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DEPARTMENT OF COMMERCE
BUREAU OF STANDARDS
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Letter
Circular

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AQUARIUM CEMENT

It requires no argument to prove that a leaky aquarium is a nuisance to its owner and may be disastrous to its inmates. This Letter Circular tells how to make and use aquarium cement, and gives more detailed instructions than it is possible to give in an ordinary letter.

The design and construction of the metal framework of the aquarium must reflect the ingenuity and skill of the maker but if the making of the cement were left entirely to him, without any helpful suggestions, he might be at a loss to know where to start. The cements for which formulas are given here are known to be good, and they will be entirely satisfactory if they are properly made and used.

It will be assumed that the frame of the aquarium is made of metal. Although it may rest on a wooden base, the construction must be such that the cement will not come into contact with the wood. If this should occur, the wood will tend to draw the oil out of the cement, thus making it slightly porous. The result may be that moisture will ooze through to the wood and cause it to warp, and thus place an undue strain upon the whole aquarium and perhaps ruin it.

The frame should be rigid, so that the pressure of the water will not be able to spread the sides apart. Rigidity without a heavy appearance of the frame is most easily secured by having a strong metal frame, or trim, around the top. This will not only hold the sides together, but it will also shield the upper edges of the glass panes, which would otherwise have to be ground smooth. If left rough they would be unsightly and dangerous. They would be pretty sure to cut the hands and chins of visiting children, who always seize the top edge of the aquarium and look in over it.

The pressure against the sides is not a matter of theory, but something very real. If an aquarium which measures 18 by 24 inches is filled to a depth of 10 inches, it will contain 18.7 gals., or 155.5 lbs., of water. The following simple calculation will give the total outward pressure against the four sides. The average depth is 5 inches, so each square inch of the sides is, on the average, under the pressure of a column of water 5 inches high. This column of water, 5 cubic inches, weighs 0.18 lb. The total area of the sides in contact with the water is 2 x 10 x 18 + 2 x 10 x 24 = 840 square inches; and 840 x 0.18 = 151.2 lbs.

From these figures it would seem that an aquarium of the size stated is about as large a one as can be made safely with

double-strength window glass. Experience has shown that the pressure is not great enough to burst the glass of an aquarium of that size. Careful tests would no doubt show that the pressure could be greatly exceeded before the glass broke, but this does not necessarily mean that double-strength window glass is safe to use in a larger aquarium. There should be a reasonable margin of safety.

Changing the proportions of the aquarium, and especially the depth of the water, even though its volume remains the same, may make a serious difference in the pressure against the sides. For instance, 15 inches of water in an aquarium 16 by 18 inches will make 18.7 gallons. But now the average depth is 7 1/2 inches, so the average pressure will be increased by one-half, or to 0.27 lb. per square inch. The total area of the sides in contact with the water will be 2 x 15 x 16 + 2 x 15 x 18 = 1020, instead of 840, square inches. Then, 1020 x 0.27 = 275.4 lbs., the outward pressure. It would not seem safe to expect anything but plate glass to withstand this pressure. Fortunately for the good of its inhabitants, an aquarium should be broad and shallow, and not narrow and deep. It is a good rule to have the depth of water no greater than the width of the aquarium. If the depth is much less, down to a reasonable minimum, so much the better.

Single-strength window glass had better not be used in even a very small aquarium, because it is so easily broken by blows.

Measuring the frame for the glass must be done carefully. Two panes for opposite sides can be full length or, perhaps better, about 1/16 inch shorter than the spaces into which they are to go. The other two panes must be shorter than the corresponding spaces by an amount equal to the combined thicknesses of the first two panes plus two layers of cement. The latter can be estimated as about 1/8 inch each. If the bottom is to be covered with a pane of glass, this can be practically full size (that is, about 1/16 inch short on each side), if it is to be inserted first. In that case an allowance must be made in the widths of the vertical panes, or they may project above the top of the metal framework. If the glass which covers the bottom is to be put in place last, its dimensions must be less than those of the bottom of the frame by an ample amount, or there will be trouble at the last moment.

Various mixtures of bituminous and tarry materials are known as "marine glue". They are used for calking seams of pontoons and for similar purposes, but they are not regarded as suitable for cementing aquaria. They remain rather soft, and in hot weather have a decided tendency to run. For an aquarium the cement should have more body, so that it will have no tendency

to flow in the hottest weather. If it does not set stone-hard, so much the better. These requirements are satisfactorily met by cements made according to the formulas given here.

The Bureau of Fisheries, Department of Commerce, has for a long time used an aquarium cement made by mixing 5 parts by weight of glazier's putty with 1 part each of powdered litharge and red lead, and enough boiled linseed oil to give the mixture the consistency of putty. The litharge, and especially the red lead, hasten the setting of the cement, but even so it is advisable to add a few drops of japan drier to the boiled oil. If slate-colored cement is desired, add a little lampblack. This is most easily done by mixing it with the dry powders, but in that case it is hard to tell just how much will be needed to give the cement the desired color.

The Bureau of Standards is not officially concerned with aquaria, though cements fall within its province. However several members of its staff have constructed aquaria at home, and nearly all of them have used a cement for which the formula is given in various books. In this formula all parts are by bulk, as follows: Mix 10 parts each of plaster of paris, fine sand and litharge, 1 part of powdered rosin, and enough boiled linseed oil to make a stiff putty.

A variant of this formula is perhaps an improvement upon the original. The plaster is omitted, red lead replaces about 1/3 of the litharge, and spar varnish is used instead of boiled linseed oil.

None of the formulas need be slavishly followed, provided the ingredients are thoroughly mixed and the resulting putty is neither so stiff that it can not be applied smoothly with a putty-knife, nor so soft that it will tend to flow and will also take too many days to set.

The cement can be made most easily on a piece of sheet metal or a pane of glass. Mix the dry materials thoroughly, then add the oil, or varnish, a little at a time, and work in each portion with a putty-knife. At one stage the mixture will seem hopelessly lumpy,, but this is a sign that the end is approaching, and that only a little more oil will be needed. The portions added should be smaller than before and the working more thorough, because kneading makes the mass softer, up to a certain point. If the mark is overstepped, a little more of the dry materials must be added.

It is not possible to calculate closely what weight of the dry ingredients will be needed to make enough cement for an aquarium of a given size, because when a solid lump of anything is ground, the powder from it will occupy a greater volume than

the lump. The "bulking value", or volume occupied by a given weight of a powder, depends not only upon the actual density of the individual particles, but also upon their size and upon how closely they are packed together. Ordinarily the air spaces in a tightly packed mass of a powder total a greater volume than that of the solid particles. Another thing to remember is that when a fine and a coarse powder are mixed, say one cubic inch of each, there will be less than two cubic inches of the mixture, because the fine particles enter the larger spaces between the coarse particles. The oil or varnish used in the cement will fill the air spaces, but it also coats the particles and keeps them from actually touching. If the film of oil between two particles is thicker than the film of air that is supplanted, the effect of the oil will be to increase the volume of the mass of cement.

One must be content with making a rough estimate of the volume of cement that will be needed. If the frame has a base 18 by 24 inches, and the vertical angle-pieces are 12 inches high, there will be 8 x 12 + 2 x 18 + 2 x 24 = 180 running inches of metal to be cemented for the sides. If the glass overlaps the metal 1/2 inch, this will mean 1/2 x 180 = 90 square inches to be covered. Finally, if the layer of cement is 1/8 inch thick, there will be required 1/8 x 90 = 11.2 cubic inches of cement. A

pane of glass on the bottom means an additional 84 running inches, or 5.2 cubic inches of cement. The total, 14.6 cubic inches, is not quite 0.6 pint, liquid measure. It would not be wise to figure as closely as this in buying the materials or in mixing the cement. The ingredients are so cheap that one can afford to make considerably more cement as a margin of safety in case of mistakes.

Before starting to put in the glass, it is advisable to make ready several slender strips of wood, which will be used to hold the panes under gentle pressure against the cement. They should be a little longer than the distance between opposite panes, so that they must be bent slightly when set in place. They will thus exert a steady pressure that will keep the glass from falling inward. The pressure should not be so great as to force out any great amount of the cement. If this should occur, the strips of wood are too long and stiff, the cement is too soft, or too much of it has been applied.

Judgment must be exercised in preparing and using the wooden strips, so that they will do their work most safely and effectively. No fixed rule can be laid down for lengths and thicknesses that will be right for an aquarium of any particular size. At least four will be needed for each two pieces of glass,

but if the panes are much over a foot in length it is advisable to use two or three more. Do not set any of the strips close to the corners, but 4 or 5 inches away, measured along the diagonals of the panes. If more than four are used, space all of them in such a way that the pressure will be as even as possible over the whole area.

With a putty-knife apply a smooth, thin layer of cement to the parts of the metal frame against which the two full-size panes are to go. Set these panes in place and press them gently with outspread fingers so as to make perfect contact between glass and cement. There should be no large air bubbles trapped in between, and especially no air channels that extend across the layer of cement. If the cement is carefully smoothed when applied and is made thinner towards the edge of the metal, the chance of trapping air will be lessened. If everything looks satisfactory, hold the panes in place by means of wooden strips. Next, cement the rest of the frame, insert the last two pieces of glass and hold them with strips.

The piece of glass that covers the bottom can be set in place before or after the others. If after, a piece of stiff wire bent at a right angle at the end should be used as a hook to let it down gently, because the clearance will be too small for the fingers. It would be extremely difficult, if not im-

possible, to cement evenly the entire bottom of the metal frame, yet the glass should be supported in the middle, or the weight of water will bend, and may break, it. Fortunately it will suffice to place little dabs of cement here and there over the bottom of the aquarium. These, with the layer of cement around its edges, will support the glass a fraction of an inch above the metal bottom. In the 18 by 24-inch aquarium that has been mentioned, the bottom is of galvanized iron, and the glass that covers it is double-strength window glass. If there is no metal bottom, plate glass or a slab of slate would have to be used for an aquarium of that size.

If the glass for the bottom is the last piece to be inserted, the strips of wood must be removed temporarily, but they should be replaced promptly. Then clean off any excess of cement, smooth its exposed edges, and give the job a close inspection. Look especially for air channels, and if there are any, try to close them by working in cement from the inside of the aquarium.

If everything seems to be right, leave the aquarium untouched for at least 48 hours. If it must be moved, pick it up by the wooden base, and never by the metal frame, unless this is very rigid.

After 48 hours, the average builder of an aquarium finds it difficult to resist the temptation to fill it with water. If

his cement was not too soft at the start, it will be safe to put in 6 or 8 inches of water, after which the wooden strips will be no longer needed. A day or two later, the aquarium can be filled to within about 2 inches from the top.

If it should happen that there is any serious leak, the only thing to do is to dip out the water, and wipe the aquarium thoroughly inside and out. Then, after the crevice has had time to dry out, try to close it by working in cement from the inside. The cement for this purpose can be softer than that used at first, to make it go into the narrow space more easily.

There may be a few tiny leaks, through which the water merely oozes. It is sometimes possible to stop these without removing the water. Get a little of the stiffest clay that can be found, moisten and work it in the hands, and apply a small ball of it on the inside, over each leak. The clay will be washed away slowly, but enough of it will be left to fill the holes and stop the leaks.

The Bureau of Fisheries, Washington, D. C., should be applied to for information about the maintenance of the aquarium. Those who live near a large public library can find books by W.L.Brind, O.Eggeling and F.Ehrenberg, W.T.Innes, I.M.Mellon, H.Mulertt, C.N.Page, M.Samuel, Eugene Smith, Hugh M. Smith, C.H.Townsend and H.T.Wolf. It is not necessary to give the titles of their books.