MOTORCYCLE ENGINEERING—13

Methods and Materials

Part Two—Welding and Bronzing

By PHIL IRVING

AS a method of joining frame-members together, autogenous welding, either by the electric-arc process or by means of the oxy-acetylene torch, has always had much attraction because it almost eliminates the use of lugs with their attendant weight and manufacturing costs. Of course, the ends of the tubes must be machined to the correct contours, and be accurate as to lengths, whereas, in most instances, square ends and quite wide dimensional tolerances are acceptable with brazed-lug construction. However, much of the attractiveness vanished in the early days of welded frames, partly because tube failure often occurred adjacent to the welds, and partly because of trouble with distortion during building.

Another objection was that if a welded frame broke it was not possible to remove the old tube and braze in a new one; furthermore, if the frame was repaired by re-welding, it often broke again at the same place. These objections were of special validity in countries where skilled service facilities were unobtainable and they contributed to the retention of brazed construction, especially on models which were exported in large numbers to places where frame-breakage was commonplace rather than exceptional. With better design, improved technique and a sounder selection of materials, the all-welded or partially welded frame can, however, be a perfectly satisfactory proposition and today many factories employ the process, which, in any case, is essential when sheet-metal components of considerable size are incorporated.

In addition to arc- and gas-welding, there is the process of bronze-welding, in which the filler-rod material, instead of being mild steel, is a copper alloy known under the trade name of "Sif-bronze." This material is applied with an oxy-acetylene torch, but owing to its low melting point the heat required is less than for true welding: the torch is fitted with a larger tip and the flame adjusted to give a less intensity of heat spread over a larger area than is the case with the former. Because of this, bronze-welding is considered by the people who should know best—the makers of the tubes—to be kinder to the steel and leaves it with more of its "as-drawn" strength; also the bronze supplies a ductile joint between the tubes, so helping to relieve any stress concentration.

When heated, bronze behaves quite differently from brazing-brass because, as it passes from the solid to the molten state it goes through a transition stage during which it is semi-molten, a condition which permits fillets or bosses to be built up and holes or gaps between mating components to be bridged over or filled in. Brass, on the other hand, has a very short solidification range—it is either melted or it isn't—so that it cannot be built up in this way. Bronze, however, lacks the penetrative power of brass and will not flow into narrow gaps by capillary action so that it cannot satisfactorily be employed for making joints in which such areas of contact exist. Instead, joints intended for bronze-welding must be designed and prepared in much the same way as for oxy- or arc-welding, and it may be necessary to add gussets, ribs or straps to joints in heavily stressed localities so as to relieve the metal in the immediate vicinity of the welds from concentrated stress. Care must also be taken to ensure that no bending takes place while the bronze is molten, either through handling the components or through movement caused by thermal expansion.

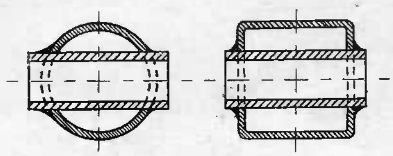


Fig. 1 (*above*): *Sections through bolt bosses formed by welding-in short cross-tubes. There is less interruption of the tube material when the original member is square instead of round.*

Otherwise there is a danger of intercrystalline penetration by the bronze and subsequent tube failure such as may occur in similar circumstances with brass.

When using drawn tube, "A" quality, as previously mentioned in Part 12, is unsuitable for gas- or arc-welding because, being a high-carbon steel, it hardens up locally due to the rapid flow-away of heat to the adjacent cold portions. This does not happen with the low-carbon "B" quality tubing and, although this type becomes softer and loses much of its strength in the portions which have been heated, it is commonly employed for parts where no great strength is required, or if cost of production is a point which must be closely watched. Where cost is secondary to excellence, "531" is the obvious selection, not only on account of its greater "as drawn" strength but because it retains 90% of that strength after brazing or welding. For cover-plates or gussets mild-steel is quite good enough, though some prefer to use 3% nickel steel for applications where strength as well as rigidity is required, as, for instance, at sidecar attachment points.

One advantage of welding or Sif-bronzing is that parts of irregular shape can easily be joined so there is no need to restrict oneself to round tube, as one has to when using brazed lugs on the score of easy machining of the latter. Tapered, oval or square tubes can be utilized or the sections

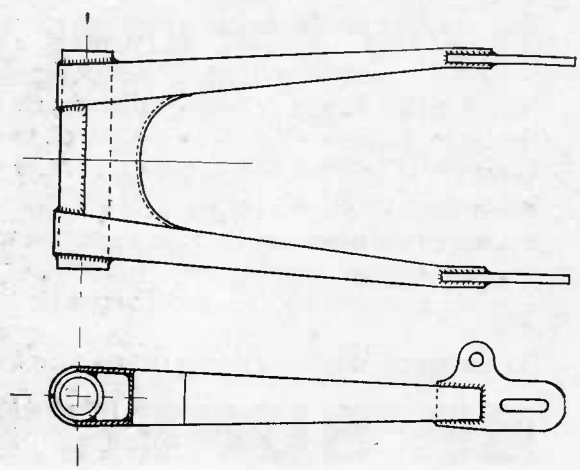
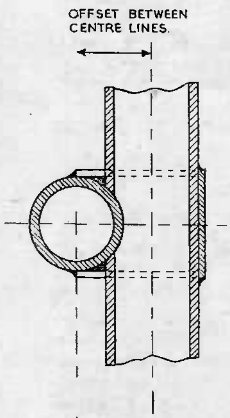


Fig. 2 (*right*): *Plan and elevation of a swinging fork with legs of tapered square-section tubes.*

may change along the length of the tube to suit the stresses encountered. Square tubing is available either in the solid-drawn form, or in the seam-welded variety, which is made by folding a strip into a square with rounded corners and continuously welding the joint as the tube is formed. Tube of this section can either be bent or notched and welded to form corners and can be welded or bronzed very conveniently to simple pressings made from steel sheet, blanked to size and with the edges folded at right-angles to provide rigidity, although it must be remembered that while a component of this nature is strong in bending, it has practically no torsional stiffness unless made into a box-section.

An example of using square tubes and pressings is to be seen in the D.M.W. frame, illustrated in Part 11 of this Series, in which the front down-tube and the members which project rearwardly to carry the pillion footrests are curved and welded to the underside of a folded platform. Another folded pressing carrying the fork pivot-bearing, and also forming the rear engine plates, is welded to the upper side of the platform, providing a construction that resists transmission stresses in a very direct manner.

One advantage of square tube is that lugs may be neatly incorporated with no loss of strength by drilling through and welding-in a short section of tube to accept, say, an engine or footrest bolt. This can, of course, also be done with a round tube but with less ease of drilling and at the cost of leaving less of the original tube material on each side of the bolt-boss to carry the applied stress (Fig. 1).



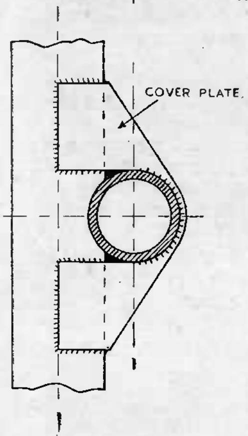


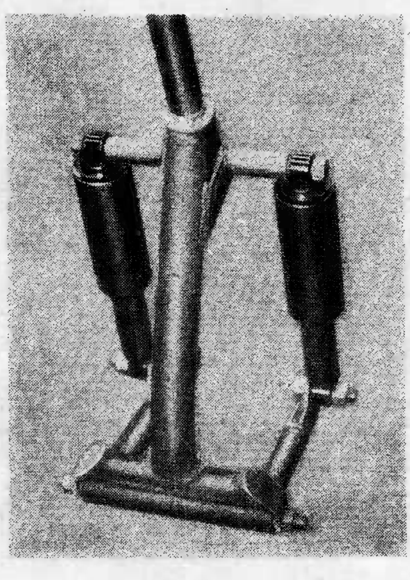
Fig. 3 *(left): A welded-on sheet-steel cover plate relieves the main weld of stress at the intersection of two tubes with considerably offset centres.* **Fig. 4** *(right): A pair of plates bronzed to cross-tube and curved down-member serve the same purpose in a Reynolds scooter fork.*

When constructing a "special" it is not a difficult matter to fold up a pair of tapered square-section tubes to form the legs of a pivoted rear fork; these can be welded to a cross-tube either adjacent to, or forming, the pivot bearing and preferably strengthened locally by two plates at top and bottom formed into a box by a closing strip on the wheel side. Such a construction would be extremely strong in all directions even if made from steel of 16 or even 18 gauge, as the strength stems more from the size of the whole section rather than the thickness of material. In the schematic arrangement shown in Fig. 2, it would be preferable for the cross-tube to be of thicker section in order to cope with the high local loads encountered at the bearings—10-gauge tube (.128 in.) thick would be about right, but this is one of the applications where it may be simpler to use a piece of mild steel bar, bored out initially slightly under-size. Some distortion of the bore is inevitable during the welding process and after this part of the work is completed, the bore can be finish-machined or reamed to the correct size to fit the bearings employed; bar-stock is easier to machine than drawn tube, even in the soft condition, owing to the different grain-flow in the metal.

When building-up a structure of this nature, great care must be taken to avoid general distortion or warping during welding as it is a difficult matter to rectify it later without resorting to local bends in one or other of the legs. Given good machining facilities and a sufficient allowance of metal in the bore of the cross-tube, small errors can be eliminated when finally sizing the bearing housings by machining these absolutely true to the fork-ends and axle-slots.

Welded head-lugs may be turned from bar-stock or made from a short section of heavy-gauge tube with two cups spigoted and welded thereto to form seatings for the head races. If the frame is of conventional form with a single straight top tube and either one or a pair of down-tubes, these should be machined to fit closely round the head-tube and then, if of heavy gauge, must be chamfered so that there is a V-shaped notch all the way round the joint in which the weld metal is deposited. If this precaution is omitted, the finished joint may not be welded all the way through, in which event it will be half-cracked before it even starts out in life and premature failure may easily take place under road loads.

In a structure built up in this manner the local stresses caused by these loads are borne directly by the welds, and even if these are perfect and there has been no under-cutting of the tube wall at the edge of the weld, as sometimes happens with badly executed arc welding, the weakest parts of the complete joint are still the portions of tube adjacent to the point where the strength has been reduced through heating. Consequently, it is common practice to add gussets or stiffening plates, partly to ensure that at least some of the loads are carried by continuous metal and partly to distribute them over a longer length of tube, thus emulating the effect of a well-designed cast lug.



Local stiffening of a tube in a transverse direction can be accomplished by welding a single rib along it, as in the case of the "Featherbed" Norton, where the duplex rear down-tubes would be insufficiently rigid in the region of the pivot bearing without the help of the gussets which are carried round the lower bends to augment the corner-wise rigidity as well. This frame, when built for racing, is composed of 531 tubing, bronze-welded at all places including the points where the tubes cross over themselves just to the rear of the head-tube.

Countering Distortion

Distortion to some extent is almost bound to take place in a welded frame and may be very difficult to eliminate if the structure is extremely strong and has no "open" or bolted joints which can be left temporarily free during the truing-up process. If cold-drawn, as opposed to welded or annealed, tube is used, advantage can be taken of the fact that, due to the compressive stress in the surface set up by the drawing process, heat applied locally to one side of the tube will cause it on cooling to take a permanent set towards the heated side. This is indeed about the only method which can be used when large tubes of over 2½ in. diameter are used and, given the necessary setting fixtures, it almost eliminates the "brute-force" system of truing-up which is not always conducive to accurate results.

As a general rule, welds should not be subjected to what may be described as "tearing" loads; they are best located in areas where the stress is as nearly as possible pure compression or tension. Sometimes it is convenient to weld a short tube at right-angles to another, but the relative positions dictated by the circumstances are such that the centre-lines of the two are spaced some distance apart; the resulting weld is of an oval shape but if the short tube is carrying heavy loads which are varying in direction —as it would be if it formed, say, the pivot bearing housing—there is a great liability that the joint will fail, either through the weld or by tearing a piece out of one or other of the tubes. This contingency can be avoided by the addition of a cover-plate, running round the opposite side of the main tube and welded to it and the cross-tube, thus forming a strong triangulated structure and relieving the original weld of most of the applied load (Fig. 3). A different arrangement with the same function can be seen in the scooter fork crown (Fig. 4) in which a pair of simple plates are bronzed to the cross-tube carrying the springs and the curved tube forming the support for the wheel-fork, thus tying the whole assembly together.