GLUES AND CEMENTS.

Glues and Cements.

A HANDBOOK ON ADHESIVES AND FILLINGS FOR WORKSHOP USE.

By

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PREFACE.

IN placing this handbook before the reader, the author has endeavoured to supply a want which he felt keenly in his more inexperienced days—namely, for a collection in one volume of recipes for adhesives and cements suitable for every-day workshop operations, many of which he could only get at by searching through a mass of miscellaneous publications. The book has been made as complete and as representative as possible, and the reader who masters all that it contains may almost call himself an expert, and will, indeed, be in a better position as regards general workshop knowledge than the majority of professional mechanics who have kept in the same groove since their apprenticeship.

H. J. S. C.

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CHAPTER I.

INTRODUCTORY.

THE art of joining together two or more articles by means of adhesives is one in which there is a great deal more than is generally supposed, both in the matter of compounding the substances and in using them. Adhesives or cements—for they are not necessarily the same—are used in almost every trade, but the most generally known are those employed by the carpenter and joiner and the builder. The one uses glue and the other mortar or cement, and these two substances are about the best examples that can be taken to illustrate the difference in the two words, although as a rule they are used indiscriminately.

Both the carpenter and the builder, however, use many different kinds of adhesives and cements, although the two mentioned above are generally all that the "man in the street" knows anything about, and it is very little knowledge indeed that he has even of them. In fact, he knows so little that, in most cases, he would be better without that knowledge, for he uses it and so does some botching which would far better be left undone.

The china and glass mender and riveter knows not the glue-pot in connection with his trade; he only knows his special adhesive—cement he calls it—and very possibly he uses a compound of his own preparation, the recipe for which he keeps to himself. The plumber, again, has cements as well as adhesives special to his trade, and the bookbinder, paper-hanger, and electrician use between them dozens of glues and cements for various purposes. The list could be extended to a great length, for a trade in which adhesives or cements are not used is the exception. Consequently there are to-day some two hundred or more different kinds of these commodities, for those used in one trade or for one class of article are often not fit for any other. The so-called "universal" cements therefore are misnomers. They are not cements, but merely adhesives, and would be useless to the electrician or to the carpenter; while the pipe-fitter and the paper-hanger or bookbinder would not know what to do with them.

Cements and adhesives are of many different classes. First, there are those which are always ready for use, and which need no preparation of any kind. Such are the "liquid glues," ordinary office gum, the pastes, &c. The second class takes in those kinds which are ready so far as mixing is concerned, but require some preparation such as heating before they are soft enough to use, and of this class the most representative variety is common glue. A third section comprises those which need some liquid added to the stock of compound to fit them for use, and a fourth includes those which require to be made up entirely every time one of the class is needed. Of all these there are many varieties, applicable to different conditions and substances, and most of them are further divisible into adhesives and cements.

Broadly speaking, the difference between an adhesive, or glue, and a cement is this: An adhesive is for use when the surfaces to be joined coincide more or less exactly, and consequently such surfaces hold together almost directly. A cement, however, is for use where there are irregularities in the surfaces which are to be joined, and these must be filled with the joining medium, which holds on to itself as much as to the surfaces being fixed. A cement, in fact, first makes a surface by filling up irregularities, and then acts as an adhesive.

Thus, in joining porcelain which is newly broken but unchipped, and in which therefore the two surfaces, although irregular, coincide exactly, the best job will be made where there is as little glue as possible used, for the closer the broken edges are together the better they will hold. The cement or mortar which is used for a wall, however, has first to fill up all the irregularities and holes in the bricks, for such irregularities are not coincident, and the wall holds together not because one brick holds to the next, but because it has had attached to it a coinciding surface of cement in the first place, and the brick under it has received the same, so that it is the brick and its layer of cement which hold to the next layer of cement and its brick. It will be obvious, therefore, that such a cement when set should be as strong as the substance joined. Although this is not recognised in the practice at least of the present day, whatever it may be in theory, yet both practically and theoretically was it carried out by the builders of olden times. They made their mortar so much stronger than we do now that in many old buildings we can see that the bricks have decayed through the action of time and weather, leaving the still intact mortar standing out like a grid.

But the scientific method of classifying adhesives and cements should be in accordance with their mechanical actions. Their setting depends upon various causes, and if these are not present they cannot set, but will remain liquid or soft for ever. This is an extremely important point, because although a particular adhesive or cement may be the very thing when applied to two substances under some conditions, it would be quite useless under others, because the special conditions under which it hardens will not be present. For instance, ordinary glue will stick tightly on most metals if they are chemically clean. But its mechanical action—

that is, the method by which it sets—depends mainly upon evaporation of the water contained in the glue. If, therefore, we attempted to glue together two pieces of metal with this adhesive, only the edges where the air could get at it would dry—the central part could never evaporate, for the metal is non-absorbent, and as the glue at the edges would become hard first the water could not get away between them.

This is merely an example of our point that the methods of setting of various adhesives have to be taken into account when using them. As this book is not merely a string of recipes of glues and cements, we shall mention the various mechanical actions upon which such substances depend for their efficiency, for the reader, if he can master those principles, will be able to compound his own cements to suit any thing or any combination, whereas it would be all but impossible to give every glue and every cement which can be made and which can be applied to every condition.

The most ordinary method by which an adhesive hardens is, of course, by evaporation. Of such adhesives glue is the commonest, and the sticking agents compounded of spirits and resins act in the same way. A second method is by cooling. Typical examples of this are sealing-wax, the marine glues, pitch, &c. Thirdly, there are those which depend upon absorption of something from the air. Common mortar is amongst these. Its action is purely chemical, and it depends upon absorbing from the atmosphere carbonic acid gas. Others depend upon taking oxygen from the air, and thus oxidising themselves into a different substance which is hard and tenacious. White lead is such a cement, the linseed oil in this instance being the medium which changes by oxidation into a hard substance (very much akin to indiarubber from a chemical point of view) that binds the particles of the white lead together. Then again, there are cements which depend upon absorbing water from the atmosphere instead of giving it out by evaporation; others are mixed with water and combine with it, changing their structure in the process, *e.g.*, Parian cement and plaster of

Paris; and there are yet others the ingredients of which combine together to form something different without any help from the air, or the water, or the carbonic acid gas therein contained. It is important to take the above points into account when joining things by adhesives, and it is for this reason that the subject has been somewhat enlarged upon.

CHAPTER II.

COMMON GLUE, ITS MANUFACTURE AND USE.

Of all the adhesives in existence there is probably not one which is so well known—by name at least—as glue. "Glue" means to almost everybody who speaks English the dark brown stuff that is boiled up in a water-jacket and used to stick things with, and so we shall begin with it. As it is the best known, so is it also that of which there is least known, simply because so many people have knowledge of the broad fact that it *is*, and that it is made by melting the buyable solid in hot water, but have no real knowledge of the details of its manufacture nor of those appertaining to its use.

The joiner uses three different kinds of glue—cheap French, best Scotch, and Salisbury glue. Of these the first two are used for work in which the joint is invisible or the wood is dark so that the glue does not show up, or when it does not matter whether or not it does show; and the reason why French glue is used in preference to Scotch is its greater cheapness, for the former can be got for about 4½d., whilst the latter costs 7½d. per pound to the tradesman, and more to the retail buyer. The third kind, Salisbury glue (which, by the bye, is mostly made at Stratford-le-Bow and in its neighbourhood), is nearly colourless, and is therefore used for joining up white woods in those cases where it is desirable that the joint should be invisible—for instance, the sounding-boards of pianos. This glue can also be used considerably thinner than the other kinds, and it therefore makes a sounder joint and goes further.

The amateur uses a glue of a kind also, and its basis is one of the three mentioned above, but it stops there. As a rule, there is not a single thing, from the initial chopping up of the original glue to the using thereof, which he does as it should be done. Consequently the work glued with this amateur mixture holds together a few weeks only—a few months if he is lucky.

The chief things which are necessary for the proper holding of a glued joint are (1) fit, (2) freshly-heated, properly-prepared glue, and (3) freedom of the surfaces from grease; but the first item is the most important. The fit of the two surfaces to be joined must be as carefully made as if they were an engine job in metal, for glue is an adhesive, not a cement (the difference between the two has been explained in Chapter I.). It is on account of the perfect fitting together of the parts quite as much as through using good glue and well-seasoned wood that the joints effected by the celebrated furniture makers of the eighteenth century are often as sound now as when they were turned out of the factory; in many cases, in fact, it would be easier to break the wood than the joint.

The proper preparation of the glue is almost as important, and so is its freshness. Glue which has been re-heated loses its strength and is useless so far as permanent joints are concerned.

The third point, as stated above, is that the surfaces to be glued must be free from grease, which is one of the greatest enemies to glue. Even touching them with a moist hand will affect the hold of the adhesive on the wood, so that after the final papering up touching should be avoided. In the case of very porous woods, the surfaces should be filled so as to enable the glue to get a proper hold, or "key" as it is termed, and we have known ultra-careful joiners of the old school to varnish a joint and rub it down smooth before glueing-up.

The above are the chief points requisite for permanency in a glued joint. There are various minor details which should be looked to as well—such as being sure that there are no chips or other dirt either in the glue or lying loose on the surfaces to be joined; that the pieces when glued are so fixed together by means of clamps or otherwise that they cannot come apart before the glue is set; and that the glue is not chilled by its application to the work.

We will take the scientific preparation of glue to begin with, premising that the process is the same for French and Scotch, and similar for Salisbury, save for the leaving out of one ingredient.

The price of best Scotch glue is from 7½d. to 8½d. per pound, French can be got for 4½d. to 5½d., and Salisbury for 8½d. to 10d. When buying glue go to a place where there is a big trade done. It will then not be likely that the stuff sold has been in stock for years; for glue even in the solid does not improve by keeping, especially if exposed to the air or to damp.

Break up this glue into pieces about half an inch cube. The best way to do this is with the household coke-crusher, but of course this instrument must be very carefully dusted down first. Failing a coke-crusher, it can be very easily broken between two thin sheets of iron or tin—preferably the latter—the bottom one of which rests on a good solid surface, such as a stone floor, and has its edges turned up all round. The blow of the hammer is transmitted through the plate, and breaks the glue up very nicely, but, of course, the plates are spoilt in the process. If this is not convenient, use a cold chisel and a hammer on a metal surface. The way *not* to do it is the way that it generally is done, and that is between newspapers or dusters. This is bound to fill the glue with bits of fluff or undesirable odds and ends of literature, which are not always easy to get out by washing, as the bits are driven into the surface of the glue.

Having broken up the glue, put it into a large dish and flood it with water, keeping it in constant agitation for a while, in order to get any foreign matter to rise to the surface so that it can be skimmed off. When clean keep the glue flooded, and let it remain so for six hours. At the end of this time drain off all the water through a sieve or a colander, and replace it by a 10 per cent. solution of bichromate of potash, leaving this to soak for another six hours in a dark place. The jelly so made must not be exposed to the light again for more than a few seconds at a time, unless it is to a red light, which does not matter.

When the second soaking is finished strain away all the bichromate liquor (this, by the way, need not be thrown away, but can be kept for a subsequent occasion, but in a coloured bottle), and put the jelly into a large tin which is capable of being closed air-tight. Many of the tins in which tobacco is sold are quite suitable for this. The ideal tin would be one which is about half as deep as it is wide, because its contents can be easily got at; but these are rare. Lyell's golden syrup tins come nearest the ideal, and are, besides, constructed to hold liquid, which tobacco tins are not. Long narrow tins should be avoided, for not only are their contents difficult to get at, but they are not easy to boil up in any ordinary household saucepan.

The object of keeping the light away from glue which is made up with bichromate of potash solution is to prevent it from becoming insoluble before its time. The action of white light on this substance when mixed with a gelatinous medium is to render it insoluble in water, and therefore bichromate glue is waterproof. If the preparation were carried on in the full light of day, the resulting glue would not be properly dissolved in the water, but would be in suspension therein, which is not at all the same thing.

All the glue jelly should be dumped into the tin, and the quantity should be calculated out in such a way that the tin is just full when the stuff is all melted. By this means air will be better kept from it. Before boiling up add a teaspoonful of boracic acid to the pound of original glue, and in addition about thirty drops of tincture of capsicum. In the absence of the tincture a few chillies or capsicums put up in a little linen bag and boiled up with the glue will have the same effect. The object of these extra ingredients is to prevent all chance of the glue going mouldy or decomposing, which it might do if such precautions were not taken.

The glue, of course, is not boiled direct, but in a water-jacket. The tin containing the jelly is placed in a large saucepan full of cold water, brought to the boil, and kept boiling for about two minutes after all the glue has melted. A glass or clean metal rod should be used for stirring, not a piece of stick, and about three minutes after the tin has been taken out of the boiling water a few drops of oil of cloves should be added. This is a further precaution against mould, and besides, it reduces the somewhat disagreeable smell of the glue. The finished hot glue when still on the fire should be about as liquid as treacle in moderate weather.

During the whole operation of heating keep the light away from the tin—daylight, that is, for the red glare of the fire does not affect it. Take out the bag of capsicums or chillies (if they have been used) whilst the glue is on the fire, and do not boil the oil of cloves with the glue, or it will all evaporate. Stand the tin with the lid off in a dark, cool place—the larder, for instance—and when quite cold cover up tightly.

Glue made from this stock has the following properties which ordinary glue, even when properly made, does not possess. First it is water and damp proof, and will hold against paraffin; secondly, it will not go mouldy; thirdly, it holds about twice as strongly as anything else when properly used, and is suitable for holding on many surfaces to which ordinary glue will not adhere.

But glue must be used properly to ensure good results, and the proper way to use it is as follows. Have a *small*, clean glue-pot, which can be bought for about ninepence—the smallest size made will do, for reasons which will be apparent presently. Get a penny paint brush, and prepare it by binding the hairs tightly with string, so as to leave only about ¾in. of hair free. When glue is wanted gouge out of the stock pot with a spoon just enough for the job in hand, and do this as quickly as may be in as dark a place as possible, keeping the lid of the stock-pot off no longer than can be helped. See that the clamps for holding the work are quite ready to hand; these should, in fact, be fitted first and the whole work clamped up as if it were already glued, so that they can be put on again without a moment's waste of time when the glueing is done.

Have the water in the outer pot nearly boiling before you put the stock in, and as soon as it is actually boiling use the glue. Let the work be as close as possible to the fire where the glue is being heated, for the hotter the latter is the better it will be, and every foot makes a difference. If possible have a gas burner connected with a tube to the gas terminal under the pot, and have the pot on the bench so that the glue can be used actually boiling.

Warm the surfaces to be glued, which should have been "filled," but do not make them hot—just warm enough to prevent the chilling of the glue when it is applied. Work as quickly as possible, glueing all the surfaces which are to come in contact, and working the glue well over as if it were paint, but without frothing it up. Clamp quickly, and allow at least two hours and a half to dry.

This setting time, by the way, is a matter of judgment and material. If the wood is very porous or soft—such as deal—the joint will set much more quickly than it will with hard, compact wood, such as oak or teak; because as glue is one of those adhesives that set by evaporation, the soft woods can absorb the water out of it much more quickly than hard, close-grained material.

There is sure to be a little glue squeezed out of the joints unless the fitting is exceedingly bad, and this should be wiped or scraped off within a few minutes of clamping together if it can be got at without disturbing anything. It will be found that this saves a lot of trouble later on, for hardened glue is sometimes very difficult to get off, and will chip bits out of the chisel used for the purpose.

Should there be any glue left in the pot when the job is done throw it away, as it will be useless—it is for this reason that we recommended a small pot. Use the warm water in the outer pot first to wash out the brush and then to clean out the pot itself, and dry both the inner and outer pots. They will then be quite ready when needed for use again, and if kept upside down on a shelf will need no dusting before use.

Salisbury glue is prepared in exactly the same way as that detailed above, except that the bichromate solution is left out. It is therefore soaked in plain water for twelve hours instead of six, and the resulting jelly is not so carefully drained off, for the glue should be thinner.

The primary reason for using Salisbury glue is that it is colourless, or nearly so, and therefore we cannot put in a strong colouring agent such as bichromate of potash. Salisbury glue, therefore, will be minus one of the qualities which belong to ordinary glue; that is, it will not be waterproof. On the other hand, as it can be used considerably thinner than the other kind, we add about one-quarter its weight of warm water to the jelly when it is being boiled up.

The foregoing may seem to be very lengthy instructions for such a simple matter as that of glueing. But it is precisely this minuteness of detail which is lacking in the average amateur-glued joint, and which makes it a failure. As a matter of practice, it does not take two minutes longer to prepare in this way than it would if it were made in the usual manner. It only needs a little more care, and that is fully compensated for by the results.

CHAPTER III.

PREPARATION OF SURFACES FOR GLUEING—CLAMPING.

THE preparation of surfaces which have to be glued is a matter which is even more important than the actual making of the glue, for a well-fitted, properly-prepared joint made with inferior glue will be much better as regards holding power than one badly fitted, even if the glue used is everything to be desired. Not one amateur in a thousand attends to the surfaces which are to come into contact, and few attend properly to clamping. The result is that joints set in an improper manner, owing to bad clamping, or do not set at all, owing to non-preparation of the surfaces. In this chapter we propose to deal with these two subjects.

To begin with surface preparation. The joiner who knows his business will always coat over the surfaces which are to be in contact with strong double size if they are in soft or porous woods, such as deal or mahogany and walnut, which latter, though they are not particularly soft, are very porous, and he uses this size almost boiling. By this means the pores in the wood are filled up so that the glue has a "key." Ordinary glue would be too thick to penetrate the pores, so that if size were not used there would be thousands of minute spots where there was no hold at all. Some joiners first give the surfaces to be glued a coat of whitewash which has been well sized, using it hot, and then rub it well down with sandpaper, repeating the treatment two or three times, especially if the surface is on the end of the grain. Others rub chalk over; but this is an example of knowing only half of the subject. The pores are filled with the chalk certainly, but it is not fixed therein, and so this method is not only useless so far as making a key is concerned, but it actually prevents the glue from taking a hold. It is, in fact, one of the best things

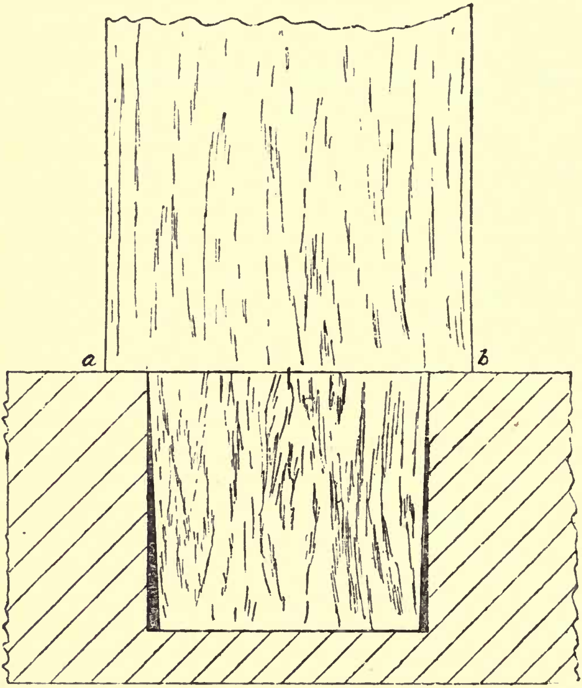

Fig. 1. Example of badly-fitted Mortise Joint, which has no strength.

to prevent it, and is the same in principle as the flouring-over of her pastry-board by the cook to prevent the paste which she is rolling out on it from sticking.

Ordinary coach varnish makes the very best preparation for a surface which is to be glued, though, of course, it requires time to dry. It penetrates well into the wood, especially when used hot or rather warm, and is an adhesive of no mean strength in itself. For such a thing as preparing a surface it cannot be beaten if time is no object, for two pieces can be glued end grain on, if brought to a perfect fit and dressed with varnish first, so as to be almost as strong as a solid piece, provided, of course, that the glue is first-class and the glueing properly done.

As observed above, the fit of a glued joint is a very important factor in its holding power. By a " fit " is meant that the pieces should touch each other all over, not merely at one or two spots. For instance, it is quite an ordinary practice with carpenters, both amateur and professional, to make a mortise joint as shown in Fig. 1. The fit along the line *a b* will be perfect, and it may be tight in the mortise for perhaps half an inch. But the rest will be taper as

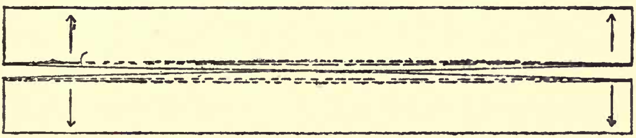

Fig. 2. Boards badly "shot," with convex edges (exaggerated).

shown, and there will be quite an appreciable space between the tongue and the sides of the mortise, which would be occupied by air only. The idea of making a joint like this is that it can be driven up quite tight and solid to all appearances, and it saves careful work and consequently time. But all wood is liable to shrink, and the least shrinkage in such a case as this would loosen the joint. Even under the best conditions of glue and glueing, this joint as shown in Fig. 1 could not hold so well as one properly made where the pin fitted the socket all over and was only held by office gum.

In straining two boards together edge to edge there is a lot left to be desired in the amateur's work, for he mostly joins them with their convex edges together, as shown in Fig. 2, which is, of course, exaggerated. This is due to bad planing on his part, for the amateur worker in wood for some reason or another does not think it necessary to learn how to shoot a board true at the edge, or to shoot it square either for that matter. The mistake, if one is allowable, should be in the other direction—that is, the edges should be slightly concave, as shown by the dotted concave lines, the straight ones representing the boundary of the boards, because the warping, if any should take place, as is probable, will be outwards in the direction of the arrows, so that the tendency of the edges will be to straighten themselves. In glueing a couple of edges such as this together they must, of

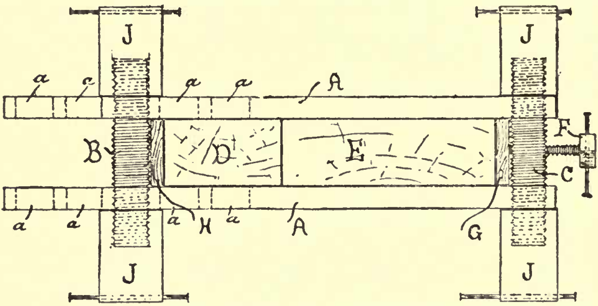

Fig. 3. Edge view of Adjustable Clamp for holding flat glued work, made from iron bar and pipe fittings.

course, be clamped, and tightly, and this brings us to another branch of glueing—and a most important one.

There are naturally many different forms of clamps, for there is a very wide range of shapes to be considered.

Let us begin with the example illustrated in Fig. 2, that of two planks, the shot edges of which are to be glued together. Now for this purpose the wood must be held in two directions. In order that the joint may be made secure pressure must be applied along the two edges opposite to those being glued, and in a direction vertical to the glued joint. But if the planks are thin and wide, pressure applied to the edges is bound to cockle up the wood in the centre, and this will, of course, open the joint. It will therefore be necessary to hold the planks firmly together parallel with their surfaces in addition to pressing them together.

A very simple clamp for this purpose can be made from two bars and some big bolts, and of this Figs. 3 and 4 show an edge view and one from the top. A, A, are two flat bars of iron, say 2in. wide and ⅜in. thick by about 24in. long, so that they will do for a couple of 11in. planks. Each of these is furnished with several holes (*a*, *a*, *a*, *a*) at one end which are central and coincident in the two pieces,

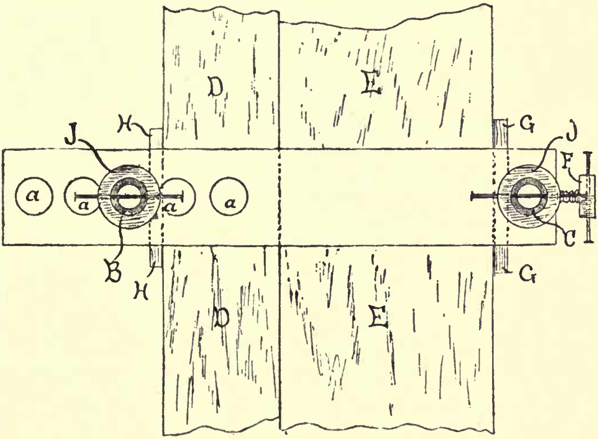

Fig. 4. Top view of Adjustable Clamp for holding flat glued work, made from iron bar and pipe fittings.

the diameter being about ¾in., or to correspond with the bolt which will be passed through them. The holes should be bored at regular intervals of ½in. as far as the centre of the bar, so that there will be, if they are ¾in. diameter, nine of them (although only five are shown in the drawings). At the other end of the bars, and not more than ¼in. or so from it, is another hole of the same size. There are now provided a couple of thick bolts, or rather studs, threaded at both ends and furnished with thumb nuts (represented in Figs. 3 and 4 by pipe-sockets, J, J, fitted with tommies). One of these (C) is passed through the single holes at the solid end, whilst the other (B) can be passed through whatever pair of other holes is convenient for the work. The thumb nuts can be screwed down so that any thickness of plank can be held between the flat iron bars and be thus kept from cockling.

In order to force the edges together one of the bolts (C) is provided with a transverse thumbscrew (F), which may be a $\frac{3}{8}$in. bolt or set screw having a hole bored through its head and fitted with a sliding tommy, as shown. By means of this, if a couple of planks (D and E) are put between the flat bars (A, A), a piece of packing (G) placed as shown to prevent injury to the edge, and another (H) at the other end, the two planks can be forced together with great pressure.

When the bolt B is in the position shown in the drawing, the clamp is taking a total width of plank which is half-way between the biggest and smallest that it will take without using wide packing. It can be adjusted in distances of half an inch by moving the bolt B backwards or forwards, and if the two planks are so narrow that they do not reach the bolt B when in the nearest hole, the space is made up by using a wide packing piece at H.

Now this is merely the broad principle on which such a clamp is made, and the reader may suit himself as to the detail of its manufacture. If he can make the bolts himself, being provided with a screw cutting lathe, or other screwing tackle, he needs no further instructions from us. If, however, he is not the possessor of that king of tools, the lathe, he can buy gas or steam barrel and make the bolts from this by threading pieces of pipe to within about $\frac{3}{8}$in. from the middle, and he can then use back nuts instead of thumb nuts. If, again, he has no screwing tackle at all, he can buy nippling in lengths, which is exactly the same thing. We have a clamp such as this made from $\frac{1}{2}$in. steam barrel which is very strong, for the two bars are never more than about $3\frac{1}{2}$in. apart, and it is this clamp which has been illustrated above.

The top and bottom clamping arrangements (J, J, J, J) consist of sockets with holes bored near their ends and fitted with sliding tommies. The sockets are each about 1¾in. long, so that there is plenty of range even allowing ⅜in. at the end of each socket for the tommy, which is ¼in. diameter and about 4in. long. As the bar from which the clamp is made is ⅜in. thick, this tool has a range of ⅜in. up to 3½in. for the thickness of the planking, and from a few inches up to 22in. for the width.

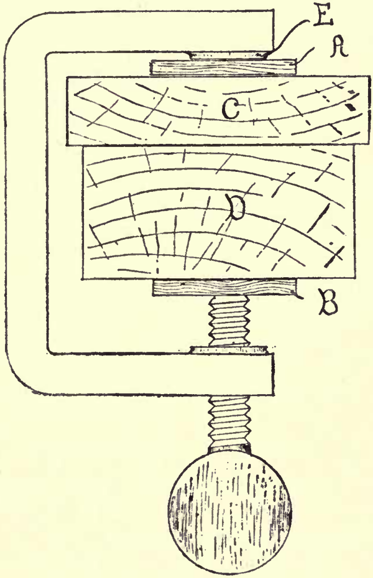

Fig. 5. A useful Cast-iron Clamp for holding small glued work.

It would hardly be possible to have a more powerful clamp than this for the special kind of work. Three of them are quite enough for a pair of planks 12ft. long, these being arranged on a piece of long work such as this so that there is one in the middle and one about a foot from each end.

Those readers who do not care to indulge in an iron clamp for use with plank edging can make a kind of substitute from hard wood such as beech. But as the screws are replaced by wedges which have to be driven, the clamp will not have the range of an iron one, nor its strength or power, and is open to the objection that the work may shift when the wedges are being driven. Also it does not allow of the rapidity of working that an iron one does.

The chief thing, however, that the reader will not be able to manage about such a clamp is the handling of the big flat pieces. He can buy the nippling ready made, and the sockets or back nuts. If he cannot get one of the pieces C in Figs. 3 and 4 drilled and tapped for him he can replace that adjustment with a wedge, and so by using a couple of pieces of oak or ash about 1in. thick by 3in. wide in place of the iron bars, he will have a clamp just as efficient as that described above, though at a somewhat greater cost. If there are no means of drilling to hand it is preferable to use back nuts instead of sockets, for they can be gripped with a wrench, and, of course, they should have washers under them so that their under surfaces may not bear directly on the wood.

A very useful little cast-iron clamp shaped as shown in Fig. 5 can be bought for 4½d. in the smallest size; this takes in about 3½in. between the jaws, and is very handy for holding short pieces of work that is being glued. When in use there should always be a packing piece both between the work and the screw and between the other side of the work and the bearing piece of the clamp. This is clearly shown in Fig. 5, in which A is a piece of wood placed between the bearing-plate (E) of one arm of the clamp and one piece (C) being glued, whilst B is another packing between the end of the screw and the part D of the work.

Those of our readers who can handle metal in their workshops can make their clamps for themselves in iron of sizes varying from ⅜in. square to ⅝in. by 1in. iron, bent with the flat, The smaller sizes can be bent up cold if it is not attempted to make too sharp a curve, but it is always better to bend hot, and it can be done in the kitchen fire quite easily for such a simple job as this. The screw would be supplied from a $\frac{3}{8}$in. set screw, preferably with a hole bored through its head in the manner shown at F in Figs. 3 and 4, for quickness in working, and provided with a sliding tommy, which should be burred up at each end so that it cannot fall out of its hole and be mislaid. A set of clamps with jaws $2\frac{1}{2}$in. long, and ranging in capacity from about 1in. to 12in. in steps of 2in. each, will be found very useful, and will take nearly all the work that the average amateur does. Made out of $\frac{1}{2}$in. square iron the average cost of them will be under twopence apiece.

Should the clamp be longer in the jaw than $2\frac{1}{2}$in. the metal used should be heavier. About $\frac{5}{8}$in. by $\frac{3}{4}$in. iron, bent

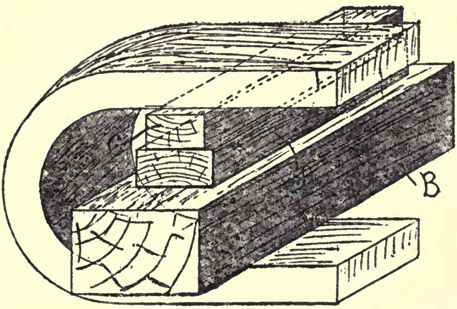

Fig. 6. Extempore Clamp made from bent iron and a wooden wedge.

with the flat, will make a strong clamp capable of being used for metal work if the jaws are not more than $4\frac{1}{2}$in. long. In making clamps of this kind it is better in the long run to use Bessemer steel, for it is much stiffer, and the extra price is only about $\frac{1}{2}$d. per pound.

Even simpler clamps than the above can be made from iron, but they are not so quick in use. They consist merely of a piece of bar of suitable thickness, bent in the form of a **U**, as shown in Fig. 6, and used with a wedge. In the illustration A and B are two pieces being glued together, and C is a wedge driven in between one of the arms of the clamp and the top piece of work.

These are, however, only extempore clamps, and are therefore made from iron about $\frac{1}{4}$in. thick by 1in. wide, which can be easily and quickly bent cold to any required size. Their hold is naturally not so firm as that of any of the patterns previously given, but they are useful when all

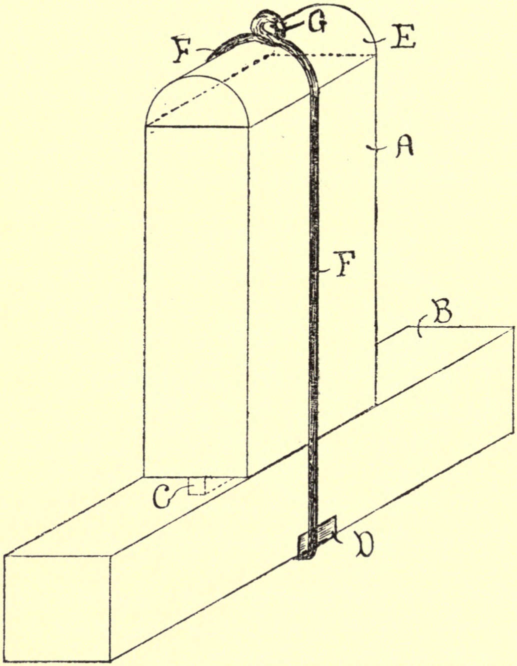

Fig. 7. Extempore Clamp of twisted string or rope for holding irregular-shaped pieces.

the other clamps are in use, or when from some other reason it is inexpedient to employ others.

There is a second form of extempore clamp which it is good to know of, as it can often be used in situations where others could not be put in place owing to irregularities in the work. Such clamps depend upon the closing action of twisted string or rope. It is quite possible that a piece of work has to be glued which is of the form shown in Fig. 7. This illustration represents an upright (A) which is to be glued into the part B. It has only a very short and narrow pin (shown dotted at C), so that when glued there will not be sufficient hold, even if the fit is perfect, to keep the two pieces in place. Now, no clamp of the ordinary kind will hold such a piece of work as this if the length of A is more than a foot or so, yet it must be clamped when being glued, or a chance knock, or even the vibration caused by a passing cart, may put it out of the square. Nor will it be worth

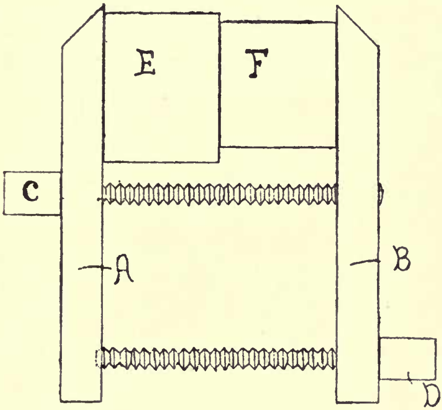

Fig. 8. Joiner's ordinary Wooden Clamp.

while to make a special clamp for it, seeing that such would not be used again perhaps for years. But we can go to work as follows:—

Get a piece of blind-cord—or anything flexible and very strong. Place pieces of thick cardboard at the exposed corner (D) and the corresponding corner which is out of sight, and make a rounded block (E) for the top. Pass the string round the whole piece as shown by FF, and twist it at the top with a piece of stick until the part A is firmly clamped to the other. If the loop (G) has been kept fairly central on the rounded block (E), the part A will be square on B. If not, it can be pushed square and tested until it is correct. All this can be done much more quickly than it takes to read the last few lines, for the twisting is done in a moment (the stick is retained by a nail in E), and the testing and setting straight do not take any appreciable time, so that a clamp of this kind is quite as rapid in use as any other.

A very ordinary clamp used by the joiner is that shown in Fig. 8. It consists of two pieces of hard wood (A and B) with a couple of wooden screws (C and D). The screw C passes through a smooth hole in the piece A, and through a

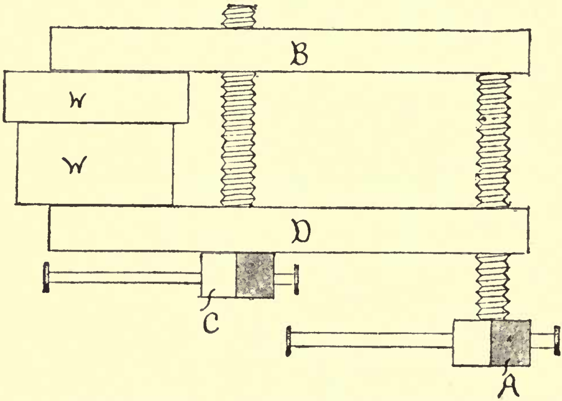

Fig. 9. Adjustable Clamp made from scrap iron and set-screws, for holding small glued work.

threaded hole in B, whilst D is threaded through B and its end butts in a shallow hole (shown dotted) in A. The pieces to be joined (E, F) are held by bringing the jaws together parallel so as just to take in the thickness of the two pieces, making this adjustment by means of the screw D, and then tightening up the screw C. These clamps can be bought for from 6½d. for a 6in. size, up to 1s. 6d. or 2s. for one which has 1¼in. screws 12in. long.

Although of wood, this form of clamp is not easily made at home, even if the reader has a screwing-lathe, for unless he has the overhead motion with its appliances, cutting screws in wood—even boxwood—is not so easy as it may seem. But a substitute on the same principle in iron is useful, and very often pieces of scrap which need no preparation can be found for the smaller sizes.

Fig. 9 shows this clamp made from ½in. by 1in. iron and ⅜in. set screws fitted with permanent tommies passed through their heads, as already explained in connection with Figs. 3 and 4. These supply the adjustment, which in this case is

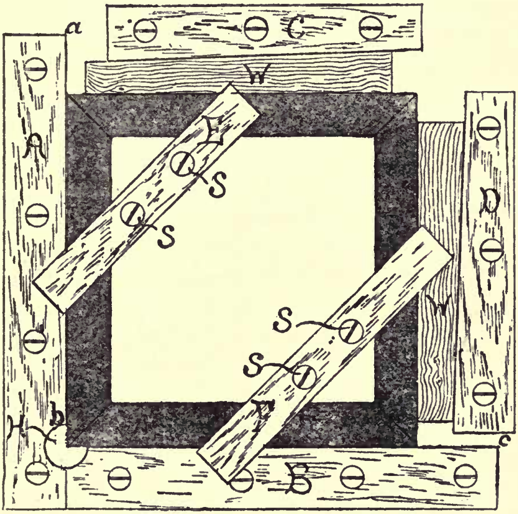

Fig. 10. Method of Clamping Glued Framed Work by means of wedges.

limited to the length of screw that can be obtained—generally about 3in. in the ⅜in. size. On this basis, the bar being ½in. thick, the extreme range between the jaws will be 2in.

In using this clamp the bars B and D are set apart parallel by means of the screw A, which butts in a slight hollow in the bar, the distance being equivalent to the thickness of the work (W, W), and the two bars are then pulled together by tightening up the screw C.

The fit of the screw C in the bar D should not be good.

The hole through which it runs should be about $\frac{1}{32}$in. more than the diameter of the screw, and the tapped hole in B should also be a loose fit. If this is not attended to the screws may bend when work is tightened up in the clamp, and will consequently work very stiffly or not at all.

It sometimes happens that glued work has to be held with the surfaces inclined at an angle with the boundary to which the pressure must be applied. A case in point is the glueing-up of the mitres of a picture frame. Here the pressure has to be applied at an angle of 45°, as shown in Fig. 10, which illustrates a mitred frame being held for glueing purposes in a specially built clamp.

It is necessary in this case to have a flat surface somewhat bigger than the frame to be glued. For small frames the bench will probably be used, but it is quite possible to have a job so big that it has to go down on the floor. If such should be the case we may remark that one over which oilcloth has been put down has a better chance of being smooth and true on the surface than bare boards, because any little irregularities on the latter will be nearly obliterated by the oilcloth.

Whether the bench or the floor be used, however, the process is the same. The first thing to do is to screw down at exact right angles to each other two pieces of wood (A and B, Fig. 10) having their inner edges (*ab* and *bc*) shot at right angles to the lower surfaces which abut on the bench or floor. The thickness of these pieces must be slightly less than that of the frame being put together—say $\frac{1}{8}$in. Then nail down two pieces similar as to thickness, and with their inner edges shot as before, such edges being inclined at a slight angle to the two square pieces (as shown at C and D). Cut two smooth wedges (W, W) to fit in between these and the frame to be glued, which in the drawing is shown shaded. Cut two more pieces (E and F) long enough to go across the corners, as shown, and provide these with strong screws (*s*, *s*, *s*, *s*) long enough to reach well into the base into which the whole is built.

The frame being duly mitred and the surfaces prepared for glueing, glue it up and place in the built-up clamp, screw down the pieces E and F, but not quite tightly, and gently drive the wedges (W, W), seeing that they do not rise from the bench. When they are home, screw down E and F firmly. The frame can then be further strengthened by nails or screws in three corners if thought necessary, and will set perfectly square even though the mitres do not make a perfect fit. Care, however, must be taken not to drive up the wedges too tightly, or the result may be the curving of the pieces of framing in the middle, which will open up the mitres at the ends.

This is one of the jobs in which it is imperative that squeezed-out glue should be wiped off at once, for part of the composition with which many frames are covered is bound to come away with it if the glue is taken off after it has been allowed to get cold. It is for this reason that, after the two pieces A and B have been set in place, a hole is cut at H so that the corner can be got at and cleaned.

Ordinary glue used on the usual woods should be allowed two hours to set. Less will do for very porous woods, and more would be necessary for oak or teak or boxwood. It is a mistake to place glued work in an ice-cold room to set, as is so often done. A temperature of about 6c° Fahr.—that of an ordinary living room—is best.

The glues and methods of glueing described in this and the preceding chapters are those which are employed for all high-class cabinet work, pianoforte building, and so forth. As to clamping, so much attention is paid to this in the latter business that special clamps are made and moulded to the contours of the job in hand, these being often highly complicated and expensive pieces of fitting. In such factories, too, the glue-pot is the exclusive care of one man, who guards his cauldron jealously.

CHAPTER IV.

ORDINARY GLUE ADAPTED TO SPECIAL PURPOSES.

THE chief use for glue such as that which has been described is, of course, for wood, but it is capable of a great many other applications without any alteration whatsoever, and of a still greater number with some slight variations.

We will take its applications in an unaltered state first. It was mentioned in the course of our remarks as to the mechanical action of adhesives that glue will stick to most metals under certain conditions. The metals to which it is safe to stick it are iron, tin, lead, silver, gold, and platinum, with a few others of the rarer sorts which need not be specified. It is not, however, suitable for use with copper or any of its alloys, such as brass, gunmetal, &c., as it is apt to form an acetate with the copper, and thus produce what is commonly known as verdigris. But when used with those metals for which it is suitable, certain conditions must be observed. For instance, in no case should one metal be glued to another, and the stuff, whatever it may be, which is glued to the metal must be of a porous or absorbent nature. Thus, cloth, paper, leather, and wood, except the very hard kinds, can be glued to metals with ordinary glue, or they can be stuck to glass successfully. But—this is most important—the solid medium, glass, metal, or crockery, *must be as hot as the glue.* Porous stones can be stuck with glue if the joint is not very wide. For example, such a thing as an ordinary flower-pot, if it should ever be deemed necessary to mend it, could be thus repaired, though, of course, it is not the best way. Small thin china can be so stuck, provided the joint is very narrow so that air can get at it and allow of evaporation, and with Salisbury glue can be mended.

There is a distinct difference, however, between glueing metal on to something soft or pliable, such as a purse, for instance, and glueing the pliable material on the metal. The second is safe to do with ordinary glue, and the first not. We should need a flexible glue to put on the metal corners of a leather purse, though the fretwork metal corners, say, of a solid wooden or leather-covered desk could be put on with the ordinary kind—always remembering the precaution as to heating mentioned above. Another precaution to take with respect to metals, pottery, or glass upon which ordinary glue is used is to make it chemically clean: the least trace of a finger-mark on glass or metal will prevent glue from taking on it.

It will be seen from this that ordinary glue has a very wide range of usefulness. It does not follow, because it *can* be used in conjunction with metals, that it is always the best thing—in fact, we shall in subsequent pages give much better recipes for this purpose—but glue is *one* of the adhesives which can be used successfully for such jobs, and so the fact is mentioned.

There are various reasons why glue made as directed in these pages is not suitable for every kind of woodwork, and so it is adapted in various ways to meet special requirements.

In the pattern-maker's shop, for instance, the work both in wood and iron is of as high a class as it is in the piano factory. But the pattern-maker does not use exactly the same kind of glue as is employed by the cabinet-maker. Eventually his work has to be exposed to very different conditions, and so his glue is made in the following manner: Soak in the glue after breaking up as previously directed, but instead of drawing off the bichromate solution after six hours, let the jelly remain in soak for twelve hours. Neither the capsicums nor the boracic acid need be used, but instead there is added, in a thin stream and with constant stirring, one-quarter of the bulk of jelly of good boiled linseed oil, the addition being made as soon as the glue is completely melted. This makes a joint which is entirely unaffected by moisture, even to the slight sticking of particles of damp sand, and which is, in addition, slightly flexible. It does not dry hard and glossy like ordinary glue, but makes a strong, sound joint nevertheless, and one which does not pick up bits of sand out of the mould as might be the case with ordinary glue.

It has already been stated that there are many ways of making glues for special purposes, or with special attributes, though there are none which result in an adhesive so strong as that first described. But it is not always policy to use a first-class adhesive for a third-rate job, so that we may need a quickly-made cheap glue which will hold firmly enough for our purpose and be waterproof.

A very efficient article of this kind can be made as follows: Take 1lb. of powdered glue (which costs 6d. per 1lb. packet), and beat it up with warm water to a thick paste. At the same time add 1lb. of powdered resin and ½lb. of red ochre. Boil these up in a water bath until the glue-powder is entirely dissolved (which will be in about a quarter of an hour after the water in the outer pot begins to boil), and use the mixture as hot as possible.

This glue is very useful for outdoor work. For instance, felt on an outhouse is very much better put down with some kind of sticking agent than it would be if nailed, and this glue, being cheap, quickly made, and waterproof, is eminently adapted for the purpose. Again, for lining a box or trunk with canvas nothing can be better, and a third use is for putting down linoleum. Of course, once linoleum is put down we must be content to let it remain where it is, for it can never be got up again save in little pieces. We may here mention, with respect to this material, that it should never be put down on a floor, either by nailing or by sticking, before it has been lying open for a week or so. If it is roughly fitted to the floor and so left for a few days before being fastened, it will fit all the better. Walking on linoleum stretches it a little, so that if put down right away it is almost sure to cockle up after a time, and will then wear through rapidly. If left, however, as directed above, the fit can be made perfect, and it will then lie to the floor, either by glueing or nailing, like a sheet of paper, and will last twice as long.

This glue goes a long way, being much thinner than the ordinary stuff, and will resist weather for years. Use a big brush for putting it on with, and go over the felt with a stiff broom on the top surface after it is laid, so as to press out air bubbles and make it lie closely to the boards beneath.

Another mixture, not quite so quick in the making perhaps, but stronger holding, and a trifle cheaper, is concocted as follows: Chop up four parts by weight of French glue and soak it in water, so that its surface is just covered, for about six hours. Whilst the glue is being melted—in a water-jacket, of course—add in a fine stream one part by weight of boiled linseed oil, and then stir in one part of oxide of iron. This also is a good outside glue, which resists weather well, and is strong.

Still another glue for outside work, stronger than the above, and cheaper as well as almost as quick in the making, is the following: Soak 1lb. of finely chopped French glue in two quarts of skimmed milk for eight hours or more—overnight is the usual thing—and boil the result until it is about as liquid as treacle on a hot day. This is probably the cheapest glue there is, and it comes next in holding power to ordinary glue prepared as described with reference to joiners' work, so that it is exceedingly strong. Like the others, it is waterproof and weather resisting, and its only disadvantage is that it will not keep. In the summer it will begin to go putrid in twenty-four hours, and even in the winter it will turn in a couple of days. This cannot be prevented even by the addition of a large proportion of boracic acid.

Bookbinders often use a glue which is flexible when set, its advantages being obvious. This is made by preparing common glue (French is good enough for the purpose) in the ordinary way, and adding to it whilst boiling half of its bulk of either glycerine or treacle in a fine steady stream with constant stirring. Of course this is not a very strong adhesive, but it is quite strong enough for the purpose for which it is wanted, and is, naturally, better than a stronger glue which would crack easily.

We have referred some pages back to the various uses to which ordinary joiners' glue can be put, and amongst those uses is the sticking of leather to metal. This book-binders' glue is the stuff with which to stick metal to leather. For instance, the small thin plates on the corners of purses and so forth can be best stuck with this medium—making the metal hot first, of course, and cleaning it properly on the glued side. On account of its flexibility the joint made with the leather will not crack if this glue is used, and, of course, it applies equally to cloth and other flexible materials to which metal has to be fixed.

Bookbinders also mix a proportion of glue with their paste when they want special strength, and to this we shall refer in the next chapter.

CHAPTER V.

PASTES.

In addition to the glues proper, which have already been dealt with, there are a few other adhesives which are used by the bucketful, so to speak, and of these perhaps the best known is common paste.

As with ordinary glue, there is a lot of ignorance regarding the proper preparation of this mixture, which is a very useful one, as it belongs to that class of adhesives that are always ready for use without any preliminary preparation. The paste which the cook prepares for us is all right so far as its sticking properties go, but as generally made in the kitchen it ferments in a couple of days, and has also knobby lumps in it which impair its usefulness.

The proper way to prepare paste is as follows: Dissolve completely in a quart of warm water ¾oz. of alum crystals—not ground alum. Let the solution get quite cold, and then beat up in it enough ordinary flour (not self-raising) to make the consistence of the mixture about that of cream. Rub this through a hair sieve so as to get rid of all lumps, and then bring it gradually to the boil, stirring the whole time. Have at hand 2oz. of finely ground resin, add this to the boiling paste, and keep on boiling and stirring for about ten minutes. Then take off the fire, and in about three minutes add a few drops of oil of cloves. If this last is added whilst the paste is on the fire the oil will volatilise and be of no effect.

Paste made in this way and stored in any wide-mouthed bottle, such as a pickle-jar, will keep sweet to the end, and if the precaution be taken to keep it well corked when not in use it will not develop hard dry lumps.

The only difference between the preceding and paper-hangers' paste is that instead of resin they add about ½lb. of size to the gallon of boiled paste; they also use nearly twice as much water, for paste for their purposes needs to be very much thinner than that intended for general use.

Paste as prepared by bill-stickers does not contain resin either, but they use about twice the quantity of alum, which increases its strength, but makes it harder and less easy to spread.

Bookbinders for some parts of their work also use paste, but as this is required to be stronger still they make it up with glue-water instead of plain water.

Belonging to the class of ever-ready adhesives is ordinary "office gum." This is made by dissolving clean gum arabic in warm water to which vinegar has been added (in the proportion of 1oz. of vinegar to the pint of water), making the solution about as thick as treacle in warm weather. As an adhesive this ranks high in the matter of strength, but it is liable to go mouldy, and therefore a small quantity of boracic acid (say ½oz. to the pint) should be dissolved in the water with which the gum is made up, to preserve it.

If an ever-ready glue which is colourless when dry is wanted, it can be obtained from rice. Dissolve ¾oz. of crystal alum in a quart of warm water, let it cool, and then beat up in it ordinary ground or flaked rice until the mixture is about as thick as cream. Let it remain thus a few hours, then rub it through a sieve and boil with constant stirring until it is as clear as it will come. When dry this adhesive will be all but colourless.

The addition of its own bulk of Salisbury glue jelly makes the preceding paste a specially strong adhesive, which is always ready for use, and possesses only a very slight yellow tinge. Like all good things, however, it has its disadvantages, for it is apt to go sour or putrid, and resin cannot be added as a preservative, for it would colour the glue. Our only remedy therefore is to make but a small quantity at a time (it lasts about a week in cool weather), and to retard its fermentation by the addition of boracic acid, which prevents it from turning for some four or five days longer than would otherwise be the case.

Rice glue is about the best thing that can be used for photographic mounting, or the sticking of prints or suchlike objects which might be damaged if any of the adhesives in ordinary use got upon their surfaces. It holds well to glass and tins if they are perfectly clean, and is therefore useful for labelling; it is also a very good medium for fastening down the little glass discs used for covering the specimens in microscopic slides.

A useful and easily made paste can be obtained from starch—simply ordinary household starch soaked and beaten up in water, only made much thinner than it would be if it were intended for the laundry, and then boiled for twenty minutes or so, or about ten minutes after it has become clear. It is changed by this treatment into "dextrine," and makes a strong adhesive in this state. It will, however, turn after a time, though this can be prevented by adding a preservative such as boracic acid. Dextrine is the principal ingredient in the gum which is put at the back of postage stamps, but it can, of course, be used on all flexible materials, such as cloth, cardboard, leather, &c.

Equal portions of starch and cane sugar well sifted and boiled up as directed with reference to dextrine make a good adhesive, and one which will not turn. It takes longer to dry than dextrine, and is not therefore quite so useful; but it has the advantage of not turning sour, so that it can be stored almost indefinitely.

None of the pastes are waterproof, and they cannot be made so, for the waterproofing medium (bichromate of potash) cannot be mixed with them. They are, therefore, only suitable for use with articles that are not exposed to damp.

CHAPTER VI.

LIQUID GLUES.

The next class of adhesive with which we shall deal comprises those which are employed for special purposes, and which are, like the pastes, always ready. They are generally used in small quantities, so that a 2oz. bottle will often last for years, and they are compounded on two distinct principles: the first of these consists in dissolving gums or resins in various spirits, and the second in digesting gelatine in acids.

Of the first kind of these the best known perhaps is shellac cement, for it is a filler as well as an adhesive, and may therefore be referred to as a cement. It is made by dissolving button or flake shellac in methylated spirit, naphtha, or petrol. If only a small quantity of the gum is used the resulting mixture is "french polish," and that makes a sticking medium which ought to be used a great deal more than it is. It is excellent for sticking paper to metal or to glass, for it resists damp and acids, if the glass or metal is properly cleaned and warmed before its application. Made thicker (of the consistence of treacle) it sticks wood to wood, metal to metal, and glass to glass, holds to rubber, wash-leather, and cloth, and is an all-round useful adhesive in the workshop, where for jobs which do not require great strength such as would be necessary when a mortise joint is made it can generally be used when it is inconvenient to get out the glue-pot. Shellac is a very fair insulator, so that it is almost indispensable in electrical experimental work; it sets very quickly, is not affected by moderate heat, either moist or dry, and when mixed with plaster of Paris, Parian cement, brickdust, whiting, or Portland cement, makes a very hard insulating filling which clings very tightly to metal or glass, or, indeed, to almost anything else.

This cement is generally made by dissolving in methylated spirit button shellac which has been well washed in order to eliminate dust or any other foreign matter that it may contain. The gum takes a long time to dissolve—some ten or twelve days if not aided by gentle heat, if the button shellac is used—but if flake be substituted for the button shellac the process is quicker, though the result is the same in both cases. As methylated spirit and all the other solvents which are used for this cement (naphtha, petrol, &c.) are extremely volatile, and also *highly inflammable*, the mixture should be stored in an airtight tin, not in a jam jar or bottle; such a tin as Lyell's golden syrup is put up in, for example, is the exact thing needed, for it can be closed down quite airtight.

Mixtures for filling such as those mentioned above should not be stored, but should be made as they are wanted from the stock shellac solution. They can then be made to any desired consistence; whereas if stored and slight evaporation took place they would probably be too thick for use—and they cannot be thinned down at a moment's notice by the addition of the solvent, as the latter takes some hours to mix properly with the gum, even if already partially dissolved. The hardest mixture of this kind is obtained by rubbing equal quantities of Parian and Portland cements into a thick paste with shellac solution which is about as thick as treacle in cold weather. This can be used for insulating purposes in cases where a circuit has to be made and broken by the contact sliding across metal and insulating material alternately, and is hard enough to grind away brass, so that the contact will wear out before the insulating material.

Shellac is also the gum from which lacquer for brass, &c., is made, but that is rather beyond the province of this book, so that we will merely mention that it should be dissolved in naphtha for this purpose—not in methylated spirit.

Should the same class of cement be needed of lighter colour the ordinary shellac may be replaced by the bleached variety, and a pale yellow cement will be made, which, however, is not quite so strong as that for which ordinary shellac was used.

There is a special use for shellac dissolved in naphtha, in the proportion of 4oz. of the gum to a quart of the spirit, and that is as an adhesive for damp surfaces. For instance, if a wall in a house is damp and the paper peels off, a couple of coats of this varnish applied to it will not only stick on firmly, but will provide a covering which is quite damp-proof and to which paper can be hung without the least danger of its peeling off.

Amongst other adhesives of the ever-ready kind which the electrician uses is rubber solution, which is really a liquid glue. This consists, as a rule, of pure rubber digested in naphtha, benzine, or bisulphide of carbon. It takes weeks to make, for the digesting process is very slow, and pure rubber must be used. The scrap rubber which may be to hand in a workshop is quite useless for this purpose, though it can be used to advantage in other mixtures that the electrician needs.

To make rubber solution one needs only patience and proper material. Pure shred indiarubber is laid in soak in naphtha, benzine, or bisulphide of carbon and allowed to digest, the process being helped by gentle heat in a water-bath. It must be borne in mind that all the solvents of rubber are *highly inflammable*, so that the utmost care must be taken when making the solution. When made, however, there is a very wide range of usefulness for this adhesive. It is *the* thing—and the only thing—wherewith to mend rubber goods, such as tyres, macintoshes, and so on. It holds rubber to anything else—cloth to cloth or leather—and is, of course, flexible when the joint is set, that is, when all the solvent medium has evaporated, for the result is that a sheet of solid rubber is fastened to both the surfaces which are joined.

Work fixed with rubber solution is ready in a couple of hours at furthest. When used for open work, as, for instance, wrapping rubber ribbon round a soldered joint in electric light wires, the wrapping will be dry in less than ten minutes, and there will be practically a solid lump of rubber round the wire which cannot be unwound by any means whatsoever.

Rubber solution must be kept in the same kind of tin as shellac, and even greater care must be taken to keep the tin airtight, for the solution cannot be thinned down under four or five days if it should have been allowed to evaporate and get thick. There is only one thing to do in such a case—to redigest the solution in a fresh lot of solvent.

As remarked above, a solution of rubber in naphtha, benzine, or bisulphide of carbon will fasten rubber to metal, and if this joint has been properly made, having the metal quite clean and warming it before applying the adhesive, it will be permanent, provided that it is not exposed to a heat greater than about 170deg. Fahr., and that it is not strained or exposed to liquids under pressure which can reach the edge of the rubber and thus force their way under it. Thus it would stand for ever if it were used for fastening down a rubber washer in a cistern, but if the cover of a flap valve were faced with rubber put on in this way and exposed to pressure it probably would not stand long.

For the latter purpose, however, we can make a liquid glue as follows: Well soak pulverised shellac in ten times its own weight of strong ammonia (.88). In from three to four weeks there will result from this a semi-transparent liquid mass, which, when applied to rubber, either pure or vulcanised, makes it quite soft and holds to metals firmly. When the ammonia has evaporated, however, the rubber next to the metal becomes hard and absolutely impermeable to liquids or gases, either hot or cold. A valve, therefore, faced in this way is about as permanent a one as can be made, and the top rubber remains in its original state—soft and pliable—so that for most purposes, if the liquid dealt with is not an oil, such a valve is not to be beaten. This cement should be kept in a glass-stoppered bottle, or one with a rubber cork, the former being preferable, as it cannot rot.

The liquid glues which have for their basis gelatine digested in acids are far more numerous than those made by resins dissolved in spirits. There are two classes of this adhesive—those which require heating before use, and those which can be stored and are always ready. It is with the latter that we will now deal.

About the cheapest kind of liquid glue of this sort that there is is made as follows: Take equal parts by weight of French glue broken up small, water, and vinegar, and dissolve these all together by gently heating in a water-bath, keeping the mixture in an airtight tin of the kind already described. With the exception of the pastes, this is the cheapest liquid glue there is. It will keep any length of time, is always liquid (save in the very coldest weather, when it needs to be slightly warmed unless the room is at ordinary living temperature), and should therefore be kept in stock in every workshop to take the place of the glue-pot or shellac-tin when it is inexpedient to use either of these. It is good for wood, coarse crockery, stone, and flexible materials, will hold on glass and some metals, and makes a good sound joint in cases where it is not exposed to heat or damp. As, however, it is an adhesive which needs plenty of air to enable it to set well, large joints in non-porous materials should not be attempted with it.

The following is a somewhat stronger but more expensive general utility glue for the workshop. Break up Salisbury glue into small bits and free it by washing of all dirt and dust in the manner described with reference to the making of ordinary glue. Then dissolve 2lb. 2oz. of this in a quart of distilled water (rain-water, if clean, does just as well), using a gentle heat, in a water-bath. When the solution is complete, and there are no lumps left, add in a thin stream, and stirring all the time, 6oz. of commercial nitric acid. This, when cool, should be stored in a glass jar—preferably one which has a rubber-faced stopper.

The preceding glue holds well on wood or roughened glass, metals, &c., if perfectly clean, and is excellent for mending earthenware or china, as it is all but colourless. When used for china, metals, or glass, the surfaces to be joined must be heated after being cleaned. Even a finger-mark will prevent this glue from sticking, for its greatest enemy is grease. Very big joints in non-porous material should not be attempted with it, for it will not be possible for the cement to dry in the middle if the width over which it is spread is more than about half an inch.

A liquid glue of somewhat similar composition consists of 100 parts of common glue, 260 of water, and 16 of commercial nitric acid, boiled together in a water-bath for at least twelve hours. It is especially good for wood and iron, but will also hold on most metals and materials, and like the one above can be used for crockery joints.

A few words may here be added with respect to varnish used as an adhesive. It belongs to that class the action of which is purely chemical, and it makes a much stronger sticking medium than might be suspected. Best coach varnish will "take" on almost anything; and, further than this, it can be used as an adhesive in very big joints, even with materials which, like glass and metals, are non-porous. The reason is that it depends upon the oxidation of the oil for its setting, and this takes place whether the edges are dry or not.

Suppose that we wish to fix a large glass disc to a sheet of glass or metal, in such a manner that the joint will bear heat to a moderate extent. If we employed one of the glues already mentioned it would dry for about half an inch all round the rim, but the rest could never evaporate even in the course of years. If we used one of the cements which are soft when hot and set when cold, the plate could not be heated without loosening the joint. But if we made it with varnish, first slightly warming both the pieces to be joined, the process of setting would be as follows: First the part exposed to the air would get oxidised, but the other part would take its oxygen from the piece already oxidised, and that would have to find some more, which it can do, being close to the air; and so on, the varnish thus becoming oxidised right to the centre of the plate in time. It would take perhaps a week to dry right through, but after that time it would be very difficult to get the two plates apart, for even boiling would have to be resorted to to shift them. Naturally, a joint so made will stand moisture, and it is an ideal adhesive save for the fact that it takes so long to set.

Even plain boiled linseed oil acts in this way, though, of course, not to the extent of varnish, for it has no gum dissolved in it as coach varnish has.

Good varnish mixed with plaster of Paris or Parian cement in the manner mentioned with respect to shellac makes a very efficient filler for some kinds of work, and clings very tightly. By mixing a little patent dryers with this it will set much more quickly, the oxide of lead which is the chief ingredient in dryers aiding in the oxidation of the oil in the varnish.

If an adhesive of the above class is wanted which will withstand the action of boiling water for practically any length of time, which will resist acids and also be reasonably strong when used over a good-sized surface, the following will meet those requirements. It has the additional advantage of being a first-class varnish as well as an adhesive, and is very useful to those who experiment in chemistry because of its power of resisting acids and moisture, either hot or cold. Boil in an untinned copper vessel 75 parts by weight of good linseed oil. During the operation suspend in this (sewn up in a linen bag, which must not touch the bottom of the copper) 15 parts of litharge and 9 parts of red lead. Let the oil boil until it has taken on a deep brown colour, and then replace the bag with another containing one big or two small bulbs of garlic, letting that boil for another ten minutes. Whilst the preparation of the oil is going on, melt 50 parts of pulverised amber (this can be got at most big drysalters', or from makers of high-class varnishes) in 6 parts of linseed oil over a strong fire. When the amber is properly dissolved add this whilst boiling to the prepared linseed oil, which should also be boiling, and let the whole boil for about three minutes longer, stirring vigorously all the time. Then take it from the fire, allow it to settle, and pour off the clear liquid, which should be put up in glass bottles hermetically sealed. This clear portion should be retained as a varnish—the rest being used as an adhesive, just in this state, or as a cement mixed with plaster of Paris or Parian.

This adhesive is the best that we have used for fixing labels to chemical bottles. It is just used as a gum—on a clean surface, of course, with paper labels, which are afterwards varnished over with it. They never come off, even from the acid bottles, and although the varnish is dark in colour, it is not so dark but that words written on white paper in Indian ink and varnished over are quite visible. Its powers of resisting moisture and heat make it useful in an infinite number of ways in the workshop, and it is therefore one of those adhesives which, although troublesome to make, ought to be stocked.

The "marine glues," generally speaking, are of that kind which need to be heated before they are applied, and they consist of gums or similar materials mixed together. The term "marine glue" is derived from the fact that this class of cement is that used for caulking ships, and for purposes generally where the joint made with it is exposed to constant wet. This is, of course, the normal condition of things at sea, and before the time of electricity the principal use of these mixtures was in connection with ships.

The chief characteristic of marine glues is, as we have indicated, their power of resisting moisture, and they belong to that class which set by a cooling process independent of any evaporation or absorption. But there are a few exceptions. A marine glue which can be employed cold will often be found useful, as it is a good insulator, and will serve in cases where shellac solution might be undesirable.

To make a liquid marine glue, dissolve in 4oz. of chloroform (get methylated chloroform, not that derived from pure alcohol, for the cost is about one-eighth) 40gr. of pure shred rubber and an equal quantity of pitch; this will take about a week. When dissolved add 6dr. of powdered mastic, which must be well stirred in and left for another week to macerate. During both of these operations the vessel must be kept tightly covered, or the chloroform will evaporate. A wide-mouthed glass bottle with a well-ground glass stopper is the best thing in which to make this glue, but a tin such as that mentioned for glue will do if such a bottle is not obtainable. The glue so made is of about the consistence of good varnish; it sets in a few minutes—much more quickly than either shellac or rubber solution—but the stopper must not be kept off longer than is absolutely necessary, and the bottle itself must be kept in a cool place. This is also much stronger than shellac solution, resists the action of acids, and is slightly flexible, besides being a good insulator.

All the liquid glues and adhesives mentioned in this chapter, whether resinous or gelatinous, or both combined, as in the preceding instance, can be mixed with plaster of Paris, Parian cement, whiting, or Portland cement, and thus make good fillers. When so mixed they are good for such purposes as fixing-in the tops of pepper-casters and mustard-pots, replacing the metal parts of paraffin lamps, and so forth. They can be used for mending crockery if it be of such a nature that it has not to be washed frequently or to be exposed to hot water, save in the case of the special varnish described on pp. 42, 43. For instance, a vegetable dish mended with the adhesive made from Salisbury glue described on page 40 would last a long time if only wiped clean with a damp cloth. It might hold if washed in cold water, provided the mending has been done under the best possible conditions, but it would probably come to pieces the first time it was washed in hot water. That particular glue, therefore, as it is all but colourless, will be excellent for mending china and glass ornaments, &c., for the stuff is always handy and needs no preparation, so that the article, whatever it be, has a better chance of being mended at once, before the edges get knocked about and dirty.

Of the liquid glues which are purchasable there is perhaps none which is so universally useful as the fish glue put up by Johnson's. It will withstand dry heat to almost any extent if the mending has been properly done, and a good deal of moisture as well—ordinary washing-up does not affect it generally; but it has the disadvantage that some hours are necessary for it to set in, and during that time the article must be clamped with tape or string.

CHAPTER VII.

SPECIAL ADHESIVES.

We now come to that class of adhesive which requires preparation of some kind before being used, and, generally speaking, these are stronger than those which are used cold. The liquid glues that have been described in the foregoing chapter are handy to have in stock, and many of them are capable of withstanding a reasonable amount of dry heat. If, however, glass or porcelain has to be mended in such a way that it has to stand the wear and tear incidental to washing-up, an adhesive is necessary which is quite different from any of those previously described.

Broadly speaking (there are exceptions, of course), the longer a cement or adhesive takes to set, the stronger is its hold. Of the following adhesives the best takes twenty-four hours to set, and is better if left forty-eight hours. Articles mended with it, however, especially if the fracture is perfectly clean and new and unchipped at the edges, may even be boiled without the joint coming apart. We have a teacup which has had the *handle* fixed on, and which has stood daily washing-up for five years; but it was properly mended under the best conditions, and was allowed a week off duty to enable the joint to set.

The particular cement with which the piece of mending mentioned was done is compounded in the following way. Soak 2oz. of bleached isinglass in 2oz. of distilled water for twenty-four hours—rain-water in this case is not safe to use. The receptacles in which the various solutions are made must be perfectly clean, and covered up so that no dust can get in. Mix the solution so made with 1oz. of pure alcohol (methylated spirit will not do as a substitute), and when the solution is complete strain the result through three or four folds of well-washed butter-linen. Now make a second solution as follows: Rub together dry 1dr. of mastic with 1dr. of gum ammoniac, and pass them through a hair sieve twice. Dissolve them in 1oz. of alcohol and strain through linen as before. Put both solutions into separate water-baths and heat them up until the water is boiling in each, when the first must be gradually added to the second in a thin stream with constant stirring, using a clean glass rod for the purpose. The resulting mixture should about fill a 2oz. bottle. If the solvents have evaporated so that there is less than that, alcohol must be added (whilst the bottle is standing in the hot water bath, and with constant stirring) until the amount is made up.

Now as to using this cement to the best purpose. To begin with, the edges to be united must be freshly broken, perfectly clean and dry. The parts must be fairly warm, which is best effected by laying them on a clean plate in the oven. The glue must be applied as hot as boiling water will make it, to both edges, and in as thin a layer as possible, a clean match free from ragged splinters or a fine camel-hair brush being the best tool to lay it on with. Press the pieces together as tightly as you can, and tie them with string or tape if the shape of the article admits of it, wiping off all squeezed-out gum at once. Let the mended article stand for at least twenty-four hours in a moderately warm place—say above the kitchen mantelpiece.

We have been somewhat minute in this description, because only by strict attention to detail can a sound job be ensured. Only if the edges are unchipped and if the making and using of the cement have been carried out according to directions will this stand boiling water with certainty. The cement being practically colourless, it is a splendid thing for mending glass, the join being only visible when the light is thrown on it in certain directions, and, of course, for china it is equally good.

If the article has been mended before, or has dirty or greasy edges, a perfectly sound joint cannot be guaranteed; but by cleansing the edges by the following process we have mended a plate which had been previously badly joined and which has not come apart so far, though it was mended about a year ago and has been in constant use since. Make a 10 per cent. solution of ordinary sulphuric acid and boil the broken pieces in this for about five minutes, using a glass or porcelain evaporating dish, for nothing else will stand the acid. Take them out, rinse them in clean water, then boil in strong soda water, and scrub the edges with an old tooth-brush. Boil next in rain-water, which will get rid of the last trace of alkali, and dry on a clean plate in the oven. The edges must not be touched with the hands after they are taken out of the soda water.

Make joints in china on a sunshiny day if possible. In fact, when the adhesive used is one of those which depend upon the evaporation of water or spirit, or upon the oxidation of the dissolving medium, do all glueing and mending in fine weather if there is a chance. It seems to make a great deal of difference so far as our own experience goes, for several joints made in damp weather, apparently under perfect conditions in all other respects, have not been successes, whereas *all* those made on days that were clear and bright have come up to expectations.

In addition to being the best thing possible for china and glass, this cement can be used for joining ivory to glass, porcelain, or metal; stone to porcelain, glass, or ivory; wood to any of the above; and all flexible materials which are not of a greasy nature. Glove leather, for example, can be conveniently stuck with it, but it would be of little use attempting to glue a piece of leather belting with this cement, for the grease in it would prevent the making of a sound joint. Shells and geological specimens can be perfectly mended with this if the edges to be joined can be slightly warmed so as not to chill the cement.

An adhesive which sets more quickly, and which will stand dry heat for some time, though not so good as the above, can be made much more easily, and is useful where an article to be mended is needed for almost immediate use. For instance, the handle of a teapot lid can be fixed with it in the morning and the pot will be ready for use at tea-time. Soak 100 parts by weight of bleached gelatine and the same quantity of Salisbury glue in 25 parts by weight of methylated spirit in a well-closed vessel for twelve hours. Then add 200 parts by weight of a 20 per cent. solution of glacial acetic acid—or, what comes to nearly the same thing, 250 parts of white vinegar—and 2 parts of alum. Let this mixture stew in a water-bath for six hours, but do not let the water boil, and keep the vessel containing the mixture well covered so as to lose as little as possible by evaporation of the methylated spirit. When made, store in a well-stoppered bottle, preferably one with a rubber cork, and use in exactly the same way as described above.

This glue is liquid in all weathers, except the very coldest, and so ranks as one of the liquid glues. It was originally compounded for use with iron and wood, for which it is specially suitable, and is therefore one of those which should be stocked in the workshop.

A joint made with this will hold for weeks—it may last for years even when the article is washed in hot water, although it may come apart in a day or so if exposed to moist heat. But it will stand almost indefinitely if properly made to begin with, and if the article is not wetted afterwards.

We will now give a recipe for a strong general sticking medium which is quite colourless, and therefore good for mending geological specimens and shells, glass, porcelain, &c. In fact, its uses are just about the same as those of the two adhesives last described, save that it will stand but little heat, nor will it do for joints exposed to damp. But the stuff is easily made and very strong within its limitations, and these are its chief recommendations.

Take 2oz. of clear gum arabic, 1½oz. of best rice starch, and ½oz. of white *cane* sugar, grind the gum up in a mortar and mix it with its own weight of water. Rain-water is better, and distilled best of all, and one or the other *must* be used if the common water is very hard. Let the gum stand in the water until perfectly dissolved. Grind up the starch and the sugar together in a mortar, and mix these well into the gum solution, after which stand the bottle containing it in boiling water until the contents are perfectly clear and colourless. The gum so made should be about as thick as treacle in the winter time, and must be well corked—with rubber for preference. It should be used hot, in the same way as already described, the edges to be joined being first warmed, and, of course, perfectly clean.

With regard to mending pottery and porcelain, there are two more adhesives which ought to be mentioned here, one being white lead and the other ordinary (or rather *pure*) milk. The former properly used on large crockery ware, such as wash-stand basins, jugs, bread-pans, and so forth, makes a joint so strong that the mended article cannot be broken again in the same place. The conditions necessary are that the crock shall have at least eight weeks' leave of absence—preferably eight months—and that it be of such a form that the pieces can be strongly clamped together, either with wire or cords, or in some other way.

Make up ordinary white lead, *which must be quite free from skin*, into a paste with boiled oil, so that it just flows—that is, make it up into a very thick paint. Clean the broken edges with hot, strong soda water and a tooth-brush, get them properly dry (this must be very carefully attended to, especially in the case of such articles as bread-pans, which are generally made of very porous material), and make them so hot that the hand can only just be borne on them, keeping clear of the edges, of course. Then paint both edges with the white-lead mixture, and wire together as strongly as possible. Lay the mended article by in a dry, warm place—somewhere in the kitchen where it is well out of the reach of chance knocks is as good a place as any—and keep it there for at least eight weeks. If the joint is allowed its proper time to set it will be permanent, but the union depends upon the thickness of the joined parts. The thicker the material the longer it will take to set, for the adhesive in this instance is one of those which work by oxidation, and the process is slow when the surface involved is wide. In this particular case it is almost imperative that the job shall be done on a clear, bright day—the chances are greatly against a success if it should be attempted in foggy or wet weather.

Crockery of this kind can also be mended by means of the heat-proof and adhesive varnish described on pp. 42, 43, but it takes almost as long to set and is not so strong by a long way as white lead. Its only advantages over the latter are its power of resisting heat—and the fact that it has a very much wider scope.

White lead made up into a thin paint as just described is used in some cases instead of ordinary glue. It is employed, for instance, in putting together the wooden parts of omnibuses, which are about the strongest vehicles for their weight to be found in the streets of London. Of course, the fit of the parts in this case is about as perfect as it can be.

We may mention here the proper way of wiring together such an article as a bread crock, or, in fact, wiring anything, whether it be broken parts or wiring material on to a solid, as it is not generally known. Fig. 11 shows how this is done in the case of a bread-pan, the illustration representing the top rim of the article. Instead of twisting the wire only at the point of juncture at A, a number of small loops are left at intervals of 3in. or 4in., as shown, and these are all twisted up in turn with a pair of pliers. By this means the tightening-up will be much more complete, for the pressure will be equivalent to as many clamps as there are loops, instead of only one, as would be the case if the wire were only pulled up at the point A.

If the job were one of wiring material on the edge of a wooden disc, and the wire were merely twisted at the point A, the chances are that the stuff would pull and cockle up just under the twist. In any case there would be great danger of cutting it through against the wood, for the wire must be pulled along over the material, and as there is a firm base under it, it would act like a blunt knife, sawing it through against the hard surface.

It is even more important to wire according to this principle in a case where there are corners to be considered. For instance, if in Fig. 12, which shows stuff (say cloth) being wired

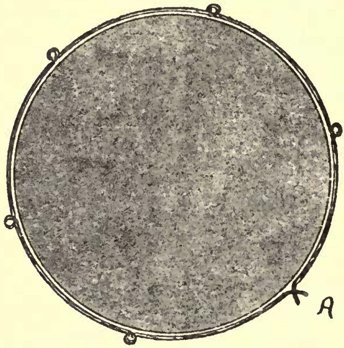

Fig. 11. Method of Tightening Wire on a Rim so that there shall be an equal pressure all round.

to a square edge, the wire were twisted up at the point A, and had to pull round the corners B and C, the friction would be tremendous, and if material were between it and the solid D it would cut through even leather. Furthermore, the wire would break sooner than come round the corners E and F, so that piece along EB and FC would not be tight except at the corners B and C, and possibly on E and F, and BC would be the only edge held even if the wire were twisted to breaking-point. By having a loop at each corner, however, as shown in Fig. 12, and one in the middle of each side—more if the edge is longer than 1ft.—the corners can be strained up separately without danger to the material, and the middle loops will pull up so that there is pressure of the wire all over the edges.

It is best when wiring on according to this system to go gradually round the piece. Twist up at the point A first loosely, just enough to keep the wire in its place. Then go round all the other loops, giving them a single twist with the fingers; go round again, giving each a whole turn with the pliers, and then tighten each up as far as it is safe without the wire breaking.

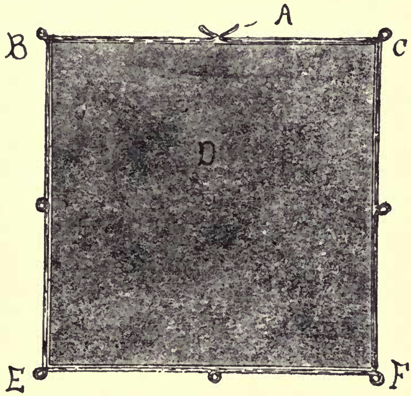

Fig. 12. Method of Tightening Wire on a Cloth-covered Square so that the cloth is not cut or cockled and the pressure is equal all round.

In the matter of a crock, the best thing to strain it with is wire rope. Telegraph wire, or that used for trellis-work, will do nicely, failing both of which use No. 14 copper wire or No. 15 or 16 annealed iron.

If rope is used—and it is very suitable, though it entails a lot of trouble—each loop must be formed in the first instance by making it as in Fig. 13; that is, first looping it and tying with a piece of string, as shown at A. The part corresponding with the twist in the wire at A in Figs. 11 and 12 would, in this case, be a knot ready tied, for we cannot twist up the ends of a bit of rope and expect them to remain so. The tightening-up of the loops is done with a piece of stick, which is passed through and twisted up, each one being done in turn, and its end held by means of a cord tied round the bottom rim of the crock, or by any other convenient way which may be suggested by the shape of the article being mended.

The second special way of mending porcelain and small crockery is by boiling it in milk. The conditions necessary to success are that there be a certain amount of porosity in the

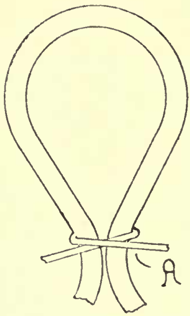

Fig. 13. Method of making Loops in Rope for Clamping.

material to be mended, and that it be freshly broken and clean. The process will not work if the pieces have been washed or mended, or if the break was first a crack which has gradually spread until it has parted. Cleaning the edges by any of the methods described above does not seem to be of any use in this case, at least so we have found.

Freshly-broken small articles of crockery can be mended by tying the pieces tightly together with string or tape or with wire, and completely immersing them in a saucepan full of cold milk, which must be fresh and *pure*. The saucepan must be gradually brought to the boil, and kept boiling for about ten minutes, after which it must be allowed to get quite cool. The milk must be stirred all the time, or it will boil over. The article should then stand in a dry, warm place, say above the kitchen mantelshelf, for twelve hours before taking off the straining tapes or strings or washing. On newly-broken china, the edges of which are unchipped as regards the glaze, the joint made in this way is quite invisible unless looked for with a glass; the article may be washed in ordinary hot water without coming apart, and will often last for years.

A few precautions must be taken in boiling. Use as large a saucepan as possible, so that there may be plenty of room for stirring the milk, and do not hit the article whilst stirring. Stand it in such a way that no air can be imprisoned either at the bottom, as might happen with a cup, or at the top. For instance, a cup stood on its bottom might trap a little air in its rim, if care were not taken, and it might do the same if inverted.

With respect to taping-up the articles, the tapes are best sewn on with nice flat seams. In the case of a cup, for instance, the tape could be fitted to another cup of the same kind first, and fitted half-way down if it has to go round the rim. It could then be stretched very tightly over the cup by damping it, and so could any other parts if they were first fitted to other and similar articles.

Amongst other adhesives belonging to the class with which we have dealt in this chapter is the so-called "Diamond Cement." It used to be common as a medium for mending crockery, china, and glass; but we do not hear much about it now, possibly because its name is changed. As the recipe originally came from India, where the stuff was used for the setting and, incidentally, in the "faking" of jewellery, as it is still, it is pretty sure to be good, for the natives of that country can generally lay claim to first-class knowledge appertaining to their trade.

Diamond Cement is made as follows :—Soak pure bleached gelatine in water, which well covers it, for about six hours. Add half of its weight of rum, dissolve the mass by shaking the bottle occasionally, and then filter through blotting-paper. Weigh up the product, and to each ounce add 1dr. each of alcoholic solution of gum ammonia and gum mastic, made up in the proportion of 2oz. of each gum in 1oz. of alcohol. These must be added separately to the gelatine solution, whilst the latter is as hot as it can be made in a water-bath.

This cement must be stored in a rubber-stoppered bottle, and when using it the parts to be joined must be hot, as must also the cement. Brandy does almost as well as rum, and arrack, with plenty of sugar dissolved in it, does better than either, and, indeed, was prescribed in the original recipe. As, however, arrack or rice brandy is difficult to obtain in this country, the reader who makes this adhesive must use rum or brandy.

A last word as to mending china and crockery generally. Work as quickly as possible, using tape or wire or string whenever this can be done (and it nearly always can) for straining the pieces together. Do not attempt too much at a time. If, for instance, an article is broken into four pieces, first join two, and then the other two, and lastly join up the lot, allowing proper intervals for each set to dry in. Of course it is not always possible to do this, and where it is not the clamps of tape *must* be fitted first, so that they are ready to go on directly the joint is made. Also be certain that if the job is done in instalments, as mentioned above, the pieces will go together, for it is quite easy to do a thing in this manner and to find that the couples, though apparently perfect in every way, cannot be got together because of their shape. Be sure of absolute cleanliness, and remember the hint given as to working on a fine, dry day—it is more important than might be suspected.

CHAPTER VIII.

ELECTRICAL CEMENTS.

We have already described many kinds of adhesives which are of special use to the electrician, but they were all included in the liquid glues, or consisted of the liquid glues made up with filling material, such as plaster of Paris, &c.

Electrical cements must possess several qualities, without which they would be of little use to the electrician. The first of these is that they must be insulating; the second is that they must stick to metals; and thirdly, they should be as hard as possible. Amongst their minor attributes they should be capable of withstanding the action of acids and water, and more particularly the *creeping* of acids.

The commonest form of cement which the electrician uses is "marine glue." This can be variously made up, but the most usual mixture is 1 part of pure rubber to 20 of shellac. The ingredients should be gently melted separately, and then mixed, but great care must be taken that they do not catch fire, for they must be heated over a stove, boiling water not being hot enough. They can be melted by standing in boiling tallow; but this is almost as dangerous as the other way.

Another way to make this kind of marine glue is to dissolve each ingredient in benzine, naphtha, or petrol, and then to mix the two solutions, to pour the made stuff out over a shallow tray, and, when nearly set, to cut it into sticks.

It is frequently necessary to cement vulcanite to glass or metal. Marine glue will do for this in such cases where it does not matter about heating the two objects to be stuck, for marine glue, whatever the mixture, must be made hot before it can be used, and to ensure a successful job the two pieces to be cemented must also be made as hot as the glue.

Marine glue is never hard—that is, it can always be indented with the thumbnail—and is therefore only useful for a cement and insulator—not where there has to be any wear upon it.

The following, however, are more or less hard as well as good insulators, and will stand acids, but, being of the nature of marine glues, require to be put on hot, and do not therefore stand much heat. We give them in the order of their hardness :—

A very hard insulating cement is made by mixing pitch 2 parts, resin 2 parts, shellac 6 parts, and Portland cement 6 parts. It must be made over a good hot fire, the resin and pitch being melted first, and the shellac (which should be of the flake variety) being stirred in last with a glass rod. This sets almost as hard as stone, and is the mixture (barring the shellac) that is used as asphalt paving, or nearly so. If the Portland cement is replaced by finely-powdered pumice-stone or lava, it makes a material which is even more wear-resisting, although no harder than the first. But it takes boiling water all its time to soften this mixture, and it has to be worked with a file to smooth it down, as an ordinary cutting tool is blunted at once on it. To use either of these the metal to which it is applied must be considerably hotter than the hand can bear—" sizzling " hot in fact —and a red-hot iron must be used to press it into place.

Pitch 2 parts, shellac 3 parts, and Parian cement 5 parts, make a cement nearly as hard as that first described, and one which, though it has a fair wearing surface, does not cut anything passing over it as does that of which pumice-stone is an ingredient.

Finely-powdered and sifted clay, too, is a substitute for Parian in the above, which works well, and, failing that, plaster of Paris, the hardness being in the order given—

that is, Parian makes the hardest insulator, and plaster of Paris the softest.

The following are suitable for coating battery-jars and so forth. They are fairly hard—harder than marine glue—and also slightly flexible:—Take pitch, resin, old scrap rubber, finely-sifted pipe-clay, and shellac in equal parts by weight; melt the pitch and rubber together; add the resin, then the shellac; and, lastly, stir in the pipe-clay. Pumice renders it slightly harder, but, of course, makes it an abrading cement—that is, it will be similar in nature to a knife-board, so that it will wear any surface rubbed on it—an advantage or not, as the case may be.

If wanted still softer, the shellac is left out, and if a very soft, flexible cement is needed, it is replaced by an equal amount of paraffin-wax.

The last three cements resist the creeping of acids, and hold firmly on glass, metal, and numerous other substances. It will be seen that the changes can be rung on mixtures of resin, cement, clay, pumice, Parian, plaster, pitch, rubber, shellac, and wax, to almost any extent, making a cement of extreme hardness, and heat-resisting to a considerable extent, down to one which is quite flexible and soft. The disadvantage of all these, however, is their having to be used with heat. The cold glues already mentioned are not fit for every case, for although strong when mixed with various thickening substances, such as plaster and so forth, they are soft and yielding. We require for some purposes a cement which can be put on cold, is insulating, will stand heat, and will stick well. Such can be made in the following manner: Dissolve 1oz. of alum in a quart of boiling water, and in this boil pine sawdust for twenty minutes. Take out the sawdust, dry it in the oven, and reduce it to charcoal in an old frying-pan. With this mix an equal quantity of well-pulverised pipe-clay. Take some coarse paper, such as that which grocers use for wrapping up sugar, and whisk it round in boiling water until it has gone to a fine pulp, of which there should be about 1½lb. Add to this ½lb. of glue whilst the mixture is hot, and when all dissolved and cold, mix with the above composition to the consistence desired. This will stand a white heat, and will hold to metals, wood, porcelain, and glass. If plaster of Paris is used instead of pipe-clay, it stands 300deg. to 400deg. Fahr., so that it is a fairly useful cement. As an insulator it does not rank very high, owing to the carbon in it. If we can replace that with something which is a non-conductor we shall get an all-round cement worth having from the electrician's point of view, and it can be done by substituting for the carbonised sawdust well-ground asbestos. The gain, however, will be somewhat counterbalanced by the appearance, for, owing to the fluffy nature of the asbestos, a nice finish cannot be got on it.

A useful cement for the electrician can be made from paper pulp and cupric ammoniate. This substance has the property of dissolving all material of a woody nature. It dissolves paper amongst other things, and so if we beat up a quantity of coarse common paper, such as that described above, into a pulp, dry the pulp, and mix this with cupric ammoniate to a paste, we shall have a fairly good insulating cement which will hold firmly to all woody substances. This is specially useful when dealing with hard fibre, or "Woodite" as it is sometimes called, which is largely used for insulating in electrical construction, and is made from paper as a base; and thus two pieces fastened together with such a cement as that above mentioned will make a very good joint. Indeed, once made it will be impossible to undo it, for the two pieces will be as much one as if they were melted together, so to speak.

Cupric ammoniate can be made by dissolving metallic copper in strong (.88) ammonia, which eventually turns a deep blue, but it can be bought at the chemist's, and this is the better way, as a considerable time is occupied in preparing it from metallic copper, whilst the process is by no means a pleasant one.

Should the reader ever desire to seal an envelope so that it cannot be opened by such processes as steaming, he can close it by means of cupric ammoniate and be perfectly sure that it will never be opened save by tearing.

A cement which is very useful from the electrician's point of view, and one which is always ready save for heating, is made as follows : Take beeswax 2oz., resin 100oz., plaster of Paris, Parian cement, or brickdust ¼oz., red ochre 2oz., and having mixed the powders intimately, heat them up with the wax in a water-bath. This must be used as hot as the water will make it, and the pieces to be joined must also be heated. For making insulated joints between brass and brass, or any other metals, fixing metals to glass, &c., this is excellent. It resists water and acids, but, as may be guessed from its composition, heat will make it soft and part the joint.

Sealing-wax is the last cement useful to the electrician that we will mention. It is made from resin, shellac, and red lead for the red kind, and the proportions are in accordance with the quality that is desired—from one half the weight of red lead to one of resin and one of shellac, to three parts of red lead, two of resin, and one of shellac. For the black kind pitch is used, and for any other tint the colouring materials in the form of paint powders which are most suitable. The nearest to white that can be got is bleached shellac two parts, resin half part, and zinc-white three parts ; this makes a nearly white mixture with a tinge of cream in it.

The mixtures given above are not by any means all the electrical cements, but they are representative. With the information in this chapter, and a knowledge of the liquid resinous glues already dealt with, an infinite variety of cements for electrical purposes can be evolved suitable as to colour, hardness, softness, and pliability to almost every job under the sun.

CHAPTER IX.

ADHESIVE CEMENTS AND FILLERS.

THE liquid glues, electrical and other cements which have been described in the foregoing pages, although their range for certain things is very great, do not "fill the bill" for every variety of job which the reader may be called upon to do. For some kinds of work, as already explained, it is necessary to have a cement that will fill up the interstices in the work as well as hold it together. The putty used for holding in windows is an example of this. We could not use any of the glues previously mentioned for such a purpose even if made up with plaster or something of that kind, because they would not work down smoothly with a knife, and for other reasons. Such a cement, however, if it would withstand paraffin, would be very useful for replacing the top of a paraffin lamp. But only one of all the cements already given will hold against that substance (it is not an oil), and none of them will withstand water permanently except the varnish adhesive described on pp. 42, 43, so that in most cases these cements are only useful for dry jobs or for work which has only to be occasionally wetted. If, for instance, we had to stop a leak in an aquarium, or even to put in a new pane of glass, we should not use a cement that was only temporary—for even the spirit cements, with the one exception mentioned on pp. 43, 44, will allow water to creep behind them in course of time, and the one referred to is too expensive a cement to use in bulk.

If, therefore, we need a cement for the purpose cited we should make it up as follows: Mix together in a mortar 6 parts of whiting, 3 parts of fresh plaster of Paris, 3 parts of silver sand, 3 parts of perfectly dry litharge, and 1 part of resin. These ingredients must be repeatedly ground in the mortar, and then passed through a sieve once or twice, so as thoroughly to incorporate them; the mixture is then ready for storage in a large glass jar—a pickle jar, for instance—and must be kept perfectly dry. To use this cement mix it with the best coach varnish (or the varnish mentioned on pp. 42, 43, which is adapted to withstand boiling water, if it is more suitable owing to the job being intended to hold hot water) to the consistence of very fresh putty. It is advisable to make up only a small quantity of this at a time—about as much as can be used in ten minutes—for it quickly becomes unworkable. It can be coloured if needed with lamp-black, red ochre, &c., its original shade being a kind of dirty white.

The parts to which this is to be applied must, of course, be perfectly clean and dry, and especially free from grease, for which reason it is always best to brush them over with a little naphtha or petrol before applying the cement. It is also an advantage to give the surfaces a coat of good varnish to enable the cement to get a good key, for varnish will hang on to glass almost as well as anything, if of good quality and put on under perfect conditions of cleanliness and weather.

The above mixture will hold water indefinitely, and is specially suitable for an aquarium, as it is non-poisonous both to plants and to fishes. For this reason also it is an excellent cement for making the joints in a slate tank, or for stopping a leak between the drain hole and the pipe of a scullery sink, for it will withstand moderately hot water even when mixed with ordinary coach varnish. In the latter instance, however, as the part to which the cement is to be applied must be perfectly dry, as well as clear of grease, the difficulty of drying (if it should arise) can be got over by laying red-hot bricks over the part, or by making a coke fire in an old bucket pierced with holes and standing it over the portion to be dried. The clearing off of the grease which is sure to be there must be done by repeated scrubbings with petrol or naphtha, or by setting the grease alight with the help of those spirits after all the water has been driven off by means of the bricks or bucket of fire.

This cement holds at first hand to glass, stone, porcelain, or lead, but does not take very readily to brass or iron. If, therefore, it should be found necessary to cement glass to iron or brass in such a manner that the joint will keep out water, the joint being so big that none of the cements previously given would be enabled to dry, we should have to look to something else. Make a soap by boiling 1lb. of caustic soda with 3lb. of resin and 2qts. of water. This mixture is not permanent, as the water separates out, or part of it does, after about a week, but it will regain its normal state when boiled up again. It can therefore be stored in any large glass jar fitted with a stopper, a rubber-lined one made of glass for preference.

When wanted for use the quantity of the above needed is mixed with half its weight of fresh plaster of Paris or Parian cement. With the former this mixture sets in less than half an hour, but with Parian cement it takes a little longer, although the result is stronger. The cement may be used on iron, brass, and other metals, for rust does not creep behind it. A moderate amount of warmth may be applied, and the mixture will even hold against paraffin, but boiling water destroys its hold. As, however, it resists the action of paraffin it is *par excellence* the thing for fixing on a lamp-top, or for making pipe joints to hold against that hydro-carbon, which we may incidentally state takes a deal of keeping in. The only disadvantage of this mixture is its property of separating out when left for a few days, and the consequent necessity of reboiling the stock when the cement is wanted, which somewhat removes it from the class of ever-ready compounds.

The following cement has all the properties of the above save that of resisting paraffin, but by way of compensation it will, when set, stand under boiling water, and is almost an ever-ready compound. As, however, it contains white lead, which is a *poison*, it should not be used in connection with drinking-water, nor for an aquarium where fish are kept. Thoroughly mix 4oz. of litharge, 2oz. of white lead (the powder, not the ordinary white lead mixed with oil), and 4oz. of fine white sand or finely powdered brickdust, by grinding them together in a mortar and passing a few times through a sieve. This can be stored in a bottle and will keep indefinitely.

When the preceding cement is wanted make it up into a putty with boiled oil and dryers, being careful to mix very thoroughly. As this becomes hard and unworkable very quickly, not more should be made up at a time than can be used in about a quarter of an hour. It becomes fairly hard in about twenty-five minutes, but if a really good job which will stand boiling water is wanted, it should be allowed a week to harden, and will then be like stone.

This cement can be mixed with the special adhesive varnish described on pp. 42, 43, and will then be of better quality, but as it is one of those cements which depend upon oxidation for its setting it should be used on a fine day when there is not much damp about. Such precaution is not absolutely imperative, however, in this particular instance, for owing to the presence of the litharge the oxidising process is self-contained to some extent, and so the setting does not depend entirely upon oxygen supplied by the air.

If an ordinary galvanised iron cistern should leak the best remedy, of course, is to solder it, and the same remark applies to a leaky lead pipe. If the pipe is an iron one the remedy would be to cut out the split portion and insert a new piece, or, if it is the joint that is in fault, to remake it, for which directions will be given presently. But in many houses, especially in the country, cisterns are made of slabs of slate screwed and cemented together, and if one of them leaks slightly at a seam a very good remedy is the following: Empty the cistern and apply hot flat irons or bricks over the leak so as to dry it thoroughly; then apply with a brush a boiling mixture of suet and resin in the proportion of one of the former to two of the latter. Instead of suet, tallow may be employed if it should happen to be more convenient, as it is just as good, and a makeshift joint such as this will often last for years.

Another extempore cement for such a purpose as this can be made from ordinary clay thoroughly dried and powdered and made up into a putty with boiled oil, and (if it can be obtained) dryers. This is a good adhesive, and being quite unaffected by cold water, it lasts for a long time.

Of course, if a slate cistern leaks in several places it is waste of time to attempt to stop the holes. The best thing to do is to take it to pieces, clean off all the old cement, and then put together again with the cement described on page 63.

A leak in a burst pipe can be temporarily patched up by emptying, drying, applying a thick coat of one of the two cements last described, and wrapping the pipe round several times with canvas or any other rough cloth that is handy, painting each layer with the cement as it is wrapped round, and finishing up with string. Very often such stopping of a leak will be permanent. There is one in our own house which has stood for four years, and which was only made with clay and oil and coarse sacking, these having been the only things handy at the time.

Even iron cisterns may be patched up in this way, but the patch must be put on inside instead of outside. Such a job, however, is not recommended, as it is unlikely to last for long, and the leak will probably break out again at a most inconvenient time.

If the reader should have to make an extempore job of this kind, however, he should proceed as follows: Empty the cistern and dry the part over the leak inside. Clean it up with emery paper, and having soaked a piece of strong canvas in varnish, or in one of the adhesives which withstand water given on previous pages, paste it over the leak so that it clings properly to the cistern, then fill up all over the canvas with a good quantity of clay and oil, doing this in the same way as putty is filled into a window pane. Allow as long as possible to dry before letting the water in.

An extempore cement for closing a leak in a barrel is not out of place here. Take tallow 25 parts, beeswax 20 parts, and lard 40 parts; heat them up together, and stir in 25 parts of sifted wood-ashes. When needed, apply the mixture to the leaky place by means of a hot knife-blade.

Fixing up a marble mantelpiece which has broken down is a job which may occur. Clean, broken edges may be mended almost invisibly by several of the adhesives already described—notably that made from Salisbury glue on page 40. But a slab which is to be replaced on the chimney-breast must be done with a cement, not merely with an adhesive. A good rough and ready way is to make up plaster of Paris or Parian cement with glue-water, or water in which gum arabic has been dissolved. If done with plaster of Paris the work must be very quick, as this substance gets hard in a few minutes, but Parian cement takes about half an hour, and is very much stronger.

It may here be mentioned that the proper proportion of water for both plaster of Paris and Parian cement is one-third. That is, for every two parts (by measure, not by weight) of plaster of Paris one of water should be added. If more is used the plaster will be rotten, for it cannot all be combined, and if less some of the plaster will be left in its uncrystallised state, for the setting of plaster depends upon the changing of the substance from an amorphous to a crystalline state, and the same method of setting applies to Parian cement, though the process is much slower.

Parian cement is much more useful in the hands of the amateur than plaster of Paris, and although it costs more, it is economy to buy it. Plaster of Paris, as has been said, sets in a few minutes, and becomes quite unworkable in less than two minutes. The result is that the amateur's jobs are unsound through too much water being used, or through the work being too slow, or else some 50 per cent. or more of the plaster is wasted. Parian, however, allows him plenty of time to work in, so that there need not be an ounce wasted if the quantity has been accurately judged, the job will not be rotten through the mixing of too much water, which is the instinctive remedy applied to prevent the plaster from setting before the operator is ready, and the result will be much stronger than plaster, even if done under the best conditions.

After this slight digression we will go on with our chimney-breast. When applying either of these plasters both the surface of the marble and that at the back thereof must be well wetted; it is non-attention to this simple matter which makes the amateur's hole-stopping in walls fall out.

Another cement which can be used for such a purpose as setting a marble mantelpiece is made from hydraulic cement and water-glass (silicate of soda). The hydraulic cements, broadly speaking, are natural cements made from blue lias limestone, such as is found in the neighbourhood of Lyme Regis, in Dorsetshire, or from any other strongly argillaceous limestone, by simple calcination. As they are natural cements, they are, of course, very uncertain in their composition, owing to impurities; but as they have the property of hardening under water (whence their name "hydraulic"), they are exceedingly useful to such people as bridge-builders and makers of dams. Portland is not a hydraulic cement.

Water-glass is a liquid which has the curious property of almost petrifying anything soaked in it and allowed to dry. For example, a cloth soaked in it and allowed to set will be as hard and stiff as wood—just as if it were coated with glass, in fact; and as when pure the liquid looks just like ordinary water it has obtained the name of "water-glass."

Hydraulic cement made up with water-glass into a kind of dough makes a useful, slow-setting cement for chimney pieces and such like purposes where colour is not a factor in the ultimate look of the thing. The colour of the cement is a dirty slate-brown, and this can be darkened if necessary with lamp-black, but other colours, as a rule, cannot be mixed with it, as they would be changed or destroyed.

Should a cement be needed which can be coloured to suit any shade of marble, a very good mixture with which the ordinary colouring powders can be used with safety can be made as follows: Melt together 8 parts of resin and 1 of beeswax. Whilst hot, stir in sufficient plaster of Paris to make it a stiffish paste, and then colour to suit the job in hand. This must be used hot, and the pieces should also be hot, or at least warmed.

With respect to the mending of marble, we might mention a cement which is used in the same way for marble as that described on page 74, for filling in nail-holes, dents, &c., in polished woodwork. Shake up fresh quick-lime in water, and when it has settled pour away the water and evaporate the residue to a thick paste. Mix this with an equal part by weight of plaster of Paris, and make up with white of egg for use. This must be put on or filled into the hole in the marble very quickly. It sets as hard as the stone itself, and will take a polish almost as good as the marble, so that a corner of a mantelpiece can be built on, and the added piece hardly distinguished from the whole. It may be coloured with lampblack or red ochre or red lead; but most of the ordinary paint powders will be affected by the lime, so that it cannot always be used for repairing coloured marbles.

Lastly, with respect to marble, the colourless liquid glue described at the bottom of page 40 may be used with good effect either in its pure state as an adhesive or mixed with plaster of Paris or Parian cement, and with this all the ranges of colour, from pure white to jet black, can be got, the ordinary dry powdered colours being used for the purpose.

If there is a hole in a plaster wall it should be plugged with either plaster of Paris or Parian cement, all the old plaster inside the hole having been well wetted, as already stated, before the new is put on.

Sometimes it is necessary to hang a heavy picture or glass on a plaster wall, and it is unsafe to drive the nails direct into the plaster, as this would not be strong enough. The usual thing to do under the circumstances is to plug the wall, and this is done by driving a hole into the plaster by means of an ordinary chisel, and having filled this with Parian cement (after wetting it, of course), driving in a wet wooden plug, and wiping off all the squeezed-out cement at once. When the cement is dry—that is, in about half an hour—a nail can be driven into the wooden plug, or a screw inserted for hanging the picture or glass on, and this will be quite strong enough.

If the wall be brick the plug is driven between the joints, and need not, of course, be cemented in; but if the wall is a lath-and-plaster one it is a different matter. There are two ways of getting over this difficulty, one of them being so strong that nearly the whole wall would have to come down before the nail came out, and the other strong enough for most purposes, which would only bring down about a square foot of the plaster if too heavy a weight were hung upon it.

The first way is as follows: Cut away the plaster over a space of about $\frac{3}{4}$in. square, and undercut it well. Fit a piece of wood in this and cement it in with Parian right up to the laths. When dry use a screw for hanging the picture on. This does not wound the wall badly, and the plug is concealed by the picture. Also, as the plaster is undercut, before the plug can come out it will have to tear out a large proportion of the wall around it, for the cement will make the plug one piece with the rest of the plaster.

The second way involves repapering the wall over the part where the plug fits, but then it will hold anything. Cut away the plaster down to the laths over a space of about 4in. each way, and fit in a piece of wood—elm for preference, as that does not split—into the hole, which should come within about $\frac{1}{8}$in. of the surface, and lie flush against the laths. Screw this to the laths with lath-screws (which are gimlet-pointed and made for fastening things to lath walls), using four or more screws, one to each corner. Plaster over the wood and into the spaces left at the side until the surface is flush with the rest of the wall, and when dry, paper. It is best to drive a screw into this for holding whatever there is to be held, for the knocking of a hammer is apt to loosen the plaster from the laths. Before this comes down the laths (generally three) to which the wood is attached will have to come out, so that at least a portion 4in. by 2ft. 6in. will have to come away from the wall.

It may be necessary on occasions to mend a plaster cast. Many of the adhesives given on previous pages are suitable for this, provided that the surfaces to be joined are first filled up in such a manner that they do not absorb the sticking medium. One of the best varnishes for such a purpose is shellac—made up from the bleached gum—this being used as a varnish first and allowed to dry, and some colourless adhesive employed to do the actual sticking.

Although there are several of the adhesives which are colourless, only one or two of the more complicated kinds would be suitable for filling the surface of plaster, and these would have to be put on in a very thin state. Shellac varnish, and any of the others which are suitable mechanically, are so highly coloured that they would only do for a painted cast—not for a pure white one. We have found the following recipe best for a job of this kind: Mix together (using a measuring glass for getting the quantities, for they are liquid measure) $\frac{1}{2}$ fluid oz. of carbonate of magnesia, $\frac{1}{2}$ fluid oz. of fresh plaster of Paris, 1dr. of powdered alum. See that these powders are thoroughly mixed, and then make up into a paste with 1 fluid oz. of water-glass. This makes about the best cement for plaster articles that can be got; it sets in about fifteen minutes, is very hard and very adhesive, and being dead white, can be used on the cleanest plaster without the joint being visible.

There are many things which need to have their surfaces prepared before an adhesive or cement will take upon them. We have already mentioned that woodwork must be properly prepared to take glue, and that it is not safe to use putty without first giving the surfaces to which it is to hold a key of either varnish, paint, or even oil if nothing else is handy.

Again, in plastering work we cannot get new plaster to stick to old unless we first wet it, and so when plugging a wall this point must be carefully attended to. Amongst special things which need a key is the metal zinc. Cements and paints will not adhere to the surface of this metal unless it is properly prepared first, and the method of doing this is as follows: Dissolve 1 part of chloride of copper, 1 of nitrate of copper, and 1 of chloride of ammonia (sal ammoniac) in 64 parts of water (rain-water for preference), and then add 1 part of commercial spirits of salt. Paint the zinc over with this and allow it to dry for twenty-four hours. After this treatment any paint, adhesive, or cement will adhere to the surface. In case the copper compounds cannot be easily obtained, they can be prepared at home as follows: Dissolve copper scrap in nitric acid until no more will dissolve; then evaporate the liquid, and the remaining blue crystals will be nitrate of copper. To make the chloride, heat some of these blue crystals in an iron melting-ladle to a red-heat, and dissolve the result, which is oxide of copper, in spirits of salt. Evaporate to dryness, and the remaining green crystals will be the chloride of copper needed.

Most amateurs may think that there is not much to be learnt respecting putty, and the filling-in of window-panes therewith. So far as this applies to ordinary perpendicular windows of small size the idea may be correct, though there is plenty of room for improvement in the manner in which panes are put in even by the professional glazier, for he leaves a margin of putty as much as a quarter of an inch wide sometimes visible from the inside. Let the amateur, however, put in a pane in a sky-light, or, better still, in a light on a sloping roof. If he does this with ordinary putty, even if a good key is given with varnish, as before mentioned—and this part of the business is often left out—it will be found that in less than a year the window will let the water in, especially if the pane is large. The reason is that the glass expands with the heat of the day, and contracts at night, and so works sufficiently loose to allow moisture to creep in between the putty and itself. This is not noticeable in upright windows, unless they are very large; but when they are horizontal, or nearly so, it is very soon found out, especially if there should happen to be a lathe or other piece of machinery under the window.

The remedy is very simple. Get very fresh putty and add to it a quarter of its weight of tallow, beating this in with a broad-faced hammer until the mixture no longer clings to the fingers, after which finish by working it in the hands. The putty so made expands and contracts with variations of temperature, and so does not give the wet a chance of getting in.

Putty consists of whiting worked up with boiled linseed oil to the proper consistence, and is so cheap that making it is not worth while under ordinary circumstances. But it can easily happen that putty is wanted in a hurry when the shops are shut, in which case it is as well to know how to make it. Whiting is stirred up in boiled oil (of which there should always be a stock in the workshop, and the whiting can generally be obtained from the kitchen) until it is too stiff to stir. Then it is put on a slab, preferably a metal one, and more whiting is added, beating it in with a flat-faced hammer until it is of the consistence of the shop-bought stuff. Failing the whiting, plaster of Paris, Parian cement (one of these should always be in stock), or even Portland cement, will make a good extempore putty. We have even had to use yellow clay dug out of the garden, dried, and made into putty with oil in this manner, and have found it work very well indeed. Of course, the putty so made is not so good as the bought stuff, for however long it is mixed with the hammer, that method cannot be as efficient as the trade one, in which a proper mill is employed. But if putty must be used, and there is no way of getting the proper stuff, the substitute is far better than none at all.

A word may be added as to the keeping of putty, for it is always a useful thing to have in the workshop. Every reader knows that in the oil-shop where he buys it, putty is kept under water. But there the barrel containing it is in use every day practically, and the renewal of the water to replace that lost by evaporation need never be forgotten. With the amateur, however, it is different. He may buy some putty for some purpose, and not have occasion to use it again perhaps for months. Then, unless he is a man of very methodical habits, when he goes to his jar he will find that all the water has evaporated and that his stock of putty is almost as hard as a stone.

If, when the putty is put away, the jar containing it is filled nearly to the brim with water, and a little sweet oil poured over this, the water will take years to evaporate, and if the jar is also covered with a loose glass, all dust and dirt will be kept out and no putty will go bad. Care, however, must be taken when the putty is wanted to pour away all the sweet oil so that none of it touches the putty, or it will prevent this from setting. If a narrow, deep jar is used, and the putty is well down under the surface, the top liquid can be poured off quite easily, and, of course, it can be used again as the oil comes to the top.

Putty is used a great deal by the plumber in making joints between the flush of the w.c. and the pan. He coats the pipe and the neck of the pan with ordinary paint, makes the joint with putty, and wraps round it several layers of cloth or canvas, painting each layer as it goes on, in a somewhat similar manner to that described for closing a leak in a pipe on page 66. His reason for using putty in preference to red-lead mixed with white, is that the latter in time gets so hard that should there ever be occasion to break the joint the pan may very easily be broken as well in the process. Putty gets hard, but not so hard as a mixture of red and white lead, and it can always be cut with a strong knife.

Belonging to the fillers is a species of cement often used by furniture restorers for filling in holes or cracks, and it is a very useful one to know of. It is used for wood for similar purposes to that described on page 69, and used for marble. If there should be a dent in a piece of furniture or other polished wood-work, a paste can be made up from shellac solution and very fine sawdust of the same kind of wood as that in which the dent is. In the case of mahogany the exact shade can be got by repeatedly soaking the wood-dust in a saturated solution of bichromate of potash until the desired colour is reached. Walnut and rosewood can be imitated by mixing with previously-dyed mahogany dust burnt umber or vandyke brown in powder. A certain amount of judgment must be used in mixing, for the shellac darkens the compound; but if the work has been properly done it is not always easy to find the repaired place, for the cement will take polish as well as ordinary wood will.

The cement which is used for sealing up bottles (that is, for covering over the cork or stopper after corking to prevent any possible loss by evaporation) may be mentioned here. It is made from paraffin-wax and beeswax in the proportion of two of the former to one of the latter. If the bottles sealed with this have to be exposed to heat much above that of the average summer a slight proportion of shellac should be added—about one-twelfth of the bulk—and if slight flexibility is desired a little scrap rubber may be melted in. If the mixture is to be white, use bleached shellac and white rubber; if coloured, use any of the ordinary paint powders. The method of making this mixture is to melt the paraffin-wax first, stir in the beeswax, then the shellac, and lastly the rubber, adding the powders, if any, when all is properly mixed. The rubber, by the way, should be finely shredded to facilitate its solution in the wax. An old tin which has turned-in edges and is not soldered is best for this work, and a clear fire is desirable to obviate as much as possible the danger of the mixture catching fire.

CHAPTER X.

MISCELLANEOUS ADHESIVES AND CEMENTS.

THERE are a number of cements and adhesives that should be made specially for jobs for which they would be used in quantity. For instance, in factories where cloth is stuck to wooden rollers (as in some kinds of calendering machines), and these have to withstand alternate wet and heat, they use the following special adhesive, though possibly some of those already described would do equally well if only one article had to be done. Equal parts of good glue and isinglass are soaked in water which covers them for ten hours, and are then boiled up like ordinary glue, after which pure tannin is added until the mixture becomes about twice as thick as ordinary glue. It is used as hot as possible and on warmed surfaces.

To cement leather to an iron pulley so as to give it a leather face which will resist the wear and tear of a driving-belt, and the consequent heating, none of the cements given in the foregoing pages is so efficient as glue and glycerine in equal proportions, the glue being first prepared in the ordinary way, and the glycerine added to the hot mixture. After the leather has been carefully fitted, the pulley is roughened with an old file, heated when possible, and the adhesive used hot, the leather being fastened down by several turns of string or wire wound round the face of the pulley.

If it should be necessary to join leather to leather so that the joint will be a very strong one, a cement made from the following ingredients will be found suitable: For joining-up leather driving-belts before sewing it has no equal, and it is very widely used by leather-belt merchants for this purpose. Mix together 100z. of bisulphide of carbon and 1oz. of oil of turpentine. In this dissolve sufficient shred indiarubber to make it of the consistence of very thick glue. The two ends of leather to be joined, having first been chamfered and properly fitted, are cleaned from grease by laying a clean rag upon the surfaces to be fixed and pressing a hot iron upon it. Blotting-paper, or, indeed, almost any clean paper, works just as well. Spread both pieces with the cement, and clamp between a couple of flat boards until the cement has become dry, which will take a few hours. After that the joint may be sewn.

Parchment may be thought to be a thing that does not need anything out of the ordinary to stick it—yet ordinary glue does not hold properly to it, nor do any of the other adhesives previously given. Those who deal with parchment therefore make a special glue from parchment clippings by boiling the latter in water in the proportion of 1lb. of the clippings to 6qts. of water. The boiling is allowed to go on until the clippings are dissolved, or nearly so (the time that this takes depends upon the thickness of the clippings—generally from two to four hours), and the solution is then strained and evaporated to the consistence of ordinary glue in a water-bath.

In setting knife-handles it is best to employ the same mixture as the professional cutler uses, although any one of the spirit cements previously mentioned, mixed with plaster or brickdust, would make a job of it. The cutler, however, uses one of the following: (1) Take finely-powdered bath-brick 1 part, beeswax 1 part, and resin 4 parts, boil up and properly mix, and run into the sockets of the handles; then make the tangs hot and thrust them in. (2) Take resin 4 parts, pitch 4 parts, tallow 2 parts, and brickdust 2 parts. Make and use in the same manner as the first.

Amongst other special cements of this class is that which is used in factories where paper labels are stuck on tins in great quantities. As the quantities are in the metric system, and they would be highly complicated if reduced to English measures, this recipe should be taken to a chemist to make up, for he will have metric weights and measures as well as the antiquated kind used in England. Dissolve 30 grammes of gum tragacanth and 120 grammes of gum acacia in half a litre of water. Make a second solution of 2½ grammes of thymol in 120 cubic centimetres of glycerine, and then mix the two solutions after having filtered the first through blotting-paper. When mixed, make up the quantity to one litre by adding water.

The wood-turner uses in his work a special kind of cement known as turners' cement, which is made as follows: Put into an old clean tin 1 part, by weight, of pitch and 4 of rosin. Melt over a clear fire, being careful that it does not catch fire, and then stir in sufficient powdered brick-dust to make it into a stiff paste. Parian cement, whiting, plaster of Paris, or powdered clay will do just as well as the brickdust, and if a specially strong cement for the purpose is needed, ½ part, by weight, of shellac, stirred in when the first two ingredients are melted, will greatly increase the strength.

Under no conditions, however, is this a very strong cement. It is suitable only for turning, and that only if the work is not exposed to shocks. It will, however, hold brass plates whilst being turned, and is very rapid in use in skilled hands. To use it, both the article and the face-plate to which it is to be held should be warmed, and, of course, the cement must be very evenly spread, or the work will not go truly on to the face-plate.

CHAPTER XI.

CEMENTS FOR IRON AND PIPE-FITTING.

Pipe-fitting in the ordinary house has but two branches in which cements are used, if we except such a job as that described on page 66. These are the joints in gas pipes and those in iron cold and hot water pipes.

Let us take gas-pipe joints first. As it is only necessary that these should be strong enough to hold gas, we do not make them with anything that dries very hard. Putty mixed with tallow and boiled oil to the consistence of a sort of very thick paint, the putty being about eight times the bulk of the tallow, makes an excellent gas joint. It does not dry away, nor hold the threads as if they were welded together, yet it holds firmly enough to withstand chance knocks. This mixture is used by painting over the whole of the thread, both on the outside and inside (that is the socket) with it, and then screwing together, massing the squeezed-out stuff round the end of the socket when the pipe is screwed home.

Cold water joints in iron pipes can be made with the same mixture, but they are better if the tallow is left out and an equal amount of red lead stirred into the putty. This sets fairly hard in a few days, and makes a strong joint, which, however, can be broken if necessary without much trouble.

If there should be a joint to make which it is never necessary to undo, a rust joint is a simple way of doing the job. It has the additional advantage that no lead is used, so that there can be no danger from lead poisoning if the pipe is used for drinking water.

A quick-setting rust joint is made as follows: Mix together 1oz. of sal ammoniac, 2oz. of flowers of sulphur, and 5lb. of cast-iron borings or turnings, which must all be well ground in a mortar. Cast iron, by the way, can be pounded up as easily as marble if in the form of borings or turnings. Make this up with water to a thick paste, and use it as directed for a gas-pipe joint. It can be used almost immediately, as it hardens very quickly. The ingredients, however, cannot be stored, as the sal ammoniac affects the iron.

If it be permissible to wait for a day or so before letting water through the pipe, the following is a better mixture, but does not set so quickly: Take 1oz. of sal ammoniac, ½oz. of flowers of sulphur, and 6¼lb. cast-iron borings or turnings. Mix with water and use as before. Boiling water may be passed through this without danger, but the joint will take a fearful lot of undoing if once fairly set.

It is better in a house to use for hot-water joints a cement made from white lead (the variety which is sold ready mixed with oil) 4 parts and iron borings 3 parts, well mixed and put on as already directed. This is reasonably soft when set, so that it will not need a sledge-hammer to loosen it. Yet it will stand steam. We have used it for steam pressures up to 160lb. many times, and always with success.

Another cement for pipes which sets very hard and is fairly permanent is: Iron borings ground up fine in a mortar and mixed with sea-water to a very stiff paste and thinned down with a 10 per cent. solution of sal ammoniac in fresh water.

A cement which becomes nearly as hard as the iron itself, and which has the additional advantage that the mixture can be stored ready for use, is made from the following ingredients:—Paris white, 5oz.; yellow ochre, 5oz.; litharge, 10oz.; red lead, 5oz.; black oxide of manganese, 4oz. Grind these thoroughly together with about ½oz. of dry asbestos. For use make into a putty with boiled oil. This will stand fire or steam or super-heated steam at high pressures. Consequently it is used a great deal in the making of boiler joints, but a pipe union once made with it cannot be undone, even if made red hot, for the pipe will break or buckle up before the joint will give. For resisting fluid pressure it is, of course, the very thing.

The engineer's best pipe-joint, however, if everything is taken into account, is made from red and white lead only. It is best because it can be taken apart easily, yet resists anything in the way of steam pressure and heat, though, of course, it will not stand the direct action of flame, nor is it intended to. Take ordinary good white lead ground up in oil, and add dry red lead to make a stiff putty. Pound this with a broad-faced hammer on a block of iron until it becomes soft, and continue to add red lead until the mass will no longer soften or stick to the fingers. A pound of white lead will absorb nearly a pound of dry red if pounded in this way. Spread this putty on the pipe threads or between the flanges of the steam joint; it makes the best general joint known. It can be stored when made by keeping it under water, taking the precautions mentioned with respect to putty.

Pipe joints may have to be made to withstand the action of paraffin, and these are best effected with grommets of tow well smeared with shellac solution. Wind the tow in the male thread, beginning about ¼in. from the end, and leave some to spare towards the body of the pipe. Screw up, and then wind the slack tightly round close up against the neck of the socket. A joint which is finished with a back nut is made in this way as well, the hollow-faced part of the nut bunching up the tow and making an impermeable joint.

In cases where the fit of ordinary pipes is not good, tow should also be used whatever the cement, and it is, of course, well soaked in water if the pipes are coupled by a rust joint as described on page 80. The only exception is the asbestos joint described at the bottom of page 80.

We have often made use of a simple lead joint for high pressures where the pipes had to come apart very often. The advantage is that the joint can be broken by the mere undoing of the nuts (this refers to flanged joints), and replaced without any clearing off of the old cement. Such joints consist merely of a thick lead washer inserted between the flanges, the nuts of which are then pulled up tight, working on each one equally in turn. Lead is not of much use in making a back nut joint, however. If the faces of the nut and the socket are not true to each other, the lead will squeeze out or cockle up when the nut is pulled up tight. A sheet of soft copper answers the purpose equally as well as lead, but not being so soft has to be pulled up tighter, and there is thus danger of stripping the threads of the bolts or twisting them off altogether. Copper, therefore, should not be used where the bolts are under $\frac{5}{8}$ Whitworth. Copper wire, say No. 14 gauge, placed in a spiral on a flange, and the two flanges pulled together, makes a good joint, but the copper must be first made red hot and then plunged into water, whilst one end of it must overlap the next strand.

Many of the joints mentioned above are makeshifts, which should only be used when there is nothing else handy. Where, in a pipe-fitting job, everything that can be desired is there for the asking, we should only use, first, for a flange joint which has often to be broken, and where the fit is good, lead; secondly, for one which has never to be broken, the asbestos cement, this applying to ordinary sockets, not to running joints; thirdly, where the fit in a flange joint is not superfine, the red lead and white lead cement, the same for back nuts and sockets which have to come apart; and lastly, in a breakdown job, the quick setting rust joint described on page 80 which will allow of a joint being used half an hour after making.

In all pipe work there is a precaution to be taken which, if neglected, may result in every joint having to be undone again. The precaution referred to is to see that every bit of pipe is clear before the joint is made. It does not often happen that a pipe is blocked, but when it is and the fact is not found out, the whole lot may have to be ripped out before the fault is found. We were once on a job where over 400 feet of steam barrel had to be taken down before the block was found, and it was then discovered in the shape of a mouse's nest situated in a bend.

Another thing to bear in mind, especially when making flange joints, is to place a piece of rag fastened to string in such a situation that it can be pulled through, so as to clear out any cement which may have squeezed itself into the pipe. Failing the possibility of this, make the joint with the cement spread to only about ½in. of the hole in the flange, so that it cannot squeeze out, and put a ring of tow about ¼in. from the edge of the bore. For socket-joints, in order that the stuff may not squeeze in, do not cover the end of the pipe, but begin about ¼in. from the end, and when doing the socket, only paint the inside with a very thin cement, about half-way down. The pipe-end, in passing through the socket, will pick up enough cement to make the joint all over, and then nothing will get into the bore.

A cement that will withstand the direct action of flame may be found useful on occasions, and it is made in the following manner: Rub together, cast-iron borings, 100z.; ordinary clay, 200z.; china clay or fire clay, 150z.; and see that they are thoroughly mixed. When wanted for use, make into a putty with ½ pint of ordinary sea-water, or of a solution of salt and water (1oz. to the pint), the first being better. When the mixture is dry, it should be fired gradually, preferably in a coke stove, until it reaches a red heat, after which it will stand continuous firing.

Cracks in stoves may be mended with this, but are better done with the mixture described below. Pulverise ordinary yellow clay, and mix with an equal weight of pure wood-ashes; add one-quarter the weight of common salt, and mix with water to the consistence of cream. For making joints in a stove or stove-pipe, or for filling in cracks at the back of a grate, this is almost the best, and certainly the cheapest, mixture there is.

If it is necessary as well to cement the stove in place, the following will be found better, but is of course more expensive, and not convenient to make, unless the user is in the country, where slaughter-houses are yet to be found, and where blood can be got easily, which is a difficult matter in London, or in any big town.

Get some freshly-made air-slaked lime, and mix 1lb. of this with 3lb. of finely-sifted coal-ashes. Then make this into a cement with blood from the slaughter-house. Be very careful not to touch this mixture with the hands, but use a mason's trowel to put it on with, as it takes weeks to get it off the hands. It must be used quickly. In less than half an hour it will be firmly set, and at the end of a couple of days will be almost as hard as iron. If it should be impossible to obtain blood, nearly the same effect may be got by using eggs—fresh or otherwise—for it is the albumen in both blood and eggs which is the active agent in this cement.

In some cases the mixture which follows may be more convenient to make than that described immediately above, and it has the additional advantage that it can, if it should be necessary, be raised to a red-heat again and again. The cement is also especially useful for plugging blow-holes in cast iron, for it will take the file when dry in exactly the same way as the metal, and it is only by its colour that it is distinguishable from the actual iron, being very nearly as hard. Mix 5 parts by weight of clay, 2 parts of sifted cast-iron filings absolutely free from rust, 1 part of manganese dioxide, ½ part of Tidman's Sea Salt, or any other variety which is to hand, and ½ part of borax. This, mixed with water to a thick paste, and used quickly, sets very hard. If intended for standing heat, it should gradually be raised to a white heat, and allowed to cool under the ashes. But for this purpose a forge is almost indispensable.

A special use for the above is the fastening of iron railings into their sockets. This is very often done by pouring melted lead in; but the method is very unscientific. The action of rain-water or other wet is to set up an electrolytic action between the lead and the iron, and this in time eats away the railing at the base. It is for this reason that iron railings are sometimes found eaten away as thin as a slate-pencil just at their junction with the stone. Another method much in vogue is to pour melted sulphur into the socket. This is not so bad, but sulphur does not make a very hard setting, though it is unaffected by moisture.

The last-mentioned cement, though it will stand direct heat, will not stand steam. Here is a cement which will. It has no special applications, and has nothing very special to recommend it above any of the others which have been described, except that it withstands frost or baking heat, wet or drought, and is easy to make and easily stored. Mix finely-ground blacklead, 6 parts; freshly-made air-slaked lime, 3 parts; and plaster of Paris, 8 parts. Make this up with boiled oil to a putty, and use quickly; it sets in a couple of days, and becomes very hard.

Still another mixture which is applicable to iron railings fastened to stone, and, in fact, is generally useful where iron has to be fastened to stone, is made thus: Take 20 parts of sifted cast-iron turnings or filings, 50 parts of plaster of Paris, and 3 parts of sal ammoniac, and mix these to a cream-like consistence with weak vinegar.

Aluminium is a tricky metal to have anything to do with, and it is not an exception with respect to the holding of adhesives on its surface. When, therefore, occasion arises for fixing aluminium display-letters on glass fronts, &c., it is better to use the following adhesive than any of those already described: Best copal varnish 15 parts by weight, linseed-oil varnish 5 parts, and the same of oil of turpentine and Salisbury glue. The glue is dissolved in the mixture of the various ingredients by gently heating in a water-bath, and, when the solution is complete, 10 parts by weight of freshly-slaked lime are stirred into the mixture.

There is one last cement which should be mentioned here.

It is a mixture for cementing together broken cast-iron, but it can only be used with success upon pieces which have not been allowed time to get rusty. Rub together in a mortar, and pass through a sieve a few times, the following: 1 part of flowers of sulphur, 1 part of dry white lead, 1/6 part borax, all by weight. To use this, mix to a thinnish paste with strong sulphuric acid (the commercial article in this case gives better results than the pure), smear both broken surfaces with a thin layer of this, and clamp together immediately as tightly as the clamp can be set up. Allow this at least five days to set, at the end of which the joint will be invisible. So strong is this cement that a joint made with it has been known to resist the blows of a sledge-hammer.

CHAPTER XII.

BUILDERS' MORTARS AND CEMENTS.

MORTARS belong to that class which depend for setting upon the absorption of carbon dioxide from the atmosphere for the most part, and in every instance their action is purely chemical.

For the purposes of these pages we will class under the mortars common builder's mortar, Portland cement, concrete, Roman cement, and the plasterer's six different grades of material.

Let us start with common mortar first. Generally speaking, everybody knows that this is composed of lime and sand. But everybody does not know the proportions used, nor the precautions necessary for the best results to be obtained. The stuff which the bricklayer uses for building a wall consists of 1 part of slaked lime to 3 or 3½ of clean river sand. It will not do to use sea sand for this purpose on account of the salt in it, which would cause a white efflorescence to appear after a time. In the country, and especially in the North, a mortar in which 1 part of sand is replaced by ground coke is often employed, and, for filling in, coarse mortar which is composed of 1 part of lime to 4 parts of coarse, gravelly sand is used.

The amateur will probably not use mortar to any great extent, for the building of a wall of any size will be beyond him. All that he will probably do is to build a greenhouse or something similar, so that it is useless to go into the various bonds, &c., used by the bricklayer; besides, such information would be outside the scope of this book.

Hydraulic mortar he may sometimes need, also beton, which is a kind of mortar concrete used for filling up. The first is composed of 1 part of blue lias lime and 2½ of burnt clay, ground together; whilst the latter consists of 1 part of hydraulic mortar as just described to 1½ of sharp angular stones.

Builders' cements—this term in the present instance being taken to apply to such substances as Portland, Roman, &c., cements—are really mortars of a superfine quality, used for putting down doorsteps, setting grates, and treads of stone staircases, &c.; also where a specially smooth surface is needed.

Should a specially hard cement be needed for outdoor work it can be made from Portland cement with chalk paste (hard or "fat" chalk, the kind found under the ordinary surface chalk), fine sand, and siliceous earth (that is, earth taken from any district where the nature of the earth is clayey) in the following proportions:—Cement 6 parts, chalk paste 12 parts, fine sand 6 parts, and siliceous earth 1 part. These must be mixed into a thick paste with water-glass and used quickly. Such a mixture is one of the best of weather-resisters.

Portland cement, if used by the amateur, must be of the best quality, to make up for lack of skill in using it. It should be of a clean, slaty-blue colour; any that is of a brownish hue should be rejected, for that colour means that it is badly burned and consequently weak. Furthermore, before this cement is used it should be spread upon a floor exposed to the air—but not to wet of course—for a short time, a layer a couple of inches or so deep, and raked over every now and again. This makes the final cement much stronger, for the air slakes out any lime which may happen to be uncombined.

The mistake which the amateur makes when mixing mortar, cement, or concrete is to make it too wet. Mortar and concrete should be waterproof when set, and to this end the ingredients should be in exact proportions. Roughly, the proportions given above for mortar, and 1 part lime, 4 parts gravel, and 1 part sand for concrete, are correct. But the ingredients differ in quality, and even a practised mixer of strong concrete has to test the amounts before getting to work. The theory is that there should be sand enough to fill in the blank spaces between the larger stuff (gravel) and cement enough to fill in the voids in the sand and hold it together. The professional goes to work thus: He finds out first how much water can be poured into a pailful of the coarse stuff. This determines the proportion of sand. Then he takes a measure of dry sand equal to the volume of the water he has just found, and tests how much water can be poured into the sand. This gives the minimum quantity of cement that must be used.

Brickwork, or work in which mortars or cements are used, should not be erected in the winter unless some provision be made to keep the frost from both cement and stones. Freezing will destroy the adhesive qualities of cements at the time of application, so that if it be imperative that such work be done during a frost, both the cement and bricks or stones must be treated artificially. The warmer the weather is, the better is it for cementing operations, and it is very probable that the lasting qualities of the mortar used by the Romans is due to their practice of using their cements almost boiling; also to an ingredient which was handy in those days—namely, blood.

When a wall has been built, if it is in such a position that proper finish is desirable, it is "pointed," as it is called—that is, the mortar is raked out from the joints to a depth of ½in. or so, and a fine cement is used to fill it up. The ordinary stuff for pointing a common brick wall is made from 1 part of lime to 2 of very fine river sand, mixed up with enough finely-ground coke, or ashes from a blacksmith's forge, to give it a slaty-blue colour. This is styled "flat-pointing." For superfine work, what is called Tuck pointing is sometimes used. This consists in laying over the blue lines a white line of "plasterer's putty" (which is a very different thing from glazier's putty), so as to let the blue show each side of the white line. Plasterer's putty is made from good lime, stirred up with plenty of water—so much that the slaked lime is suspended therein. The water is then allowed to evaporate until the pasty remnant is of the proper consistence for working, *i.e.*, about the same as plaster of Paris freshly mixed.

The plasterer uses in his work no fewer than six different kinds of cement. The first of these he calls "coarse stuff." This is used for laying over the laths which have been nailed to a wall, and is generally from $\frac{1}{4}$in. to $\frac{3}{8}$in. thick in what is called "one-coat" work. Coarse stuff consists of a mortar composed of 1 part lime and $1\frac{1}{2}$ parts of sharp fresh-water sand, with 1lb. of hair to 3 cubic feet of the mortar. This is laid on the laths and smoothed off with a trowel.

If the job should be a "two-coat" one, the plasterer proceeds as follows: With a birch broom, or with a lath which has been bevelled to an edge, he scores or undercuts the surface of the mortar which has just been put on, before it is dry, and on the top of this he puts "fine stuff." This is exactly the same as plasterer's putty, except that it is used a little thinner than would be the case if a wall were being pointed. In some cases "fine stuff" is replaced by "gauged stuff," which consists of 3 parts of fine stuff mixed with 1 part of good plaster of Paris.

"Three-coat" work, or, as it is otherwise technically called, "float and set," is done as follows: When the first coat or "pricking-up" coat is dry and scored, the surface is divided up into 8ft. squares by "screeds" (broad division lines) of coarse stuff, 8in. wide, and carefully levelled. These when dry are then further filled in by coarse stuff, and floated properly level with the trowel, after which the finishing coat of gauged stuff is put on.

"Stuccoing" is a branch of the plasterer's art, and he uses two kinds of stucco. The first is called "common stucco," and consists of 1 part of lime to 4 of clean washed river sand; whilst the second variety, which is called "bastard stucco," is composed of 2 parts of "fine stuff" and 1 of clean sand, together with a little hair.

Another kind of stucco, which sets as hard as marble, and stands the weather almost as well, is used in the East a great deal; but has not found its way to England to any extent. It is made by mixing precipitated lime or "fine stuff" with an equal bulk of plaster of Paris, and making it to the proper consistence (about that of freshly-mixed plaster of Paris) with white of egg. This will take a polish even, though not so fine a one as marble, and is very suitable for houses in the country, which are far away from any smoke or dirtying influences, as the stuff is a pure white. It can be coloured to suit; but, of course, the colours must be such as are not affected by the lime.

Akin to stucco-work is the following cement wash for both iron and wood work exposed to the weather. It prevents dry rot when applied to such covered-in work as would be liable to that disease, and is also a good thing to cover woodwork which is exposed to a gas flame or other heat, as it prevents charring. Mix 1 part of Portland cement with 2 parts of fine sand, and make these into a wash with 1 part of skimmed milk. Only enough of this should be made at a time to last for half an hour's work, and it should be well stirred during the time of using to prevent the sand from settling.

A mixture which gives a smoother surface, but which does not go so far, is fresh cement mixed with skimmed or curdled milk to a paint. Both of these are put on with an ordinary whitewasher's brush, and two coats should be given, the second thicker than the first.

The laying of a plaster or concrete floor is a job which may easily come to the lot of the reader; for instance, if he should build a workshop outside, or a greenhouse, or even if it should be necessary to relay a scullery floor. In such a case he will do much better with the following than he would with concrete, cement, or asphalt: Intimately mix 1 part of lime which has been well slaked by air only, not by water, with 6 parts of good plaster of Paris; mix this, like plaster of Paris, a little at a time with water, and lay it down as quickly as possible, working the trowel over it no more than is necessary. Then let the floor become thoroughly dry, and soak it with a saturated solution of sulphate of iron (ordinary green vitriol) or sulphate of zinc (white vitriol). The iron gives the strongest and hardest floor, for the resistance to breaking is some twenty times as great as that of ordinary plaster. If sulphate of zinc is used, the floor remains quite white, but is not quite so strong. The iron sulphate makes a floor the colour of rusted iron, but if this is dressed with a couple of coats of linseed-oil, boiled with litharge (about ¼lb. of the litharge to 1½lb. of oil), it changes to a beautiful mahogany colour, and is still more increased in strength; whilst a couple of coats of copal varnish make a very handsome floor indeed of it.

A floor such as this should be laid about 1in. thick, and should be smoothed by means of a planed plank, as long as it can be conveniently used, and some 3in. wide by at least 1in. thick, the edges being slightly bevelled, so that the board may ride over and smooth out irregularities. If laid over worn bricks, so as to get a level floor, of course the result is extremely strong, and in this case a thickness of ¾in. at the thinnest part need not be exceeded.

Just a few words in conclusion. The chief aim of this book has been, not to give a string of recipes for adhesives and cements, but to teach the reader the principles governing their use and preparation. Hence, as far as possible, only representative recipes have been given. But the reader who knows the theoretical part, and can apply the knowledge which it has been endeavoured to instil in this book, will have no need of recipes, for he will be able to compound his own cements and adhesives to suit any job which he may be called upon to undertake.

INDEX.

D.

E.

F.

G.

H.

I.

J.

K.

L.

S.

T.

U.

V.

W.

Z.