FRAME ALTERATIONS---
THE ART OF DOING IT RIGHT

A handful of tricks can maintain original strength

By Randy Smith

There comes a time for most of us who like to alter stock bikes to suit our own tastes, when we are faced with the task of making certain structural modifications to the frame. Whether it is done to implement our own design standards, such as raking the neck, or for actual mechanical improvement, such as installing mounting brackets for a disc brake assembly, is not important for the purposes of this article. What is important, is the method which is used in such modifications, so that original strength and integrity is not lessened.

Too often a completed alteration dangerously weakens the structure, when a proper procedure would not have affected the strength, and in many cases could actually strengthen the section. We intend to present some facts which represent good welding and engineering practices, which can be utilized without weakening when making changes to your bike's frame. We will not attempt to cover all aspects of welding, nor can we hope to prepare the reader for a career in mechanical engineering. The information, which is to follow, was arrived at through experience; either our own, or that of countless others which has been amassed in volumes of technical books and periodicals.

CHOICE OF METALS

The joining of dissimilar metals presents special problems and never results in as satisfactory a weld as when similar metals are joined. The frames of most motorcycles are constructed of low carbon steel, sometimes called mild steel. The carbon content is usually below 20%, which means it is quite easily welded, yet possesses good strength. It is always best to use low carbon steel stock when adding pieces to these frames.

In certain cases a chrome-moly frame will be encountered. Most of these frames were built for racing or custom purposes, and are better left in the stock condition. Although chrome-moly can successfully be welded, it is not within the capability of the average chopper builder (or accessory manufacturer, for that matter) to do so. To maintain structural integrity after welding, chrome-moly should be stress relieved, which must be done under controlled conditions using special equipment usually found only at heat-treaters. Simply passing a torch over a finished weld will not produce the results necessary for a properly executed and safe job.

If you are unsure of the type of metal in your frame, or of which type of metal you have on hand in your workshop, a simple test can be performed which will indicate what it is. The test is referred to as a spark test.

The test should be made on a high speed grinder, holding the piece in question so that sparks are given off horizontally. A darkened background will provide the most accurate results. The color, shape and average length of the spark should be noted, for these factors are characteristic of each type of metal, and will provide the clues you need in order to determine which type is being tested. Fig. 1 depicts three spark comparisons which are common.

STRUCTURAL SHAPES

Steel comes in a variety of shapes. Among them are tubes in either round, square, rectangular, or oval; solid stock in either round, square, rectangular, hexagon, or octagon; flat or plate stock; and beams such as I-beam, T-beam, and channel. The type of modification you are involved in should make your choice of shape obvious.

It might be clever looking to replace some of those tubes in your frame with hex stock, but it is far from clever if you hope to retain the original high degree of strength.

Round tubing is usually selected by frame designers because it combines light weight with stiffness and is equally strong when stressed from any angle. The strength of a tube, however, depends upon its round shape to such a degree that a hole drilled in it will upset the structural balance, dangerously weakening it.

A glance at Fig. 2 will reveal the proper way to place a hole through a tube. Let's say you want to put a quarter-inch hole through a one-inch tube. Obtain a piece of tubing with a quarter-inch or smaller inside diameter. Measure the outside diameter and drill a clearance hole that size in the desired location. Next cut the small tube to length and grind the ends to match the curve of the one-inch tube.

Fig. 1

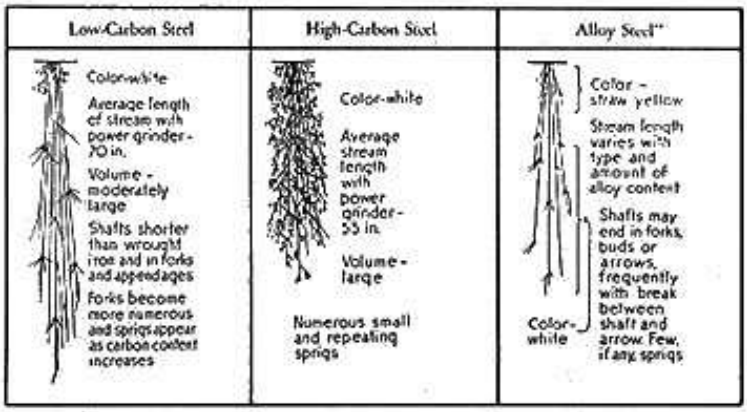
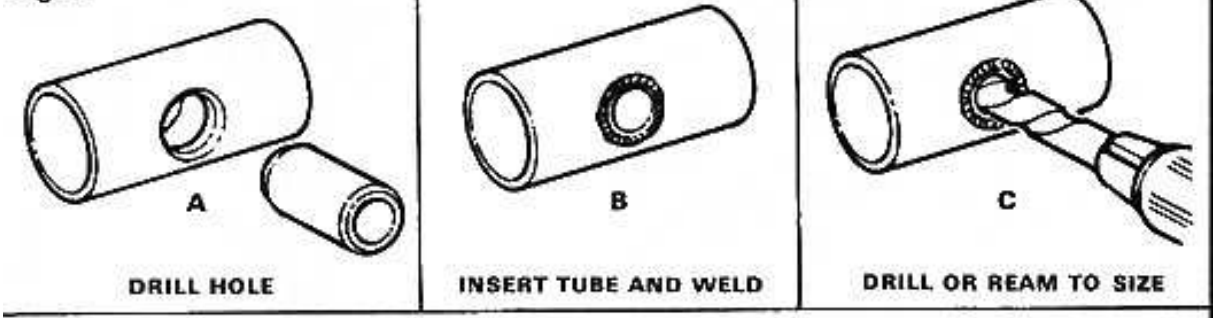


Fig. 2



Chamfer the edges of the small tube and the drilled hole. Insert the tube and weld both sides. Now the quarter-inch hole can be reamed or drilled to size. Of course, a little discretion should be used. I would not recommend using this method for putting in a hole which exceeds ⅓ of the diameter of the large tube.

As a piece of steel is manufactured, regardless of shape, the molecular structure forms a particular pattern. The pattern imparts much of the strength to the piece. High temperature can upset and alter the pattern drastically, which can result in a seriously weakened condition. For this reason it is wise to do any required bending without heat. I know it's not as easy, but it will result in a far stronger bend.

FITTING METAL SHAPES

When preparing a piece of metal to be welded to your frame, always spend a little time preparing it for a proper fit. Heavy paper or light cardboard sometimes proves valuable for determining the final shape of the piece. Gussets can be cut to the exact shape by first cutting out a piece of cardboard to fit, then transferring the shape to the metal plate. In the case of a tube, the cardboard can be rolled to the correct diameter before fitting.

The ends of fitted tubes are usually found in one of five basic shapes. Fig. 3 depicts these and the weld applications for each. In the case of the diagonal and the zig zag cuts, remember that an additional smaller diameter tube should be used inside the two butt welded members.

The shape of the first two tubes are so shaped simply to form a good fit on the mating tube. The other three shapes are purposely made in such a way as to cause a long weld bead. This will spread the weld over a considerable length of tubing, distributing the load over a greater length. Never simply end butt two pieces of tubing together.

In the case of a mounting bracket, one edge of which is to be welded to a tube, always form the bracket so that it can be bent, forming three weldable sides, see Fig. 4. Again a piece of cardboard should first be cut to fit, then transferred to the metal. The reason for the three welded sides should be obvious, as a single weld would tend to crack under stress.

In certain cases, such as particularly long mounting brackets, it is better to use a series of short (about one inch) interrupted welds, rather than one long weld to secure it, especially if a fairly heavy object is to be bolted to it. Vibration will attack a long uninterrupted weld in this type of situation more than the dash type. See Fig. 5.

A final word on shaping pieces to be welded is to always bevel or chamfer any edge which is to be welded. This will allow for maximum fill and penetration, producing a sounder weld.

WELDING TIPS

Some frames (most Harley frames for instance) were originally joined by furnace brazing. The surplus brass sometimes flowed out a considerable distance from the area to be welded; in fact the entire area adjacent to the weld should be ground clean of all contaminants such as paint and bondo, too. Any of these impurities which are allowed to enter a weld can

Fig. 3 TYPE OF CUT

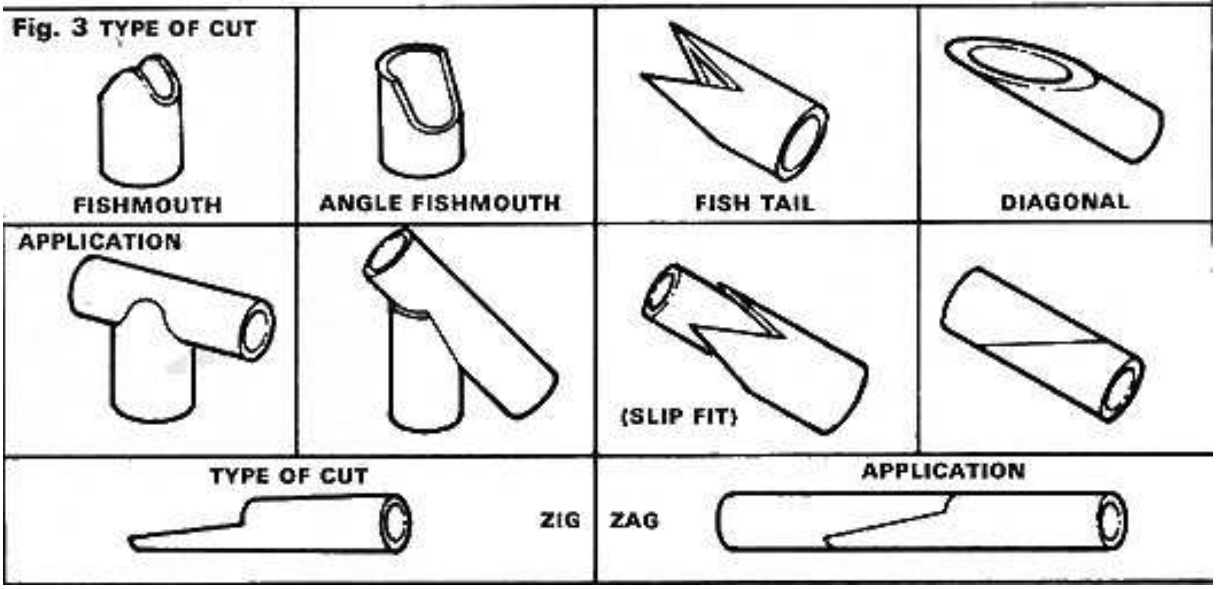


Fig. 4

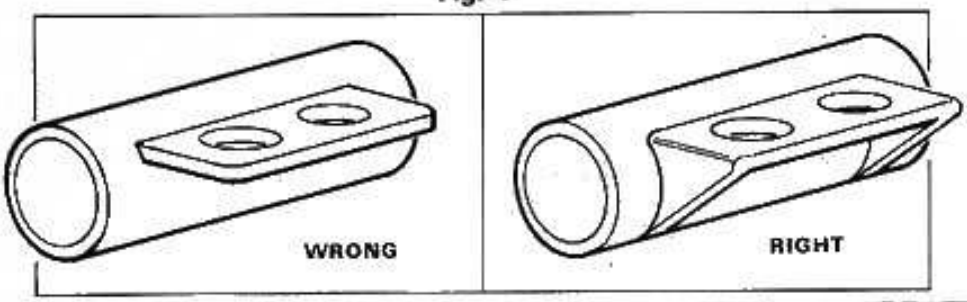


Fig. 5

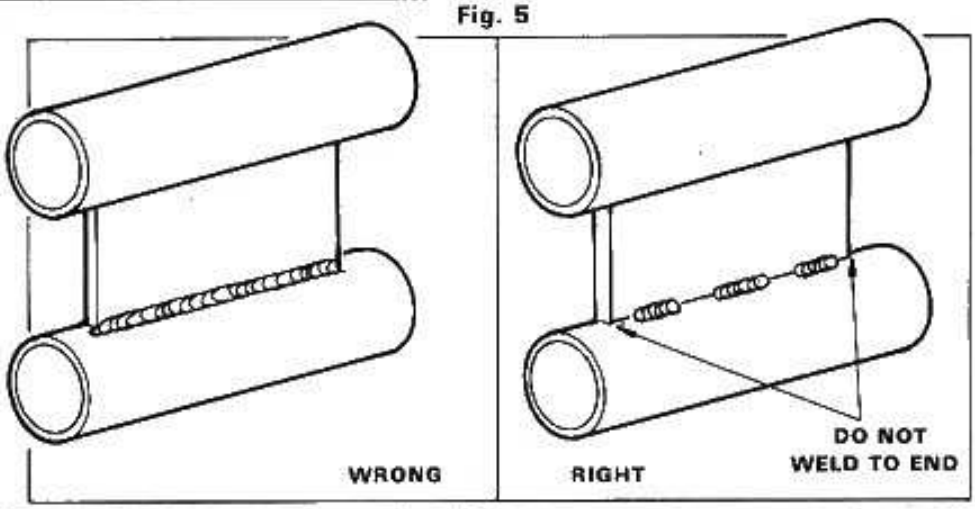


Fig. 6

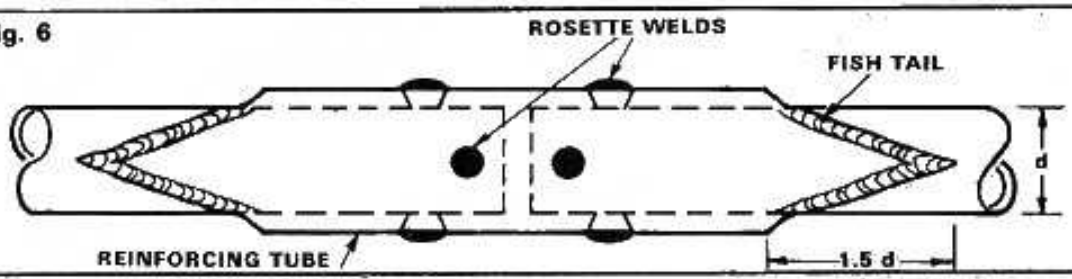


Fig. 7

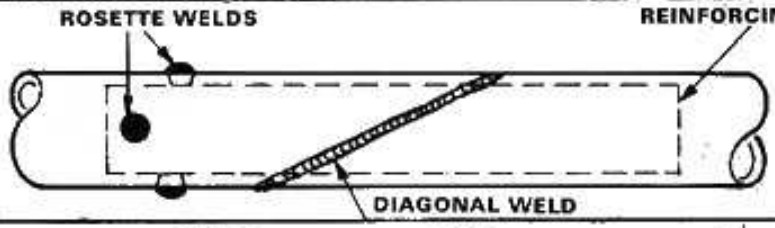


Fig. 8

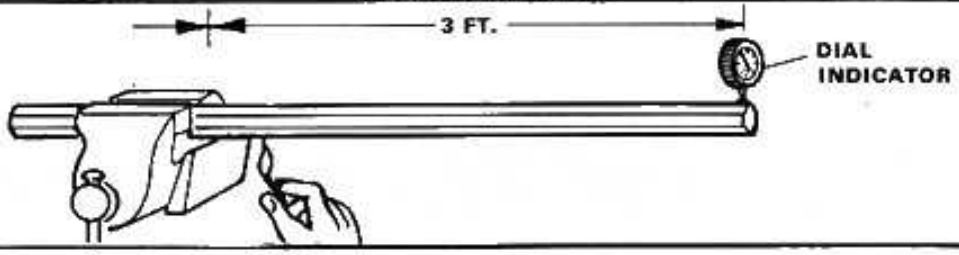
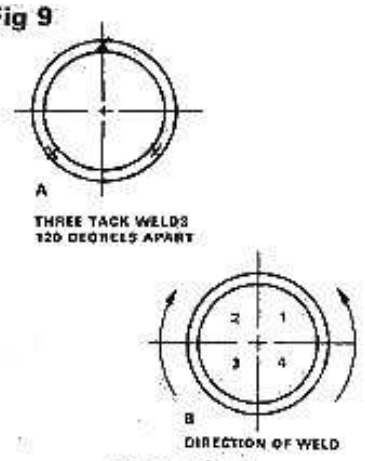
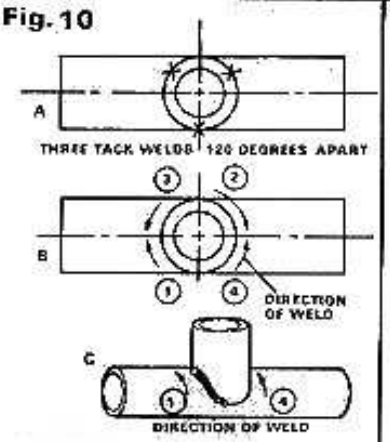


Fig 9



BUTT WELD

Fig. 10



T-WELD

cause big problems.

Tubing can be successfully butt welded in either of two ways. If a simple butt joint weld were used, the joint could fail under bending loads. Therefore, the joint is reinforced by telescoping another tube, either over the joint or within the joint. In the first method, see Fig. 6, the two ends being joined may be cut square, while the reinforcing tube is fish-tailed on each end. The inside diameter of the reinforcing tube should be nearly equal to the outside diameter of the butted tubing. Holes are drilled in the reinforcing tube to facilitate rosette welds. Rosette welds are plug welds and are quite effective in this type of application.

The second method is similar, except that the reinforcing tube is telescoped within the butted tubes, see Fig. 7. The outside diameter of the reinforcing tube should be nearly equal to the inside diameter of the butted tubes. The ends of the reinforcing tube may be cut square, but the ends of the butted tubes should be cut either diagonally or zig zagged. Holes are drilled in the butted tubes to facilitate rosette welds.

WELDING SEQUENCE

Welding can cause considerable warpage to a structure. To settle an argument a few years ago, I set up a little testing apparatus. It is a very interesting experiment and one which you might want to try. Refer to Fig. 8, begin by clamping a heavy piece of metal (I used one-inch hex stock) in a vise so that a three foot section extends beyond the vise. Clamp a dial indicator to the work bench, so that the finger rests on the top part of the piece of metal at its outer end. Light an ordinary paper match and pass it under the metal about three inches from the vise. You will notice that

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even though the low heat from the match is only briefly in contact with the metal the dial indicator will register a thousandth or so movement. Next hold a match in place under the same spot. You might be amazed at the amount the heavy bar moves (about 1/16 inch in a matter of seconds). Notice that the bar warps away from the heat. Now imagine how hard it is to control welding warpage.

Heat warpage can be controlled, however, by using the proper sequence. Figs. 9 and 10 show typical sequences for welding tubes. The natural tendency is to start at one point and continue around the tube until the starting point is reached. The sequences illustrated here will hold warpage to a minimum, and should be followed.

First tack weld the pieces in three places, 120° apart. Next, complete the weld in four segments, observing the direction of the weld in the illustrations.

RAKING THE FRAME

In the past, frame raking was very common. Although it is far less in favor today due mostly to an adverse effect upon bike performance and handling, a few words on the subject might be of interest to those builders who still persist in the practice.

One of the best methods consists of making a vertical cut with a hacksaw, not a torch, from the bottom of the frame head to within about ½-inch of the top. Don't sever the neck completely. Without using heat, pry the neck to the desired location and very carefully align it.

Get out your cardboard and cut a template which will cover the entire center of the head forging. Transfer this shape to a piece of 3/16-inch mild steel plate and duplicate it twice. Tack the two plates to either side of the forging in three or four places. Weld the plates in with short beads, alternating sides, until the welds are complete.

Next cut a template which fills the bottom opening formed by the two side plates. Transfer it to the piece of the same plate and bend it as necessary to neatly fill the area. Tack it in four places and weld it as with the side plates.

Do not grind these welds or any other weld as it will weaken it, possibly even destroying all of its strength.

The preceding construction methods are all proven procedures. Making use of them will give you a superior bike due to correct workmanship. Remember, if you build it right to begin with, it won't let you down. ***CC***