LABORATORY GLASS WARE ECONOMY

A PRACTICAL MANUAL ON THE RENOVATION OF BROKEN GLASS APPARATUS

BY

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LABORATORY GLASSWARE ECONOMY

TO MY

FATHER AND MOTHER

PREFACE

SINCE the commencement of the war, very little glassware has been received at the Khalsa College and no new consignment has arrived for more than fifteen months.

I was faced with an increase in the number of students and the demand for glassware was keenly felt. For these reasons I set to work to carry out what had been my intention for some years—to seek for easy methods of renovating and adapting, to new uses, damaged apparatus made of glass.

We commenced with simple repairs, and, encouraged by success, my Senior Demonstrator, Pundit Kirpa Ram Sharma, B.A., and my second Laboratory Assistant, Lala Devi Prasad, started to search in the waste-box for any broken glass which could be adapted to useful purposes.

By their industry and application in this branch of laboratory work my two colleagues have enabled the Science Classes to continue their regular practical work under abnormal conditions.

What has been done by one can be done by others, and I have put these notes together in the hope that they may be helpful to those experiencing difficulties similar to my own.

I wish to emphasise the following facts, which I have verified by daily experiments ranging over a period of nearly two years.

1. Every operation mentioned in this book has been carried out successfully many times.

2. The percentage of failures (except in the cases noted in the text) has been very small.

3. All the processes described can be performed by a comparatively unskilled workman. Other processes, in which a good chance of success cannot be guaranteed to the average worker, have been omitted, *e.g.*, the manufacture of burette floats, lactometers, etc., and the repair of such apparatus as water hammers and glass models of pumps, etc.

No man can expect good results at the first attempt. Practice makes perfect. This book would not have been written had not Lala Devi Prasad shown that, by keenness and hard work, success can be assured.

My grateful acknowledgments are due to my pupils, Bhai Balwant Singh, B.A., and Bhai Umrao Singh, for the assistance they have given me in the preparation of the manuscript and diagrams.

I wish also to record my sincere thanks to my sister for indexing the book and for seeing the proofs through the press.

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June 20th, 1917.

CONTENTS

LABORATORY GLASSWARE ECONOMY

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CHAPTER I

APPARATUS

§ 1. **The Arrangement of the Laboratory.**—In this chapter will be found a brief description of the apparatus used by my assistants and myself, together with a sketch and plan of the corner of the laboratory in which the work described in the sequel was done. Very few laboratories include a room or part of a room specially designed for the convenience of a glass-blower, and workers will have to adapt themselves to the laboratory they use.

I chose a corner in which there was a small window 3 ft. by 2½ ft. and placed the blowpipe table to the left of it so that the light did not shine directly on the worker's face. This window had a north-west aspect, and, in the mornings especially the light was particularly good. The window could be partially covered or completely darkened if desired. To the right of the worker was another window 3 ft. by $2\frac{1}{2}$ ft., and the wall behind the table was painted dead black. The door behind the worker was kept shut. It was not glazed.

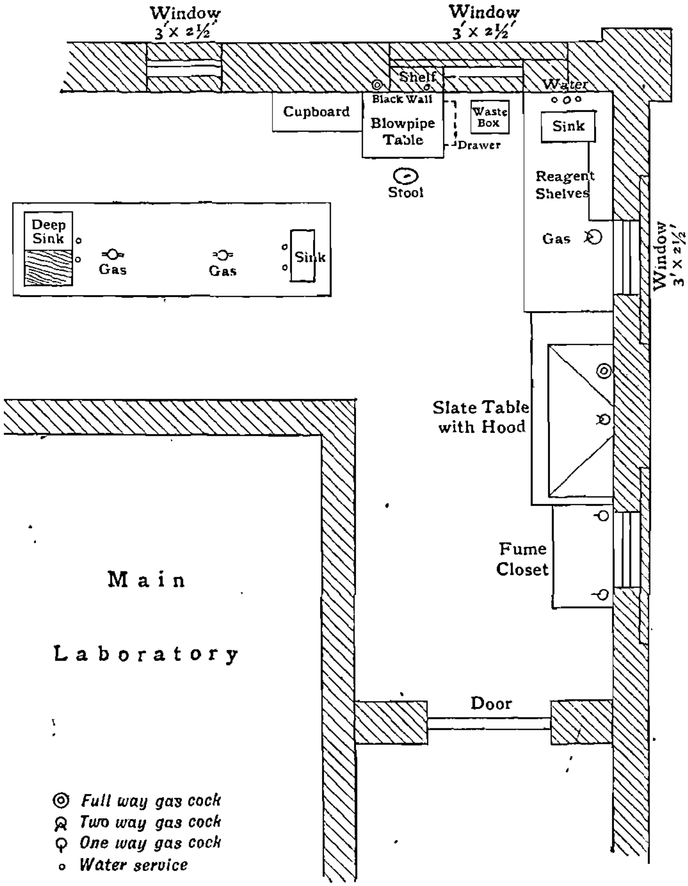


FIG. 1.—Plan of the corner used for doing glass work in the Chemical Laboratory of the Khalsa College, Amritsar.

There were no skylights in the room and night work could be done either by electric light or by gas light. By closing the windows and the doors, the room was kept quite free from draughts—the arch-enemy of successful glass-blowing. There was

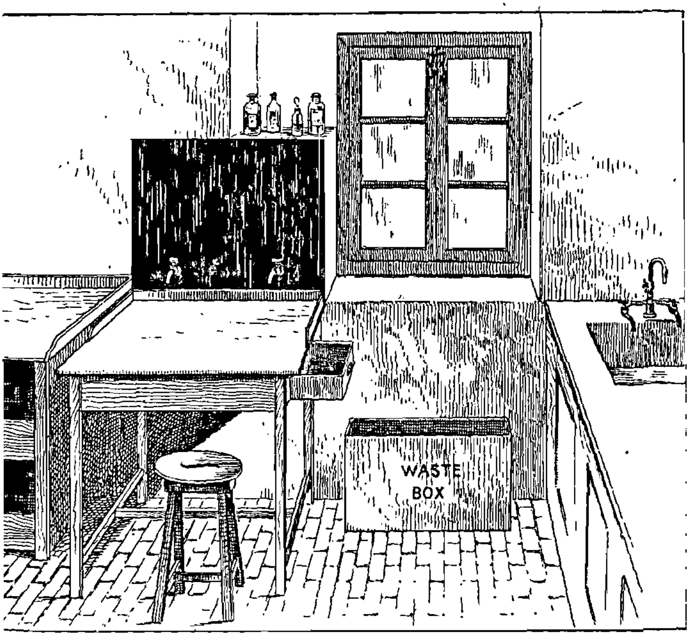


FIG. 2.—Sketch of the Blowpipe Table and general arrangement.

plenty of convenience for water and gas supply. One full way cock and an ordinary $\frac{3}{8}$-inch cock were provided for the blowpipe table, and, in the place shown in the plan, a slate table covered by an asbestos hood and supplied with gas was close at hand.

To the left of the table was a small cupboard upon which the broken apparatus, properly cleaned and sorted, was kept until disposed of.

The waste-box to the right of the table was used as a receptacle for rubbish for which no further use could be found.

§ 2. **Furniture and Apparatus.**—The blowpipe table is 2 ft. 6 in. high and the top is covered with asbestos

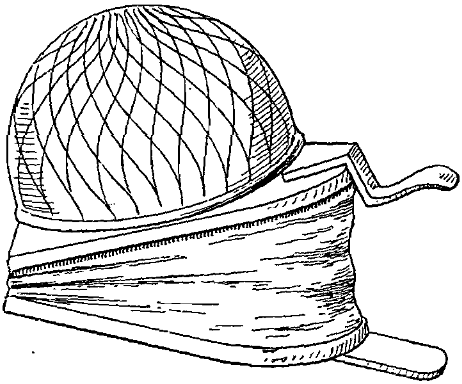


FIG. 3.

board and measures 2 ft. deep and 2½ ft. wide. There is a drawer on the right-hand side.

The bellows used are Fletcher, Russell & Co.'s No. 5 foot bellows with birch boards with leather sides, indiarubber reservoir with net, and iron treadle (see Fig. 3).

The bellows should be fixed in a convenient position, otherwise they are liable to get out of control at an important moment.

The stool used is 2 ft. high. The table is furnished

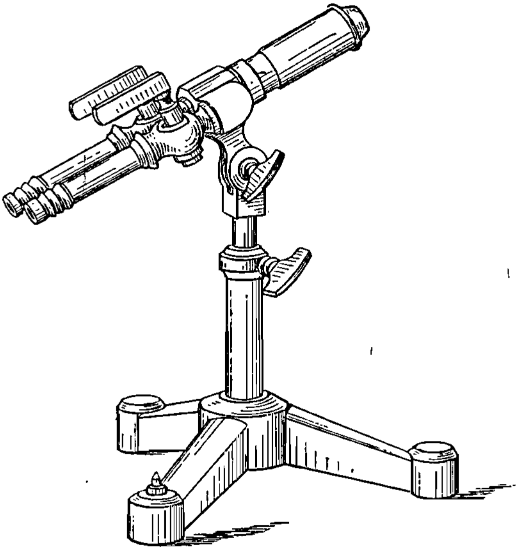


FIG. 4, A. Blowpipe.

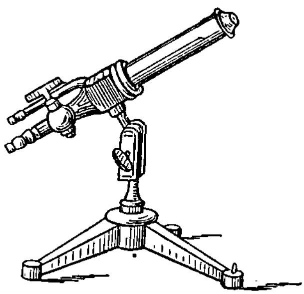


FIG. 4, B.

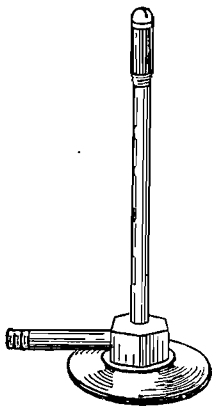
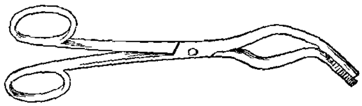


FIG. 5.
Batswing or fishtail burner.

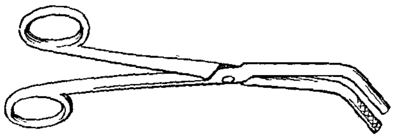
with a foot blowpipe, an ordinary Bunsen burner and a fishtail burner, together with their rubber or flexible metal tubing connections.

The types of blowpipe used are shown in Fig. 4. The fishtail burner should be fitted to a stand 9 in. or 1 ft. high (Fig. 5).

A support for heavy tubing may be fixed to the table, but a retort stand placed on the cupboard for supporting tubes projecting on the left, or in



A



B

FIG. 6.—Crucible Tongs. A—With bows. B—Without bows.

the drawer for supporting tubes projecting to the right, serves quite well for the purpose.

A pair of small crucible tongs, with or without bows. (Fig. 6).

Files, triangular, ratstail, and flat, of various sizes, also all the worn out files used in the laboratory. Keep the new and old files in separate boxes.

Iron rods and iron wire $\frac{1}{20}$ in., $\frac{1}{16}$ in., $\frac{1}{12}$ in. and $\frac{1}{8}$ in. diameter.

A tripod stand and a porcelain triangle. A small sheet of iron 4 in. by 4 in.

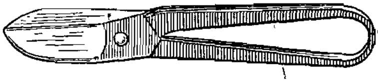


FIG. 7.—Hand metal shears.

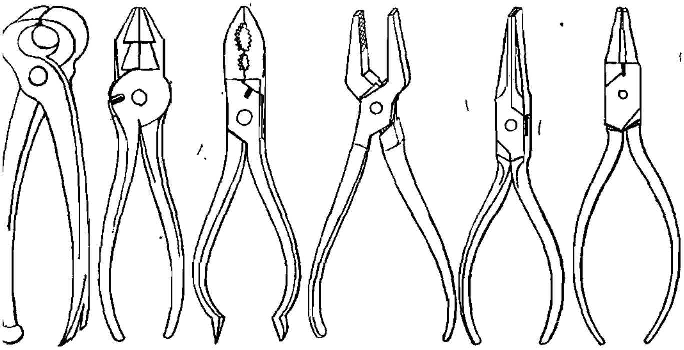


FIG. 8.

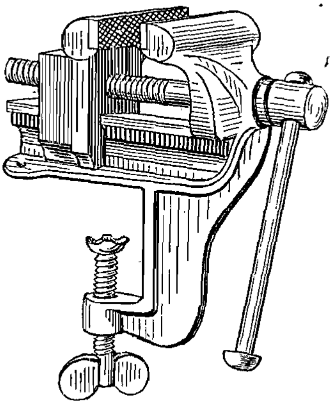


FIG. 9.—Vice.

Metal shears (Fig. 7).

Ordinary scissors.

Pliers of various types, amongst which must be one pair of wire-cutting pliers (Fig. 8).

A vice (Fig. 9).

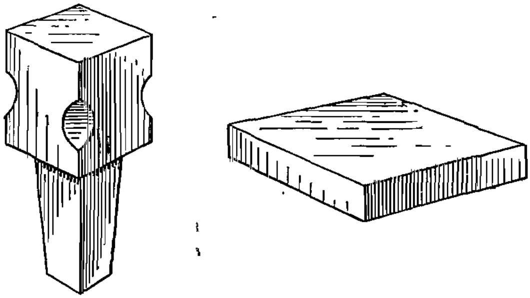


FIG. 10.—Anvils.

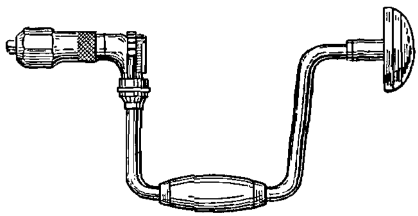


FIG. 11.—Brace.

A set of sieves for sifting sand, etc.

A hammer, and a small anvil (Fig. 10).

A brace (Fig. 11) may be useful but is not necessary.

A diamond pencil (Fig. 12).

A set of cork borers.

Rubber tubing of various diameters.

A pencil for writing on glass. (Fig. 12).

Strong string for cutting glass.

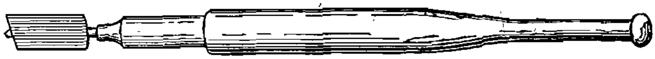


FIG. 12.—Diamond pencil.

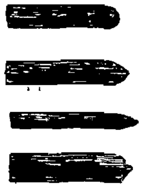


FIG. 13.

A small slab of charcoal ground level.

Carbon cones for bordering tubes. These may be made from ordinary wood charcoal by filing them carefully to shape (Fig. 13. See also Fig. 39).

§ 3. **Apparatus for Grinding Surfaces.**—A slab of slate with a truly ground level surface. A small slab of marble with a level surface.

Sand sifted into various grades of coarseness.

Powdered glass sifted into various grades of fineness.

Emery powder.

A stone grinding-wheel with its bottom portion dipping in water. When using, rotate the wheel away from the operator.

§ 4. **Lubricants and Sealing Agents used in this work.**—Raw linseed oil.

Turpentine oil.

An 8 to 10 per cent. solution of camphor in turpentine. This will be called " T.C. Solution."

Alcohol—methylated spirits will do.

50 per cent. solution of glycerine in water.

Canada balsam. The solvent for this is xylol, and the solution may be diluted to the desired concentration as required.

Vaseline.

Note.—In hot climates ordinary vaseline has too low a melting point to be used efficiently for many purposes. The following prescription has given a grease of a consistency and melting point suitable for somewhat higher temperatures than prevail in the West :—Melt 100 grams of ordinary vaseline and pour in, with constant stirring, 20 grams of melted paraffin wax. Stir the mixture as it cools.

"*Sealing mixture.*" This is useful for making joints air-tight. It does not dry quickly, nor is it likely to crack if the place upon which it is smeared is subjected to strain.

Take of ordinary soap (we use Calvert's carbolic soap) 20 parts by weight, water 40 parts by weight, and boiled linseed oil 40 parts by weight. Grate or scrape the soap into fine pieces and then mix with the water and warm with stirring until the consistency of the soap-water mixture is thick. Add the linseed oil with constant stirring and boil again (stir). On cooling, the whole will set to a solid, putty-like mass.

§ 5. **Material upon which the work is done.**—All broken apparatus should be carefully cleaned and sorted. In the case of test-tubes, flasks, etc., the apparatus should be sorted into lots of the same size. All apparatus suffering from the same kind of breakage should be put together.

The following damaged articles will be dealt with in this book:

(1) Test-tubes, boiling-tubes, and ordinary tubing of all sizes.

(2) Bottles, Woulfe's bottles, aspirators, however damaged, or bottles having stoppers corroded into the mouth.

(3) Flasks of all kinds, even if only the neck remains intact.

(4) Beakers.

(5) Gas jars or cylinders.

(6) Calcium chloride tubes or towers.

(7) Broken window-panes.

(8) Glass rods.

(9) Old bottles and stoppers from broken bottles.

(10) Broken retorts.

(11) Broken condensers.

(12) Broken burettes, pipettes, measuring cylinders, etc.

(13) All pieces of special apparatus, *e.g.* broken "Kipps," Schleicher's apparatus, potash bulbs, drying bottles, etc.

At any time, in order to improvise a piece of apparatus, a special shape such as may remain unbroken in a piece of damaged apparatus may be required and which you yourself are not sufficiently skilled or have not the proper appliances to execute.

CHAPTER II

HOW TO CUT GLASS OF ALL SHAPES

§ 6. I. **Sheet Glass** is cut by means of a diamond pencil. Place the ruler on the glass and draw a line on the glass by means of the diamond pencil. Do not press the diamond too heavily upon the glass, otherwise the glass will be *scratched*, not cut. The " feel " of the pencil when in use will soon let the worker know when the glass is cutting. This can only be acquired by experience.

Place the glass on the edge of the table with the cut edge uppermost and just over the edge of the table. Press the sheet on the table with the left hand and the overhanging portion with the right hand. The glass will be found to break with a clean, sharp edge along the line where the cut was made.

Practise this on pieces of broken window or picture glass.

II. If a diamond is not available, a triangular file may be used. Break an old file and harden the edges if necessary by making the broken edge white hot and then plunging it into mercury. Put a ruler where it is desired to cut the glass and draw one of the sharp points of the broken file along the edge of the ruler on the surface of the glass. Break the glass as described in § 6 I. above. This method requires considerable knack, and it has not been very successful in this laboratory.

III. *To cut glass with scissors.*—Trace the desired pattern, say a circle, on the glass by means of a glass writing pencil. Hold the glass in the left hand and *immerse* the hand to above the wrist in the water. Take the scissors in the right hand

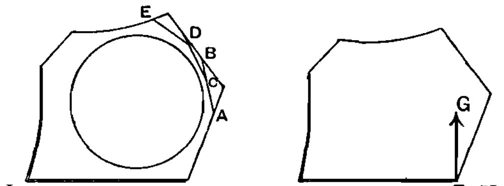


FIG. 14.—Cutting window glass with ordinary scissors.

and immerse both in the water until the water is over the wrist.

Now cut the glass away in small pieces by making small cuts as shown in Fig. 14, I. Cut first along the line *AB*, then along *CD*, then along *DE*, and so on, making that kind of cut until you have reached the outline of your circle. Do not try to cut into the glass as shown in Fig. 14, II. *FG.*, or it is probable that the glass will crack in all directions. The edges should finally be ground smooth in the grinding-wheel.

IV. A piece of glass may be broken to shape by first tracing the pattern upon it with a diamond and then snipping small pieces of glass away by means of a pair of pliers until the desired shape is attained. Smooth the edges down by means of the stone wheel.

V. Start a crack and lead it round into the desired pattern by means of a hot rod as described below in § 8, II.

§ 7. **To cut a narrow tube or rod.**—I. Small tubes are cut with a file. Hold the tube firmly on the table with the left hand and then draw the sharp edge of a triangular file once straight across the tube. Do not *saw* at the tube. Draw the file across the tube once only.

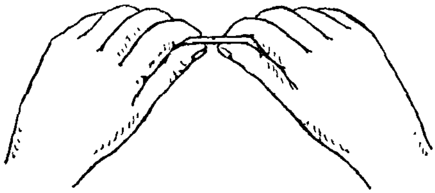


FIG. 15.—To break a tube or rod.

Now hold the tube as shown in Fig. 15 so that the fingers are above the tube and the thumbs are below it with the scratch in between them. Now press outwards with the two thumbs and, at *the same time*, give the tube a pull. The tube or rod should break into two parts with clean, square ends.

§ 8. **To cut wide tubes or bottles.**—There are many different methods. Of these, six will be described, and an attempt will be made to give the particular applications, merits, and demerits of each.

I. Make a scratch all round the tube by means of a file. Take a glass rod made of the same kind of glass as the tube and draw it out to a point. Heat the glass rod until the point is very hot. Put the hot point of glass on the scratch on the glass tube. The tube should split across uniformly. If it does not split at all, heat the glass point and try again. Do not put a blob or large mass of heated glass on the scratch. Use a heated *point* of glass. If the tube only splits round a portion of the circumference, continue the crack by again heating the glass point and putting it on the scratch at an uncracked point, *just beyond* the nearest cracked portion.

This method may be tried for cutting ordinary wide tubes, cutting the neck off a Winchester quart, etc.

II. *The Hot Rod method.*—Once a crack is started it may be continued in any direction, and in any glass of reasonable thickness, by placing a hot iron point just ahead of the crack and in the direction in which it is desired that the crack should extend. With practice, long lengths may be cut with a single heating of the rod. The hot rod is moved just ahead of the crack, and the crack creeps after the rod: *e.g.* in the beaker (Fig. 16), the crack, started at *D*, has been led off along *DB* and then round the circle *BCA* to make a dish of the lower part of the broken beaker.

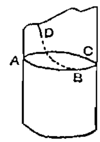


FIG. 16

In many broken articles the crack is already started, but if it is desired to start the crack it may often be done by heating one point of the vessel and then quickly touching it, when hot, with the wet finger, or make a scratch with a file and touch the scratch with a hot point. For thick vessels do not heat by means of the flame—heat by means of a red-hot rod. For this purpose old files have been found to be extremely useful. Bend the handle end upwards as shown in Fig. 17. This is the portion used as the "hot rod." A straight, thick wire or a wire with a slight curve is also used.

For this method a glowing carbon pencil is also used with success. To give an idea of the variety of materials which may be cut by this method, the

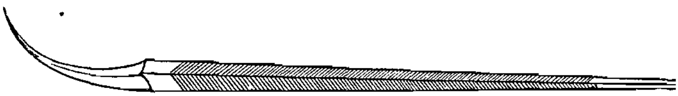


FIG. 17.

following list of successful operations may be quoted.

(1) Ten litre aspirator cut in half. Bottles cut at angles (see § 55).

(2) A circular plate cut from window glass (see § 11).

(3) Watch glasses cut from old flask walls (see § 35).

(4) Beakers and test-tubes cut in halves (see § 40).

(5) Arches cut in bottle bases in the making of beehive shelves (see § 15).

(6) Crystallising bowls from broken flasks and retorts (see § 39), etc.

III. *Hot Wire method.*—For tubes which taper somewhat a hot wire may be used. Wind a piece of wire round the tube and twist it so that it forms a ring at the place where it is desired to cut the tube. Slip the circle of wire off the tube and, holding it by means of the crucible tongs, heat it in the blowpipe flame to a bright red heat. Slip it, while hot, on to the tube and let it remain at the desired point for a quarter of a minute or so.

Slip off the wire ring and touch any part of the hot circle on the glass with a cold iron rod or with a drop of water. The tube will crack across.

Try this method for cutting the neck of a broken retort at any desired place.

Uniform tubes may also be cut by this method. It is quite successful with test-tubes.

IV. *The "String" method.*—Not suitable for thin glass. Take a wide tube or a bottle and wrap paper round it on both sides of the place at which it is desired to cut it. Leave a small space between the two rolls of paper.

Let one man support the tube in a horizontal position by holding the rolls of paper tightly, one in his left hand and one in his right. Take a piece of strong string and turn it round the tube as shown in Fig. 18. Stand opposite the man who is holding the tube, and by pulling the right and left hand strings alternately, always taking care to keep them taut, the glass between the paper rolls will get hot owing to the heat produced in the glass by the friction of the backward and forward motion of the string on the glass.

The tube may break across of its own accord, but if the string starts straining pour water on the glass between the paper rolls and the tube will break across with a beautiful, even fracture. This method is especially recommended and is particularly successful.

Practise this method on a gas cylinder, a wine bottle, a lamp chimney, etc.

V. Roll two rolls of wet blotting paper round the tube, leaving the place at which it is desired to cut the tube between the two rolls. Now play the

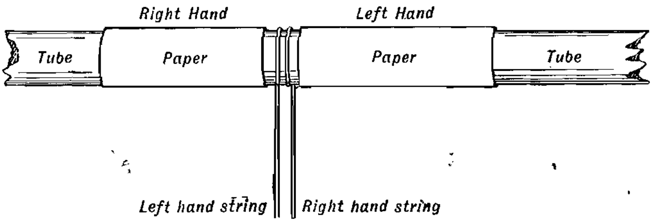


FIG. 18.

small pointed flame of the blowpipe (§ 26) on the glass between the rolls of paper. Rotate the tube. The tube will crack on the line between the rolls of wet blotting paper. A scratch may be made round the tube at the line of scission, but this is not absolutely necessary. Test-tubes may be cut in this way.

VI. *The "Oil" method.*—To cut a bottle or wide tube the bottle may be filled with oil up to the line at which it is desired to cut the bottle. Heat an iron rod in the blowpipe, and, when hot, plunge it in the bottle. The bottle should split across at the level of the liquid surface. Do not touch the neck or sides of the bottle with the hot rod. This method is given in some books, but though I have tried several different kinds of oil and many different kinds of glass the results are rarely satisfactory, the cut line being, as a rule, very irregular.

Try this on some old bottles.

CHAPTER III

BORING HOLES IN GLASS. METHODS OF GRINDING GLASS SURFACES

§ **9. T. C. Solution.**—For this work the 8 to 10 per cent. solution of camphor in turpentine is required. It will be referred to as " T. C. solution."

This solution, used as a lubricant on a file or boring instrument, makes the glass work without chipping, somewhat like a fairly soft metal.

§ **10. To bore a hole in the base of a bottle.**—Cut the bottle off so that its bottom half will rest firmly on the working bench when upside down. Break an old file and, if the steel is not sufficiently hard, temper it by heating it to white heat and then plunging it into mercury.

Hold the file in the right hand, either in the manner shown in Fig. 19 or so that the end of it is in the palm of the hand. In the latter case it will be found necessary to cover the end with a duster, or it irritates the palm of the hand. Hold the bottle in the left hand. Some workers prefer to protect themselves from possible accidents by holding the bottle with a duster. Put a few drops of T. C. solution at the place at which it is desired to bore the hole and commence to bore by twisting the file backward and forward as shown in the figure.

The file frets its way through the glass quickly and a clean round hole is produced. Do not use

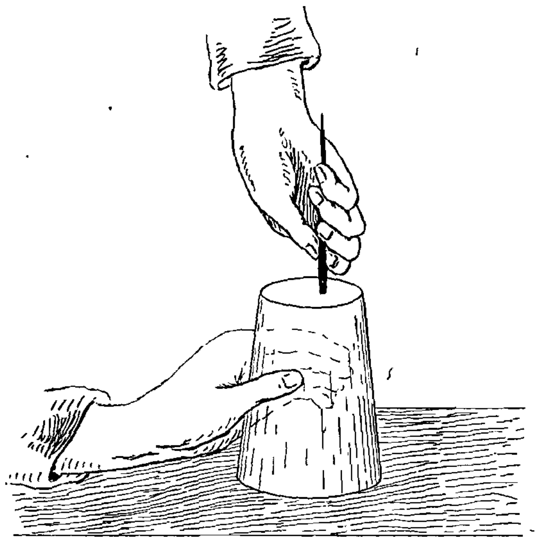


FIG. 19.

undue pressure, and, when the hole is nearly through the glass, be careful, otherwise the file will rush through the hole and splinter the edges and possibly make radiating cracks round the perforation. Once the glass is pierced the hole may be enlarged to any desired size by filing with a file kept well lubricated with T. C. solution.

When the filing surface has become dull break another short length off the file and a new boring surface will be formed.

The use of a brace (Fig. 11) for twisting the file is *not* recommended. Experience has shown that much better results are produced by the backward and forward motion used in hand work, and, moreover, the hand is more sensitive to any irregularities in the working which, if attention is not directed to them, would lead to the fracture of the glass.

§ 11. To make "Grease plates" or Covers for gas jars.—It is quicker to make square cover slips with rounded corners. The size is about 3 in. or 4 in. square. Round cover slips may be cut by any of the methods given in § 6, I. to V. In either case smooth down the edges by rubbing with sand or by grinding on the wheel. The edges may also be smoothed off by rubbing with a file lubricated with T. C. solution. Bore a hole in the plate if required (see § 10). To "frost" one side make a mixture of raw linseed oil and sand which has passed through a 60-mesh sieve and rub the plate, face down, on the slate slab with a slight pressure. It is most important that the sand should contain no large, hard particles. These will cause the glass to break or make deep scratches on the surface.

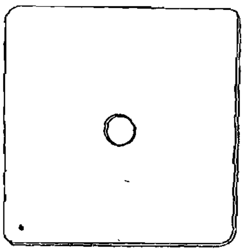


FIG. 20.

§ **12.** There are several ways in which glass may be "frosted," cut surfaces ground level, and joints ground to fit.

(1) Rubbing the glass on a mixture of sand and oil as described above (§ 11). Water may be used instead of oil, but it is considered that the oil-sand mixture gives better results and leads to fewer breakages. The fineness of the grinding is regulated by the fineness of the sand used. Powdered glass may be used in place of sand.

(2) Rub the glass surface with a mixture of fine sand and oil, using a piece of marble, ground quite flat, as a rubber. Glass powder may be used in place of sand.

(3) Rub the surface of the glass with a muslin bag containing powdered glass (glass passed through a 60-mesh sieve serves the purpose quite well).

(4) To get the matte surface very fine, grind first with sand and, having washed the surface free from oil and sand, finish off the grinding with fine emery powder and T. C. solution.

(5) "Glass paper" may be used instead of sand or powdered glass.

(6) The edges of cut bottles, watch glasses, etc., may be ground flat on the sand-slate surface well lubricated with oil. To obtain a fine finish the grinding may be finished off with emery and T. C. solution.

(7) The method of grinding in stoppers and joints will be described in § 13.

(8) An ordinary stone wheel, such as those used for grinding knives, may be used for grinding rough

edges. The surface of the wheel *must* be kept well watered or lubricated. This method is both rapid and efficient for grinding down rough edges of cover slips (§ 11) or bottles in which the split has not gone straight. The slate method of course does, but is lengthy. The wheel gives a fairly rough finish, but the edges may be finished off by the methods described above.

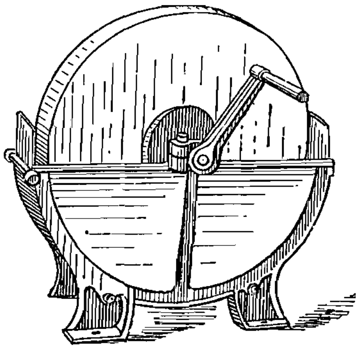


FIG. 21.—Grinding-wheel.

§ 13. To grind stoppers into bottles.—Bottles without stoppers are much cheaper than those with stoppers ground to fit them. On the other hand, while the breakage of stoppered bottles may be large, the stoppers are rarely broken. Hence one may find oneself with a stock of unstoppered bottles and also a number of bottleless stoppers. It is convenient to have a method of grinding an old stopper to fit a bottle which has not been ground. To do this, select a stopper which is rather too large for the neck of the bottle. It will sit high in the neck as shown in Fig. 22. Now dip the stopper in a paste made of raw linseed oil and sand (60-mesh sieved) and grind the stopper with pressure. As the sand gets worked out of place put more sand in and keep the surfaces of contact well lubricated with oil.

(Water and sand may be used, but oil is better. This grinding may be done by giving the stoppe a backward and forward motion. Remove th stopper from time to time and replace it in a new position. Continue this grinding until the surface of the inside of the neck of the bottle is all rubbed dull. This may be done by inspecting the surface after cleaning away the sand and oil with a piece of muslin or a duster. Unrubbed portions will be detected at once by the shining surface of the unattacked glass.

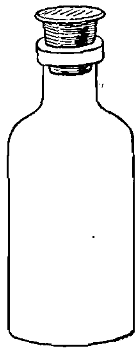


FIG. 22.

When the whole of the seating of the stopper has been ground, clean off all the sand and oil. Dip the stopper in a paste made of fine emery powder and T. C. solution and again grind in the stopper. In this case only twist the stopper in one direction. Sand is not suitable for getting a fine finish. If you forget to keep the surfaces which are being rubbed well lubricated, the stopper may stick or the glass may get so hot that the neck will crack. The stopper can be considered to fit really well when no vibration can be felt when you try to shake the stopper, even if the stopper has not been pushed in or twisted into the neck of the bottle.

§ **14. To make a Specific Gravity bottle.**—Take a small bottle—say a half-ounce or one ounce bottle—with a narrow neck. Choose an old stopper as described in the preceding section and grind it in first with linseed oil and sand and finally with T. C. solution and emery powder. In order that the bottle may be exactly filled every time, an outlet or overflow tube must be provided in the neck.

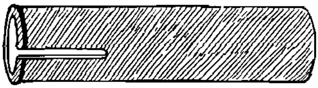


FIG. 23.

This is done by filing a groove down one side of the stopper.

Take the wooden lid of an old thermometer case and cut a narrow section from the length of its wall as shown in Fig. 23.

Now push the tapered end of the stopper into the mouth of the lid of the case and hold it in the left hand as shown in Fig. 24.

Take a triangular file in the right hand, dip it

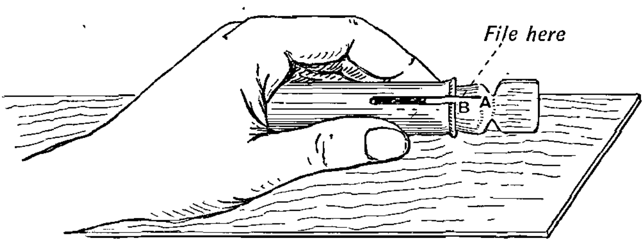


FIG. 24.—Filing a groove in a stopper.

into T. C. solution, and file a groove lengthwise on the stopper as shown. The slot in the box lid guides the file, otherwise it is very difficult to make the line straight. As soon as the line is started it is easy to finish it off without the groove. The section of the lower portion of the stopper will be as shown in Fig. 25. If the bottle is filled with liquid and the stopper carefully pushed in, all surplus liquid will be squeezed past the stopper and up the groove (Fig. 26), just as is the case with the central tube in the ordinary specific gravity bottle shown in Fig. 27.

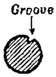


FIG. 25.

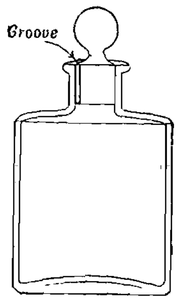


FIG. 26.

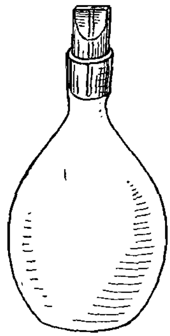


FIG. 27.

§ 15. **To make a Beehive shelf.**—A use for flat-bottomed bottles of which the upper portion is broken or of which the stoppers are stuck. Woulfe's bottles when broken at the tubulure are very suitable.

Cut off the lower portion of a bottle of suitable size (§ 8). Choose a bottle of which the bottom is flat, not domed. Grind the cut flat as directed in § 12. Break off a small file so as to make a sharp edge and bore a hole in the bottom of the cut off portion of the bottle (see § 10). Enlarge the hole as much as desired by rubbing it with a ratstail file well lubricated with T. C. solution. Heat a glass rod and press it at one point in the *edge* of the cup. This should start a small crack. If it does not do so, heat the glass rod again and press it on another place along the edge of the cup. If the crack does not start, touch the hot spot with the moistened finger. This should produce the desired result. If it does not do so, scratch the surface of the glass with a file and touch the scratch

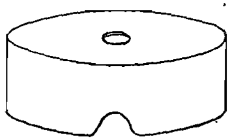


FIG. 28.

with a hot rod. If unsuccessful, try again until you succeed. Dry the surface and lead off the crack in the form of a small semicircle by means of a hot rod (§ 8, II.). When the semicircle is complete the small piece of glass will drop out. File the edges of this little arch by means of the file lubricated with T. C. solution, and a very neat and efficient glass beehive shelf will have been produced from a broken bottle.

CHAPTER IV

BENDING GLASS. CORK BORING. TO MAKE A WASH BOTTLE

§ **16.**—For glass work the glass should be free from air bubbles, stripes, and other blemishes. In this work we may meet with all kinds of glass, as the object of this book is to show how damaged apparatus may be utilised. Hence one must expect to encounter the most varied kinds of material, and only experience can dictate the method in a particular case. In the present chapter the methods of bending glass tubes, drawing out or choking wide tubes, sealing tubes, etc., made of glass considered to be of good quality, will be considered. Glass may lose its transparency on heating. This is often due to "devitrification" and may be the result of overheating or because the glass is old.

The hottest flame used will be the air-gas blowpipe flame, and hence working in hard glass or in silica cannot be considered. For this work other books may be consulted. I have not introduced it in the present volume, as comparatively few laboratories have arrangements for working in the oxygas or oxy-hydrogen flames, and my object is to present subjects which can be carried out in any average laboratory.

Before heating any kind of glass *it should be thoroughly cleansed.* Flasks, etc., may be washed in the ordinary way. Tubes may be cleaned by pushing tight wet wads of cottonwool through them. Glass which has to be heated *must be dry* before being subjected to the action of the flame, otherwise it is nearly certain to crack.

The kinds of glass to be considered in this chapter are—

(1) Soda-glass. This easily melts and is readily worked.

(2) Lead-glass, which has a higher melting point.

In working with these varieties of glass three kinds of flame will be used :

(*a*) The batswing or fishtail flame ;

(*b*) The flame of the ordinary Bunsen burner ;

(*c*) The blowpipe flames. (i) The smoky flame, (ii) the pointed flame, (iii) the "brush" flame.

§ **17. Bending glass tubes.**—The batswing flame is used for bending glass tubes. It consists of a luminous portion (*A*) and a non-luminous portion (*B*). These portions are marked *A* and *B* respectively in Fig. 29. For bending glass tubes the luminous portion is used. Hold the tube horizontally in the length of the flame and keep it moving backwards and forwards in the flame so that the glass may be heated uniformly all round. Rotate the tube uniformly with both hands so that when it gets soft it will not become twisted.

The tube becomes covered with soot, and after warming for some time the glass softens. When you feel that the tube is soft and is flexible remove it from the flame and bend it steadily to the angle required. The two limbs of the bend must lie in the same plane. This result may be achieved in two ways: (1) by pressing the two limbs (while the bend is still hot) on a piece of flat asbestos board or on a flat slab of charcoal; (2) close one eye and hold

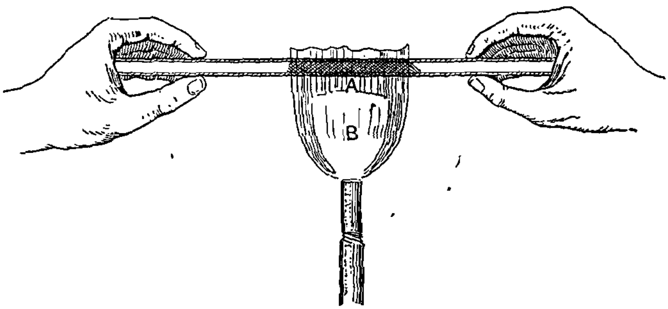


FIG. 29.

the tube in front of the open eye. Bend it away from you in such a manner that the limb of the tube more remote from your face is completely obscured by the limb nearer your face. This can only happen when the two limbs lie in one plane.

If the bend has to extend over a wide sweep of the tube, the curve may be made by progressively heating the tube first between *A* and *B* (Fig. 30) and letting a certain amount of bend take place. Then heat between *C* and *D*. The bend will turn still further, and so on in stages until the sweep of the bend is complete. It may be necessary to press the bend level by again heating it and pressing the

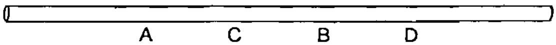


FIG. 30.

heated bend on the asbestos board. In such cases it is often useful to let the tube bend by its own weight.

If the tube is overheated the bend will collapse and a "kink" will be produced which is weak and likely to break and also chokes the tube. To bend wide tubes either (1) blow into the tube, closed at one end during the bending, or (2) fill the tube with

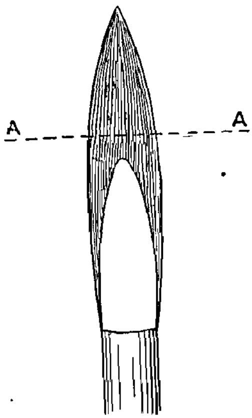


FIG. 31.

dry sand and loosely cork both ends. Heat the tube filled with sand and bend it while still filled with sand. The sand acts as a cushion and prevents the walls from collapsing.

§ 18. **To draw out a jet for a burette, wash bottle, etc.**—For this purpose the tube may be heated in the ordinary clear Bunsen flame at the point marked *A*....*A* in Fig. 31. Keep the tube rotating as before. The glass will commence to thicken and will present

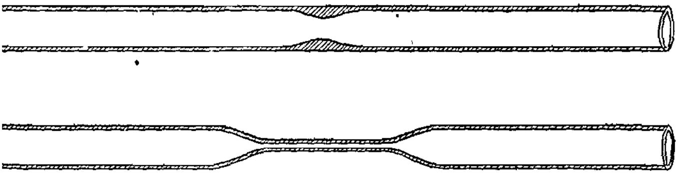


FIG. 32.

the appearance shown in Fig. 32, *A*. Remove the tube from the flame and slowly draw the tube out until it presents the appearance of Fig. 32, *B*. Draw a file once across the narrow tube in the middle of the constriction and two jets will be produced, each of which looks like Fig. 33.

The ends of all tubes should be rounded off in the ordinary Bunsen flame before being pushed into corks or bungs, otherwise the sharp edges of the glass will cut the cork or rubber. To round off the end of the narrow part of the jet heat it very carefully on the outside edge of the base of the Bunsen flame.

FIG. 33.

Tubes may be more easily pushed into rubber the bend is complete. It may be necessary to press the bend level by again heating it and pressing the

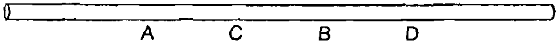


FIG. 30.

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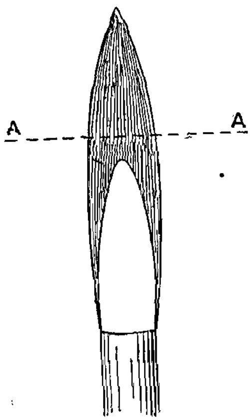

FIG. 31.

dry sand and loosely cork both ends. Heat the tube filled with sand and bend it while still filled with sand. The sand acts as a cushion and prevents the walls from collapsing.

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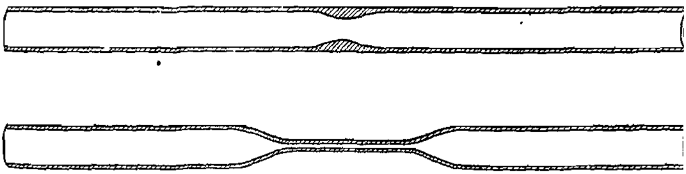

FIG. 32.

the appearance shown in Fig. 32, *A*. Remove the tube from the flame and slowly draw the tube out until it presents the appearance of Fig. 32, *B*. Draw a file once across the narrow tube in the middle of the constriction and two jets will be produced, each of which looks like Fig. 33.

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FIG. 33.

round off the end of the narrow part of the jet heat it very carefully on the outside edge of the base of the Bunsen flame.

Tubes may be more easily pushed into rubber tubing or corks if the glass is first moistened with water or with 50 per cent. glycerine solution.

§ 19. **To make a capillary tube.**—Heat the tube in exactly the same manner as that described in the preceding paragraph but, instead of drawing the thickened tube out slowly, draw it out fairly quickly. Long lengths of capillary tube may be made by thickening wide tubes in the blowpipe and then drawing the two ends apart. Capillaries many feet in length may be made in this way in a single operation (see Fig. 38, *A*, § 28). Draw the tube out when it is in the stage represented by *A* in that diagram.

§ 20. **To bore a cork.**—Select a cork of which the narrow end just goes with difficulty into the neck of the flask to be used to make the wash bottle. Wrap the cork in paper and soften it by rolling it on the floor under the sole of your boot. The cork can now be pushed into the neck and makes a good air-tight fit.

Take a cork borer of which the diameter is a little less than the external diameter of the tubes to be used in making the wash bottle. Dip the cork borer in a 50 per cent. solution of glycerine in water, and, holding the cork firmly on the table, place the borer perpendicularly on the cork at the point at which you desire to make your first hole. Be sure the borer is vertical. Now press the borer downwards, making short turns to the right and left alternately. The borer cuts into the cork. Let it pass halfway through. Withdraw the borer. If the borer is tight give it a slight twisting motion when pulling it out of the cork. Turn the cork upside down and carefully bore in the opposite direction to meet the first half of the cut. Withdraw the borer from the cork and the cork cutting from the borer. Bore the second hole in exactly the same way. The two holes should be quite parallel. *Always clean a borer after use.*

When boring holes in rubber bungs use alcohol as a lubricant instead of 50 per cent. glycerine solution.

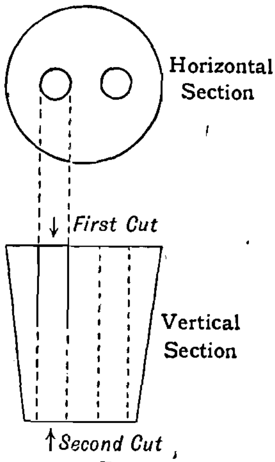


FIG. 34.

§ 21. To make a wash bottle with an insulated handle.—A wash bottle may be made of any kind of bottle, but if it is desired to use it for hot liquids a flask should be used and the neck should be covered with some insulating material, so that when in use the hand may not be made uncomfortably hot.

(1) Press a cork of suitable size and carefully bore it with two holes of a size suitable to take the glass tubing selected (see § 20).

(2) Cut off sufficient tubing for your purpose. Do not waste material, and make two bends as shown in Fig. 35, Method § 17. Round off the ends of the tubes at both ends.

(3) Make a jet from the same tubing. Round off the cut ends of the jet (see § 18).

(4) Connect the jet to the supply pipe by means

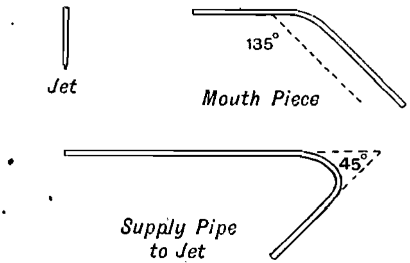


FIG. 35.—Tubes for wash bottle.

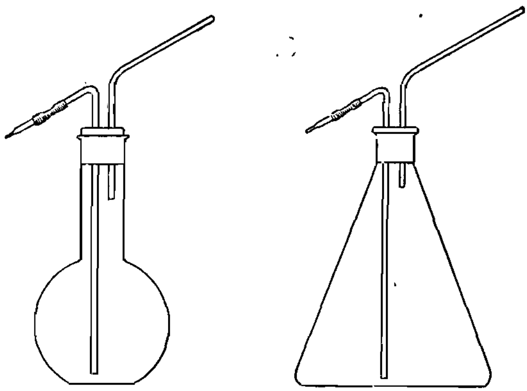


FIG. 36.

of a short length of rubber tubing of suitable diameter. This causes the jet to be flexible, and the stream of water can be turned in any direction when the wash bottle is in use.

§ 22. **To insulate the neck of the wash bottle** and so make it suitable for use with hot liquids. This is done by means of string.

Take one free end of the string, lay it along the neck of the flask, and keep it in position with the thumb. Now wind the string round the neck of the flask and, at the same time, bend down the free end

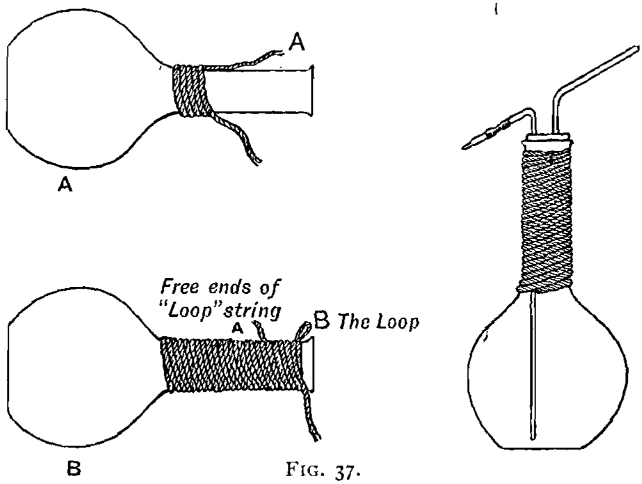


FIG. 37.

of the string which has been laid along the neck of the flask (Fig. 37, *A*). The windings must be tight and so wound that each successive turn touches the previous one.

When the winding has gone to within one inch of the mouth of the flask, pull tight the free end, *A*, and cut it off sharp with a knife (Fig. 37, *B*). Now lay a loop of fine, strong string along the still exposed length of the neck of the flask and so arrange it that the free loop, *B*, is at the mouth of the flask (Fig. 37, *B*). Continue binding the thick string round the neck of the flask until it reaches the end of the neck. Now slip the free end of the binding string through the loop *B*. Pull the free ends of the loop string (and the binding string with it) under the turns round the end of the neck of the flask. Pull it tight, and cut off the free end. String bound and fastened in this way will not come undone.

CHAPTER V

THE BLOWPIPE

§ **23.**— There is a large number of patterns of foot blowpipe upon the market. Any of these may be used for performing the experiments described. The two most commonly used by the author and his assistants are illustrated in Fig. 4, *A* and *B*, page 5.

The essential thing is that there should be separate controls for air and for gas. The air-tube passes up the centre of the burner and the gas comes up by means of an annulus of which the air supply pipe is the central portion.

The bellows used are Fletcher, Russell & Co.'s No. 5, as described and illustrated in Fig. 3, page 4. The use of all leather bellows controlled by a spring is not recommended. It is practically impossible to get a steady blast with them, and a steady blast is essential for successful glass working.

The blowpipe gives three important flames :—

(i) The smoky flame.
(ii) The pointed flame.
(iii) The " brush " flame.

§ 24. **The smoky flame.**—The first flame which is obtained when the blowpipe gas is turned on and lighted (but when no supply of air is turned on) is a large, luminous flame which varies in size with the amount of gas supplied to it, but it is always very smoky and gives off large quantities of soot. The larger the amount of gas supplied the more copious is the soot.

This flame is used for (1) giving glass the preliminary heating before turning on the blast, and (2) annealing the glass after it has been worked to the correct shape (§ 27).

Glass is not "worked" in this flame.

Never bring glass into a hot flame quickly. The glass, being a poor conductor of heat expands irregularly and cracks. If a thick-walled bottle be heated suddenly it splits with such violence that pieces may be thrown to some distance. Even thin glass is likely to crack if put into a hot flame without preliminary heating.

The rule is always to heat the glass slowly by first moving it backward and forward in and out of the large smoky flame and then holding it in the flame, with constant turning. The glass will be covered with soot and will get quite hot. Gradually open the air cock and work the bellows, and slowly increase the supply of air until finally the burner is at full blast. The flame will be large and hot. Its size will depend upon the relative quantities of air and gas. Keep the glass moving during the whole time that you are heating it.

§ 25. **The brush flame** is produced by turning on a considerable supply of both gas and air. The flame is bluish, non-luminous, and very hot. The size of the flame depends upon the supply of air and gas. It is called a "brush" flame because its shape roughly resembles that of a camel's hair brush. A small brush flame is shown in Fig. 60, *B*, § 46.

The features of the flame can only be studied properly by using it.

§ 26. **The pointed flame.**—If, when the burner is giving a small brush flame, the gas supply be diminished and the bellows worked carefully, the flame diminishes in size and narrows down till it is pointed and looks somewhat like a dagger. The size of the flame may be varied with the same blowpipe within certain limits. *As a general rule only the tip of this flame is used.*

The features of this flame also must be studied by practical experience.

§ 27. **Annealing.**—When a piece of glass has been strongly heated and the work on it is completed, it must not be immediately laid aside, or the outside portions will cool first and, owing to the poor conductivity of glass, the inside portions will be in a state of strain. The glass, so cooled, will probably crack on standing. It certainly will not stand any shock without breaking.

This trouble may be avoided by allowing the glass to cool slowly so that the entire thickness of the glass cools at about the same rate.

This process of slow cooling is called "annealing." It may be done in three ways.

1. Move the hot glass about in the smoky flame until it is covered with a *permanent* layer of soot and then lay it on one side to cool in a place free from draughts.

2. Allow the hot joint to cool slowly by covering it, when hot, with hot sand and allowing the whole to cool slowly by standing on one side.

3. Cover the joint with cottonwool. Take care that the cottonwool does not catch fire. If, by this method, the glass becomes soiled with a brown stain, it may be washed off by means of alcohol or methylated spirit.

The process of annealing is absolutely necessary for successful glass working. As a general rule, do not blow glass while it is in the flame unless special directions to do so are given.

§ 28. To seal off or to "choke" a wide tube.—Use a blowpipe and during all heating rotate the tube backwards and forwards between the fingers. Do not twist the tubing.

1. At the point at which it is desired to seal or choke the tube, heat it in the smoky flame until it is black with soot.

2. Gradually turn on the blast and heat the tube till it thickens as at *A* (Fig. 38).

3. Withdraw the tube from the flame and draw it out slowly, *B*.

4. Cut the narrow portion midway as shown at *C*.

5. Seal off the end of the constricted part, *D*.

6. Heat the cone-shaped end with constant motion of the tube. Remove it from the flame at intervals and blow gently. It will first assume the shape shown at *E*.

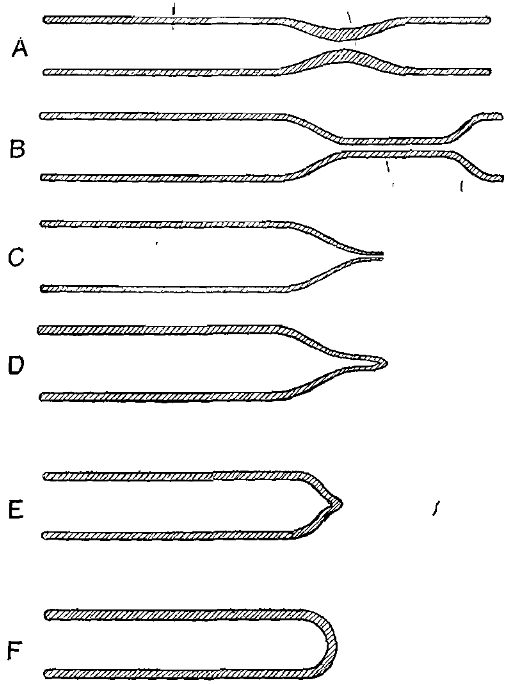


FIG. 38.

7. Heat the whole of the end of the tube and, when just about to fall in, keep the tube twisting and blow gently at the open end. The tube will finish up nicely rounded as in *F*.

8. Move the completed tube about in the smoky

flame *until the layer of soot remains permanently on the glass,* when the tube is withdrawn from the flame for a few minutes. Leave the tube on one side to cool. This method of annealing is recommended, but the others may be used.

To "*choke*" the tube, stop the operation at *A* or *B*, as the case may be, but do not forget to anneal the choked portion before allowing it to cool down.

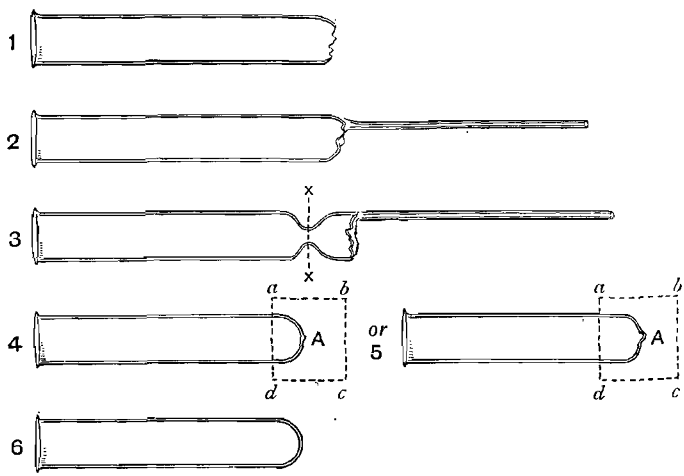


FIG. 39.

CHAPTER VI

USES FOR BROKEN TEST-TUBES AND DAMAGED CALCIUM CHLORIDE TUBES

§ 29. To make a new test-tube from a damaged one.—If the test-tube is broken as shown in Fig. 39, No. 1, the end may be drawn off and blown out. Hold the tube in the left hand and warm the end gently in the flame. At the same time heat a piece of narrow tubing in the flame. Use a fairly small brush flame. When *both* the ends are glowing press them together until you feel them grip together and then pull slightly. Allow this joint to cool a little. The result shown in Fig. 39, No. 2, will be obtained. The thin tube acts as a support.

Holding the test-tube in the left hand, heat it with the pointed flame at *X*—*X* until a portion of the wall collapses. Twist the tube a little and heat another point, and so on, all round the tube until it presents the appearance of Fig. 39, No. 3. Take the tube from the flame and pull it out. Break this portion away and heat the end of the tube to seal it off. If a little blob of glass forms at *A*, heat it with a small flame and then blow. The tube will look like Fig. 39, No. 5. Now, with a brush flame, heat the area marked *a b c d* in Fig. 39, Nos. 4 and 5, and when glowing blow gently to the shape shown in Fig. 39, No. 6.

When practice has made the worker quick at these operations a tube can be repaired in one minute and a few seconds (about fifty tubes can be repaired in one hour).

§ **30. Bordering the ends of tubes, etc.**—It is sometimes required to push out the mouth of a tube or flask

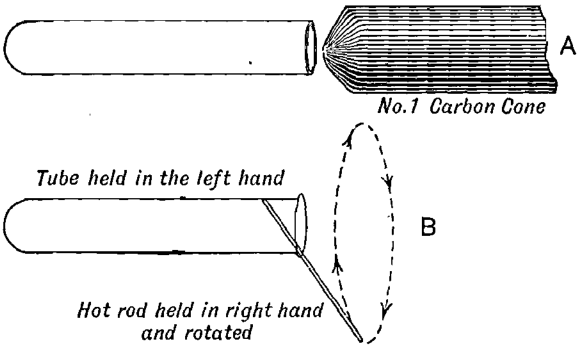


FIG. 40.

in the form of a lip or border. A piece of carbon is prepared with a cone-shaped end and too large to go right into the tube. After cutting the end of the tube off square by any of the methods described in §§ 7 and 8, the mouth of the tube is heated, first in the smoky flame and with the gradually increasing brush flame until the edges glow. Remove the vessel from the flame, press the carbon cone into the mouth of the tube, and give it a twisting motion at the same time. If the desired lip or border is not produced in one heating, heat again and continue the operation with the cone again. If it is desired to form a spout as in beakers or measuring cylinders, press out one point of the heated edge with a *hot* iron rod. This method serves for thick or thin glass.

Very flat edges on thin glass are sometimes made by pressing out the lip with a hot rod. Heat the edges of the tube and, holding it in the left hand, put the hot rod in the mouth of the tube slantwise, as shown in Fig. 40, *B*. Now turn it round and the edge will be pressed outwards.

§ **31. Weighing tubes.**—A. Seal off the small tube as described in § 29, but at the finish direct a small

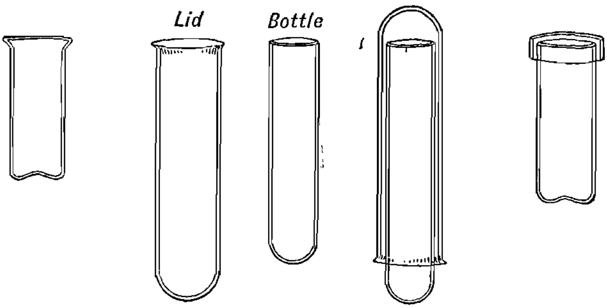


FIG. 41.

brush flame on *to the rounded bottom* of the tube with constant turning of the tube. The round bottom will collapse and become flat as shown in type *A*. The base may also be flattened by pressing it, while hot, in charcoal, but the flat bottoms so produced are not so strong as those obtained by the first method and are likely to crack.

B. Select two tubes of which one will just slip into the other without force. Remove the border from the mouth of the one of narrower diameter and round off the edges (see § 30). These two tubes can be made of any desired length from broken tubes of suitable diameter. The bottom of the bottle may be flattened if desired. These are very useful for many purposes, but especially for weighing a porcelain boat containing substance or ash in "combustion" experiments.

C. A small flat lid may be made. This is done by flattening the base of the "lid" (see type B) first, and then cutting off the tube at the required length by means of any suitable method (§ 8).

§ 32. To make a "Soxhlet" tube.—Broken test-tubes of narrow diameter, say $\frac{3}{8}$ in. or $\frac{1}{2}$ in., are suitable for this. The stages are indicated in the series of diagrams given in Fig. 42.

Heat the tube and fuse a small piece of waste tube on to the end to use as a handle or support (§ 29). Heat the tube about $2\frac{1}{2}$ in. from *L* with a pointed flame. Heat one point first and go round the tube and a constriction like that shown in Fig. 42, *C*, will be formed. Now heat just below this constriction so as to make a thickened collar as shown in Fig. 42, *D*. This is done with the pointed flame. When the glass is sufficiently thick there, heat the area *a b c d*, and, when the glass is soft, take the tube from the flame and slowly pull the rod (*E*).

Let the tube cool with annealing. Cut the rod off at *E* and trim up to shape (Fig. 42, *F*).

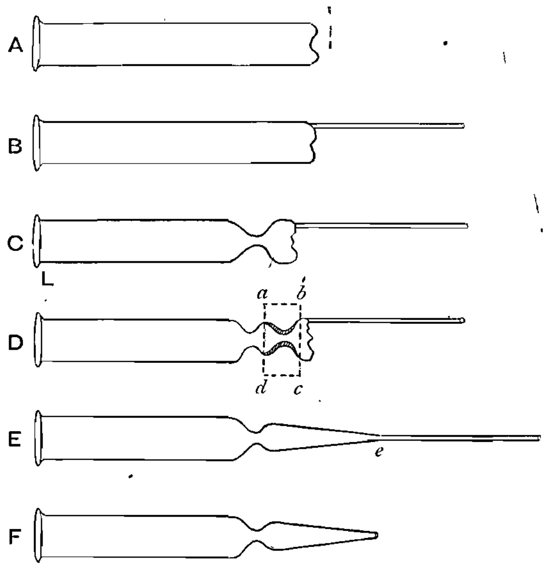


FIG. 42.

§ 33. **To make a test glass on stand** from a broken test-tube or boiling-tube. Have a hot plate ready on a tripod stand. The series of operations will be readily understood from the diagrams in Fig. 43.

Draw off the broken end (*B*). Blow a small bulb on that end (*C*). Perforate the bulb by heating at *D* with a pointed flame and blowing while hot. Break the thin bulb that forms. Seal the supporting tube on at *D* for use as a handle, *E*. Thicken up the tube at *X—X* (Fig. 43, *F*) until it melts into a short, thick solid connection.

Break off the handle and heat the bulb in the brush flame. Flatten the base as explained in § 31, *A*, or, when it is soft and just about to collapse,

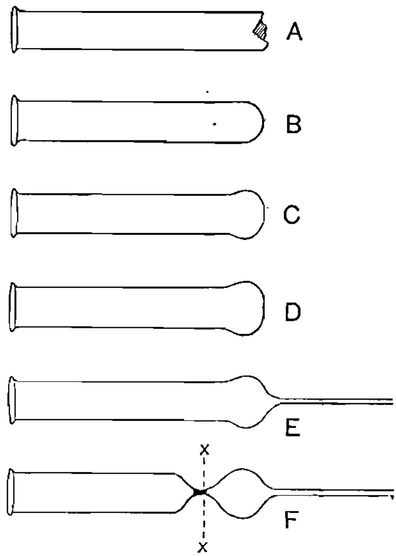


FIG. 43.

press it upon the *hot* plate, taking great care to keep the tube vertical. Anneal very carefully the whole of the parts that have been heated. It is difficult to prevent cracking, but although a fair number of failures have been recorded, the assistant was able to make some good test glasses by this method.

§ 34. **Uses for broken calcium chloride tubes.**—The commonest shapes are shown in Fig. 44, and breaks usually occur at the points marked *X—X*.

A. *Tubes of type A* are best drawn off into two

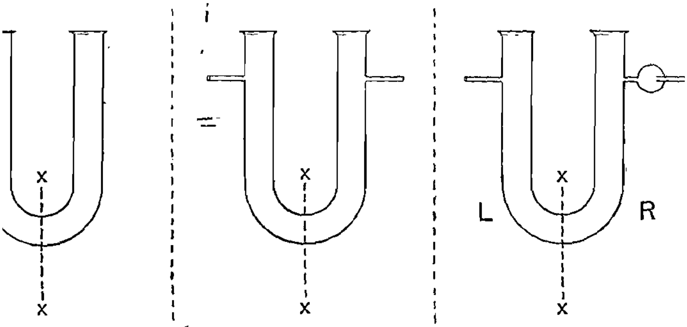


Fig. 44.

test-tubes as described above in § 29. They may also be drawn off as shown in Fig. 45, *B*, and used as tubes for connecting together two tubes of different diameter. Details as to the methods for choking tubes and making their ends suitable for slip-on rubber connections are given in § 32 and § 42.

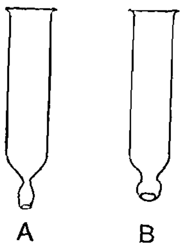


Fig. 45.

B. *Tubes of type B* (Fig. 44) may be drawn out as described in § 29 and the end closed (Fig. 46, *A*). This is useful as a short distillation tube, also as a washing apparatus for H_2S gas in the apparatus described in § 54, Fig. 69.

If both ends are left open and bordered, type *B* may be used as a T-tube with two wide limbs and one of narrow bore, and is applicable to many purposes (Fig. 46, *B*.). The tube may also be drawn out as shown in Fig. 45, *A*, and used as a reducing joint with a side tube.

C. *Tubes of type C*.—Use *L* limb as described above under § 34, *B*. The right limb is useful as a drying bulb. For the purpose seal off at the end

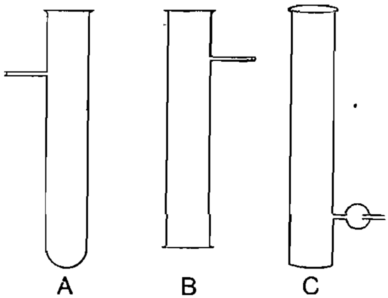


FIG. 46.—Apparatus made from calcium chloride tubes.

near the side bulb and use the tube upside down. If more convenient leave both ends of the tube open and border them (Fig. 46, *C*). The tube is more easily cleaned from damp calcium chloride if this is done.

There are several uses to which these tubes may be put, and it is suggested that they are stocked with open ends until required, as any of the forms described can be made in a few moments when wanted.

CHAPTER VII

USES FOR BROKEN FLASKS

§ 35. **If the base of the flask is smashed,** the walls of the bulb may be used for making watch glasses.

Watch glasses may be made of two kinds : (1) with handles, (2) without handles. The size of the watch-glass which can be obtained depends upon the size of the flask and the extent of its walls which are unbroken.

A crack must be started somewhere in the wall or on the broken edge of the flask. If a crack already exists it may be led in any direction. In order to start a crack, heat one point of the broken edge and touch it with a wet object. A tiny crack may be easily started in this way, or make a file mark on the glass and bring a hot point into contact with the scratch.

Lay a watch glass of the desired size on the undamaged portion of the flask wall and mark round its edge with a pencil which will write on glass. Such pencils are easily procurable and cost only a few pence each. Now lead off the crack by the hot rod method (§ 8, II.) until the desired figure is traced out. When the cut is completed the " watch glass " drops out. Its edges may be trimmed down on the slate by rubbing with sand and oil. If, however, a handle is made, as shown at *B* in Fig. 47, the glass cannot be finished off on the slate. A file moistened with T. C. solution may be used.

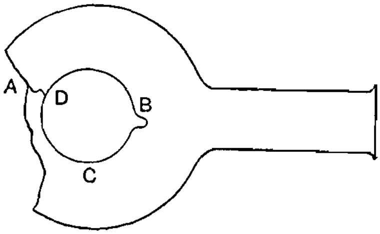


FIG. 47.

In the case of flasks *with very thin walls* it is very difficult to polish the edges of the watch glasses by friction. They may be left alone or heated *very cautiously* first in the smoky and then gently in the brush flame (see § 39). The neck of the flask may be used as described in § 37.

§ 36. **If the bulb of the flask is intact** and the mouth of a part of the neck is damaged, cut off the neck at the point *A*. It is better to use the hot rod method here, as the use of the string method would involve the loss of a certain amount of the length of the neck. When the cut has been made, heat the mouth cautiously first in the smoky-, then in the brush-flame till it glows. Quickly press out the edges to a border or lip as

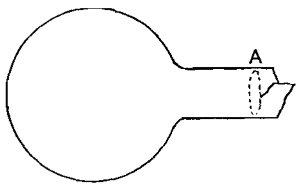


FIG. 48.—To repair the broken mouth of a flask.

described in § 30, and then move the mended mouth of the flask about in the smoky flame to anneal it. If this is not done it is sometimes found that the border snaps off, owing to too rapid cooling of the mended part.

§ 37. Adapters made from the necks of damaged flasks.—The various stages of this operation are shown in the series of diagrams given in Fig. 49. The neck of the flask should be intact, otherwise there is usually too little of it to be of any use. (See also § 57.)

The glass is broken off to about the quantity shown in *B*, Fig. 49, and a rod is welded on to the raw edge as described in § 29.

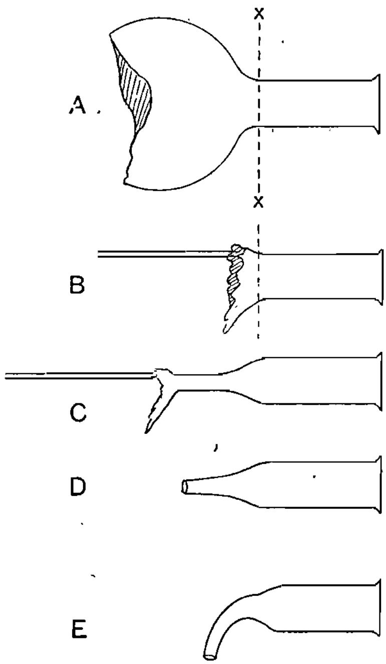


FIG. 49.

The flask neck is then heated with rotation until it thickens and then it is slowly drawn out as shown at *C*. The raw end is cut off and the edges rounded off in the flame. Anneal the end of the tube which has been heated.

In order to get the shape shown at *E* the bend may be made at the same time as the tube is drawn out, or it may be made by bending the straight tube after it is finished.

§ 38. **To make a steam trap.**— Cut the neck off at *X*—*X* by any convenient method. The hot rod method will be found useful. Round off the edges of the cut end and put a border round it by means of a charcoal cone. Anneal the new end. Fit the ends with corks and short glass tubes as shown in Fig. 50.

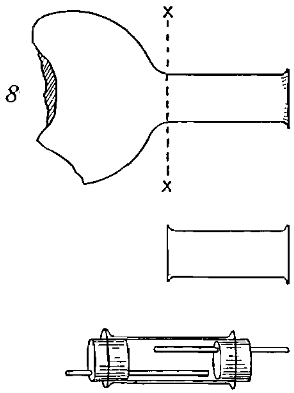


FIG. 50.

It was found that the necks of flasks often devitrify when drawn out. This does not affect the efficiency of the adapter, though it certainly does not improve its appearance.

If short lengths of the necks be cut off and ground flat on the slate, they may be used as vessels for containing calcium chloride in the desiccators described in § 57. To make them into cups for this purpose they are fastened to the centre of the glass plate by means of Canada balsam.

§ 39. **Crystallising bowls** may be made from flasks of which the upper portion is broken.

Suppose a flask is cracked as shown at *E F* in Fig. 51 and in addition the neck is broken. The bottom portion of the globe of the flask can be cut off and used as a crystallising bowl. Draw a line, *G H J*, round the flask and then, by means of the hot rod, lead off the existing crack until it meets the line drawn. Lead the crack along this line, and the bottom portion of the flask will separate. The edges may be ground flat if the flask walls are thick enough to stand it. If the flask walls are very thin the edges may be rounded by cautious heating, first in the smoky and then in the brush flame.

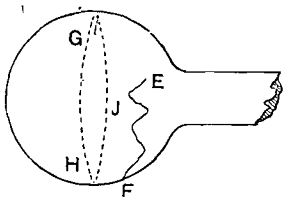


FIG. 51.—To make a crystallising bowl from a broken flask.

To do this, place the basin on a tripod stand and heat it with the smoky flame very carefully. Gradually increase the temperature and allow the brush flame to play upon the edge at successive points until the whole circumference is rounded off. You can tell when any point is rounded off by the fact that the edge becomes bright and free from carbon deposit. When this happens, pass along to the next point. When the whole of the edge has been smoothed, heat the whole basin with the big smoky flame until a permanent layer of soot remains. Then set aside to cool.

I find that placing the basin mouth downwards makes the process easier, as by this method it is not necessary to hold the blowpipe in the hand.

CHAPTER VIII

USES FOR BROKEN BEAKERS AND BROKEN RETORTS

§ 40. **When a beaker is broken at the mouth,** as in figure 52, *A*, take a heated rod and lead the crack off to some marked line such as *B C* and lead the crack all round the wall. The bottom portion will separate and a small thin-walled bowl will be formed. The edges may be rounded off as described in the last chapter, § 39. If required, a spout may be made as described in § 30.

If the beaker is broken at the base it is not of much use. They have been used as flame steadiers by cutting off the base and so making a wide but short glass cylinder. By means of two lengths of wire a stand is twisted into shape by twisting it at *N* and *O*. Turn up the ends of each of the radiating pieces of wire and slip the cylinder on to this support as shown in the figure, *P*. This device enables one to see what the flame is like. I have used this for heating vessels in lectures during the hot season whilst two overhead electric fans were running at full speed over the class and the fan over the lecture table was running at about 60 per cent.

of its full speed. The tripod-stand I used had a wire gauze on it. Without this device the flame was blown about so that the flask or other vessel did not get appreciably heated at all.

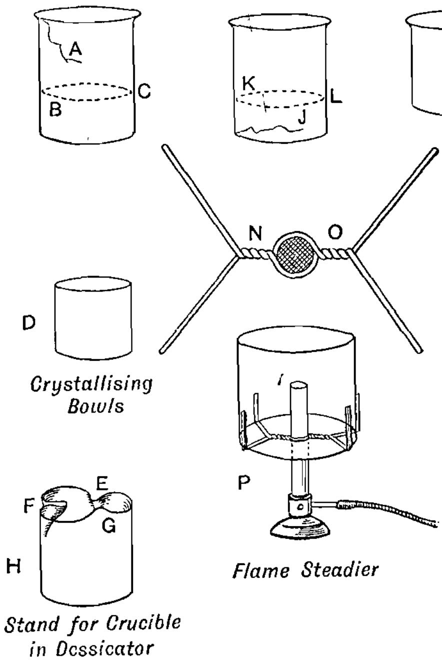


FIG. 52.

Beakers the bottoms of which are cracked may also be used as supports for crucibles in place of glass or porcelain triangles (when the crucible has not to be heated).

The beaker is cut off just above the crack as mentioned above, and then the mouth is cautiously heated, first in the smoky- and then in the brush-flame. When a portion of the rim is soft, take a hot iron rod and press the rim *inwards*. If this is done at three points a vessel like that shown in the diagram, Fig. 52, *H*, is produced. Anneal the heated rim and let it cool slowly. The specimens made did not crack even when a moderately hot crucible was placed upon them.

§ 41. **Broken retorts.**—The commonest break in a retort is at the tubulure as shown roughly by the

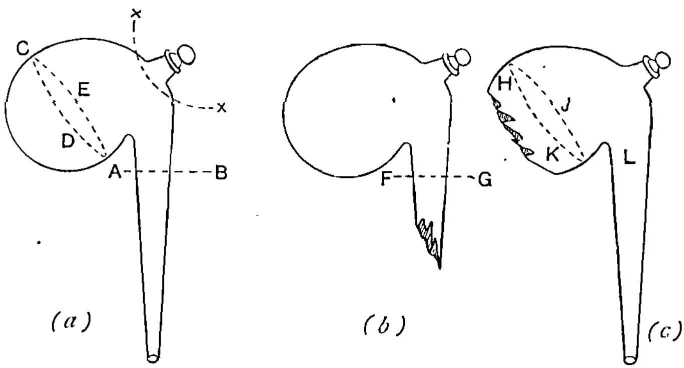


FIG. 53.

lines *X*—*X* in Fig. 53, *a*. In such cases the bottom of the bowl of the retort may be cut off and used as a crystallising bowl. The edge is rounded off as described in § 39. The neck of the retort may be cut off at *A*—*B* (Fig. 53, *a*) and used as a tapering tube for repairing broken Kipp's apparatus as described in detail in § 55. The neck may be cut off by the method depending upon a ring of wire (see § 8) or by the hot rod or string methods.

If the neck is broken the jagged edges may be removed by cutting as at *F* (Fig. 53, *b*) and the apparatus used for the formation of solutions of very soluble gases. To do this, pass the tube by which the gas is led to the solvent through the tubulure. Dip the short end into the solvent. If there is very rapid absorption, the solvent gets caught up in the bowl of the retort and so is prevented from passing into the gas-generating apparatus.

If the bottom is broken out of the retort as shown at *C* (Fig. 53), cut off the broken edges at a line such as that shown at *H J K*, and the apparatus so produced may be used for passing a gas into a substance with which it forms a solid body. In this way the gas meets the substance over a wide area, *i.e.*, *H J K*, and it is impossible for the solid substance to block up the tube *L* which leads in the gas.

CHAPTER IX

TO REPAIR BROKEN BURETTES. THE "BEAD" TAP

§ 42. **To repair a broken burette.**—A. *Burettes are often broken at the mouth* by having funnels put into them roughly, by careless washing, and so on. To repair the damage, cut off the tube by the string method (§ 8) or any method which you find simplest. Cautiously heat the raw edge, so produced, first in the smoky flame and then in the brush flame until it commences to melt. Make a slight border to the edges by means of a carbon cone. Allow the end to cool with annealing. It does not matter if the burette has to be cut where there are graduations. All volumes run in from the burette are measured by the difference in two readings, so it is immaterial at which point on the scale you start.

B. *If the burette is broken at the tap*, or, what is most common, if the cock of the tap is lost, the best thing to do is to cut the remainder of the tap off the burette and to fit on to the end a rubber tap either of the pinch-cock type or a "bead" tap (§ 43).

If the tap remains it may be used as a handle during the heating. If you have a raw edge to deal with, weld on a small piece of tube to act as a support for holding the tube, just as was described in § 29.

Two methods of procedure are possible. I find that either gives good results, but some workers prefer one and some get better results with the other, so both will be briefly described.

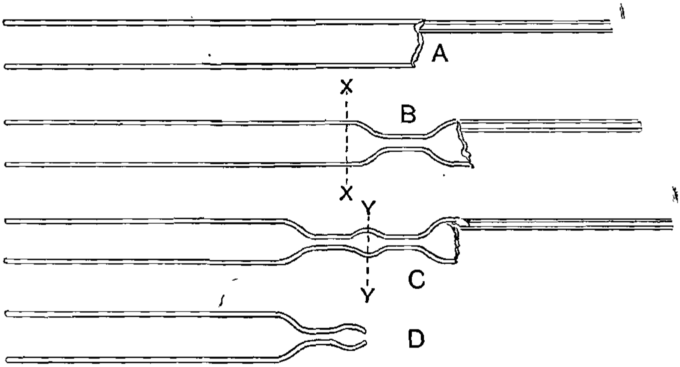


FIG. 54.

I. (*a*) Weld on the tube to act as a support.

(*b*) Draw off a constriction, as shown at *B*, as near the broken end as is practicable.

(*c*) Heat the tube to the left of the constriction at *B* at, say, *X*—*X*, and draw off the tube again.

(*d*) Cut the little bulb at *Y*—*Y* (Fig. 54, *C*).

(*e*) Warm the raw edges of the cut bulb and they will become rounded and fall in slightly. The cross-section is shown in Fig. 54, *D*.

(*f*) Anneal.

The rubber tap will not slip off an end of this type.

II. (*a*) Weld on the tube to be used as a handle or support (§ 29).

(*b*) Draw off a constriction in the tube at a distance of about one inch from the broken end of the tube (Fig. 55, *B*).

(*c*) To the right of that constriction (say at

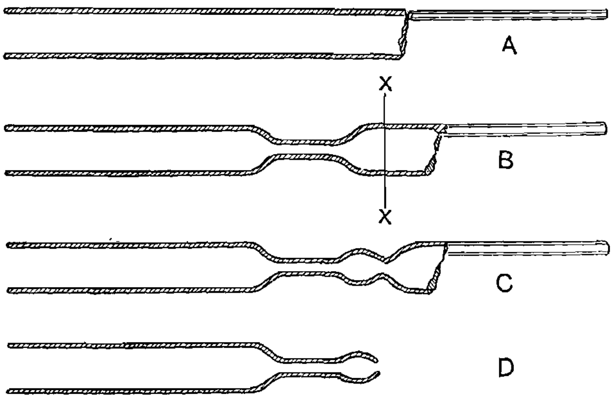


FIG. 55.

X—X) draw off a second constriction, and the tube takes the shape shown in Fig. 55, *C*.

(*d*) Cut off the tube at the second bulb and round off the edges.

(*e*) Anneal the tube carefully.

Note.—It often happens that the glass goes black when being worked in the flame. This is due to the fact that the lead in the glass has been partially reduced to the metallic state. I advise that the tube be left as it is. It does not look so pretty as clear glass, but it in no way impairs the efficiency of the burette. The blackness may often be removed by the application of an oxidising flame, but this method is not recommended for this kind of work, as it is found that the blackness is very hard to remove, and also that in a number of cases efforts to remove the blackness have resulted in the spoiling of an otherwise good piece of work.

Devitrification may set in. This may also be removed by heating the glass to a temperature above its crystallising point. The method is sometimes successful, and if the devitrification is caused by overheating the glass, it is very likely to be successful, but if the devitrification is due to the deterioration of the glass by age, anything made from that glass is likely to be brittle. The method is always worth a trial, however.

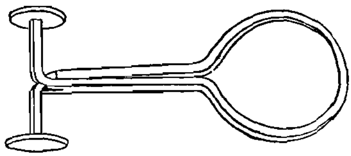


FIG. 56.—Mohr's Clip.

To finish off the tap, draw off a jet (§ 18) and fit it on to the end of the tube made on the burette. The flow of liquid is controlled by an ordinary metal pinch-cock (Fig. 56, Mohr's clip).

§ 43. **The "Bead" tap.**—Draw off a glass jet and round off the edges as described in § 18. Connect to the drawn off end of the burette by means of a suitable piece of rubber tubing.

Procure a piece of glass rod which is a fairly tight fit for the bore of the rubber tubing and cut off a piece about $\frac{1}{4}$ in. or $\frac{3}{16}$ in. long. Hold it in the tongs and heat in the Bunsen flame till all the edges are rounded off. It will now look  like this and constitutes the "bead" of the tap. Wet it and slip it into the rubber connection so

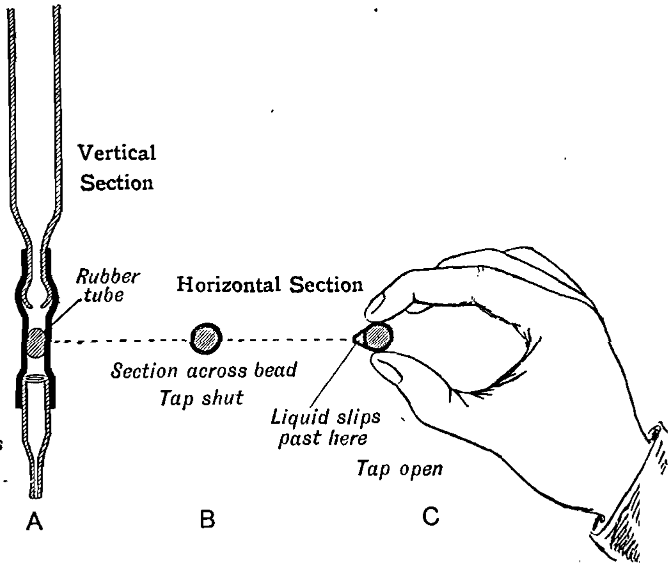


FIG. 57.

that it lies between the burette and the jet as shown in the sectional diagram (Fig. 57, *A*).

To use the tap, pinch the rubber connecting tube where the bead is and a little to the far side of the centre (Fig. 58), not at the extremities of a diameter. The rubber will bulge at that point and the liquid slips past the "bulge." With a little ›ractice perfect control of the tap :an be acquired, and it possesses :he advantages that (1) it is cheap, 2) it is efficient, (3) it is easily nade, (4) it cannot be left open, 5) it does not leak.

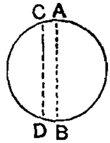


FIG. 58.—*AB* is a diameter. Pinch at *CD*.

§ 44. **To mend a broken measuring cylinder.**—Cut off he broken mouth. The string method is very ;ood. Heat first in the smoky flame, then in the

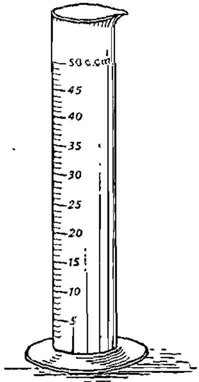


FIG. 59.

›rush flame, and press out a spout by means of a ıot iron rod. Do not forget to anneal the hot dges. This is worth doing, even when the cylinder s broken below where the graduations commence.

CHAPTER X

PIERCING AND WELDING GLASS. T- AND Y-TUBES. THE TEE TAP.

§ 45. **Bulb-tubes.**—Collect all short lengths of tubing which are left over when apparatus is being set up. Even pieces of only 2½ in. in length are of use. They may be made into bulb-tubes in performing preliminary dry tests in ordinary qualitative analysis. To do this, heat one end of the short tube in the small brush flame until it collapses. Remove it from the flame and gently blow into the tube. The end will swell out to a small bulb (see *G* and *H* in Fig. 63).

Keep a stock of the longer pieces of tubing, measuring about 6 to 8 in. in length, which accumulate owing to the breakage of apparatus. They should have both ends rounded off, and a number should be kept standing in water by the H_2S apparatus in every fume-closet. After use, the student should remove his dirty tube from the rubber connection on the Kipp and put it in another vessel, labelled " dirty tubes" and containing water. If the used tubes are kept wet they will be much more easily cleaned than if they are allowed to dry dirty.

§ 46. To weld together two tubes of equal diameter.—The process of joining two tubes together is called "welding" or "soldering." Only attempt to weld tubes made of the same material, *i.e.*, weld soda glass to soda glass and lead glass to lead glass.

Prepare a number of "stops." These consist of a short piece of rubber tubing which will slip over the end of the tube to be welded and of which one end has been closed by means of a piece of solid glass rod. Close one end of one of the tubes to be welded by means of a "stop" (*A*). Take the two tubes and, holding one in each hand, heat the open end of the closed tube and either end of the other simultaneously in a small brush flame (*B*). Keep the two tubes moving backwards and forwards and do not heat so much that the ends fall in. When the two ends commence to glow press them together so that they adhere along their entire circumference, and then gently pull and blow gently into the open end.

When pressing the tubes together do not press so hard that a thick bulging ring of glass is produced at the point of junction. The tube will present an appearance like that at *C*. This join is not strong and would probably crack on cooling. To complete the welding heat the joint again,—*a portion at a time* and with *the pointed flame.* When the portion being heated gets soft blow *gently* at the open end of the tube. Do this until you have gone all round the joint. There will be a slight bulge all round the joint when this part of the operation is complete (Fig. 60, *D*).

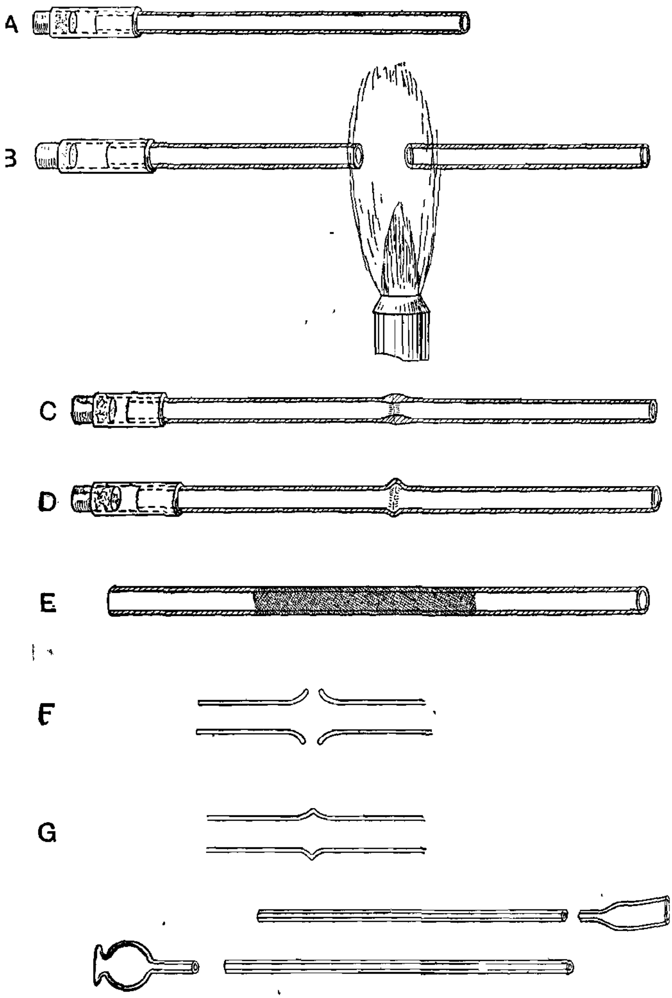


FIG. 60.

Increase the size of the flame a little and heat the whole joint while turning the tube until the glass is just soft all round. Now gently pull the tube till the diameter at the joint is about the same as that of the rest of the two tubes. *Do not forget to anneal the new joint very carefully* (*E*).

This method gives a good and trustworthy joint, but some workers prefer to widen out the ends of the two tubes before welding them. The method of widening the ends is given in § 48. Before joining, the appearance of the two tubes to be joined is shown at *F*. Just after joining the tubes appear as

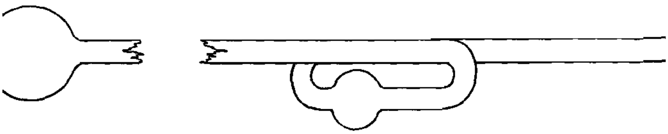


FIG. 61.—A new thistle funnel may be constructed from these two broken parts.

at *G* (Fig. 60). Heat each portion of the joint and complete the operation as described before.

Note 1.—Small tubes may be welded in the ordinary non-luminous Bunsen flame

Note 2.—If a very narrow bore tube is to be welded do not blow into it with the mouth. Use a small hand bellows such as is used in scent sprays. The moisture from the breath is liable to condense in, and congest the bore of a capillary tube.

A thistle funnel may be made from one the bulb of which is smashed and from another the bulb of which is unbroken, with a short length of tubing attached to it.

§ 47. To weld together tubes of different diameters.—*To make a pipette* from a piece of sufficiently wide tube and two pieces of glass tubing of the same kind.

1. Draw out the wide tube and see that the walls are fairly thick. Cut off the tube at the constriction at such a place that the diameter of the choked wide tube is equal to the diameter of the narrow tube

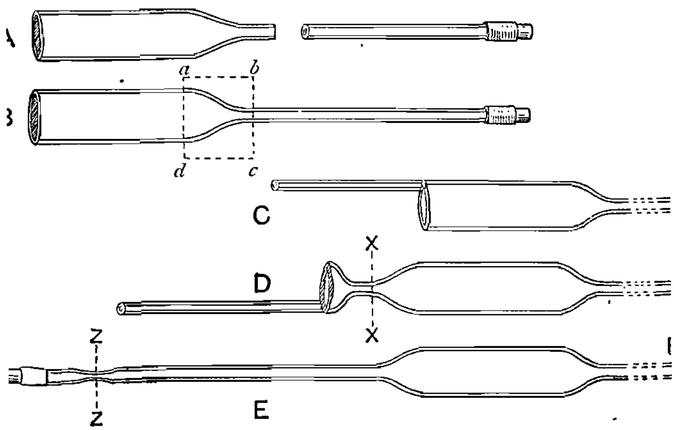


FIG. 62.

which has to be welded to it. This is shown diagrammatically in Fig. 62, *A*.

2. Put a "stop" on one end of the narrow tube and, following out the directions given in the preceding § 46, weld the two tubes together, blowing from the open end of the wider tube when necessary.

3. After the weld is completed heat, with constant movement, the area marked *a b c d*, and when the glass is just soft pull the two ends of the tube and

blow gently. The finished joint should have the gentle curves of Fig. 62, *C*.

4. Anneal this joint very carefully.

5. Weld a "handle" tube on to the wide open end of the wider tube. Fix the stop on to one end of the second length of narrow tube.

6. Draw out the wide tube as shown in Fig. 62, *D*, and cut it off at a point *X*—*X* in the constriction at which the diameter is equal to the diameter of the tube which has to be welded on at that place.

7. Weld on the second tube and finish off the joint as described in the former case. Blow when necessary from the end marked *F*.

8. Anneal the joint.

9. Draw out a jet as described in § 18 and cut off the stoppered portion at *Z*—*Z*. Round off the two openings, and the pipette is complete.

It may be graduated in the usual manner.

Note.—The description of all the stages of the operation have been given in which the edges of tubes have been cut square. If the worker finds it easier, the ends may be opened out as described in § 49 and the joints made as described there for T-tubes or Y-tubes.

§ **48. To pierce a glass tube.**—When a hole is made in the side of a tube or in a bulb, etc., the tube or bulb is said to have been "pierced" This process will be described in connection with the method of making a T-tube.

§ **49. To make a T-tube.**—See Fig. 63. Fit a stop on to one end of the tube to be pierced. Then, with a

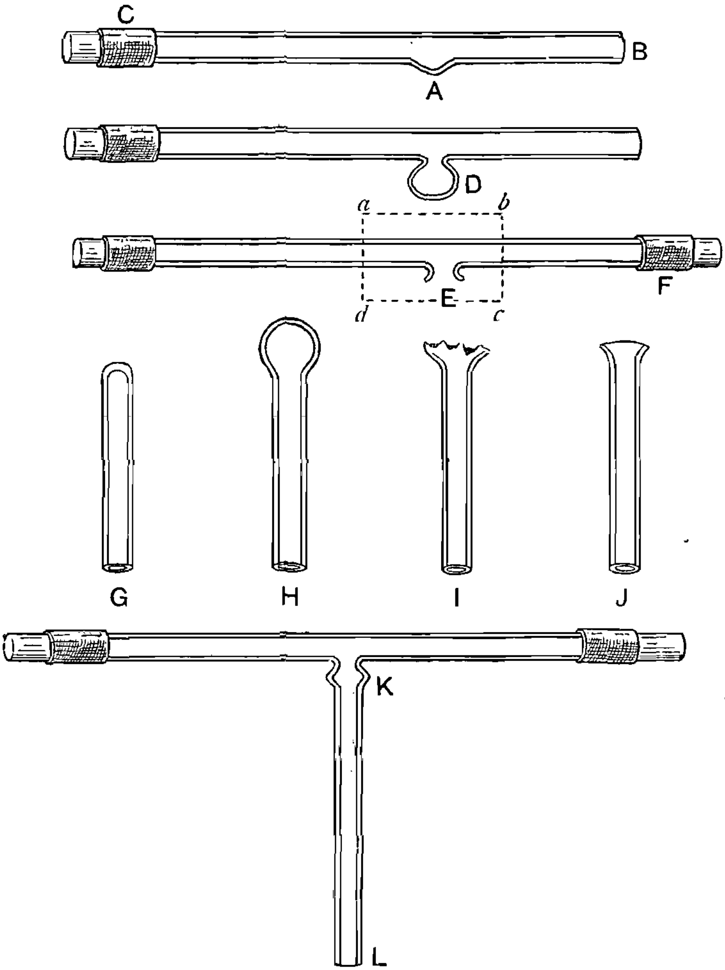


FIG. 63.—Stages in the making of a T-tube.

pointed flame, heat *one point* of the wall of the tube until the tip of the blowpipe flame is yellow. The glass at *A* is now soft. Blow gently from the end *B* and the tube at *A* begins to bulge.

Now heat again on the summit of the bump and blow again. The bump increases to a bulb of which the walls (except those near the tube) are thin. Break the outer part of the bulb and shape it off as shown at *E*. Before laying the tube aside heat it at *E* in the smoky flame. Now take a short length of tubing of the same kind and diameter and seal up the end by simply heating the end in the blowpipe or Bunsen flame. When the tube has just collapsed blow gently till a bulb, about the size of that shown

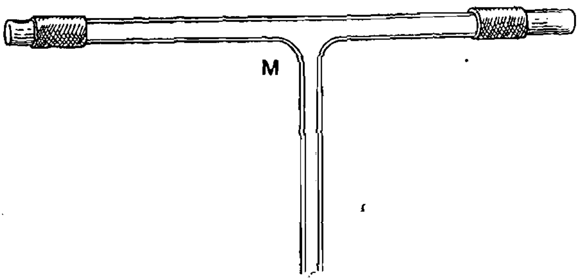


FIG. 64.—The completed T-tube.

at *H*, appears. Break the bulb and with a file shape the edges down as shown at *J*. Now put a second stop at *F* on the tube you have already pierced. *Give the pierced tube a preliminary warming up in the smoky flame*—this is most important. Gradually increase the temperature. When the small brush flame is working, heat the open mouths *E* and *J* simultaneously. When both are glowing press them together, and as soon as the two ends have "bitten" give the tubes a slight pull apart, and very gently blow into the tube at *L*. Now heat, in succession, each part of the joint at *K*, blowing at *L* as each successive point becomes soft. Then the appearance shown at *K* will more or less be produced. Now heat the joint as a whole in the brush flame till

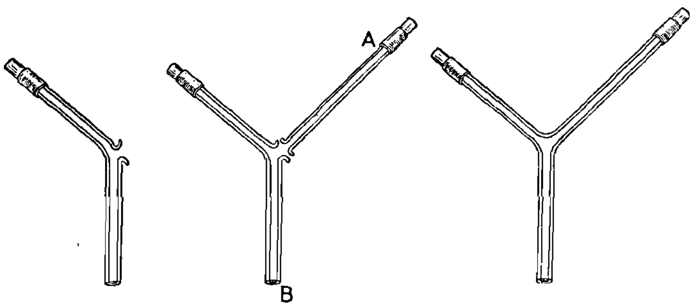


FIG. 65.—The completed Y-tube.

the glass is soft, and then remove from the flame and blow again. The joint should take on the appearance of *M* in Fig. 64.

Anneal the joint carefully in the smoky flame and allow it to finish cooling in cottonwool.

§ 50. To make a Y-tube.—The method used is the same as that employed in making a T-tube except that (1) the longer tube is bent first; (2) this tube is pierced on the outside of the bulge and the extra tube fastened on as shown in Fig. 65. It is optional whether one "stops" *A* or *B*.

§ 51. **The Bunsen valve.**—This valve is very useful in experiments in which gas is being evolved and in which it is desirable that the gas should get out, but that from outside no gas should be able to enter the apparatus. Such experiments are those in which iron has to be reduced before titration. It is desirable that hydrogen should be able to leave the apparatus, but detrimental that air should enter it.

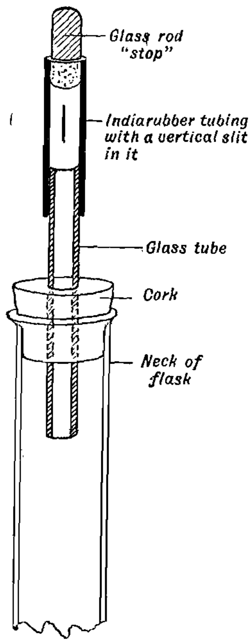
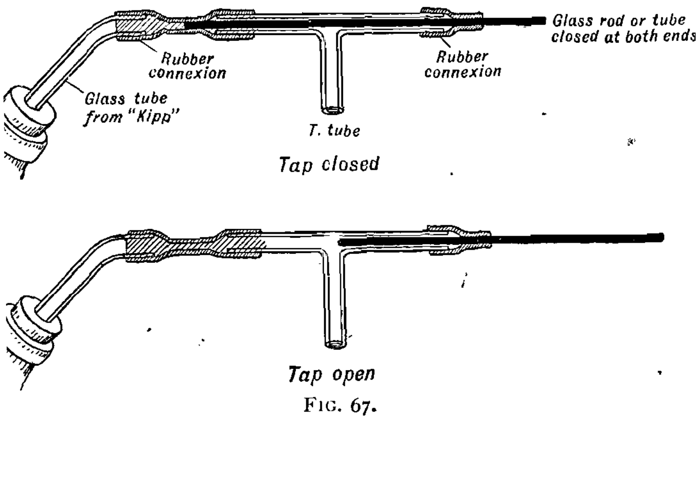


FIG. 66.

Take a piece of glass tubing and a piece of glass rod, both of the same diameter. If the necessary piece of rod cannot be found, the " stop " may be made by sealing a piece of the glass tubing and fitting that into the rubber tubing. Find a cork which fits the flask to be used. Soften it by rolling it under the foot. Bore a hole in it that will be a tight fit for the glass tube. Cut off a short length of the tube and round off both ends, also round off the edges of the glass rod stop. Cut a short slit in the length of the wall of a piece of rubber tubing that fits the glass tube and rod and fix the rubber tubing on to the end of the glass tube. Close the open end of the rubber tube with the glass rod and the valve is complete (see Fig. 66).

§ 51. **A. Tee Tap.**—This tap was devised to use with a sulphuretted hydrogen apparatus, and it worked very satisfactorily when in use in the B.A. class in chemistry. The structure can be best understood from the diagram. The T-tube is of the same diameter as the gas exit tube from the Kipp. The rubber tubing is a very tight fit for these tubes, but its internal diameter is just a trace less than the external diameter of the glass rod. The glass rod is well lubricated with glycerine or vaseline, and slips in and out of the rubber tubing without any effort. At the same time, when in the first position it provides an effective stop against the flow of gas. If desired, the rubber tubing may be wired on to the glass tubes, but in the taps used in this laboratory this was not found necessary.



Tap closed

Tap open

Fig. 67.

CHAPTER XI

OTHER APPARATUS IMPROVISED FROM OLD MATERIALS

§ 52. **Aspirators from old bottles.**—A Winchester quart bottle may be made into an aspirator by boring a hole near its base by means of an iron file as described in § 10. It is difficult to start the hole, as the file skids about over the round surface of the bottle. In order to hold the file till the surface of the glass will hold the point of the borer, take a piece of the ordinary iron band that is used round packing cases and punch a hole in it sufficiently large to allow the file to pass through it. Trim off the edges of the hole with a file. Bend the band of iron round the bottle and, by holding the iron band and boring through the hole in the iron, the perforation in the side of the bottle may be started. When the erosion is started the band may be removed.

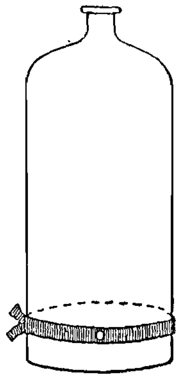


FIG. 68.—Boring a hole in the wall of a "Winchester quart."

A simpler method is to stick a fairly thick paper label on the glass at the point where it is desired to bore the hole. The hole is bored *through* the paper and the paper holds the borer sufficiently long for the latter to attack the glass.

Use T. C. solution as lubricant for the borer. Enlarge the hole as much as is necessary for the insertion of a cork or rubber bung fitted with a tube.

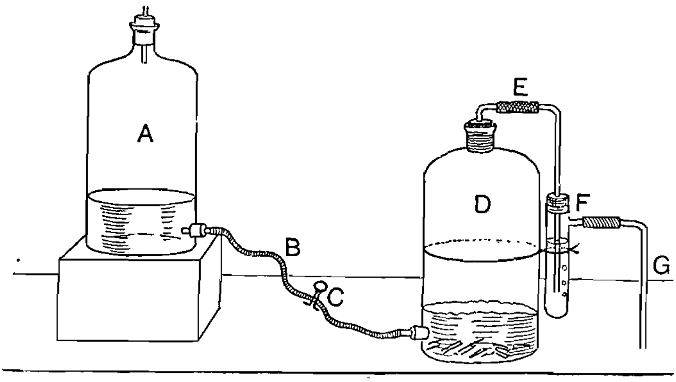


FIG. 69.

This is a good use for Winchester quarts of which the stoppers have become corroded into their seating or of which the neck has in any way got broken.

§ 53. An apparatus for obtaining a constant supply of gases, such as hydrogen, sulphuretted hydrogen, or carbon dioxide, may be made up of old material. The parts will be understood from Fig. 69.

A is a bottle perforated at the base and fitted with a glass tube. It is shown with a cork in the neck. This is unnecessary, and a bottle with a broken neck does adequately.

B, Rubber tubing.

C, Mohr's clip (see Fig. 56), to prevent acid running from *A* to *D* when the apparatus is out of action for some time.

D, Bottle perforated at the base, as *A*. The neck of this bottle should be sound.

E, Connecting tube fitted with either a bead tap or with a pinch-cock. The Bead cock tap is recommended as the gas cannot be left "on."

F, Scrubbing tube made from a broken calcium chloride tube or from the neck of a broken distillation flask by the method described in § 34, *B*.

G, Delivery tube for gas.

Note.—The tap is placed at *E* because it is found by experience that it is most efficient there, and also on account of the fragility of the scrubbing tube. If the tap is placed at *E*, there are the fewest possible places on the supply side of the tap at which leakage can occur. Moreover, if the scrubber gets broken the gas cannot run to waste.

The importance of having a scrubbing apparatus for a sulphuretted hydrogen supply cannot be overestimated.

Hydrogen produced by the action of sulphuric acid on zinc always contains sulphur gases as impurities. These may be washed out by filling the scrubber with some absorbent material.

§ 54. The renovation of broken "Kipps."—A Kipps apparatus is an expensive article, and it frequently occurs that parts of the apparatus get damaged and a number of portions of different partly broken

Kipps are lying about the stock room. An attempt will be made to give some suggestions for the utilisation of these parts.

Most frequently the upper portion gets broken by the laboratory assistant when withdrawing it for cleaning purposes, and the usual break is shown in Fig. 70 at *X—X*.

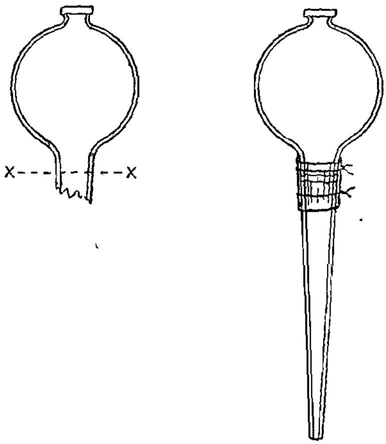


FIG. 70.—To repair the upper portion of a "Kipps" from the broken portion and a broken retort.

Cut off the jagged edges at *X—X*.

Take the neck of a broken retort. Cut off as shown in Fig. 53 (*a*), *A—B*. Connect the two tubes by a piece of wide rubber tubing and bind them on by means of copper wire. Several apparatus so renovated have been in constant use for nearly a year. If you have a large-sized base portion and a small upper portion, fit the upper portion into the collar of the lower portion by passing it through a cork which fits the collar. Smear the cork over with the linseed oil-soap preparation described under lubricants (Chapter I).

If the tubulures get broken, the damage is usually fatal. Repairs can sometimes be made by cutting round the hole by the hot rod method or by filing it to shape, fitting the enlarged hole with a cork, and finishing off the repair with a liberal smearing of linseed oil-soap "stopping." It possesses putty-like properties and does not dry quickly.

The vaseline-paraffin lubricant is recommended for Kipps. It frequently happens that the gas escapes through the collar between the upper and lower portions of the apparatus when vaseline alone is used.

§ 55. **Damaged aspirators** may be adapted to various uses, depending upon where the breakage has taken place.

These break chiefly at the tubulure owing to the taps being knocked. It is sometime possible to effect a repair by cutting out the tap by the hot rod method and then filing down the hole so made with an ordinary file and T. C. solution. The hole can be fitted with a cork in which a glass tube is fitted.

If the tubulure is badly broken and, as frequently happens, the break is complicated by radiating cracks round the hole, it is practically useless trying to mend the hole. Lead one of the cracks off and cut completely round the aspirator. The rough edges may be rounded off and a large bell jar will be formed.

If the upper portion of the aspirator is broken, cut it off and use the lower portion as a pneumatic trough with a hole.

The lower portions of wide bottles are very useful as small pneumatic troughs or as dishes for various purposes. If the bottom of a bottle is broken it may be cut off and the upper portion of the bottle used as a small bell jar or as a cover for protecting small specimens from dust, etc.

§ 56. **Liebig's condensers** made of glass frequently get broken. The commonest fractures are shown in Fig. 71.

1. The inner tube may be broken at the narrowed point *DE* (Fig. 71). This is easily remedied by drawing off the tube by the methods already given (§ 28).

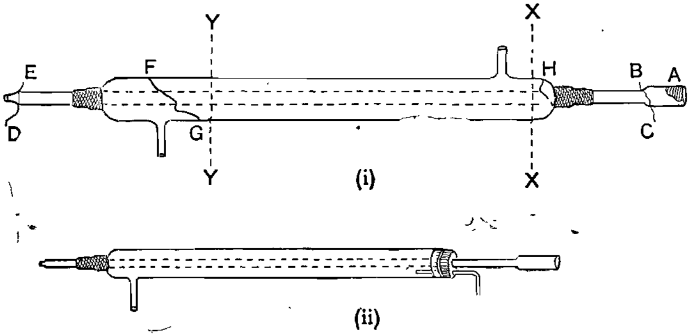


FIG. 71.—To repair broken condensers.

2. The inner tube may be broken at *A*. Cut off the damaged portion (§ 8) and border the edges (§ 30).

3. The inner tube is broken at *BC*. Cut off the tube below the break (§ 8). Take a boiling-tube and choke its diameter to the diameter of the condenser tube and join the boiling-tube to the inner tube of the condenser (§ 47). Anneal the joint carefully.

4. The outer jacket is broken above the side tube—at *H*. Cut off the jacket at *X*—*X* and border

the edge. Fit the end with a cork and pass the inner tube through it.

5. The outer jacket is broken above the side tube at *FG*. Cut off the outer jacket at *Y*—*Y*. Border the edges and fit it with a cork bored with two holes—one for the inner tube and one for the water exit tube, as shown in Fig. 71 (ii).

§ 57. A cheap form of desiccator.—The form of the apparatus is seen from Fig. 72.

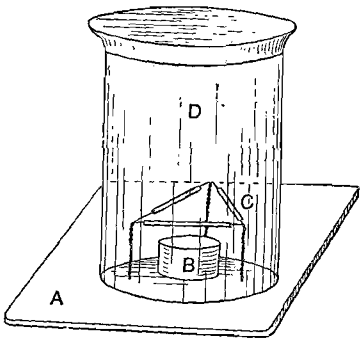


FIG. 72.—Desiccator.

The methods of making the parts will be found in preceding paragraphs.

A is a square of glass or a porcelain tile glazed or a piece of slate or marble ground level and true.

B is a small vessel which contains calcium chloride. It may be made in one of the following ways:

(i) A boiling-tube, flattened at the bottom, about 1 in. high.

(ii) A small bottle cut off about 1 in. above the bottom.

(iii) A portion of the neck of a broken flask cut off and ground true on the slate slab. It is fastened to the glass or porcelain, etc., by means of Canada balsam.

C. A porcelain triangle with the legs bent vertically downwards. This may be made from iron wire and short lengths of glass tubing as described in § 58. The glass apparatus made from a broken beaker and described in § 40 (Fig. 52, *H*) may be used.

D. The bottom portion of a broken gas cylinder of suitable diameter, cut off and ground true, or the upper half of a bottle of which the stopper has stuck or the lower portion become damaged. This is caused to give an air-tight contact with the plate by means of vaseline-paraffin mixture.

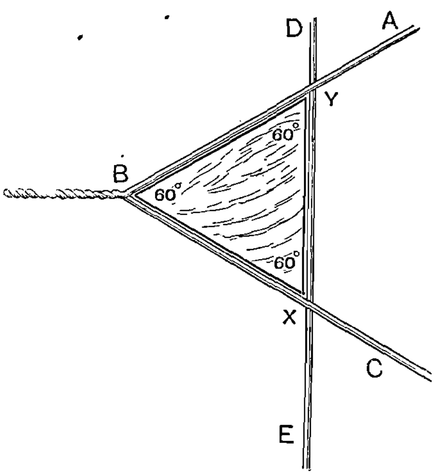


FIG. 73.

§ 58. To make the triangular crucible support from iron wire.—Take two strands of the wire and carefully twist them together. Between the legs of the V-shaped opening *A B C* (Fig. 73) insert a wooden prism of which the cross-section is an equilateral triangle and press the wires along two of its sides. Along the third side place the third strand of wire so that it lies below both *AB* and *BC*. Now simultaneously twist *D* upwards and *A* downwards with one hand or with a pair of pliers, and with the other hand twist *E* upwards and *C* downwards. After the first turn has been made the other bindings can easily be completed as shown at *B*. Remove the prism and bend the legs vertically downwards at *B X Y* and cut them off with the pliers until the triangle stands level.

If desired, glass tubing may be slipped on the wires between *BY*, *YX*, and *XB* before the third strand of wire is twisted into position.

§ 59. **Tripod stands** may also be made from iron wire. Three lengths of iron wire each 18 in. long of $\frac{1}{6}$ in. to $\frac{1}{8}$ in. diameter are cut off. Each of them is bent twice at right angles at the points marked *B* and *C*, so that the wire all lies in the same plane. The long portions of the bends are then wired together by thin iron wire and a stand like that shown in Fig. 74 results. It is strong and steady and cheap.

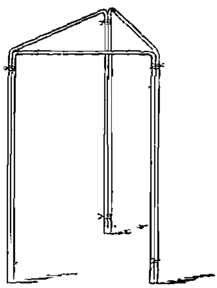


FIG. 74.

Other pieces of iron apparatus may often be made locally, *e.g.*, filter dryers, sand-baths, etc. For some time I used an old kerosene tin laid on its side on bricks as an air-oven. Inside was slipped a piece of tinned iron bent into the shape shown in Fig. 77. On the floor of the oven was a little sand and the top was perforated for the introduction of a thermometer. The "door" consisted of a lid made of a sheet of tin cut thus and bent along the dotted lines (Fig. 76) at right angles.

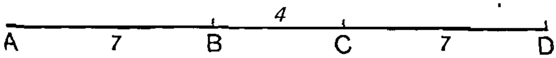


FIG. 75.

A is the kerosene tin with a perforation at *B* for the insertion of a thermometer. *C* represents the support for funnels put in the apparatus to dry. Sand was spread at *D*.

The burners were placed between the two rows of supporting bricks.

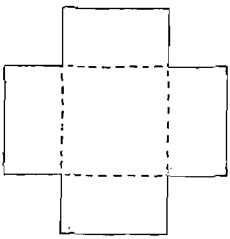


FIG. 76.

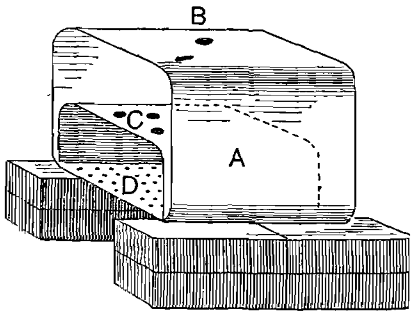


FIG. 77.—Air-oven.

§ 60. **Conclusion.**—The object of the preceding chapters has been to show how broken articles may often be mended or modified and put to a useful purpose. Expensive glassware is often employed when cheaper and less perishable articles would be equally efficient; *e.g.*, in volumetric analysis, when titrations have to be done in the cold, teacups with plain white interiors are excellent—hard to break and easy to wash. In making chemical preparations, etc., small enamelled bowls form an effective substitute for beakers and flasks. These are only two examples of the replacement of easily procurable and cheap apparatus for glassware, and many other possibilities will occur to the practical teacher.

INDEX

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