is closed at one end like a test-tube, and at about 2 inches further up it is strongly heated and thickened; it is then to be drawn out so as to form the neck of the retort, *a*. The tubulature, *b*, is then formed by the method given at pp. 242 and 407, and the end is broken, so as to allow air to enter while the other end, *c*, is closed; the tubulature, *d*, is then made, and the neck bent as at *a*. To introduce the fluid to be distilled, the end, *b*, is dipped into it, contained in a small capsule, and suction is applied at *d* by means of a glass tube and cork; when sufficient has entered, the extreme point of the tubulature, *b*, is held in the flame, suction being continued; by this means the point may be closed without much of the glass being melted, this being essential where the retort is to be used many times. The aperture at *d* is left open in some cases during the distillation, but where the presence of air is objectionable, the fluid is made to boil until all the latter is expelled, and the end of *d* is then sealed by momentary exposure to the flame. By this means the distillation may be conducted *in vacuo*, and consequently considerably below the ordinary point of ebullition of the fluid. The receiver portion of the apparatus is, of course, kept cold during the operation.