The gist of what follows was first posted to <Clockers> (now Clocksmiths) at the end of February and the beginning of March, 1996, but it has been revised, edited and expanded in an attempt to increase clarity and remove ambiguities. I am indebted to several list members who asked questions and made comment then and later, thus contributing to its completeness.

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# PIVOT-HOLE BUSHING with the BERGEON BUSHING TOOL.

## A brief word on Terminology:

Common parlance often tends to be rather loose, and the words 'bush', 'bushing', 'rebushing' (or 're-bushing') are often used interchangeably. However, if you think about it you will realize that 'bush' refers to the small brass cylinder (usually drilled), whereas 'bushing' (as a noun) should be used more correctly only to refer to the completed job after this cylinder has been inserted in its position in the clock plate. Again 'bushing' (as a verb) is the act of installing a bush for the first time as a pivot hole, whereas 'rebushing' is the replacing of an old worn bush with a new one in its stead.

## Range of Bushes:

For those of you interested, here is how I usually carry out straight-forward bushing using a Bergeon bushing tool and brass Bergeon bushes. I carry a full range of bushes #1 to #60, which I keep replenished as necessary with 10-packs. I also have a few simple gadgets that I have made for doing awkward things like a hole near the edge of the plate or the hole in a French cock. (Yes, that's what we call it here ! Maybe some of you have some other name for it [;-))) )

## Selection of Bush:

After filing and burnishing the pivot as necessary, and presuming that the hole has not been bushed before, select a bush of suitable length, and smallest *outside diameter*, compatible with the pivot size. This will usually allow a wall thickness of about 0.5mm for the smaller sizes of clock pivot. The hole will later be expanded to the required diameter, which I usually find to be somewhere around 0.03mm to 0.05mm over the pivot diameter, but final size must always be checked out by running between the plates. Even if the hole in the bush seems OK, I would always give it a light touch on either side with a cutting broach, followed by a good burnishing with a smooth broach.

## Reaming out:

+ Place, and tighten (with its grub screw), the centre-point into the vertical tool holder that has a hand-wheel at its top -- the "mandrel". + Slacken off the two sliding carriers and two plate clamps.

+ Set the clock plate in the tool, _inside face upwards_, centering the hole approximately.

+ Very lightly tighten the mandrel's knurl-headed holding screw on the front of the frame, so that any slop is removed, and the mandrel is held firmly vertical.

+ Bring down the mandrel, and as you do so, slide the plate in order to guide the centre point into the pivot hole. Then press down, and tighten the knurled screw so that the clock plate is held firmly in position.

+ Position the slides, with at least 1/8" gap in each clamp jaw behind the edge of the plate -- this ought to avoid any chance of the plate being displaced during the final clamping process.

+ Fully tighten the bottom screws of the slides, still leaving the plate clamps slack.

+ Keeping the mandrel *forced* down into the pivot hole, slightly slacken off the knurled screw, rotate the plate back and forth just a little (with your other hand) and fully retighten the screw.

+ Once more rotate/oscillate the plate very carefully -- this is the really important operation for correct positioning. The idea of this action is to allow the mandrel itself to slide the pivot hole to the perfect centre position as you perform the rotation. The rotation should be small -- 20deg or less either way -- and great care should be taken not to apply any linear "push" to the plate.

+ Now fully tighten the top plate clamps, bringing on the pressure equally and simultaneously on to both sides of the clock plate.

+ Release the mandrel, and once more check that the slide and clamp screws are fully hand tight.

Comment:

All this at first reading might seem to be a little long-winded, but the reasoning behind the method is this: The great majority of clock plates have had their pivot holes deburred or chamfered on the inside. It makes sense that a manufacturer would do this to reduce the friction at the pivot shoulder. On the other hand, the lateral wear in the pivot hole will not be chamfered in this way. The use of a depthing tool or other methods for obtaining original centres have been suggested, but I have found my method to be virtually foolproof, no matter how "oval" a pivot hole has become by wear. Provided the pivot hole position has not been compromised by a previous repairer (eg punched up), and the pinions and wheels are in reasonable condition, this method of centering has been successful for me.

Regrettably this comment also probably applies to the recommendation that the pivot hole might be filed out to balance the wear, as I fear that this too might compromise my centering method, but I have never had a problem in using the tapered cutters carefully as described below, to form a properly centered hole for the bush.

Bushing and Sinking:

+ Open out the pivot hole using _each_ size of reamer in turn (starting with the smallest) until the correct diameter for the selected bush is reached. It is important to keep the knurled screw of the mandrel (on the front of the frame) lightly tightened so that any slack is completely removed, and the maximum possible centering accuracy is maintained. Also, with the first cutter, you should frequently withdraw it, and use the minimum of downwards pressure, in order to keep the cut central.

+ Very lightly deburr the hole and hammer in the bush with the mandrel. + Drill out the bush up to just undersize of the measured pivot. Do this, using the mandrel, with a succession of small drills mounted in the Jacobs chuck (supplied with the bushing tool).

+ The plate should be now removed from the tool and the hole finished off from both sides with a tapered broach, aiming to get the narrowest part of the hole about central or slightly nearer to the inside of the plate.

+ Lightly deburr the pivot hole at both ends, fashion the oil sink and adjust the length of the bush as you feel necessary. Finish off with a smoothing broach, pressing it firmly into the hole, using a low-viscosity lubricant (or water). This lubricant is important to obtain sufficient pressure for achieving some degree of work hardening in the brass without the binding of the broach in the hole.

Some general comments:

+ Some years ago I was of the opinion that I should always finish off a bush so finely that it would be barely detectable on inspection. Now, from a conservation standpoint, I have come round to the opinion that the work must of course be neat, but it is more desirable that the finished job remains visible as a good repair, rather than be concealed. This will also result in removing less original metal, and may assist a future repairer, who will not be surprised to find a previous bush when he thought he was working on a virgin plate.

+ Except for the final finishing, I prefer to use small twist drills rather than tapered broaches, as it is much easier to maintain the hole upright and centred when there is a significant amount of enlargement being done. Also there would not be enough headroom in the tool to use broaches in a holder. I used to use the hand broaching method entirely, but I have found the drilling method quicker and more reliable, since I am very often enlarging the hole quite considerably.

+ It has been suggested that to use a drill to enlarge an existing hole is a sure way to lose the hole centre, but I use small twist drills, and have experienced no problem. You do have to be careful and go very gently, whilst at the same time pulling back (up) a little as you go; also it is important to not try using too large a drill each time or the drill will very likely snatch. I usually go up in steps of 0.1mm at a time. Spade drills might possibly work a little more smoothly and it would probably also help to modify the drill cutting angles, but I haven't been forced into the need for either of these. Purpose-modified or mounted short tapered broaches might also be worth trying, but these experiments all represent additional time and expense.

+ If you feel it necessary to put in a projecting bush to reduce end shake [some restorers might frown severely at the very thought {8=)} ], beware that such a bush may create a problem when reassembling the movement if it is in the top plate.

Devices:

+ On the principle of necessity being the mother of invention, I have devised a couple of simple devices to get around the problems that the bushing tool cannot directly cope with.

+ A problem quite frequently encountered is when the pivot hole is too close to the edge of the plate and the sliding plate clamp (Bergeon calls it a "chuck") cannot be brought in close enough to grip the plate edge. My device consists of two pieces of 1/8" thick x 1" x 1-1/2" brass (or steel) overlapped by 1/4" on their long edges and screwed together to form a step. This can then be held by the sliding clamp to form an over hanging extension to support the clock plate at the same level as normal. The plate can then be held fast in position with one or two toolmaker's clamps. When making the final centering adjustment, I find it better to now consider the gadget as an extension of the clock plate -- ie I slacken off the Bergeon tool's clamp and not the toolmaker's clamp(s) for this.

+ Another gadget is used for bushing small loose parts such as the pivot hole cocks found on French clocks. This is a flat piece of brass 1/8" x 1" x 4", in which I have drilled a hole of a little under 1/4" diameter. In use, this is clamped, just like a clock plate, over one of the Bergeon stakes, with the hole roughly at the bushing tool's centre. Beside this hole another is drilled and tapped, suitably positioned for the fixing-screw hole of the cock that you are bushing, and then a screw put in to hold the cock fast in position to this gadget plate. You may of course have more than one staking hole, and each can in turn have additional screwed holes to accommodate the dimensional variety encountered. It also good to have more than one screw size for differing sizes of fixing hole in the cocks, so that there is not too much play available.

Finally I have tapped extra holes near one end of my plate to act as a "parking lot" for the range of screws that I need. I also use this plate for cranked (offset) cocks such as the minute-wheel cock, by carefully selecting or making a packer to build up the depth of the offset, and all fixed with a longer screw.

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