AUTOMOBILE WELDING WITH THE OXY-ACETYLENE FLAME

M. KEITH DUNHAM

Automobile Welding
with the
Oxy-Acetylene Flame

A PRACTICAL TREATISE

Covering the repairing of Automobiles by Welding, with a non-technical explanation of the principles to be guided by in the successful welding of the various metals.

Helpful to all users or prospective users of the Oxy-Acetylene flame, since the fundamentals for successful repair welding are clearly outlined.

By M. KEITH DUNHAM

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PREFACE

The use of the oxy-acetylene flame for automobile repairing is by no means new. When the process was introduced into this country ten years ago, the automobile industry, or rather, perhaps, the automobile owner, was the first to recognize its value. Broken frames, requiring ugly patches or the complete dismantling of the car, were quickly repaired with the oxy-acetylene flame. Smashed cylinders, crank and gear cases were made as good as new at a cost but a fraction of a new part.

The purpose of AUTOMOBILE WELDING then is not to introduce a process—rather, to show how to weld properly those parts which should be welded and as well to point out those parts which should not be welded.

The workman who can successfully weld all automobile parts is capable of welding anything, since in the construction of the automobile practically every commercial metal is used. The principles of automobile welding then are applicable to all kinds of welding and even though we are not particularly interested in the welding of automobile parts, we can with profit study the various details of successful automobile welding, since it is principles, rather than details, which must be grasped in any kind of welding, and these principles the author has tried to explain in a simple, practical way.

M. KEITH DUNHAM.

October, 1916.

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AUTOMOBILE WELDING

CHAPTER I.

APPARATUS KNOWLEDGE.

Oxygen Supply—Care of Oxygen Cylinder—Acetylene Generation — Care of Generator — Regulators—Care of Regulator—Creeping Regulators—Gauges—Care of Gauges—Welding Torch—Care of Welding Torch—Effects of Heat—Hose and Goggles.

A workman in any line must have a knowledge of the tools he uses. The operator of the oxy-acetylene flame must understand the principles of his apparatus to avoid serious errors. Knowledge of the gases used, as well as an understanding of the regulators, torch, supplies and shop equipment, is essential to an intelligent application of the flame.

Oxygen Supply.—Tank oxygen is today in universal use by oxy-acetylene shops. There is no method of producing it on any small scale which will compete in cost with it. When we specify tank oxygen, we mean that purchased in seamless drawn cylinders under a pressure of 1,800 pounds to the square inch.

The oxygen purchased in this form is produced by two different methods—one by the electrical decomposition of water, which consists of two parts of hydrogen and one of oxygen. By this method, which is termed the electrolytic process, the water is decomposed into its constituents and the oxygen after being led into a gasometer is from there pumped into a steel cylinder under pressure. The other process is known as the liquefaction system. The air, which consists of four parts nitrogen and one part oxygen, is frozen. When the air reaches this liquid condition, the nitrogen boils off first, leaving the oxygen, exactly the same as if gasoline and oil were mixed together and placed in an open vessel, the gasoline would first evaporate. The oxygen is then led to the gasometer and from there pumped into a steel cylinder ready for shipment.

Both methods produce a commercially pure oxygen with practically no difference between them for welding purposes.

Care of Oxygen Cylinder.—Oxygen is a non-combustible element. *It will not burn*, but it is the supporter of combustion—without it nothing will burn. Obviously, some care must be used, since its escape from the cylinder in the vicinity of sparks, a flame or any greasy or oily substances, may be hazardous.

Oxygen is usually supplied in a cylinder with a narrow base which is easily tipped over unless some precautions are used to guard against this. If a truck is employed, the tank is chained or strapped to the truck. If the cylinder is used without a truck *it should never be left standing without support*, but should be clamped to the wall or the bench, and where this is not possible it should be placed in a horizontal position on

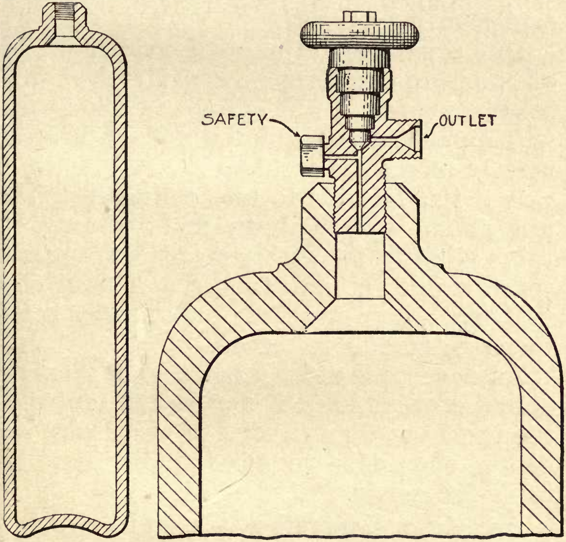

FIG. 1.—Oxygen cylinder and valve.

the floor. Regulators are sometimes destroyed by the oxygen cylinder being tipped over and care should be taken to prevent this.

Since oxygen is the supporter of combustion, particular *caution must be exercised not to oil or grease any part of the oxygen supply line,* particularly the outlet of the oxygen tank valve or the oxygen regulator. If any grease is present with oxygen under a high pressure there is an ideal condition for spontaneous combustion and a violent explosion may result.

Due sometimes to natural conditions, but at others to carelessness, considerable water may be present in the cylinder. This water will damage the regulator and as well adversely affect the welding flame. At intervals it is advisable to test cylinders by tipping them upside down and opening the valve slightly to detect the presence of any considerable volume of water. This method will expel the water from the cylinder before the regulator is attached.

As a general rule, repairs to the oxygen cylinder valve should not be attempted by the user, but the cylinder, if in a leaky condition, should be returned to the manufacturer for repair.

Acetylene Generation.—Acetylene gas is produced by allowing carbide to come into contact with water. The process of manufacture is so very simple that apparatus not meeting the requirements of safe and pure generation has been common. Lately, however, these poor generators have been very much in the minority and very few are now sold. A generator which will deliver reasonably pure gas safely must be built with the following requirements:

A capacity of one gallon of water for each pound of carbide; means to prevent a pressure greater than 15 *pounds to the square*

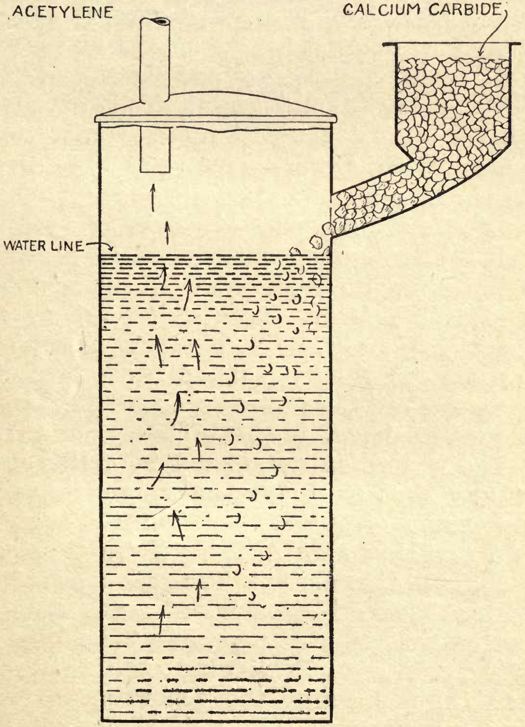

Fig. 2.—Principle of acetylene generation—carbide to water.

inch; automatic control of feed mechanism; water valve to prevent return of flame into the generator; filtering or screening devices to prevent dust or dirt getting into the flame.

These are but a few of the proper requirements of a good generator. The National Board of Fire Underwriters' rules specify in detail how the generator shall be constructed. It is hardly necessary to add that any user should see that his generator is built in accordance with these specifications.

Care of Generator.—One of the important things to guard against in the use of the generator is the excessive use of gas. If it is generated too quickly, there is undue heating of the gas, and *when acetylene reaches a critical point of temperature it ceases to be acetylene*, but is a mixture of gases. It will burn, but it gives an improper flame—one wholly unsuitable for steel welding particularly.

The generator should not be called upon at any time to deliver *more than one foot per pound of carbide per hour.* This, if it is a carbide to water feed; if water to carbide, half this speed. That is, a generator with a 50-pound capacity of carbide should not be used at a rate greater than 50 cubic feet per hour. Particular care should be used in recharging the generator, to thoroughly wash out all the residue and to follow minutely the instructions of the manufacturer in its care.

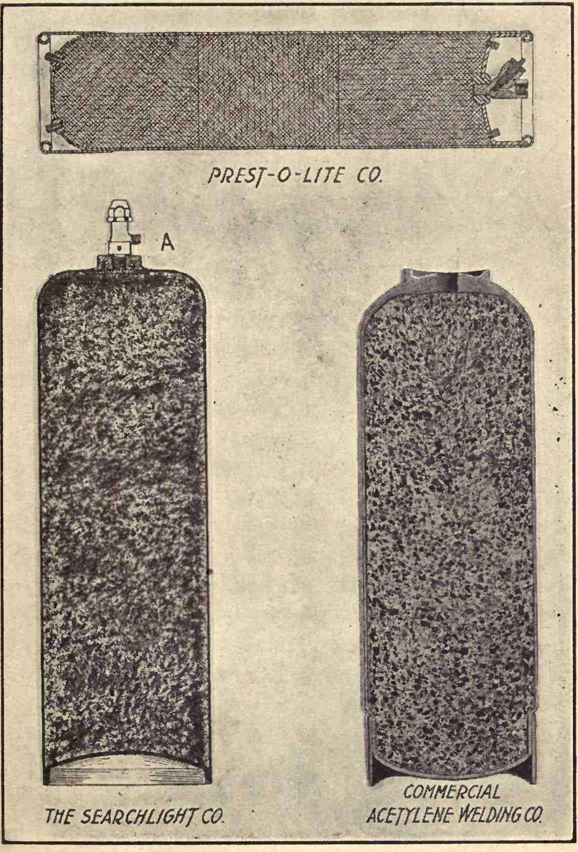

Fig. 3.—Sections of dissolved acetylene cylinders of the principal companies.

There is a custom at times among users not familiar with the peculiarities of acetylene gas under pressure to lock the safety device. *Such a proceeding is criminally careless* and may lead to loss of life.

Dissolved Acetylene.—Dissolved acetylene, or as it is more commonly called tank acetylene, is in wide use by all classes of users. Here gas is bought in ready-made form, ready for use by the opening of a valve. Care is exercised by the manufacturer of dissolved acetylene to purify it before it is compressed into the cylinder. These cylinders vary in size according to the needs of the user, from 100 cubic feet capacity to 500 cubic feet capacity.

Since acetylene is dangerous under pressure in a free state, the method of eliminating this hazard is interesting. The cylinder is filled with a porous material and then acetone, a very volatile liquid, is poured into the cylinder. This acetone absorbs the acetylene and as there is no free space in the tank there is no danger in handling or using acetylene furnished in this way.

Care of Acetylene Cylinder.—Since the acetylene gas is dissolved in acetone it should not be withdrawn from the tank at a rate fast enough to bring out with it this liquid, which is harmful in its effects on molten metal. *The flame used should not require an acetylene consumption at a rate greater* *than one-seventh the capacity of the tank per hour,* that is, a 100-foot cylinder should last 7 hours.

It is for this reason that steel welds made with acetylene from an automobile lighting cylinder are so often unsatisfactory. The gas in automobile cylinders costs more than that in regular size welding tanks and except in emergencies the automobile cylinder should not be used. If it is necessary to employ these cylinders instead of welding cylinders, it is advisable to connect three or four on a manifold to eliminate the possibility of the withdrawal of the acetone.

Acetylene cylinders, when full, should be kept away from any excessively hot place, since the pressure in the cylinder will double as the temperature is doubled.

When the cylinder is exhausted of its gas the valve should be closed, for it must be remembered that the tank still contains acetone which will evaporate with the valve open and it will do this especially quick if the cylinder is in a warm place.

Leaks are quickly detected, as acetylene has a decided odor. It is hardly necessary to state that these leaks should be hunted for with soap suds and not with a match.

Regulators.—An essential part of the welding equipment is the regulator. *Successful welding demands that the two gases be delivered to the torch in unvarying proportions* and it is the duty of the regulator to reduce the pressure of the gases in the cylinder to the desired using pressure. In principle, all regulators are alike. A diaphragm is interposed between the cylinder pressure and a spring, and when the pressure in the body of the regulator exceeds the tension of the spring, the diaphragm is pushed outward, overcoming the spring tension. Attached to the diaphragm is a seat or plunger, varying in design with the different types, which closes the inlet from the cylinder, as the spring tension is so overcome.

The details will of course vary—in some instances the diaphragm is metal; in others, a rubber composition. At times, the action of the seat, in conjunction with the diaphragm, is direct; at others, it may be compounded. Some regulators are equipped with diaphragm safety devices to permit the escape of gas if for any reason the seat does not properly close. Others do not have this safety. The manufacture of a proper regulator is no easy task and undoubtedly there are poorly constructed ones in use. *But even a good regulator will not long remain in good working order unless it is cared for properly*, and the user cannot give it this care unless he understands its principle.

Care of Regulator.—In Fig. 4 is illustrated one type of regulator which is in wide use. The regulating screw pushes against two springs, one within the other, the object in this instance being to secure flexibility by having a comparatively light spring take care of the pressure up to about five pounds and the heavy, outer spring actuate from five pounds up. As the springs press against the diaphragm, the seat, which is attached

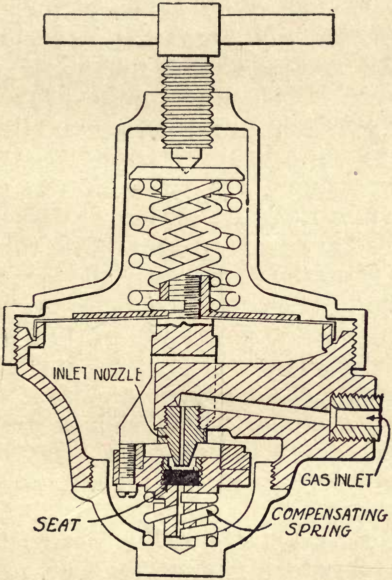

FIG. 4.—Section of diaphragm regulator.

to the diaphragm by means of a yoke, is pushed away from the inlet nozzle. As the spring tension is released the seat closes against the nozzle; or when the regulator is in use the pressure of the gas entering the regulator will close the seat when it becomes greater than the spring tension.

It will be seen that the diaphragm is constantly moving, and that therefore the seat is subjected to considerable wear by being brought into contact many times with the inlet nozzle. *The user must see that this movement of the diaphragm is never sudden;* otherwise, the seat is liable to be quickly destroyed.

A very frequent cause of regulator trouble is due to the operator turning on the pressure by opening the valve of the gas cylinder while there is tension on the springs. Since we have learned that while the spring tension is on the diaphragm, the seat is away from the inlet nozzle, it can be appreciated that the sudden entrance of the gas will cause the seat to be thrown against the inlet nozzle with considerable violence.

One rule, then, which should always be followed: *Have the spring tension released* (thumb screw unscrewed) *when turning on the gas.*

Another way of quickly destroying the seat is to reduce from a higher to a lower pressure with the outlet closed. To illustrate, assume that the torch is being operated with a large tip requiring an oxygen pressure of, say, forty pounds. The tip on the welding torch is changed to a small one requiring a pressure of one or two pounds and the thumb screw then unscrewed (tension of springs released) and the valve of the welding torch then opened. There being little or no tension against the diaphragm, it is suddenly forced outward and the seat again brought violently against the inlet nozzle. This abuse is likely also to buckle the diaphragm, so that still another rule to remember in handling the regulator is:

Always reduce from a higher to a lower pressure with the outlet open.

Creeping Regulators.—A regulator "creeps" when the seat does not close against the inlet nozzle, allowing the gas from the cylinder to enter the body of the regulator beyond the pressure desired. *A creeping regulator is detected by the low pressure gauge,* the one over the body of the regulator, the dial of which is calibrated in pounds up to fifty or seventy-five. With the valves on the torch closed, the hand on the dial does not remain stationary, but indicates a higher pressure than it did while operating the torch. A creep of a few pounds is allowable, but when it is ten or fifteen or twenty pounds beyond the operating pressure, the use of the regulator becomes a menace, since the pressure may become great enough in the body of the regulator to burst the diaphragm or the gauge with considerable force, if there is no safety of an approved design.

The user then should become acquainted with his regulator and be able to renew the seat when required. In the type illustrated the back cap, which is in the form of a square nut, may be screwed off, exposing three screws which hold the seat retainer to the yoke. After these screws are taken out, the seat may be examined and if in bad condition, it may be turned over and the other

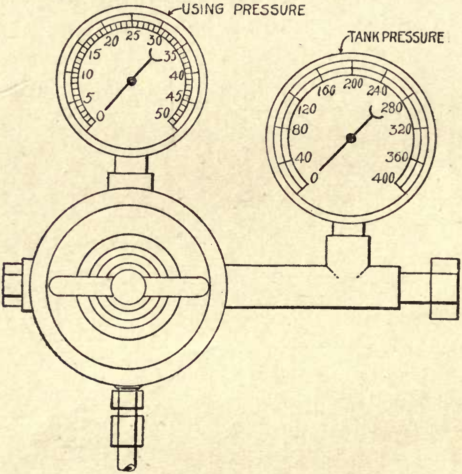

FIG. 5.—Regulators should have two gauges.

side used; or if both sides are in poor shape, a new seat may be put in.

Particular care should be exercised that this seat be correct. Any material handy must not be used since there are very few substances suitable. It is advisable to secure from the manufacturer extra seats when the regulators are purchased and have them on hand. For reasons already explained, *see that no grease or oil gets into the interior of the regulator.* Some little judgment is necessary in adjusting the regulator, after inserting a new seat, and it is sometimes necessary (in the type illustrated) to bring the seat closer to the inlet nozzle by putting a small piece of paper in back of the seat. In other types it is only necessary to screw the seat closer to the nozzle, but with all, the idea is to have the seat in contact with the nozzle with the spring tension relieved; then with the gas from the cylinder turned on, no gas should come through the regulator until some tension is put on the springs.

Considerable space has been devoted to the regulator, since it is a common practice to pay no attention to the action of it. Not only is good welding difficult with a regulator out of order, but there is a danger hazard not to be passed over lightly. A good mechanic understands his tools—see then, that we understand the regulator.

Gauges.—Both the oxygen and acetylene regulators, if we use the tank system of acetylene, should be equipped with two gauges each, one indicating the pressure in the cylinder and the other the using pressure. Some of the lower price apparatus are sold without these tank indicating gauges and while the regulator may be, and probably is, of good construction, the user is handicapped without them, since he cannot at any time estimate the cost of the job being done or tell the contents of the cylinder.

The dial of the high pressure oxygen gauge is sometimes calibrated in atmospheres and sometimes in pounds, and recently there has been a tendency to use both calibrations on the same dial and as well a percentage graduation. This is sometimes confusing to the user.

While the cubic capacities of the cylinders vary, some being of 50, others of 100, 150, or 200 feet, the initial pressure is always the same—120 atmospheres. For all practical purposes, we may consider one atmosphere equal to 15 pounds, so that a full cylinder will register on the high pressure gauge 120 atmospheres or 1,800 pounds or 100 per cent. Knowing the size of the cylinder, it is very easy to figure how much gas is used or how much is left in the cylinder.

The tank pressure indicating gauge on the cylinder of acetylene does not indicate the contents of the cylinder, as it does with oxygen. As we have already learned, acetylene is dissolved in a liquid and there is no method of determining the contents of the acetylene cylinder by gauge pressure—this gauge is merely a help in estimating the contents. In later chapters, we will take up the method of ascertaining costs.

Care of Gauges.—At all times care should be used not to break the glass of the gauge, and if broken, it should be promptly replaced. Remember that the low pressure gauge on each regulator is the index of reg-

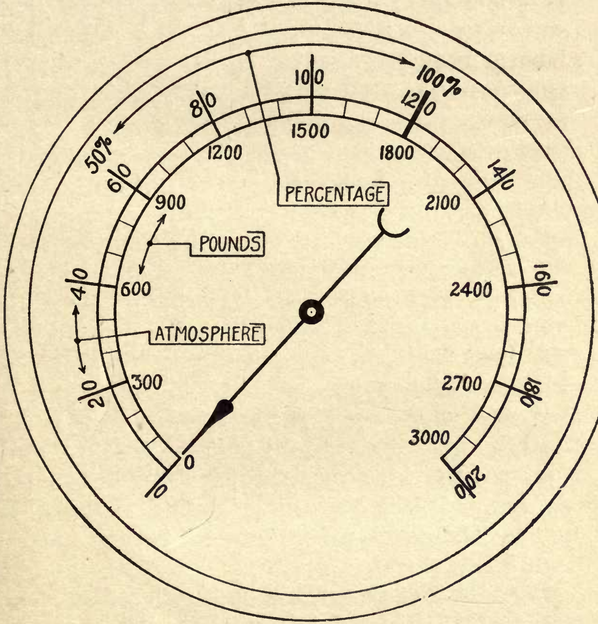

FIG. 6.—High pressure oxygen gauge dial.

ulator trouble—it warns us of the need of repairing the regulator. *It is the danger signal of the welding apparatus* and should always be in good working order.

Welding Torch.—There are as many different types of welding torches as there are kinds of automobiles. Some use the acetylene under a very low pressure; these we call injector torches. Others use the acetylene under a pressure up to eight or ten pounds and are termed medium pressure torches. In both of these designs, the oxygen is used under a considerably higher pressure than the acetylene. And finally, there is the equal pressure torch, using both gases under about the same pressure. It is not our purpose to discuss the relative claims of the exponents of the various classifications. *Mechanically, the welding torch which is to be used for repair purposes should be rigidly constructed,* since it is subjected to considerable variation in temperature. A torch which is built from very light material may be exactly right for light gauge welding and wholly unsuitable for repair work. The weight of the welding torch used for automobile repair work should be sufficient to insure its standing up under the rather hard usage it gets.

Whether the gases mix in the handle, the head or the tip is of minor importance, provided the torch is properly designed. The construction of the torch is, of course, outside the influence of the user. Since it is a very simple matter to destroy a good torch by improper use, let us see how to take care of the welding torch to get the best out of it.

Care of Welding Torch.—The welding torch is something more than a couple of pieces of tubing terminating in a head. The mixing chamber proportions the two gases and the tip, as a rule, is carefully made to insure an even flow of the mixed gases. *Dirt, obstructions of any kind, rough spots, depressions, etc., cause an interruption of this even flow and result in an improperly shaped flame and as well may cause the torch to flash back,* that is, the gases, instead of burning at the tip where they properly should, go back to the mixing chamber. To a greater or less extent, the user controls the proper working of the torch provided it has been properly constructed.

Effects of Heat.—At times it is necessary to execute a weld in a corner, a depression or some place where the heat arising from the metal strikes back against the head or tubes of the torch. If at the point where the gases mix, this heat becomes great enough to ignite the gases, a flash-back is the result in most types of torches. *When a flash-back occurs, the two gases are burning inside the torch and continue to burn until the oxygen is turned off.* The combustion is not perfect, however, and considerable carbon is deposited in the interior of the torch, which makes a desirable condition for a second flash-back. The heat of the flash-back is often sufficient to partially melt some section or to roughen up the walls, and when the torch gets into this condition, continued flash-backs are inevitable. In working in confined areas then, the torch should be frequently cooled by dipping in water, slowly—not plunging the torch quickly.

When the torch is particularly warm, the tips should not be unscrewed or screwed up, but the torch first cooled. The tips should make up by hand freely to the last half turn or so; when they bind and it is necessary to use a wrench to start them on the threads, the threads should be recut. *Avoid dirt*—keep the torch hanging up when not in use and see that the tips are in a rack. *Don't shorten the tips by filing*—the length of the tip is usually one of some exactness to maintain the proper shape and velocity of the flame. The shut off valves should be kept free and easy working. Repack when necessary, using the same packing material, which is usually one of graphitic asbestos. If the interior of the torch becomes clogged connect the oxygen hose to the tip and blow the obstruction back through the torch.

Bear in mind that brass or bronze when hot, as a rule, is quite brittle—don't use the welding torch then as a pair of tongs in turning over a cylinder in the fire. If the torch gets the flash-back habit, that is, if it is difficult to keep lighted, or if the velocity of the flame is so great that it is impossible to control the flowing metal in the weld, return it to the manufacturers for repairs. If the torch is not then right, purchase a new one. *Good welding is hopeless unless the torch is correctly designed and properly manufactured* and it is probably needless to add that all welding torches are not properly manufactured.

Hose and Goggles.—There are a great many varieties of hose used for welding purposes. The choice is largely a matter of personal fancy, but it is to be remembered that size and weight do not necessarily mean strength and that clumsy, heavy hose is not essential.

Preferably the hose should be clamped to the connections on the regulator and torch by a device similar in construction to that used on the hose for water circulation in the automobile motor. If the hose is wired on care should be used not to cut or break the wall and cause a leak. *Take care of the hose.* Don't allow it to trail on the floor to be tramped upon, to pick up oil, or to be cut or damaged. Replace it when it becomes imperfect. A leaky hose may cause a serious burn or a fire.

To protect the eye from the intensity of the light of the flame, as well as the incandescence of the melting flux, it is necessary to use a darkened glass. For automobile work a simple design is all that is necessary, the lens of a greenish gray color, the depth of which will depend upon the workman. Don't weld without this protection—serious impairment of the vision will result.

This completes the welding equipment. Of course, we need some aids to welding, fluxes, welding rods, a fire of some kind, etc., which we will next take up.

CHAPTER II.

SHOP EQUIPMENT AND INITIAL PROCEDURE.

Preheating Agencies—Welding Table—Location of Welding Outfit—Starting the Welding Outfit—Adjustment of Flame—Principle of Welding—General Welding Knowledge—Welding Rods and Fluxes—Choice of Tip—Expansion and Contraction.

Preheating Agencies. — The blacksmith shop, garage or service station, after the purchase of the welding equipment, has little to buy in order to do successful welding. The tools necessary to prepare and finish auto parts are in most cases already in use for other purposes. Files, chisels, a grinder, clamps, etc., are some of the aids to welding that we will speak of only as may be necessary in illustrating their use. It is necessary, however, that we have some method of heating many of the parts to be welded other than the flame of the welding torch. As the case may be, we preheat a part for one or all of three reasons:

First—*To save oxygen and acetylene, since other forms of heating are cheaper.*

Second—*To offset strains set up by welding and so avoid warpage or fracture.*

Third—*To improve the quality of the welded section.*

Charcoal, gas and oil are the three agencies used for preheating purposes and their popularity and probably their efficiency are in the order named. Gas offers some advantages over charcoal for heavy work other than automobile repairs and it is many times used in preference to charcoal even in automobile welding. Undoubtedly it is necessary to use more care in preheating with gas or oil torches than with charcoal, because of the fact that the flames are concentrated and it is rather difficult to heat slowly all sections. For many kinds of welding, a concentrated heat is desirable but *for automobile welding a slow even heat is preferable* and this we are better able to obtain with charcoal than with a flame.

In shops equipped with natural or city gas it is sometimes preferred as a preheating agency. Torches suitable for the purpose are quite simple in design and may be purchased about as cheaply as they can be made. These torches use air under a very low pressure, usually one or two pounds. If we were newly equipping a shop, this air could best be obtained by the use of a positive pressure blower. If air is being used for other purposes, such as filling tires, we can use this supply. A general idea of the layout of gas preheating torches may be obtained by reference to Fig. 7.

It will be noted that a header or manifold is used to reduce the velocity of the air coming from the pressure tank. This header may be constructed from two or three-inch pipe, welding in the ends.

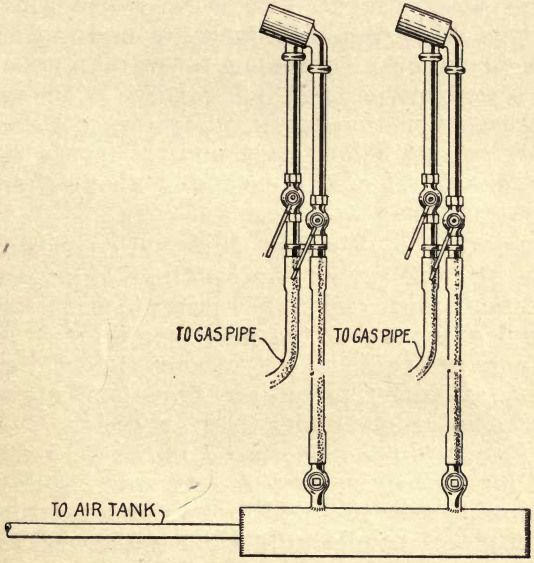

Fig. 7.—Gas preheating torches, with manifold for air.

Welding Table.—We need a table upon which to do the various welding jobs. Large shops have several styles but we can get along nicely with one type which we can easily construct. Note

Fig. 8, a table made from angle iron, with all joints welded. We can as well make it from pipe or flat stock if angle iron is not easily secured. The shelf may be used for fluxes and welding rods, and the top is filled with fire brick which may be renewed when broken.

The table should be large enough to hold good sized crank cases and to construct upon it a temporary fire brick furnace whenever desired. The measurements shown both for surface and height need not be strictly adhered to. They will be found about right, however, for general use.

Location of Welding Outfit.—In choosing the place to set up the welding equipment, particular care should be used to get away from any part of the shop where gasoline vapors are present; not because the welding flame is dangerous but any flame is likely to prove hazardous under these conditions.

Preferably the welding equipment should be located where visitors are not allowed. Tripping over the welding hose is a favorite pastime of people unfamiliar with welding apparatus, and this is very likely to result in burning the operator of the torch.

Good welding demands concentration. The welding flame is noisy, the gases burning with a hissing sound much like escaping steam; and this noise precludes conversation with the operator at any distance. As each detail of the molten metal must be carefully watched, it is advisable to have the welding equipment isolated—to insure concentration and safety.

There are as well many other reasons why the welding outfit should not be too outstanding, and one of these reasons pertains to the price secured for work done. It is sometimes a difficult matter to persuade a

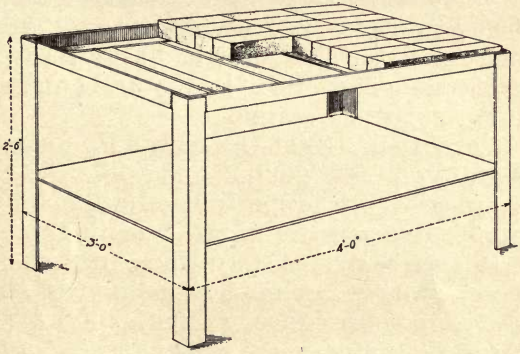

FIG. 8.—Welding table, angle iron construction with welded joints.

customer that fifteen minutes work may be worth a couple of dollars but if the customer doesn't know that only fifteen minutes of labor were consumed, it obviates the necessity of explaining that oxygen and acetylene, as well as fluxes and welding rods, are factors entering into the cost of the job as well as the labor.

Starting the Welding Outfit.—Previously we have explained in detail the care of regulators and torch, the necessity of having the hose firmly attached, etc. Usually, though not always, the threads on the valves of the oxygen and dissolved acetylene cylinders are different; but we can recognize the proper regulators by the high pressure gauges, the acetylene being in pounds up to not more than 500 and the oxygen calibrated up to 3,000 pounds or 200 atmospheres or both. Each regulator should make up to the valve by means of ground joints and washers should not be employed.

Bear in mind that the oxygen is under a pressure of 1,800 pounds and while there is no danger if we properly handle the apparatus, it behooves us to use care in turning on this pressure. Always then turn on the oxygen from the cylinder, opening the valve slowly, in accordance with Fig. 9. *Stand behind the cylinder, the spring tension of the regulator off, the valve on the welding torch open and if there is a shut off valve on the regulator, have this valve also open.* Make this a rule from which there will never be any deviation. Then when the oxygen comes into the regulator and the pressure indicates on the gauge, the valve on the torch may be closed, provided the regulator does not "creep," the danger of which has been previously described.

Adjustment of Flame.—So far as possible, the instructions of the manufacturer should be followed in adjusting the flame, paying particular attention to the pressure of each gas; yet many times it is difficult and sometimes impossible to secure the correct welding flame if these directions are followed,

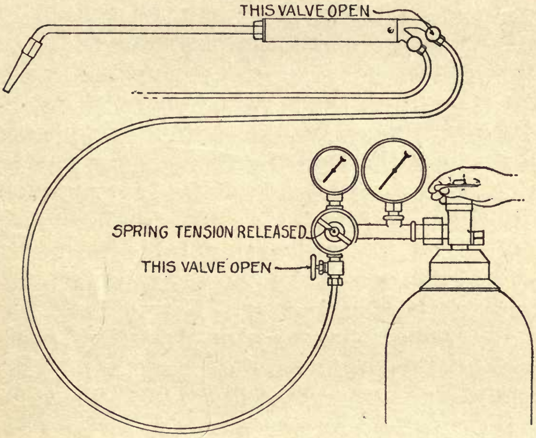

FIG. 9.—Turn on the oxygen carefully.

since conditions beyond the control of the manufacturer may preclude the proper carrying out of these instructions. Since we must first learn that we may obtain *three kinds of flames and that only one is suitable for welding*, it is necessary that we know how to obtain the right flame and to recognize the other flames in order to change them to the correct one.

As we have already learned, different types of torches use the gases under varying pressures and the size of the orifice in the tip governs this also. No hard and fast rule can be laid down as to exact pressure to use on each gas for a certain size tip yet the best results are secured if we can even approximately use the pressures recommended.

To light the torch, open the acetylene valve on it, then turn the regulating screw on the reducing valve or regulator until gas is coming through the tip. Light it over a gas jet which should be kept burning in proximity to the welding table or on a piece of burning charcoal on the preheating table or which may be kept in a small can for this purpose; or use a friction lighter. Do not hold the tip over the gas flame or the lighted charcoal first and then turn on the pressure. Wait until the gas is coming through. The first method is a bad one because the air has not been expelled from the torch and as a rule the gas coming through lights back into the interior of the torch, with a snapping noise. While there is no danger to this procedure, it fouls the interior of the torch with carbon and in time affects the proper working of the instrument. With most types of torches, the acetylene should blow away slightly from the tip and the flame have the general appearance of Fig. 10. The distance it should

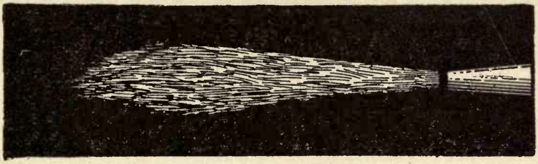

FIG. 10.—Acetylene blowing away from tip.

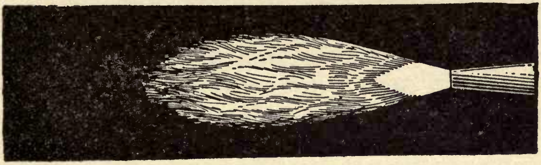

FIG. 11.—Carbonizing flame—not enough oxygen.

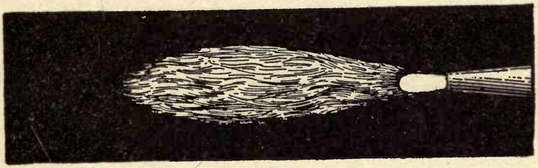

FIG. 12.—Neutral flame—proper proportions of both gases.

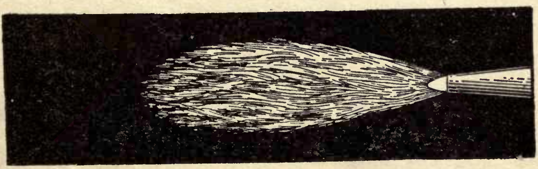

FIG. 13.—Oxidizing flame—ruinous to good welding.

blow away will vary with the drill size of the tip, just a little distance on a small tip and around a quarter of an inch on a large one.

Now proceed with the oxygen in the same manner, increasing the tension on the regulator spring until the flame begins to assume the shape shown in Fig. 11. It will be noted that the yellow flame has entirely disappeared and this one is blue white in color with two distinct shapes, the inner one whiter in color than the longer, outer one. This is termed a carbonizing flame. Not enough oxygen has yet been turned on but at this time we should watch the flame closely for we are getting to the point where the adjustment becomes important.

Fig. 12 shows the neutral welding flame with which all welding is done. The inside cone is blunt and the ragged edges of the flame in Fig. 11 have disappeared. Too much oxygen, causing an oxidizing flame, is shown in Fig. 13. The shape of this cone is exaggerated and long before it has become sharp and pointed as shown it may be oxidizing in character and so ruinous to successful welding. Fig. 12 then is the correct welding flame and *it must be frequently tested to make sure it is neutral.* When the flame is properly adjusted, it is good policy to decrease the oxygen pressure until the ragged edges of the cone as shown in Fig. 11 begin to appear and then increase the oxygen until the ragged edges disappear.

Once adjusted, it does not necessarily "stay put." Regulators may fluctuate slightly and the heat arising from the molten metal may expand one gas more than it does the other, so *not only at the start of a welding job but at intervals during the work the flame must be tested.*

Understand this flame adjustment thoroughly. Appreciate that a carbonizing flame on mild steel will make it hard and brittle, that an oxidizing one will burn the metal and that a neutral one will join it without materially changing its character. To become successful welders then, *one of the first requirements, and it is by no means the least important, is a neutral welding flame.* Surrounding the inner cone and extending out from it is a flame of darker color which we term the envelope. It will be necessary to refer at times to the cone or to the envelope and before proceeding, let us understand that the cone is the short blunt inner shape and the envelope the longer, outer one.

Principle of Welding.—*With the cone of the welding flame in contact with steel and held slightly away on all other metals,* the temperature of over 6,000 is sufficient to melt the metal at that particular point. If the torch is properly adjusted, and correctly operated, the metal becomes a fluid and should run or flow together without harmful effects. Welding by this process then is the actual melting of the parts to be joined and no pounding is necessary, as is the case where the metal is heated to a point approaching the melting point. It must not be confused with soldering or brazing, where the bond is made with a metal of a lower melting temperature than the material joined. Beginners often mistake oxy-acetylene welding for brazing and *fail to realize that the torch must be held on the break or joint until the sides have actually melted and flowed together.*

General Welding Knowledge.—With nearly all automobile parts it is necessary to first bevel the break and the angle of this may be about 90 degrees. This bevel is made for two reasons—to insure the bond for the entire thickness and to have a clean line of welding. Welders with little experience are very likely to underestimate the importance of grinding or chiseling and to depend upon the velocity of the welding flame to penetrate to the bottom of the break. *This method is almost sure to prevent a good weld,* and with cast iron, for instance, the welded section is likely to be porous and the weld deficient in strength. There are instances where exceptions may be made which will later be mentioned, but until we are well trained in oxy-acetylene welding, beveling should always be done.

Welding Rods and Fluxes.—If the two sections to be joined are beveled in this manner, It is obvious that we must add more material to get the original thickness and this added material we call the welding rod or the filler rod. The quality of this rod is usually of considerable importance, as we shall later see. For automobile repair work we can get along with one size with but few exceptions and this size should be either one-quarter or three-sixteenths round. It should be remembered that this rod is approximately the same metal as the article welded and that it melts at the same temperature—therefore, *the rod and the break must be melted at the same time if a proper weld is to be made.*

Certain detrimental changes may take place in melting metals together unless we provide against them with proper welding rods and fluxes. The flux may aid in preventing serious oxidation (burning) or it may help in maintaining the same physical characteristics of the metal; a good flux then does something more than make the metal more fluid. Fortunately, the automobile welder does not have to consider the manufacture of either the rod or the flux and it is sufficient here to state that both should be purchased from a reliable house to insure quality. The price of these supplies is not a factor, since the quantity used is very small.

Choice of Tip.—The different metals used in automobile construction have different melting points, different degrees of heat conductivity, different heat absorbing qualities and are of varying thicknesses; yet all these things govern the size of the flame to be used. One of the first questions asked by the inexperienced operator is "What size welding tip will I use?" No definite answer can be given this question, since drill sizes have not been standardized so far as the numbering of tips is concerned and a number five of one manufacturer may be about the same drill size as a number ten of another. The proper choice of the tip can only be made after some practice. *Too large a tip makes the melting metal difficult to control—too small, the metal does not melt easily and the heat from the welding flame is conducted away from the weld.* It might be well to add that the flame should not be materially reduced in velocity nor increased, after the adjustment is made, to obtain a flame of less or greater force; but the tip should be changed to a smaller or larger size as desired.

Expansion and Contraction.—*Metals expand when heated and contract when cooling.* Knowledge of such elemental nature would hardly seem worth while repeating yet it is a strange fact that the blacksmith who heats a tire so that it will shrink to the proper size when cooling and fit the wheel will attempt to weld an aluminum case without thought of this same expansion and contraction. The repair man will shrink on a bushing, taking advantage of the contraction of metal while cooling, and yet fail to take into consideration this same contraction when the water jacket of a cylinder is welded. If we do not grasp this principle, the successful welding of cylinders, cases, housings, etc., is impossible, *since the preservation of alignment is fully as important as a good weld.*

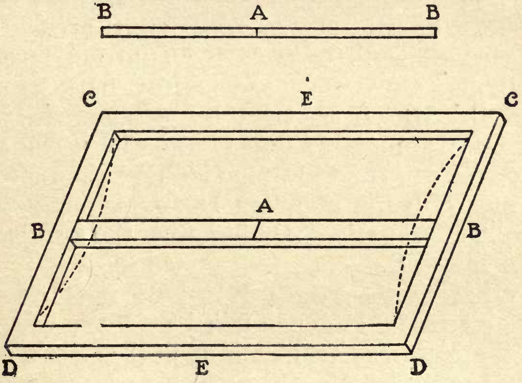

FIG. 14.—Effects of expansion and contraction.

One of the best known ways of illustrating the effects of expansion and contraction, but which often is improperly explained, is represented by Fig. 14. Here is a rod or bar which is broken at A. If the weld is made, no ill results will follow since when the section around A is heated, the ends B are free to move, and when the metal starts cooling they will contract. To be sure the break at A should be slightly separated before the weld is started to allow for this contraction and to maintain the same length of the rod.

Now we take this same bar and make it the middle member of the frame as shown, with identically the same break in the same location. If we make the weld in the same manner as we did when the bar was not a part of a frame, we would note that as the metal at and surrounding the break A started to cool, the ends B would not freely contract, since they are rigidly held by D and C. But if we heat the sections E, we expand the bars D and C and the break at A opens up, the weld is made and the points A and E being of about the same temperature cool equally and therefore the contraction is equal.

What is the result if we do not follow this course? It depends upon the character of the metal used for the frame. Cast iron being quite brittle, the weld would probably break. Steel being ductile at practically all heats, *the ends B would probably pull towards the weld* and the frame would then be out of alignment as shown by the dotted lines. Aluminum might break at the weld or it might twist the same as steel; it would depend upon the alloy used in the casting. From a practical standpoint the weld would be unsuccessful in either case, since the article would not be usable.

There are other ways of offsetting the ill results of expansion and contraction besides heating, but in automobile repairs they are rarely used. It must not be assumed that all parts must be heated at some point to guard against fracture or warpage. The figure illustrated will clearly indicate that the bar, with the ends free, did not need any attention. The frame of an automobile may be similarly used as an illustration. The bar when it became joined to a frame, however, presented difficulties which had to be overcome by heating another section. An alum inum crank case, broken anywhere in the body of it, would have to be treated along the same lines.

Naturally, not all parts are so simply treated or so easy to handle as the one illustrated. *The break may adjoin a heavier section and this heavier section requiring more heat than the lighter one, more judgment would be necessary in keeping this heavier section hot to avoid the too quick cooling of the lighter part.* But if we but understand the principle, it is not difficult to handle individual cases. Metals must expand when heated and must contract when cooling and the use of clamps, vises or bolts cannot prevent either. We must understand moreover that *expansion will always take place the easiest way* and not the hardest. If we bolt or clamp two ends or otherwise hold them to make the weld in the center, we have not prevented expansion. To be sure, the two ends did not move but the expansion took place toward the weld as this was the easiest way and as cold metal must occupy a smaller space than hot metal, upon cooling the weld will break or the piece will warp, since the ends are held and cannot move. Clamps may be used in helping to secure alignment or in guiding expansion—*they should never be used to prevent expansion, since this is impossible.*

Failure to understand expansion and contraction is undoubtedly responsible for most of the troubles of repair welders. Keep in mind the principle illustrated, study each job carefully before attempting to weld it, ascertain where the contraction strain will be set up and then overcome that strain by heating either another section or the whole casting.

So far the instructions have been general, applicable to all metals and to any work but we must understand these general principles before we start on actual welding. How to prevent warping an automobile cylinder and maintaining the alignment of an aluminum crank case is more easily understood if we but get hold of the fundamentals.

CHAPTER III.

CAST IRON.

Simple Welding—How to Hold the Flame—Hard Cast Iron—Pin Holes and Blow Holes—Lug on Cylinder — Water Outlet — Cylinder Welding— Compression Head — Finishing and Testing — Scored Cylinders—Cylinder Parts—Fly Wheels— Pistons — Crank Cases — Babbitted Bearings— Valve Guides—Preserving Threads—Conclusion of Cast Iron.

Simple Welding.—A frequent small repair by oxy-acetylene welding is the lug of an exhaust manifold. We prepare this by first grinding both pieces, each on an angle of about 45 degrees, leaving just enough of the old metal at two points or on the bottom so that the pieces fit together. As we have a planed surface, alignment is simple and it is necessary only to lay the pieces on a flat object—a piece of tire iron will do (Fig. 15) or some shops have for this purpose a portion of an old planer bed or a section of cast iron one or two inches thick with a planed surface. Now, after fitting the two pieces together, *separate them ever so slightly*—about 1/64th of an inch. Have the two pieces securely held by means of clamps or by heavier pieces of metal so that they will not move until a portion is bonded. Now, we "tack" the two pieces to hold them. In welding shop language, "tacking" means that the flame is brought down and concentrated on one spot until the edges flow together. There is a difference between welding and tacking, since the latter is merely a surface weld and is not of good quality and later as the weld is made, this metal is removed by pulling it out with the welding rod. After tacking, it is advisable that *we*

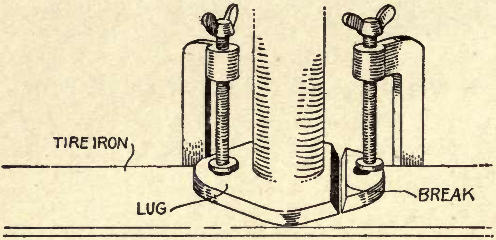

FIG. 15.—Set up of exhaust manifold.

remove the manifold from the metal plate and put it on the fire brick table.

How to Hold the Flame.—If we do not preheat the manifold, and on small pieces it is not customary to do so, *we hold the end of the cone some distance away from the break and move it slowly back and forth in line with the break*, warming the entire section. It will be found that the broken lug probably has a tendency to get hot much quicker than the manifold, because the lug usually being smaller, does not absorb so much heat nor has it as much chance to conduct the heat. It will be necessary, therefore, to so direct the angle of the flame that the greater part of it is directed toward the manifold and a very little of it strikes the lug, as in Fig. 16. This procedure must always be followed in welding a lighter to a heavier piece.

As the metal reaches the red heat, we stop moving the torch and concentrate it in one

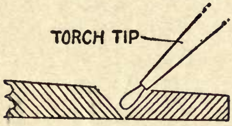

Fig. 16.—Flame directed toward heavier section.

Fig. 17.—Start of the weld—sides flowed down.

spot, *the end of the cone not quite touching the metal.* As this spot starts to melt, flux is added from the end of the welding rod previously dipped while hot into the flux can and the sides of the break are flowed down to the bottom as shown in Fig. 17. *It will be noted that as yet no metal has been added from the welding rod.* We now proceed in the same manner on the spot immediately adjoining, flowing down the sides without adding metal from the rod until we have a half or three quarters of an inch welded. Then the rod is brought down in contact with the metal, a portion melted off the rod and fused with the metal at the bottom and sides by a circular motion of the torch. This operation is continuous until the thickness of the weld is slightly greater than the original metal. The manifold is then turned over and the weld made from the other side so that no portion is unwelded or any crack shows.

If this is our first job we must particularly guard against the following: *Trying to get the metal to flow too quickly by bringing the cone in direct contact with the metal*—this results in burnt spots. *Failure to melt the rod with the metal of the manifold*—unless all portions are actually melting when the rod is added, the metal merely adheres and does not become a part of the weld.

Apparently we have paid no attention to expansion and contraction. Let us find out if we have distorted the lug. Try it with a straight edge, as in Fig. 18. If we have welded correctly, the lug should be in line with the opposite side, as it originally was. Perhaps, though, we will find it as shown by the dotted line in Fig. 18 and in this case it will be necessary to add more metal to the finished surface to build it up to the proper height. The reason for this distortion should be understood, since this is our first practical illustration of the effect of contraction.

To begin with, the lug should have been slightly separated from the manifold and then tacked, as described. *When the metal at the tack cools, it should close the crack.* Then as we warm that entire section before starting to weld by moving the torch slowly back and forth, the crack again opens up and when the entire weld cools, it should contract into place.

Because jobs of such simplicity can easily

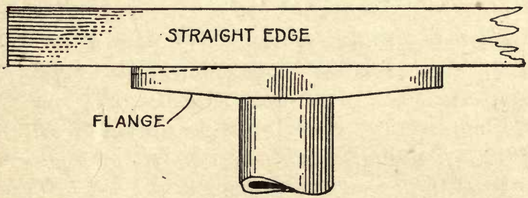

FIG. 18.—Testing for alignment.

be remedied if not in line, the usual custom is to make the weld while the lug is clamped to the plate and without separating the edges. It may quite readily be seen that *the metal at the bottom must cool first* (due partly to the heat conducting qualities of the plate) and as the weld is completed, the lug will naturally twist toward the direction of the shrinking or cooling metal, as cold metal must occupy a smaller space than hot metal.

Hard Cast Iron.—In filing the surface to a finish, we may find that the metal is so hard that it resists the file and that it is necessary to use the grinder. Since hard cast iron is very brittle, and therefore easily broken, it is to be avoided. If the welding rod and flux used are the right quality, *this hardness may be caused by the too quick cooling of the welded section.* Each time cast iron is melted (or welded) it becomes harder and unless particular care is used to allow it to cool slowly, the proper rod and flux will not prevent this hardening action. It will be noted that we advised taking the manifold off the plate after the tack was made—this for the reason that the conducting qualities of the plate too quickly would cool the metal, which would cause hard spots on the finished surface. At all times, the cooling of any cast iron should be effected slowly and evenly and a safe rule to follow is:

Preheat whenever possible at least the area around the weld and cool in short fibre asbestos, lime, ashes or any cheap similar material.

As cast iron becomes harder each time it is melted, it is necessary to use a special casting for a welding rod containing an element—silicon—which tends to soften the weld. As it is the material from this rod which constitutes the weld, because we have grooved out the old metal before welding, the weld will be soft and workable if we but cool slowly. *If it is necessary at any time to reweld, grind out the metal.* Do not depend upon the force of the flame to get to the bottom of the weld, since this course is almost certain to produce brittle iron, as the old metal is not removed, but simply melted.

Pin Holes and Blow Holes.—As the weld is ground or filed down, it may be noted that the line of welding possibly has a number of holes, perhaps very small or in some cases quite large. While this porous condition makes little difference on a weld of this character, it would be decidedly bad on the water jacket of a cylinder. What causes these holes? Very frequently dirt; therefore, the line of welding should be thoroughly clean before starting to weld. More often, the large holes are caused by not getting the material from the rod in fusion—actually melting—with the weld, and this, of course, causes a weld deficient in strength as well. *But probably the chief reason for these holes is the absorption of gases.* When cast iron is melted, it is really a liquid and in this condition it will absorb air, for instance, and in cooling to a solid state will partially give up this air or perhaps all of it. If the iron comes to a solid state before all the air is expelled, a blow hole is the result. While air has been named as the gas which is absorbed, it must be remembered that other gases are present in the welding flame which may be taken into the iron with the same result.

Largely, the elimination of blow holes is controlled by the proper manipulation of the welding torch. Since it is the liquid metal which absorbs gases, care must be used in bringing the metal to the molten condition not to have too big a zone melting at one time—which would be the case if too large a flame were used—and not to keep this flame on one spot after fusion has taken

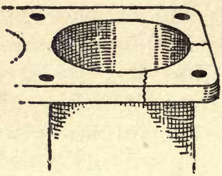

Fig. 19.—Broken cylinder lug.

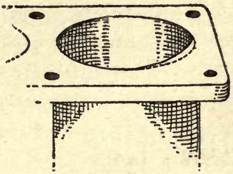

Fig. 20.—Bore warped as shown.

place. Beginners often do this—yet economical and good welding consists of bringing all parts in fusion quickly and as quickly moving to the adjoining spot.

Lug on Cylinder.—Bolting the cylinder to the crank case, a broken connecting rod, or a loose or missing nut on the stud holding the cylinder, may cause a break, as outlined in Fig. 19. It is not unlike the lug on the exhaust manifold; yet the welding presents more difficulties, due to the fact that the bore of the cylinder must not be too greatly warped to permit the proper fit of the piston. If it is a single cylinder, we can properly take care of contraction by heating the four lugs, after tacking the broken lug in one place only, in this way opening the break slightly so that the weld, in cooling, will shrink sufficiently to have the bore the same diameter. But modern cylinders are rarely cast singly and to heat a block of cylinders to weld a lug would undoubtedly distort other portions. *We must then, in this instance, make the weld without regard to contraction* and when finished, we will find the cylinder out of round as shown in Fig. 20. The bore will be slightly smaller, the shrinking metal of the welds pulling the lug in slightly towards the cylinder and as well the lug will not be absolutely level, for the same reason that the lug on the exhaust manifold twisted. In some shops, work of this character is welded from the outside only, but it seems preferable to weld from both sides to secure the best job. In finishing a weld of this character, a portable grinder is desirable, but the work may be done with a stationary one or a file, finishing with emery cloth, particular care being used not to touch the bore where it has been unaffected by the weld. The piston should be frequently fitted to ascertain where grinding or filing is necessary. Work of this character is easy to weld, but rather "fussy" to finish; yet the weld is not successful unless the cylinder is practically as good as new. Since the heat of the welding flame is so concentrated, the bore is not affected, except below the piston rings, and the compression of the cylinder remains the same, but unless care is used in finishing, a piston slap will result if too much metal is taken off.

Water Outlet.—The water outlet is another illustration of a job rather difficult to preheat, but which warps easily unless we guard against contraction. This should be

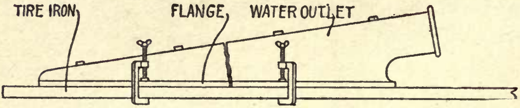

FIG. 21.—Water outlet set up for welding.

clamped lightly to a face plate or a planed surface, as in Fig. 21, with the edges slightly separated. Because this casting is usually quite thin and therefore will cool quickly, the entire width of it should be kept hot, care taken not to have one edge welded and cool while welding the other edge. On work of this character, it is preferable to start welding from the center and work toward the edges, holding the entire line of welding at as even a heat as possible.

The exhaust manifold, the lug on the cylinder and the water outlet are quite simple welding jobs; yet many shops are improperly welding them. *Because the welding of them is simple, the method should not be too quickly passed over,* since principles have been discussed, the proper understanding of which is necessary in more intricate work.

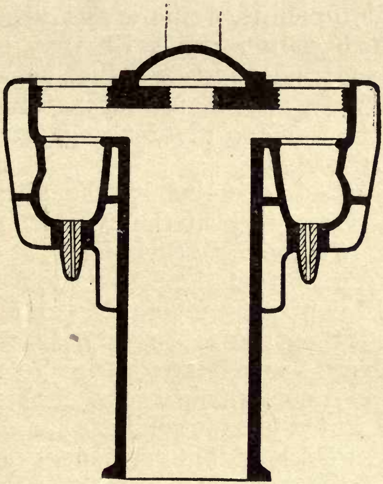

FIG. 22.—Cross section of cylinder, showing heavy and light metal.

It may be seen that where the ends are free to move, as they are in these cases, preheating is not necessary to prevent fracture or warpage, but with cast iron is desirable for another reason—maintaining the softness of the metal.

Water Jackets.—If all parts of a cylinder were of the same thickness, there would be no difficulties in welding any portion of it. Note Fig. 22, representing a cross section of a single cylinder. It will be seen that the wall is considerably thicker than the jacket, that there are sections joining the wall with the jacket and that the metal around the valve seats is much heavier than at other places, yet we have learned that heavy metal requires more heat than light metal and that to prevent warping or breaking, parts must be evenly heated.

On breaks in a cylinder, other than a lug, it is necessary to heat the cylinder prior to welding, *to expand that portion of it affected by welding,* so that the cooling metal of the weld will contract without fracture. If the cylinder is not heated evenly, fractures in other places are imminent (due to unequal expansion) consequently the first requirement of water jacket welding is a slow fire.

If the welding table previously described is used, build upon it a temporary fire brick furnace large enough to easily move the cylinder around in it, placing the charcoal in first and the cylinder on top of it and then lighting the charcoal. If the welding is done on a forge, the blower should not be used and if gas is employed, the air should be cut down to a point where the flame is yellow instead of blue, the object being to heat slowly.

The break has previously been beveled out with a diamond point chisel and for a distance of a half inch each side of the weld has been thoroughly cleaned; all fittings have been removed, valve caps, petcocks, springs, valves, etc. Then the cylinder is placed head down in the fire. There is no necessity for heating the lower part of the cylinder on a water jacket weld, since this portion is unaffected. It will take some time to heat it, depending, of course, on the size of the cylinder and the amount of fuel we are using, but this remember: *Do not force the fire—let the cylinder heat slowly.* How hot shall we heat it? Probably to a very dull red is the best heat as a rule but many shops make the weld before the cylinder reaches the red heat and others believe in heating to a bright red. Examine the cylinder at intervals to see if the heat is even; possibly around the valve chamber the metal is still black, while further away it is a bright red. Change the position of the cylinder then that the heat be more evenly distributed. If the break is a small one the weld may be made without stopping but if it is long enough so that the cylinder begins to cool, stop the weld and again heat the cylinder to an even point.

It is desirable to weld the cylinder while it is in the fire and personal comfort demands that all portions of it except the weld is covered with asbestos paper—and as well this method shelters it from draughts.

Cylinders cast *en bloc* naturally are more difficult to handle than single cylinders, since it is harder to heat them evenly, yet once we grasp the idea of evenly heating and examining each job to find the general construction, i. e., where we must apply more heat because the metal is thicker, their successful welding becomes almost routine.

In Fig. 23 is illustrated a four-cylinder *en bloc* casting, the water jacket of which usually breaks along the general line A. In this type of cylinder the head is removable

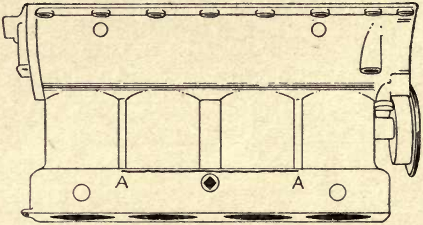

FIG. 23.—Water jacket break in four-cylinder casting.

and the even heating of the casting is not difficult, as it may be laid head down on the fire and all parts thoroughly heated because the fire has an opportunity to reach all sections. Closely adjoining the break is the wall of the cylinder. On the other side is heavier metal, as we can see by examining the construction. Here is a condition where we must use care in so arranging the fire that we direct more heat on the heavier metal than we do the light; *for unless this heavy metal is sufficiently hot it will absorb the heat from the weld,* causing that section to cool too quickly, which will result in a shrinkage crack, either in the weld or close to the wall of the cylinder. If through improper heating the crack gets near the cylinder wall, we may consider the casting ruined, as a weld at this point would warp the bore and make regrinding necessary. The initial cost of this particular casting forbids this expense.

We may conclude that water jacket welding is not at all difficult; rather *the difficulty lies in properly judging where and how much to heat.* If a cylinder is merely thrown in a fire with no study of its construction in relation to heavy and light parts failure, while not inevitable, is very likely.

Compression Head.—Welding the compression head of a cylinder is no harder than welding the jacket, with the exception that the crack is sometimes harder to follow to its end. Here it is rarely practical to weld the head or dome from the interior of the cylinder but the water jacket should be cut or drilled off to enable us to reach the break. In cutting the jacket, make considerable allowance for the crack, that is, cut it so that it is reasonably certain there will be plenty of room to get to the break. With the jacket removed, the cylinder will look about as shown in Fig. 24. All rust should be removed from the vicinity of the weld and the break beveled out nearly to the bottom—not quite through, however, since in a break of this character, it is better to provide for

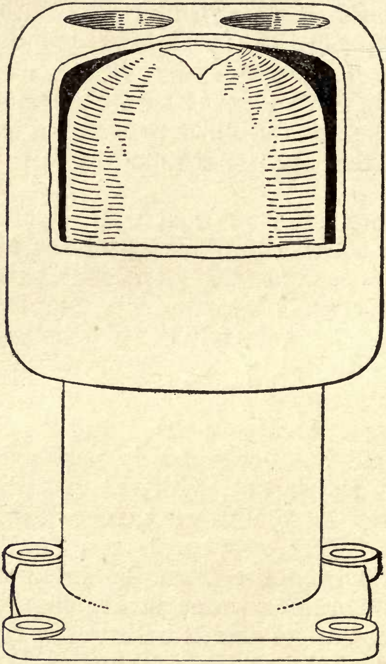

FIG. 24.—Break in compression head.

strength by building up with excess metal rather than go entirely through, for the reason that globules of metal or rough spots in the compression head will reduce the compression space and as well afford an opportunity for carbon to accumulate. It will be noted that the break as shown in Fig. 24 runs quite close to the valve chambers. The weld should be started at this point then, since *it is desirable to weld first that section adjoining a heavier part, leaving until the last the weld which will join approximately even thicknesses.* The reason for this may be apparent if we consider that the heavier

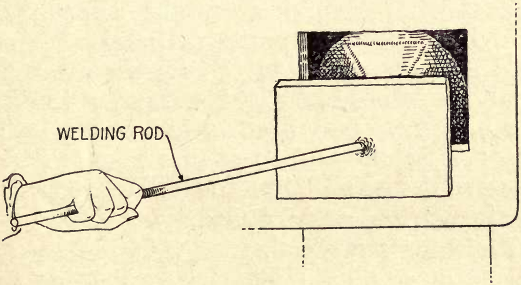

FIG. 25.—Welding rod tacked to jacket.

section will absorb or pull the heat from the weld and if there is still an unbonded section, that end will move instead of the weld breaking. This rule should at all times be followed. If the break is in proximity to the spark plug hole, for instance, start the weld near that opening, since here is heavy metal. This rule is rarely observed, yet lack of its observance is responsible for many contraction cracks and ruined cylinders when the break finally gets into the valve seats or spark plug opening.

After welding in the compression head, as a rule the cylinder should be allowed to cool down and then tested with gasoline to ascertain whether the head is tight. Then the cylinder is again heated and the water jacket welded in. It is rather risky to weld in the jacket without first testing the cylinder with gasoline, yet at times it may be necessary to do so, where time is an object. It is a little difficult to fit the jacket properly into place with the cylinder at a red heat and a suggestion to overcome this difficulty is offered in Fig. 25. Here a welding rod has previously been tacked to the jacket and the jacket can be put into place without inconvenience and the rod melted off after the jacket has been bonded.

Finishing and Testing.—Finishing a cylinder is of equal importance to welding and more so from the owner's standpoint. A great many welding shops leave bunches of material piled up—the welded area perhaps being twice as thick as the surrounding metal. *Since a cast iron weld properly executed with the right welding rod is really a better material than the casting,* there is no need of reinforcing a weld on the outside of the cylinder and the weld should be ground down practically smooth Then the cylinder should be tested under water pressure for leaks. To do this, plug all water connections, except two, one for the water inlet and the other for the escape of air, and then connect with the water supply, if the pressure is under fifty pounds. If over this pressure, a reducing valve should properly be used. When the jackets are full of water, close the remaining outlet and if there are any cracks or porous places, they may be quickly detected. If no water supply under pressure is available, simply fill the jacket with water, close all openings and connect the oxygen hose to a water inlet and use the oxygen under a pressure of fifteen or twenty pounds. Most shops have various fittings and plugs at hand with which to make connections but a few rubber plugs tapered to fit various size holes will be found handy for testing purposes. After testing, the cylinder bore should be wiped out with oily waste and as well the valve seats and chambers and then the cylinder painted with a heat resisting paint. Pay attention to the finishing; it means dollars to spend a little time in having a nice appearing as well as a properly executed weld.

Scored Cylinders.—Not an infrequent occurrence to a cylinder is a scored condition, resulting in loss of compression. Filling this depression with new metal and regrinding so that the same piston may be used is not at all easy. Filling the score and regrinding to use an oversize piston is simple but this latter course involves considerable expense. Since the welding flame must in this instance be in the bore, and contraction take place there, necessarily the greatest care must be used in heating the cylinder as evenly as possible. It must be frequently turned in the fire and no part allowed to reach a greater heat than another. In a weld of this kind, no beveling, of course, is necessary, since the score itself is the groove. Cleanliness of the weld and adjacent section is especially to be desired. A torch with a straight head or one with but a slight angle is almost essential to do good work, the position of the flame in relation to the weld being about as shown in Fig. 26. It will be noted that the cone is about parallel with the break unlike most welds, where it is nearly at right angles with it; but in this instance, the object is to add metal without breaking down adjoining sections. The force or velocity of the flame if allowed to play directly down upon the score, as would be the case in ordinary welds, slightly collapses the metal adjoining the score and in regrinding there would be a depression on each side of the weld. To overcome this, the torch is held as described.

Cylinder Parts.—In rare instances it is necessary to build up the valve seat with new metal. *Remembering that the remelting of old metal produces hard cast iron,* the surface of the seat should be either turned down before welding or particular care used to scrape out this old metal while making the weld—otherwise, machining the seat will be a difficult matter. Sometimes it is necessary to build up threaded portions—valve caps or the valve chambers perhaps—and the same rule should apply. Whenever possible, the threads should be turned or ground off before making the weld. Valves

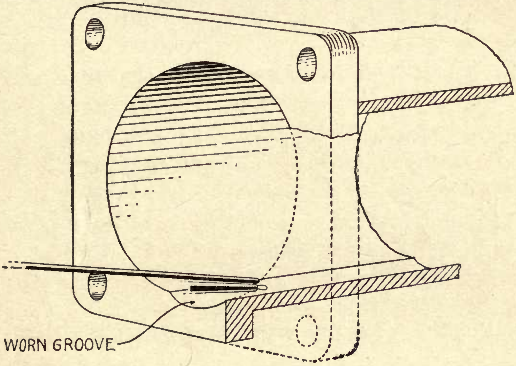

FIG. 26.—Welding scored cylinder—position of flame.

may be enlarged in the same manner, watching out for too quick cooling and the use of too large a flame which would produce a very porous condition.

Fly Wheels.—There is no particular difficulty in the way of successfully welding fly wheels, either solid or with spokes; simply the same judgment in where and how much to heat that is used with cylinders. Here the rim is the heavy section and more fire must be directed to this portion than to others.

Pistons.—Pistons may be welded the same as cylinders but they are much simpler, due to their construction.

Crank Cases.—Fig. 27 illustrates a cast iron crank case, which has been broken and the piece lost. We have three methods of

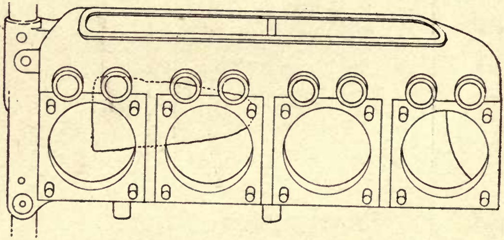

FIG. 27.—Cast iron crank case with steel patch.

repair open to us. A plaster paris mold may be made and the piece recast—parts may be made up from old castings around the shop—or a piece of sheet iron or mild steel may be cut out and welded in, since in this instance there is practically no strain on the welded section. In welding cast iron to steel, a cast iron welding rod is used, as well as the cast iron flux. While the weld is hard and brittle, it is strong enough for this purpose. The case must be preheated the same as cylinders to prevent fracture.

Babbitted Bearings.—In the case illustrated in Fig. 27, there is a center bearing which is poured. In a well known car, where the upper half of the crank case is cast integral with the cylinders, the bearings are also poured. The repair man in welding these parts is often confronted with the trouble of repouring these bearings and

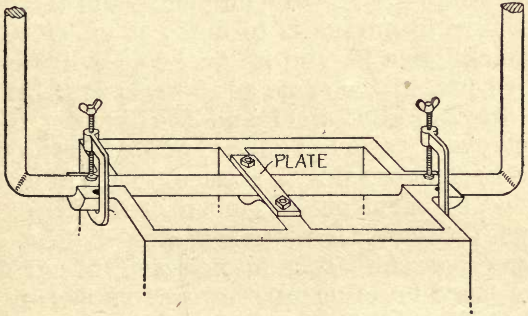

FIG. 28.—Method of saving babbitt.

makes many efforts to save them. Since babbitt melts at a very low temperature, the fire used to preheat the casting is usually sufficient to melt them. If they are far enough away from the fire, the method outlined in Fig. 28 may be tried. Pipe the right diameter to snugly fit into the bearings is clamped or bolted to the stud holes and water kept running through it to keep the bearings cool. *It is to be advised that the saving of the bearings is of secondary importance* though and the weld should be given first attention—in other words, not to save the bearings at the expense of the weld.

Valve Guides.—Old cylinders, and these are the ones usually difficult or impossible to duplicate, frequently have the guides so worn that bushing them is impossible. Welding a new guide is the only cure and the best method to pursue is to first cut off close to the cylinder the old guide. The cylinder is then heated the same as if we were to make a water jacket weld and the making of a new boss, which is later drilled from the valve chamber side, is started. The old metal must be burnt out as shown in A of Fig. 29 and the new metal added almost down to the valve seat. Then as we reach the surface we start building up the boss as shown in B of Fig. 29. With a little skill, the general outline may be maintained quite easily but if the metal is inclined to "run away" a block of carbon or graphite may be used, as in C of Fig. 29, to hold the metal in place.

Preserving Threads.—Sometimes cracks or breaks run through threaded portions, where it may seem necessary not to touch the thread. A graphite or carbon block is used in this instance to plug the hole—never clay as is sometimes recommended—and the weld carried up nearly to the thread. But such a course should never be pursued when it is possible to recut the thread. This is "hit or miss" welding.

Conclusion of Cast Iron.—Do not mistake malleable iron, which is used in rear housings and other parts of an automobile, for cast iron—malleable iron is later treated. It cannot be welded with cast iron. Use care in welding any cast iron which has been previously brazed. Make certain that all

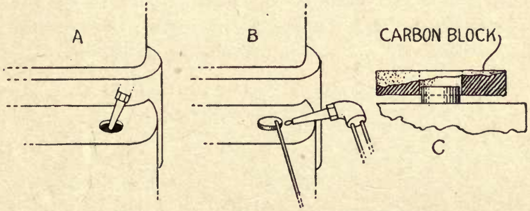

Fig. 29.—Making new boss for valve guides.

brass is removed before starting to weld and if this is impossible, scrape out the weld as much as possible while adding the welding rod. This completes the cast iron subject.

Necessarily the subjects have been briefly treated and principles rather than details have been outlined, since the full description of any one welding operation would constitute a chapter. It will be necessary for the reader interested in crank case welding for instance to study the principles of cylinder welding. Most important is the carrying out of the ideas by actual welding on old parts easily obtainable from garage scrap heaps or junk yards.

CHAPTER IV.

ALUMINUM.

Use of—Welding Knowledge—Puddle System—Flux System—Comparison of Systems—Welding Rod—Preparation of the Weld—Inlet Manifold—Arm of Crank Case—Welding the Arm Without Taking Out the Motor—Break in the Body of Case—Welding Cold—Wrong Method of Setting Up—Lug or Boss Welding—Preheating the Case—Gas Preheating Flame—One Side or Both—Collapse of Weld—Broken Bearings—Direction of Welding—Shrinkage Cracks—Missing Parts—Finishing—Die Moulded Castings—Body—Other Parts.

Use of.—The use of aluminum in automobile construction is wide—crank and transmission cases, perhaps the cylinder and pistons, the body, etc. Except in the body, it is rarely used in the pure state but is alloyed with one or more other metals, copper, tin, magnesium or sometimes zinc.

While the repairman as a rule considers the welding of aluminum the most difficult of all the metals, *as a matter of fact it is quite simple*—very little harder to master than cast iron—but unless the welder thoroughly understands the principles of expansion and contraction, failure is certain. Briefly, let us understand the characteristics of this metal before proceeding to actual welding.

Welding Knowledge.—*Aluminum with a melting point about half that of cast iron conducts heat three times as fast.* Its shrinkage is also greater—the same section will cool from a molten state to a smaller space than cast iron. These facts will guide the welder to choose for the same thickness of aluminum a tip as large or perhaps a little larger than for cast iron and to particularly guard against warpage or fracture, remembering that because of its great conductivity *there is a large zone of metal around the weld which is very hot*—and therefore expanded—and when cooling this metal must occupy a smaller space.

Aluminum castings are not as brittle as cast iron ones and a crank case will usually, though not always, stretch or warp considerably before breaking. Throughout the text, constant reiteration has been made of the fact that cold metal must occupy a smaller space than hot metal. Once this fact is grasped, the great obstacle to repair welding is removed, for we then plan to meet this condition usually, as we have already learned, by heating and thus expanding the area or section affected by the cooling metal of the welded zone. Unless we do understand this, return to the principles of expansion and contraction, for without this fundamental knowledge aluminum case welding is beyond us.

An aluminum break when melted does

not flow together as other metals do but the edges creep away from each other. There is a film on the surface, dull gray in color, wrinkled in appearance. *This film is aluminum oxide which melts at a much higher temperature than the metal and it must be destroyed or removed before the edges can be bonded.* The welder has two methods of eliminating this oxide—one by mechanical means, scraping it out with a rod and the other by dissolving it with a flux. The first way is termed the puddle system and the other the flux method.

Puddle System.—Welding rods used for

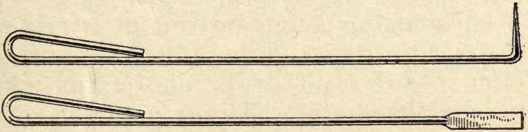

FIG. 30.—Rods for puddling aluminum.

steel welding may be shaped up about as in Fig. 30, one end bent to form an eye, so they may be hung up and found when wanted and the other end shaped as shown. The pointed end rod may be used for scraping out the weld and the flat end for "paddling" the new material from the rod. The puddle system of aluminum welding is not unlike the method used by children in making "mud pies" but instead of water to bring the material to the right consistency to pat it into form, the welding flame is used, but care must be exercised not to make the metal too fluid as this would cause the metal to collapse. This may be controlled by the choice of proper tip size and as well by the proximity of the flame to the metal.

The oxide of aluminum forms each time a new surface is exposed; i. e., as we melt the metal and scrape out the oxide that portion of new metal on the surface immediately becomes an oxide. Care should be used then to have the welding rod plunged into the molten metal when adding it to the weld to avoid too much oxidation.

Theoretically the flame should be so adjusted that it delivers an excess of acetylene —a carbonizing flame instead of a neutral one—as this flame more fully protects the molten metal from oxidation. *In practice however, the neutral flame is used,* since the carbonizing flame heats too wide a zone and as well the operation is longer due to the lower heat of such a flame. Right handed welders will as a rule find it more convenient to hold the torch in the left hand, using the right for adding the welding rod and handling the puddler.

Flux System.—By means of a suitable flux, aluminum may be handled practically the same as cast iron, the hot welding rod picking up enough flux to destroy the oxide as the rod is brought down into contact with the break. Aluminum welded in this manner should have about the appearance of

Fig. 31. As the flux meets the metal the dull gray color of the oxide disappears and momentarily the metal assumes a bright silvery appearance and then resumes the dull gray color as the oxide forms on the surface. A flux weld should always be washed when cool, either in running water or with wet waste.

Dirt in the line of welding is removed by getting the weld to a melting heat, scraping

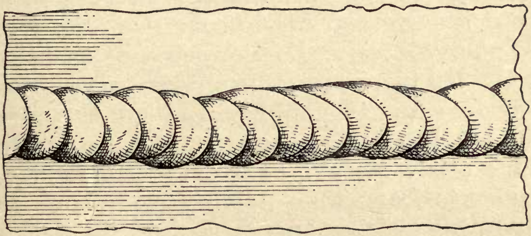

FIG. 31.—Appearance of flux weld.

the old metal out with the welding rod, adding the flux to the rod and then bringing it in contact with the break. There are two distinct operations then when the break is more or less filled with oil or grease—first, the use of the welding rod to scrape out the weld; second, the use of the rod with flux attached to add to the metal.

Comparison of Systems.—The puddle system is in wide use by repair shops and when skilfully executed requires less finishing than a flux weld. It takes longer to make the same weld than by the flux system since the welding flame cannot be held continuously to the line of welding but must be lifted away while the metal is scraped and puddled. It is more difficult to learn than the flux method, it inevitably leaves some oxide in the weld but the strength of the weld, while not as great as a properly executed flux weld, is amply sufficient. Sheet aluminum cannot be welded by the puddle system. *The growth of the flux method has been greatly retarded because of the many inferior fluxes marketed*, many of them useless. No mechanical means are necessary if a proper flux is employed to bond the metal, the break flowing together much easier than with other metals. Flux welding is much easier to learn than puddle welding, is considerably quicker and removes all oxide from the weld. As previously stated a flux weld must be washed off when cool, lest the aluminum is later attacked by chemical action, but there are no detrimental after effects if this is done. Sheet welding, to a very thin gauge, is quite easily accomplished with a proper flux, the aluminum bodies of the automobile being manufactured by this method.

Welding Rod.—The rod most commonly used in successful repair shops is an alloy of 93 per cent aluminum and 7 per cent copper. Except for sheet aluminum welding, this composition casting should be used. The drawn aluminum rod offers the objection of being too ductile—it bends very easily—and does not mix so readily with the weld. As with other welding supplies, caution should be exercised in its purchase to make certain that it is cast from pig material, no scrap being used, to avoid excess impurities and oxide.

Preparation of the Weld.—Unlike other

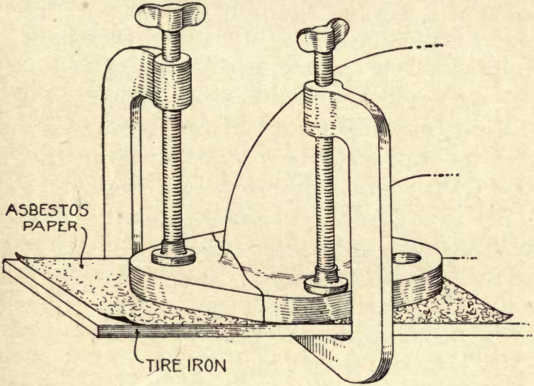

FIG. 32.—Set up of aluminum manifold.

metals, the break of an aluminum casting is not grooved or beveled out preparatory to welding, since the edges have a tendency to separate as the metal comes to a molten condition. Cleaning the casting by washing in gasoline or soda is desirable and unless the break is in a lug or away from the body of the case all shafts, oearings, etc., must be removed. If the break runs into or through any threaded portion holding studs or bolts, these should be removed and the hole welded solid.

Inlet Manifold.—Assume that the first aluminum break to be welded is the lug on a manifold. We follow the same method as we did with the cast iron one, clamping it to a flat surface after separating the edges. In this instance though, we may advisably place a piece of asbestos paper between the surface of the plate and the manifold (Fig. 32) to avoid the conduction of heat by the plate. Instead of removing the clamps after tacking, the weld is completed from the one side with the clamps lightly attached.

As the flame is brought down to begin welding, no apparent change in the metal takes place for some time. Unlike other metals, aluminum does not change in color as heat is applied. The beginner is often impatient to see the metal melt and does not consider the conductive qualities of aluminum. If the puddle system is employed, the iron rod may be scraped across the weld to determine when it is melting. The weld should be scraped out to the bottom and then the welding rod added and puddled. The control of the flame is effected by raising it away from the metal as it becomes too fluid. If the flux method is used, the flame should be directed into the break and its velocity will still further separate the edges. As the metal assumes the wrinkled appearance the rod, previously dipped while hot into the flux, is brought down into the break and a portion of the rod melted. A circular movement of the torch brings the sides and rod into fusion and we move to the spot adjoining. The manifold is then taken off the plate and welded from the other side.

Due to the great conductivity of the metal, the beginner will find difficulty in preventing the metal from collapsing. He must remember that aluminum when highly heated has no "strength," and that this is true not only in the weld, but for some distance all around it, that a clamp tightly attached is sufficient to crush it and considerable skill is necessary in properly judging the heat to raise the flame away from the metal at the critical moment or to direct the flame to another section.

Arm of Crank Case.—Due to vibration or poor alignment in bolting the case to the frame, a break similar to that outlined in Fig. 33 is frequent. Here the end of the arm is free to move, so it is not necessary to plan for the effects of contraction, the only requirement being to slightly separate the edges. In setting up work of this character, that is, any job where the break entirely separates the pieces, make certain that the sections will not move before they are bonded. Clamps are not always necessary

—the use of fire bricks, pieces of iron, etc., are many times more convenient.

It is rather difficult for an experienced operator, and impossible for the beginner to weld aluminum in any other position except horizontally—consequently, this break may be welded along the top first, remembering to warm the entire area by moving the torch

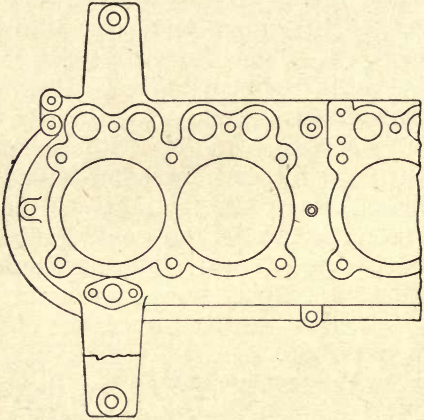

FIG. 33.—Break in arm of case.

slowly back and forth in line with the break before concentrating it on one spot. After completing the top, the sides may be welded in turn and usually in jobs of this character the weld is also made from the inside, reinforcing considerably by adding metal from the rod to make the welded section thicker.

To make this weld—the break being some

distance from the body of the case—it is not necessary to strip the engine; in fact, no part of the motor need be taken off.

Welding the Arm Without Taking Out the Motor.—When time is an element to be considered, it is possible to weld a break of this kind without taking the motor out of the frame, first removing the pan underneath the engine and taking all strain off the lugs

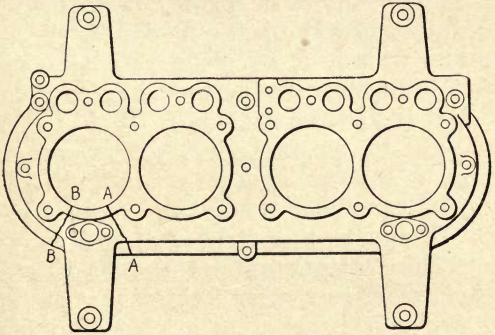

FIG. 34.—Arm broken into body of case.

of the crank case by the use of jacks supporting the case. The broken lug is then unbolted from the frame and the same method pursued as in welding with the motor out of the frame. Naturally, the weld is a little more difficult to handle, but in some instances, the time saved in not removing the motor is of such importance that a weld of this kind is essential.

Break in the Body of Case.—In Fig. 34, the break extends into the body of the case. Here conditions are entirely different than in the preceding illustration and it is necessary to entirely strip the case, since *provisions must be made for the effect of expansion and contraction;* and the presence of cam shafts as an example would prevent the proper movement of the case as it expands under heat.

To understand the proper welding of an aluminum break in the body of the case, perhaps it would be clearer to the reader to first demonstrate the improper manner in which it is so often executed. With no attention paid to the fact that *cold metal must occupy a smaller space than hot metal* the weld is first made on the line A-A and then B-B. Usually, the weld will hold, but in determining alignment we find that the case is shorter on the welded side than the other and the end bearing is out of line in the direction of the welded arm. The lower half cannot be attached to the case since the bolt holes are not in line; neither can the crank shaft or cam shafts be put back, and while we may have made a perfect weld, the case is useless. *Even welders of experience many times try to violate the law of expansion and contraction* by welding a break of this kind without preheating. As the welded area cools, the metal shrinks, the welded side shortens in length and in doing so, pulls the end of the case toward the weld.

Welding Cold.—It is possible but rarely practical to effect this weld without preheating in the following manner: The edges of the break on the arm are ground down on one side enough so that there will be a space sufficient to separate the edges of the weld at A-A. This weld is then made, allowing it to cool. By means of a screw jack, the case is then sprung slightly, open-

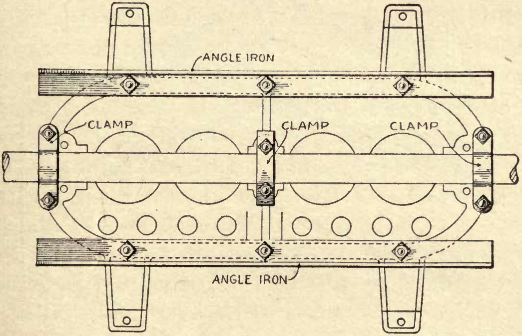

FIG. 35.—Wrong method of setting up case.

ing the break at B-B about three-eighths of an inch. This weld is then made, the jack removed and in cooling the metal will shrink and the case be approximately in line. It should be understood that this is an emergency method for use where there may not be facilities for properly handling the case and should not be undertaken by beginners.

Wrong Method of Setting Up.—The use of flat stock, angle iron and shafts is allowable in setting up a badly broken case. They should never be attached as shown in Fig. 35 securely fastened to the case by bolts, since this prevents the proper expansion or contraction of the case. They may be lightly attached by clamps, but in preheating the

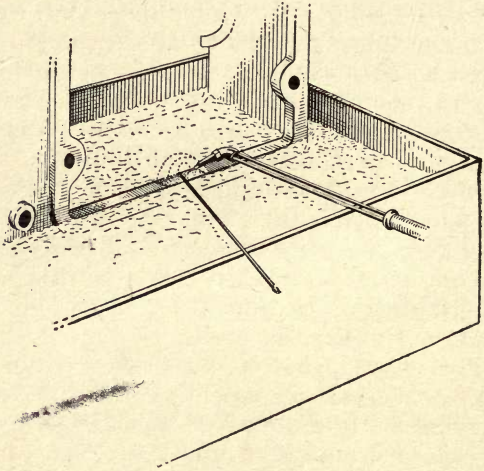

FIG. 36.—Use of water to prevent expansion.

case these shafts or irons are cumbersome and dangerous, their weight being sometimes sufficient to collapse the case. *The successful welder rarely uses them* except as a preliminary to welding in pulling the case back to shape if it is sprung and in tacking many broken parts in their proper position.

Lug or Boss Welding.—Sometimes the work to be done may be the building up of new bosses or lugs and the case may be otherwise perfect. The object here is to form these bosses without preheating the case if it is possible to do so. In Fig. 36 is shown one method of *preventing* expansion. The case is put in a pan of water, which covers the side but which does not quite touch the lug. The water keeps the side of the case cool while the boss is being built up. In lug or boss welding where the broken piece is small, it is usually inadvisable to attempt to weld it back. The new boss may be roughly built on by means of the welding rod, added a drop at a time, *particular care being used to have the metal in fusion while adding the rod,* since in work of this kind the temptation to add the rod before the metal of the case is melting is great.

Short fibre asbestos soaked in water or scraps of asbestos paper treated the same way may at times be used when the shape of the case prevents its being placed in water, but this method is not so safe as the use of water.

Preheating the Case.—With the arm of the case spot welded or "tacked" or lightly clamped in place as in Fig. 37, it is ready to heat in order to offset the strain set up by the cooling weld. If the welding table previously described is used the charcoal fire may be made on the fire brick top and without building any furnace as we do for cylinders; in fact, we must guard against getting the case too hot, remembering the low melting point of aluminum. *It is not necessary to heat all the case,* but only that portion affected by the cooling area of the weld. In this instance, that section would be about as shown by the dotted lines in Fig. 37. We are trying to expand by heating all that section *so that the side opposite the weld will be just as long as the welded side is while*

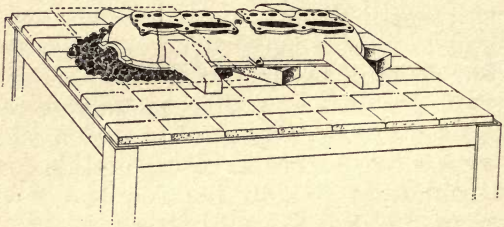

FIG. 37.—Preheating to avoid warpage.

at the welding heat and so will contract to the same length after cooling. How hot shall we heat it? Some welders determine the proper heat by waiting until just before the case begins to "sweat"—that is until tiny beads or globules of metal form on the surface; but this method is not definite, since the appearance of these beads largely depends upon the alloy of the casting. Some shops wait until the metal is hot enough to quickly char sawdust; others until the metal gives off a dull sound when tapped lightly with a hammer and still others until half and half solder quickly melts when touched to the case. Largely the proper heat is a matter of individual judgment and considerable latitude is inevitable, particularly as some alloys need more heat than others, but for beginners the sawdust test is probably the easiest.

Particularly with aluminum it should be a slow heat, and if heavy sections are in the area affected by the weld, these heavy sections should be heated as hot as the lighter ones—and to do this takes time. Always the metal should as well be cooled slowly, packed in asbestos, lime or ashes the same as cylinders or wrapped in asbestos paper.

Gas Preheating Flame.—In using gas preheating torches rather than charcoal, more care must be exercised to secure an evenly distributed heat. The flame striking on one spot only, except in the rare instances where it is necessary to heat only one spot, is likely to expand one portion more than is required, actually setting up more strains than if it were not used at all. In the absence of a helper to manipulate the gas torches, keeping the flames moving over the entire section to be heated, it is advisable to use fire brick as a baffling plate, the flames striking first against the bricks and the heat radiating from the brick to the case along the idea of Fig. 38.

One Side or Both.—The finished weld presents a better appearance if welded from both sides—yet it is difficult to handle the case to do this without a helper in constant attendance. If it is desirable or necessary to do so, weld only one or two inches on one side at a time, never completing the weld from one side and then welding the entire length from the other. As may readily be

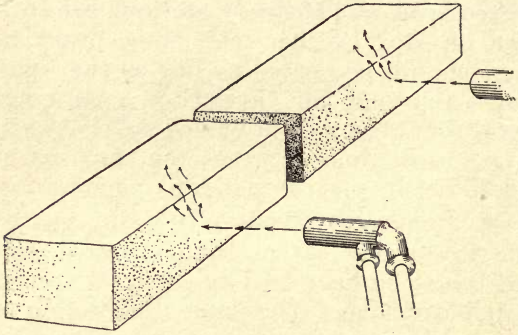

FIG. 38.—Indirect heating with gas torches.

seen, this method sets up a very unequal expansion.

In welding from one side the metal should slightly collapse before adding the welding rod, forming on the other sides beads of considerable size which may be chiseled off when finishing.

Collapse of Weld.—Beginners have difficulty in judging the heat of the metal and since there is a zone around the weld practically as hot as the weld itself, very often this whole section suddenly collapses. To prevent this, it is advisable for the student of aluminum welding to make a mould of two-thirds short fibre asbestos and one-third plaster paris, mixed with water to a thick paste and place it on the inside of the case about half an inch thick. This mould is made to support that section likely to collapse. It should be thoroughly dry before

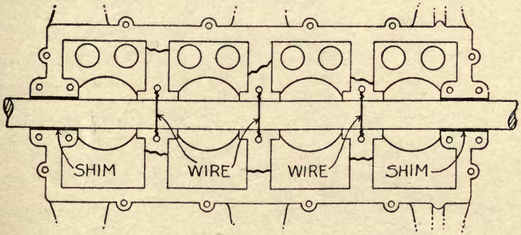

FIG. 39.—Use of shaft to line up broken bearings.

starting to weld and this drying should not be forced. *Admittedly, the use of a mould prevents to a certain degree the proper expansion* of the case, but its use is advisable in preference to destroying the case by melting it.

Broken Bearings.—Bearings entirely broken out may be lined up as shown in Fig. 39, a shaft being used to hold them in place. If one or more bearings are intact, a thin shim should be placed between the shaft and the bearings at this point, which will slightly raise the broken bearings—separating the break. The breaks are then tacked to hold them in place and the shaft removed before the case is preheated.

Direction of Welding.—In Fig. 40 is illustrated a crank case with several breaks.

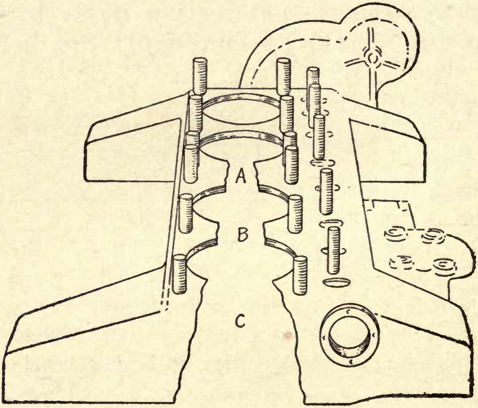

FIG. 40.—Direction of welding—toward unbonded section.

Wherever possible any weld should always be executed toward an opening. As an example, a square piece with the break starting in the centre and running to the edge, should be welded toward the edge—not toward the centre. In Fig. 40 then the end bearing should not be welded first, since this completely closes the case and the expansion set up in welding the other breaks makes the job more difficult to handle. By welding at A, then B and then C, the end of the case at C is free to expand or contract as the necessity may arise in the welding and cooling of A and B.

A case with two bottoms offers no particular difficulties if evenly heated. It is to be remembered that a break on the inside bottom cannot be welded without fracture or warpage unless we heat the outside to which it is attached and *vice versa—we must expand so that in cooling both will contract equally.*

Shrinkage Cracks.—In some instances, even with all precautions apparently taken, the case cracks in cooling close to the weld. Sometimes this crack is very small—just a fissure—and at times it may be quite large. Generally, we may look for the reasons; first, *in the too rapid conduction of the heat by a heavier section adjoining*, and second, *in the alloy of the metal;* or not unlikely a combination of the two. If it is difficult to prevent this cracking, we may resort to cutting the case in another spot to relieve the strain caused by the pull of the heavier piece. To illustrate, note Fig. 41, with the break at A adjoining the centre bearing B, which in this instance is very heavy metal. We cut the case with a hack saw as shown at C *so that the cooling metal of the weld will not break by the rapid conduction of the heat by the section B, but will open at C.* Then the weld at C is made, remembering to heat that general section shown by the dotted square.

Missing Parts.—When parts broken out have been lost, the repair man has several methods of replacement. One common form is to bend a piece of thin sheet iron to the

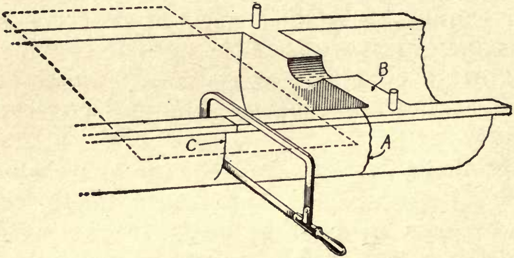

FIG. 41.—Case cut to relieve strains.

general shape of the break and place it on the inside of the case, completely covering the hole. Sections broken out of another case are then laid on this and melted together with the torch, adding stock from the welding rod whenever required; or a plaster paris mould made along the same lines.

Sheet aluminum, which may be purchased in any gauge, may be used on the lower half of the crank case and on some types of transmission cases, but the irregular shape of the upper half of most crank cases ordinarily prohibits its use on these.

Finishing.—The ordinary file is useless for aluminum and that known as the Vixen is necessary. Grinding wheels fill up quickly, but *the liberal use of ordinary lubricating oil on the wheel will be found helpful.* Shops

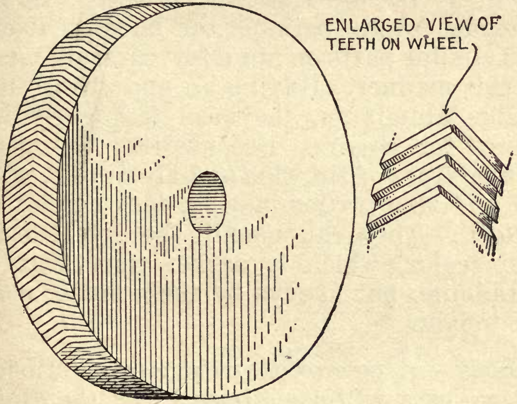

FIG. 42.—Finishing wheel for aluminum.

using a portable grinder will find it advantageous to purchase or make a steel wheel with teeth shaped about like Fig. 42. All surfaces should be tested for alignment and the bearings as well. Do not always expect that bearings will line up as exact as they were before welding. Some finishing is generally essential and before the shafts are put back in, the bearing metal must, of course, be scraped as it would be in overhauling a motor. If there are low spots in the case, they may be built up with the welding flame.

Die Moulded Castings.—Manufacturers sometimes find it economical to cast small sections out of what is usually called white metal by the die moulding process. Pump housing covers, perhaps the housing itself, and similar parts on not a few cars, are made in this manner. Having an appearance not unlike aluminum, they are frequently accepted for repairs. Because they are made of a mixture of tin, zinc and aluminum, with tin and zinc predominating, *they cannot be welded.* They can usually be detected by their color, which is darker than that of aluminum, but always by their much heavier weight.

Body.—A pole of a carriage or a collision of two cars will sometimes break the aluminum body. Conditions here are entirely different than with cases and housings, since it is impractical to strip the body or to preheat it, yet we must guard against contraction cracks. Breaks of this kind are usually jagged and the first operation will be to cut out the broken section, *so that the hole in the body will be oval or round.* The paint is then burned off for some distance around the break and the edges of the hole filed until they are bright, removing all dirt. Then a patch is made from sheet aluminum the same gauge as the body and this patch is made slightly larger than the hole it is to fit. The edges of this patch are also filed bright. The patch is then dished, as shown in Fig. 43, so that it will just fit the hole. For a welding rod, a drawn aluminum wire is used—about a No. 9 gauge is correct. The flux is then moistened with water and the

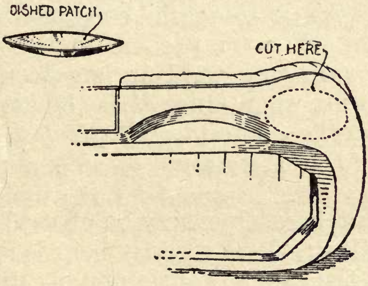

FIG. 43.—Preparation for body welding.

edges of the break and the patch covered with the flux. The patch is then tacked in three or four places and the weld made in the usual manner. Here contraction of the cooling metal is provided for in the shape of the patch and as the weld cools the patch pulls towards the weld and it straightens out. It will probably be necessary to do some hammering to completely finish the job, this hammering being perfectly safe on sheet aluminum which is very ductile. The oversize of the patch will largely depend upon the size of the hole, but this may be determined by first welding a similar size patch in the centre of a piece of sheet aluminum. It is desirable to have another torch or a gas flame warming the patch as the weld cools to aid in the straightening out of the dished patch, but this is not essential.

Other Parts.—There are, of course, other parts of the automobile constructed from aluminum which may come to the welding shop. Crank case welding has been particularly dwelt upon since it is the most difficult; *and the principles illustrated may be applied to the welding of any aluminum parts.*

The clutch casting may be classed as simple welding; the running board is easily welded; the fenders present no difficulty. The spider of the steering wheel is somewhat harder to handle, due to the wooden hand grip. Where it is not practical to remove this wooden handle, wet asbestos may be packed on each side of the break and the expansion thus limited while the weld is being made.

CHAPTER V.

STEEL.

Welding Knowledge—What the Flame does to Steel—The Welding Rod—Simple Welding—Position of Flame—Reinforcing the Weld—Frame Welding—Lengthening the Chassis—Tube Housings—Worn Parts—Gear Welding—Case Hardening—Light Metal Welding—Gasoline Tank—Welding Adjacent to Rivets—Shaft Welding—Construction of Parts.

The successful welding of steel presents many difficulties not apparent to the beginner. Based, perhaps, on previous experience or understanding, he considers cast iron the most difficult and steel the easiest; *whereas the reverse is true.*

With cast iron and aluminum, the difficulties encountered are largely in the control of the effect of expansion and contraction and the actual bonding of the metal is comparatively simple. In the welding of steel parts of the automobile, practically no attention need be paid to expansion and contraction, but the greatest care must be used in flowing the metal together. *No detail is unimportant*—the absolute adjustment of the welding flame to a neutral cone; the proper choice of the welding rod; a flame neither too large nor too small; and finally the proper manipulation of the flame to secure a sound weld without seriously affecting the character of the metal. How to guard against discouraging failures may be better understood by some knowledge of the behavior of steel as we melt and flow it together with the flame.

Welding Knowledge.—To attempt to classify the various grades of steel and their qualities would lead to long considerations of the effects of vanadium, chromium, nickel, manganese and other alloys used to strengthen, harden or toughen, and while these alloys are of interest to welders well advanced in the art, *they need not be considered by the beginner.* A failure of a steel weld is many times thought to be caused by the presence in the metal of one or more of these alloys—when more often it is because of lack of knowledge of an elemental nature.

It is necessary to understand that the carbon content of steel must always be considered—*steel low in carbon may be quite easily welded, and if high in this content, it is very difficult to weld.* No steel weld can ever be as strong as the original metal (if there were no flaws) for reasons which are obvious, the weld being simply a local recasting and not subjected to heat treatment, rolling or forging. With low carbon steel, we can very closely approach the original strength and because the metal may usually be reinforced by making it thicker than the original piece, we can really make that section stronger than ever. In cases where this reinforcement is not possible, due to the shape or location of the article, considerable ability is essential and, as well, a knowledge of the use of the article, that is, knowing what strain or service test it must undergo.

Steel low in carbon is very ductile—it bends or twists quite easily—but as we increase the carbon, the metal becomes harder and more brittle, less than one per cent of carbon representing the difference between low and high carbon steel. The carbon content of automobile parts may be largely determined by their duty. A stamping, such as the lower half of the Ford motor, or many of the rear housings may be considered low in carbon or as the metal is more commonly called, mild steel. The crank shaft, on the other hand, having to stand a series of shocks, is hard steel or high in carbon. The front axle may be of a carbon content between these two, and this may be called half hard steel. We may conclude that welding a rear housing is considerably easier than welding a crank shaft; and that the axle is a little more difficult than the housing, but not so hard to handle as the shaft.

What the Flame Does to Steel.—*The welding flame melting a section of mild steel must be adjusted to as nearly a neutral cone as is possible for the operator to control.*

An excess of oxygen burns the metal—the oxygen uniting with it and forming iron oxide, and this oxide or burnt metal remaining in the weld, seriously weakens the bond, the extent depending, of course, upon how much the metal has been burnt. It is to be remembered too that oxygen present in the air may also oxidize the metal each time a surface is exposed, the same as with aluminum; consequently *the size of the flame chosen should be large enough to melt the spot it touches and not so large that it keeps a large zone in fusion,* since we want to keep oxidation or burning down to the minimum.

Recall now the adjustment of the welding flame, the importance of which has been previously emphasized. We learned that a carbonizing flame—one with too much acetylene or too little oxygen—would badly affect the molten metal. Acetylene being very rich in carbon may add to the weld a sufficient amount of it to make it extremely brittle, unless the flame adjustment is properly made. It may be seen that there is only one flame—neutral—suitable for steel welding especially, and that either a carbonizing or oxidizing one is ruinous. *Avoid lighting the torch on steel while it is at the red or white heat* and allowing the acetylene to play upon it while turning on the oxygen. This habit, frequently indulged in by welders, may ruin the weld by depositing a sufficient amount of carbon to make it hard and brittle.

No flux is necessary on mild steel, *because of the much higher melting point of the metal than the oxide,* the oxide being destroyed by the flame itself, provided the weld does not cool too quickly. The quick cooling of the weld, however, or the use of a tip too small to keep the metal in fusion and thus cause rapid conduction of the heat away from the line of welding, will result in trapping this oxide in the weld.

Due to the lower melting point of the metal it is impossible to weld high carbon steel with as much freedom from oxides, since in this instance the metal has an opportunity to solidify before the flame destroys them. In addition, the carbon is more or less destroyed and the metal absorbs gases, making it porous.

FIG. 44.—Twisted wire should not be used.

The Welding Rod.—Undoubtedly the ideal rod from the workman's point of view is Swedish iron, since this is free from carbon and impurities and welds easily, but for most automobile work it is too ductile and *it is better to use a rod of mild steel* in order to gain rigidity—in other words we do not want the weld easily bent. The rod must be free from impurities, clean and without rust, and its purchase carefully made. No welding should be done with wire twisted together as in Fig. 44, as this, we can readily see, offers more surface for oxidation to take place.

Simple Welding.—As an example of simple welding, let us take the rear housing, which may be constructed of two stampings. The older cars with this construction rivetted the two parts together—the later ones weld them. Let us assume that these two parts have separated and are leaking grease and allowing play in the differential. The surface should be cleaned and if the joints have been previously welded, the old metal should be ground off. No further preparation is necessary, the edges already being butted. Adjusting the flame properly, the torch is brought down until the end of the cone nearly touches the metal and moved slowly in a short circle until the metal each side of the weld for a distance about three times as wide as the metal is thick is at the red heat. *Then the cone is brought into direct contact with the break,* the end just touching the metal. Steel is the only metal with which the cone is brought into actual contact, but it should not be brought so close that the cone bends and spreads on the surface; *the end just licking the surface is the correct position.* By a short circular motion, the two edges are flowed together and the torch comes back to the original starting

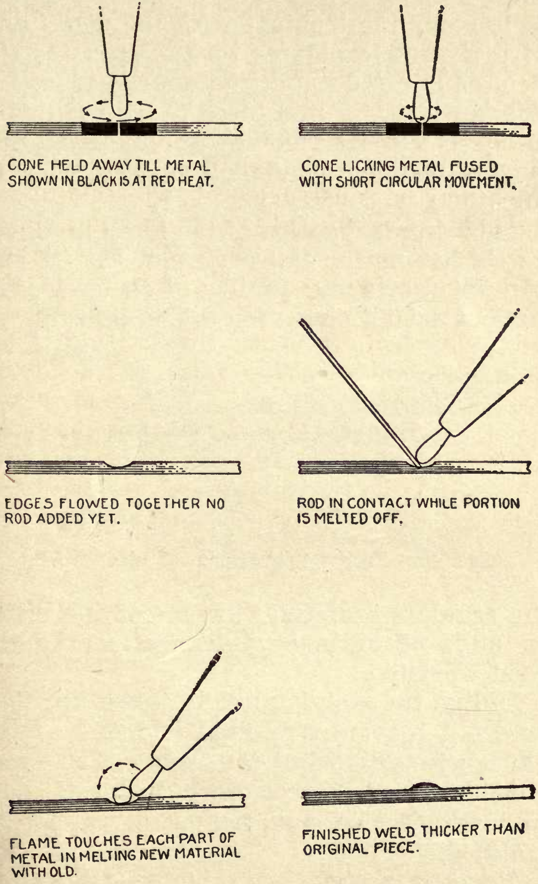

FIG. 45.—Principle of steel welding.

point. At this time, the welding rod should be brought into contact with the metal and with *the flame playing on the metal of the weld and on the rod at the same time*, a portion is melted off and fused to the weld with the short circular movement. Perhaps this may be better understood by reference to Fig. 45.

This circular motion of the torch produces a weld having the appearance of Fig. 46 and without sacrificing quality of the weld, the student should strive for this appearance as

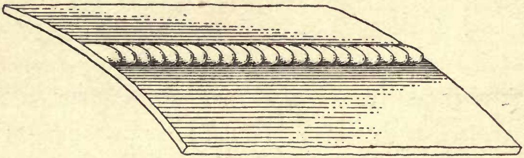

FIG. 46.—Proper appearance of steel weld.

the regularity of the "waves" of the metal on steel of ordinary thickness marks the good workman.

Unlike the metals already taken up, steel does not become very fluid and there is no danger in collapsing the weld. The flame must come into direct touch with each part to insure fusion and the metal cannot be puddled.

There is a slight sparking on mild steel, growing more rapid as the thickness increases. Excessive sparking is an indication of burning and the operator may detect the use of an oxidizing flame by the shape and character of these sparks, *those from an oxidizing flame breaking as they fly*, while with a properly adjusted flame they retain their shape. If the flame is not properly adjusted, *the weld will, as well, usually foam*, and this foam will be in a circle surrounding the flame. The use of a flame too

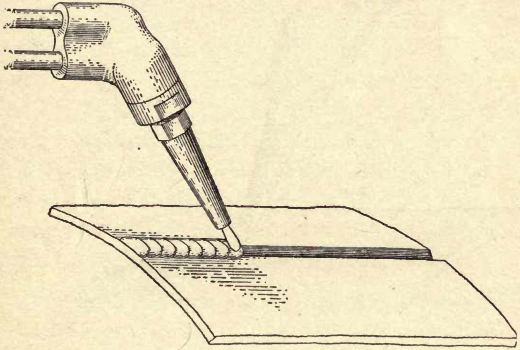

FIG 47.—Most economical position of welding torch.

large will also cause oxidation and particularly with steel the flame must not play on the metal after it has been bonded. Melting the material from the rod and allowing it to drop *on to* the weld is still another reason for oxidation. *The rod should be in contact with the weld* so that the conducting qualities of the material will prevent excessive burning as the rod is melted.

Position of the Flame.—The flame should be so directed that it touches both sides of the break, not directed toward one side. Good and economical welding is best executed with the torch in the position as shown in Fig. 47 *in line with the weld working to-*

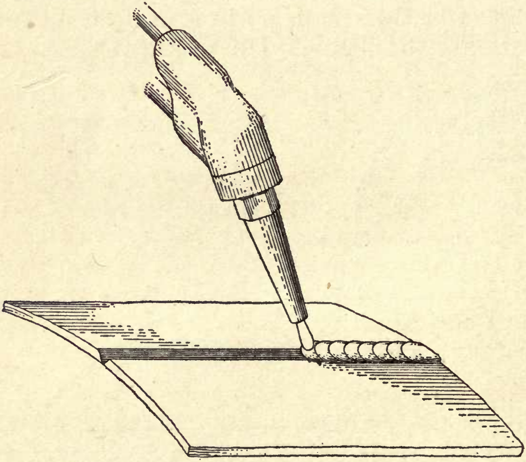

FIG. 48.—Torch at right angles—likely to weld one side only.

ward the unwelded section. This method takes advantage of the heat of the envelope of the flame to assist in the heating of the section to be welded. Beginners sometimes have difficulty in mastering this position without leaving spots unwelded and prefer that position shown in Fig. 48, the torch at right angles with the line of welding and the flame directed towards the welded section. This position of the torch is open to criticism on the ground that the flame is continually directed towards the bonded section, thereby increasing the liability of oxidation and as well inviting the welding of one side only, the metal merely adhering to the side nearer the operator.

Reinforcing the Weld.—To secure additional strength, steel welds wherever possible should be made thicker than the adjoining metal. In the housing described, for instance, it is advisable to weld inside, as well as the outside seam. It is where we are unable to reinforce with added metal that oxy-acetylene welding calls for the highest skill —on rear axles, drive or crank shafts, steering knuckles, etc.

Frame Welding.—For no other part of the automobile is the welding process more efficient than for welding broken frames or for lengthening or shortening the chassis. Very little and sometimes no dismantling is necessary to effect a permanent repair; and the extent of this dismantling will depend upon the location of the break. If under the body, it is not essential that the body be removed—jacking it up two or three inches will usually be found sufficient. If very close to the radiator this must be removed to prevent melting the solder but if four or five inches distant, the lower part of the radiator where it adjoins the frame may be protected with wet asbestos, cloth or paper. The frame should be supported by jacks each side of the weld, and if the springs

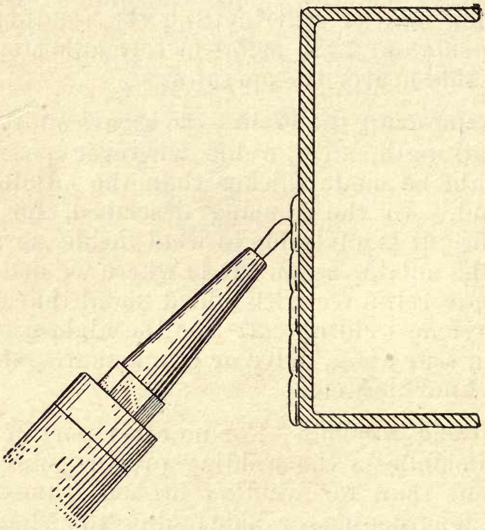

FIG. 49.—Beginning the frame weld—flame directed upwards.

interfere with this support, they should be unbolted from the shackle. *No beveling is necessary on pleasure cars,* since the thickness of the metal is such that the force of the flame will easily penetrate through; on truck frames it is advisable to grind out the break, however. Clean the section to be welded, getting out all oil, sand or dirt.

Then we start welding as shown in Fig. 49 at the bottom of the break working upwards, the direction of the flame being at the angle shown to drive the molten metal up. *Vertical welding of steel is not difficult to master,* due to the rather plastic condition of the metal while it is in a molten condition. After the top, the inside of the channel is

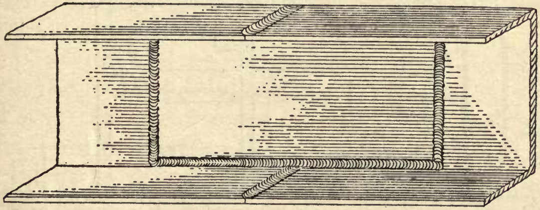

FIG. 50.—Reinforcing inside of frame with welded plate.

welded and if it is desired to finish the outside so that no repair shows, the added metal is placed here. This method is used where the frame is broken by accident, by the improper drilling of holes, etc. Where the construction is bad or the metal too weak, a different method is used, a plate being welded to the inside of the frame, the plate being about the same thickness as that of the frame and as long as desired, as shown in Fig. 50. The break is then welded from the outside and finished flush. When a cross member interferes, this procedure may be reversed, the plate being put on the outside. It is advisable in this instance to remove the rivets holding the cross member and to weld the cross member in place. It is often necessary in frame welding to weld the lower flange of the channel from underneath the

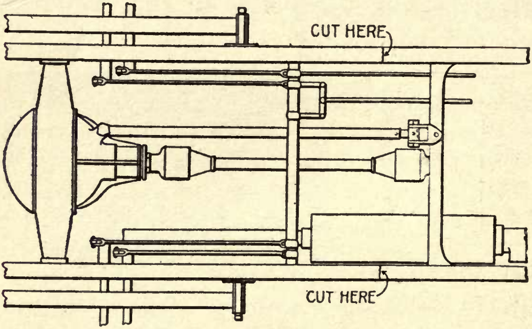

Fig. 51.—Where to cut the frame for lengthening.

car, which requires overhead welding. At first this will be found difficult to master, but after vertical welding is accomplished, overhead welding will come easier, if we but *remember to have a wider zone of metal hot as we add the welding rod,* that is, the metal each side of the break is nearly melting as the rod is melted with the break—and the rapid conduction of heat from this section holds the added metal from the welding rod in place.

Lengthening the Chassis.—It is often desirable to lengthen the chassis and the oxy-acetylene flame has made this practical. The frame is cut in two just between the forward universal joint and the brake cross shaft, as shown in Fig. 51. It will be seen that by cutting at this point it is unnecessary to disturb but few of the component parts—merely the drive shaft, the torque rod and the brake rods. These members will, of course, have to be lengthened as well as the frame.

One method of lengthening is to purchase channel iron of the desired length and of about the same width as the channel of the frame and butt weld, using the plate for reinforcing on the inside as previously described.

Another method, and one employed more often, is to use flat stock and weld as shown in A of Fig. 52. Then an angle iron is made as shown in B of Fig. 52, the stock used being about the same thickness as that of the frame and the flange welded on. The length of the angle iron is the length we are increasing the chassis. This angle is then placed in the frame as shown in C and welded from the inside to the flat stock first placed there and as well the two vertical welds are made. Then the top flange is made by welding a strip to both pieces (the flat stock and the angle) as shown in D of Fig. 52. *The welds should be ground flush on the outside so that when painted no evidence of the bond appears.*

Tube Housings.—Enclosing the drive shaft

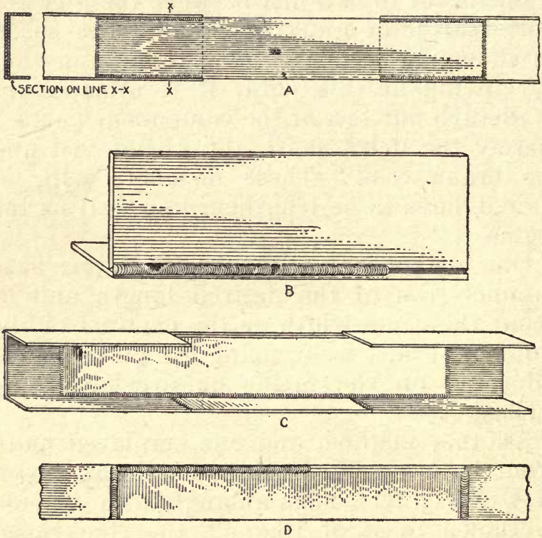

FIG. 52.—Method of lengthening frame.

A, Flat stock welded in. B, Angle iron made up by welding. C, Angle iron welded to frame. D, Welding the top flange.

is usually a housing as shown in Fig. 53, constructed from tubing rivetted into a casting on each end and as well usually brazed. In lengthening the chassis, this, of course, must also be lengthened. Cut in the center or at least well away from either end and weld in the desired length of tubing, or if tubing is not at hand double extra heavy pipe. Frequently these housings break, usually close up to the casting. *A weld at this point is rarely practical*, due to the presence of brass which vaporizes and deposits impurities in the weld. This casting, moreover, is usually malleable iron, which cannot be welded, so that for at least two reasons a weld at this point which would bond the casting to the tube would be inefficient. The proper method of repair is to cut the tube three or four inches away from the casting,

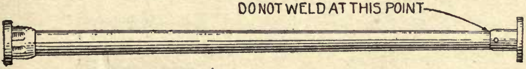

FIG. 53.—Drive shaft housing.

then take out the old piece from the casting and rivet back the new one, which, of course, will be the proper length, and then weld at the point where the old tube was cut off.

Worn Parts.—All automobile welding is by no means the repairing of a broken part. Shafts which are scored, journals which need to be larger, destroyed threads on axles or steering knuckles, cams worn down, universal joints, dogs on the rear axles or wheels, ball joints on the torque rod—these are made as good as new at a huge saving in time over other methods and since their welding is all the same in principle, we need but to illustrate and describe one operation to understand all. In Fig. 54 the crank shaft journal is being enlarged, so that when turned down it will be say one-quarter inch larger in diameter. *The mild steel rod is used, as it may be on all work of this character.* It must be remembered that the shaft is heavy metal, that it will absorb considerable heat and as well will conduct heat rapidly and

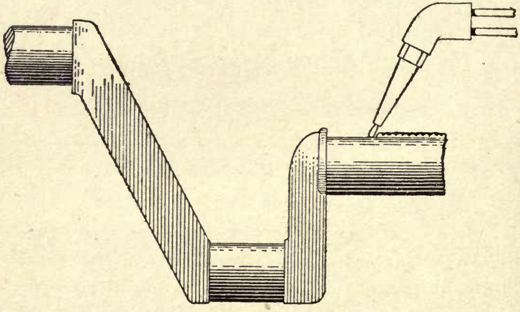

Fig. 54.—Building up journal of crank shaft.

that the rod we are using is very small in comparison with the size of the shaft. If, then, the shaft is not kept at a red or white heat in the fire, *the added metal from the rod is cooled before the oxides are destroyed* and the result is rather hard metal difficult to machine and of a porous nature. To be sure, by using a tip of large size the shaft may be kept hot enough to prevent this, but while many welding shops do not preheat work of this nature, economical and good welding is easier executed by welding while it is in the fire, insuring slow cooling.

As shown in Fig. 54 the torch is preferably held in line with the weld, adding the metal lengthwise. By turning the shaft slightly as one stretch is completed, the entire surface is built up to the desired size. It is to be remembered that the shaft must be in fusion as the rod is added, else the metal will not be truly bonded and will as well be hard, due to the rapid conduction of the heat by the heavier piece as already explained.

Gear Welding.—Putting new teeth in gears may be considered the same as building up a worn part. The broken tooth is not used nor a new one made to fit, but the welding rod is added a drop at a time to build up the new section which may later be filed or milled to shape. Note Fig. 55, representing a typical gear welding job. It will be seen that while the tooth itself is small and does not require a large flame to melt it, *there is a heavy section to which the tooth is attached which requires a great deal of heat to bring its surface to the melting heat.* Most gear welding failures are caused by adding the rod before the metal is in fusion and forgetting the rapid conducting qualities of the heavy metal, the result being that the added metal pulls away from the gear. We should then heat that section which we are to weld and keep it in the fire while welding—insuring a sound weld and one which can be easily filed to a finish.

Case Hardening.—It is necessary with gears, universal joints, cams, etc., to harden them after they have been filed or machined. It is not our purpose to describe the various methods with which the repair man is already familiar. A method not usually employed but which will be found practicable, however, is to heat the section to be hardened to a bright red—almost a melting heat

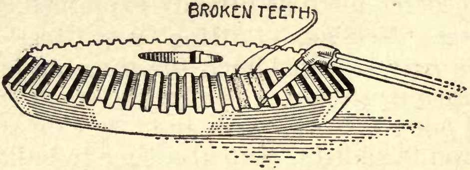

FIG. 55.—Gear welding—tooth added a drop at a time.

—and *play the welding flame with a decidedly carbonizing cone over the surface.* The excess of acetylene in the flame, which is rich in carbon, will harden the metal to a sufficient depth.

Light Metal Welding.—Fenders, running boards, top supports, wind shield brackets or frames, etc., are usually constructed from light gauge metal and their welding is not at all difficult. The welding rod ordinarily used is much too large for this work and soft iron wire of small diameter is necessary.

About fourteen or sixteen gauge will be found right or the wire used on baled hay is good enough for this purpose. The size of the flame is necessarily small and it will usually be necessary to hold the torch in the position as shown in Fig. 56 to avoid burning holes in the material, *the flame striking the metal on an angle nearly horizontal to the line of welding.* As with all welds, the work should progress toward the opening. On fender welding for instance, broken half way

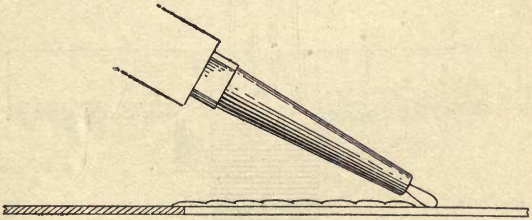

FIG. 56.—Position of torch for sheet metal welding.

across, the weld should start in the centre and work out and the end should not be tacked as is many times done. It will probably be found helpful to clamp the fender, slightly separating the edges on the end, to avoid warpage.

Gasolene Tank.—Repairs to gasolene tanks are made with a soldering iron when the metal is galvanized, since this material cannot be welded. Some tanks, however, are constructed from black iron and leaks in these are amenable to the welding flame if proper care is used in preparing the tank. After the gasolene is drained off, the tank should be thoroughly washed out several times and then live steam employed for at least an hour to rid the tank of all liquid or vapor. *Never should a flame of any kind be used unless the tank is so cleaned—washing alone is not sufficient.*

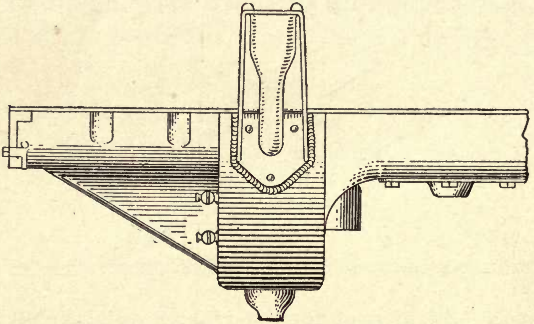

FIG. 57.—Weld or tighten rivets when weld is adjacent.

Welding Adjacent to Rivets.—In welding the arm to the case (Fig. 57) of the lower half of the Ford motor, which at times works loose, the weld necessarily is a lap, due to the construction. This weld will hold the case sufficiently rigid, but oil will work out through the rivet holes unless they are tightened up or the heads welded to the case. The expansion and contraction of the metal caused by the welding flame is usually sufficient to loosen rivets where the weld is adjacent to them and in nearly all cases—frame welding for instance, near a cross member—it will be found advisable to tighten them or to weld the heads to the sheet or plate.

Shaft Welding.—To properly line up a shaft preparatory to welding many shops

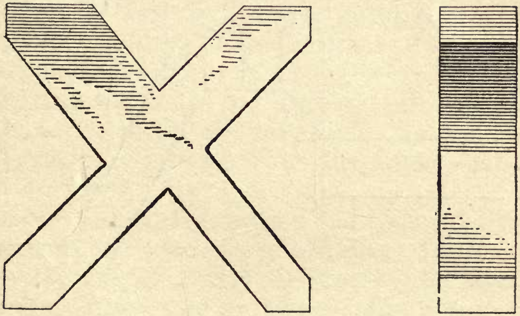

FIG. 58.—Cast iron V blocks for alignment of shafts.

use V blocks (Fig. 58) constructed from cast iron and accurately finished. As a general rule, it may be stated that *the importance of V blocks is greatly exaggerated* and their use may lead to the belief that alignment of the shaft is preserved. If we have digested what has been said about expansion and contraction, the futility of depending upon V blocks and clamps to hold the shaft in line during welding may be apparent. Many large welding shops do not use V blocks; the small shop without them need not feel that their purchase or construction is essential.

The break is ground down from both sides to a chisel edge—not a pointed one—different positions of the break being outlined in Fig. 59. The welding rod to be used will largely depend upon the carbon content of the shaft. The mild steel rod may be used

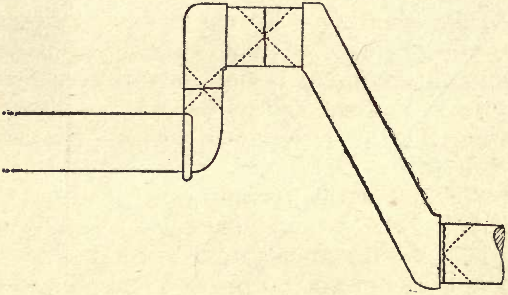

FIG. 59.—Various breaks in crank shaft prepared for welding.

on those shafts from old cars (or from small stationary engines, motor boat engines, etc.), but it will be necessary to use on the more modern cars a rod of less ductility. One with a slight percentage of vanadium is preferred by some shops; by others one of nickel alloy.

Without the aid of V blocks, the shaft may be lined up in a lathe; by using the crank case; a couple of vises; or it may be blocked up on a table and lined up with the eye. *Irrespective of how careful we may be in lining it up before welding, the shaft must be put in a lathe after welding to be straightened;* and to a degree this straightening will be a test of the weld.

Many welders do not heat a shaft while welding; yet for reasons already explained, the welding can be more economically carried out by first tacking the shaft to hold it and then welding it in the fire. Particular care must be used to avoid excessive burning —getting the metal to flow together with the material from the rod as quickly as possible and getting the flame away instantly as that section fuses.

Some authorities recommend the use of the cast iron flux; others a solution of silicate of soda (liquid glass) to protect the metal from oxidation and to prevent absorption of gases *but the benefit of either is doubtful.* All the details essential to successful mild steel welding may be considered doubly necessary in shaft welding.

The beginner should not, of course, attempt shaft welding on a commercial scale, but should first become proficient in mild steel welding and then weld round sections of cold rolled steel, remembering that workmanship probably constitutes 90 per cent of successful shaft welding.

Unlike other welding work, where a guarantee may be made that the weld will not break, because it is stronger at that point than the original metal, shaft welding should never be attempted with this promise; rather *it must be understood that the weld is not as strong as the original metal.* Ordinarily, a weld properly executed is amply strong enough, since the factor of safety in the original shaft was probably a large one. When the shaft is easily and cheaply duplicated, welding should not be done, but when time and cost are elements to be considered their welding is feasible.

Rear axles and drive shafts are welded with the same care and judgment as crank shafts. At all times they should be put in the lathe after welding to straighten them. Shafts out of line must break and as the weld is the weakest place, the careful workman, after welding, will see that they are properly straightened, lest the responsibility for the break be placed upon him, rather than upon lack of alignment.

Springs.—The welding of springs should rarely be attempted, since they are in the class of high carbon steel difficult to weld and are as well tempered. It is practically impossible to weld them when they are broken through the bolt hole for instance to secure a bond which will stand up. The leaf which bolts to the shackle may be welded when broken on the end (Fig. 60) with better chance of holding, mild steel being used and the metal built up as shown. *No retempering is necessary,* the added metal being sufficiently rigid. Work of this kind should be properly classed as emergency, that is if no spring is available, welding should be employed, but with the understanding that it is not a permanent repair.

Construction of Parts.—In overhauling, remodeling a pleasure car to a truck, building metal bodies or constructing a racer or speed car, *the uses of the oxy-acetylene flame are*

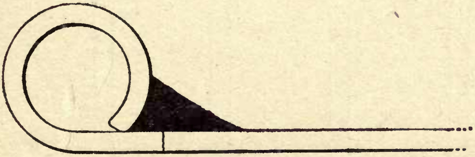

FIG. 60.—A spring weld at this point will usually hold.

innumerable. Engineers of automobile factories are beginning to recognize its value in construction work—the repair man may often employ it for making a part.

In Fig. 61 is represented an exhaust for a racer, made by the welding process. The flanges which bolt to the cylinders are steel, welded to the pipe, which in turn is welded to the manifold, and this is constructed from eight to ten gauge metal rolled up and welded as shown. If the shop is equipped with a cutting torch, as well as a welding torch, the flanges and sheet metal may be cut to the proper shapes by its use.

Along the same lines, radiators to be heated by the exhaust or water may be made out of pipe or tubing welded together. Exhaust manifolds with water or air jackets, a construction difficult to cast, may be easily constructed by welding a tube within a tube.

Round or oval gasolene tanks may be constructed from sheet iron. The steering col-

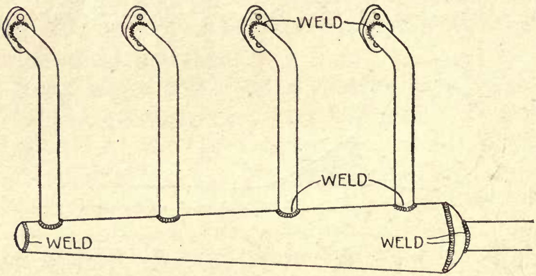

FIG. 61.—Exhaust constructed by welding.

umn dropped and lengthened by welding on a section to the shaft and tubing. The shifting gear levers and emergency brake may be lengthened, shortened or offset. Clutch and brake pedals lengthened or shortened. Seats, steps, irons for canvas guards, etc., may be quickly made with no other shop equipment except the oxy-acetylene flame.

Cross members of the frame may be welded to the side members to eliminate the rattle caused by rivets working loose. The rear construction may be stiffened by welding braces to the housing to permit the safe use of trailers.

There are literally hundreds of uses for the welding flame in the repairing of automobiles and the successful shop will bear these suggestions well in mind, remembering that with steel it is possible to construct as well as repair.

CHAPTER VI.

MALLEABLE IRON, COPPER, BRASS, BRONZE.

How to Detect Malleable Iron—Brazing Malleable Iron—Rear Housing—Reinforcing the Braze—Brazing Tube to Housing—Building up Worn Parts—Copper—Brass and Bronze—Silver Soldering.

Not infrequently malleable iron is used in automobile construction where the strength of steel is not thought necessary but where the brittleness of cast iron must be avoided. *Malleable iron cannot be successfully welded,* since the melting of it causes it to become extremely hard and brittle. It unites well with cast iron used as a welding rod but the bond is without ductility and especially on the edges of the weld, where the cast iron joins the malleable, it is without the strength of even cast iron. Mild steel or Swedish iron used as the welding rod does not unite well with it, the weld being very porous and the malleable clinging to the rod as it is brought into fusion, rather than the rod fusing to the casting. It has been claimed, usually by those unfamiliar with the qualities of the metal, that it may be welded with steel or cast iron or with both, and some shops attempt to handle it in this way, but inasmuch as the character of malleable changes when it is melted, we can see that this is not practical and that a bond of this nature is almost certain to break.

How to Detect Malleable Iron.—Beginners are usually puzzled in determining whether a casting is malleable iron or steel. At times it is used in certain sections of the automobile where prudence would dictate that steel be employed. This is particularly true with cars of earlier models. Most modern cars use some malleable iron, usually in rear housings, the casting rivetted to the drive shaft tubing, the casting on the hub of the wheel, lamp brackets, etc. If the break is clean, malleable will show two distinct colors, white in the centre and black on the outside, this black ring extending into the casting from a sixteenth to a quarter of an inch, depending upon the thickness of the casting. Whatever doubt may exist as to the character of the metal is removed when the flame melts a small section. Malleable has several peculiar characteristics, the one most prominent being the tendency of the metal to draw away from the flame as it comes to the melting heat. It sparks a little, considerably less than steel, but enough to show that it is not cast iron, which does not spark at all.

Brazing Malleable Iron.—*Malleable is suc-*

cessfully brazed with the oxy-acetylene flame, a bronze rod being used and proper cleansing flux. Tobin bronze is usually used, though some shops prefer manganese bronze, the latter being less fluid in a molten condition than the former. The break should be beveled out, the same as if a weld were to be made, and should be most thoroughly

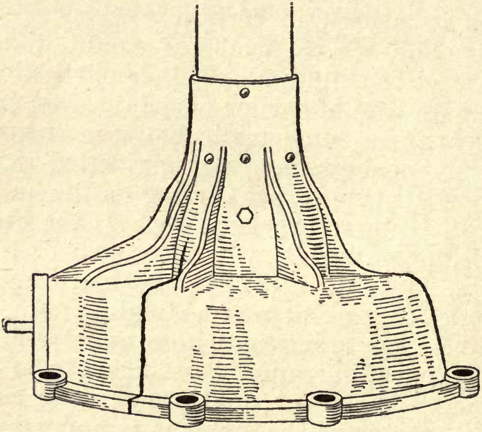

FIG. 62.—Break in malleable rear housing.

cleansed, since we are going to effect a bond of two different metals and do not want any foreign substances to prevent this bond. *A much larger tip than for the same thickness of cast iron should be used,* since we want to heat a wider zone and yet cannot bring the flame close enough so that any portion will melt. A slightly carbonizing flame, rather than a neutral one, is preferable for beginners.

Rear Housing.—As shown in Fig. 62, cracks or breaks are frequent in malleable rear housings. Most shops do not preheat work of this character, due to the ductile nature of the metal. It is to be remembered that while malleable will rarely break in cooling, it will certainly contract and *if the crack as shown is brazed without preheating, starting in the centre and working toward the edge, the surface will be low in the section of the braze,* the housing will probably leak grease and, furthermore, the brazed joint is likely to give way under the strain caused by lack of alignment. We should then treat malleable iron exactly the same as cast iron and preheat to prevent contraction cracks or distortion. As well, of course, this method is more economical than welding cold.

When the metal reaches the bright red heat, the bronze rod covered with flux the same as with welding work, is brought down and a considerable portion of it added—much more than if a weld were being made. Care must be used to see that the bottom of the break is as hot as the sides, else the bronze will not adhere at this point. *The cone should not touch the bronze rod, but the casting and rod brought to the proper heats without the cone coming into direct contact with either.*

Reinforcing the Braze.—The bronze may be built up higher than the adjoining metal and may, as well, be wider than the usual weld. Sometimes it may be found desirable to reinforce by placing wrought iron straps, as shown in Fig. 63, crosswise of the break and braze these to the housing as well as fill up the beveled break. Rarely should this

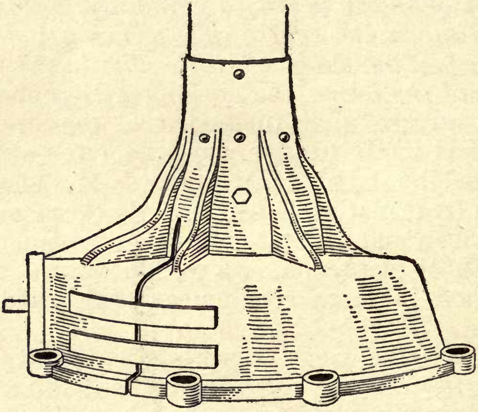

FIG. 63.—Housing reinforced with wrought iron straps.

be necessary—only when the strength of the original malleable housing is not sufficient to meet the strain placed upon it.

Brazing Tube to Housing.—Drive shaft housings, as well as rear axle housings, are many times constructed of tubing rivetted and brazed into a malleable casting. In time, due to continuous vibration, the rivets become loose, the brazing breaks away and it is then necessary to securely fix the tube to the casting. One of the first methods thought of is to make a weld at A as shown in Fig. 64, which will bond the tube to the casting. Two objections are open, first, that malleable becomes hard and brittle when melted and second, that this method does not tighten the rivets and there is still play in the housing. *A housing welded or brazed at this point alone will not hold.* If new rivets are put in, the chances for holding are considerably better, but a repair easily effected and to be considered permanent is as follows:

Chisel off the heads of all rivets and back them out; then turn the tube within the housing until the old holes in the tube are not in line with the holes in the housing, but are covered. Then treat the job as if it were a broken piece of malleable, bonding the bronze to the tube and filling the holes in the housing with it. Where the position of the other end will not allow turning the tube, the heads of the rivets may be cut off and the brazing done with the remainder of the rivet in place.

Building Up Worn Parts.—Adding more metal to worn sections of malleable is executed the same as any other metal, except in this instance care must be used not to melt the surface of the casting. Bronze is, of course, used as the rod, the same as for a break.

Copper.—While copper may be successfully welded with the aid of a phosphuretted rod and the proper flux, so little of it is used in automobile construction that *it is customary to braze it in repair work,* exactly the same as malleable iron is handled.

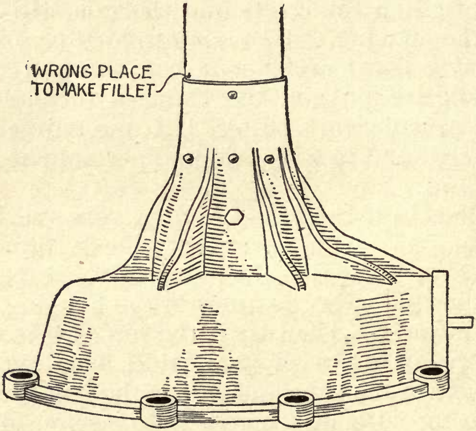

Fig. 64.—Wrong point to weld or braze tube to housing.

Instead of the bronze rod, soft brass wire may be used, since inlet manifolds, water jackets, tanks, etc., are usually of thin gauge material and the rod is too heavy to flow easily.

The material should be thoroughly clean and the metal brought to a red heat before adding the rod covered with flux. In this instance, it is best to use a flame slightly carbonizing instead of neutral.

Brass and Bronze.—In bonding brass or bronze, the repair shop will use for the welding rod either Tobin or manganese bronze or with very thin castings, soft brass wire. The alloy of the castings will vary so much that it would be impossible for the repair shop to keep on hand the necessary rods to insure at all times a true weld; and as well the workman would have no means of knowing the alloy used by the manufacturer. The bronze rod used on malleable iron is therefore usually employed and there will be no question of the strength of the bond with such a rod, if the weld is properly executed.

Even with thin sections, *it is desirable to bevel the break where it is possible to do so.* Rarely would preheating be necessary, but it should be remembered that copper, which is the largest ingredient of the casting, is a very rapid conductor of heat and has a high melting point as well, and that zinc, which is present in varying proportions, has a very low melting point. It can quite readily be seen then that if the cone is brought into direct contact with the material, the zinc will burn out long before the copper is hot enough to melt. The workman will take into consideration the conductivity of the casting and hold the cone some distance away from the break until the metal is at the red heat. Then it is brought down close to the metal, a portion of the rod melted and the flame immediately raised. *Unlike steel or cast iron, the flame is not held continuously to the line of welding,* but is lifted away from the weld as fusion takes place.

Small sections broken completely through, such as hinges or wind shield parts must be carefully set up so that they will not move while being bonded. *As a rule, brass or bronze, in cooling, is very fragile.* If clay is used to hold the parts while being welded, exercise care that the under side of the break is not covered with it—the two pieces may be held by clay, but it should not closely adjoin the weld.

On heavy sections, which are rarely met with in modern cars, but which in the older types might be found in axles, crank cases, driving gears, etc., it is desirable to preheat both for economy, and to avoid contraction cracks. Building up worn sections, such as valve caps or filling holes, is accomplished in the same manner as with other metals.

The beginner will usually have difficulty in welding heavy sections because of the rapid conductivity of the metal; this condition is evidenced by the appearance of the metal, the casting becoming porous on the surface, *the zinc burning out in the form of a gray powder, and the material from the welding rod lying in balls on the surface* without being bonded to the casting. This condition may be overcome, of course, by preheating, and by the use of a large tip and some patience, remembering that the area round the weld must be at the red heat before the cone is brought down sufficiently close to melt the break.

Silver Soldering.—At times it is necessary to have a strong and ductile bond between copper and brass or perhaps on delicate work where it is not practical to destroy the contour of the piece by melting. Brass, bronze or copper or combinations of these metals, *may be soldered with silver*, the flame used should be carbonizing and the pieces to be soldered thoroughly clean and covered with flux. They should be equally hot wherever the bond is desired, unlike welding where the heating is local. At a bright red heat, the silver is brought in contact with the metal and it will at this time flow to all parts of the section to be soldered, provided the metal is at the correct heat. This method is particularly advantageous in joining copper tubing to brass or bronze fittings, where the strength of soft solder is not sufficient to withstand the strain or vibration.

CHAPTER VII.

CARBON BURNING AND OTHER USES OF OXYGEN AND ACETYLENE.

Principle of Carbon Burning—Method of Operation—Lead Burning — Soldering — Case Hardening—Heating Uses.

Principle of Carbon Burning.—The removal of carbon from the combustion head of automobile cylinders by the oxygen process is eminently practical, but its very simplicity many times leads to carelessness or misunderstandings which result the same as do poor welding jobs, in a condemnation of the process.

Let it be said that the heat generated by the burning of the carbon is not greater than that in the combustion chamber when the motor is running—consequently *there will be no damage to the valves, piston or cylinder walls.* It will remove all carbon from the chamber. It will not remove it from the cylinder walls; and if carbon is present here a new piston or a regrinding of the cylinders, or both, is necessary; and the use of any carbon destroying method is impractical. *The process will not burn sand or graphite* and it will not regrind valves.

It will be noted that oxygen alone is necessary for carbon burning. In the welding process, the acetylene is the fuel burnt by the oxygen, but in the oxygen carbon burning process, *the carbon is the fuel*, and it is necessary only to ignite it, and thereafter combustion is kept up, or to put it another way, the fire is kept burning by the oxygen.

The apparatus required is very simple,

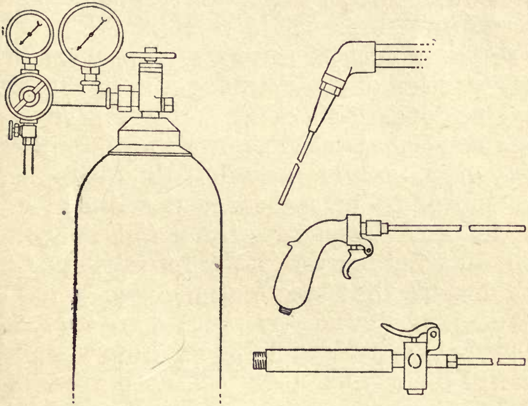

Fig. 65.—Oxygen carbon burning apparatus, with different types of burners.

the oxygen cylinder with the usual regulating valve, a length of hose and a section of annealed copper tubing twelve to fifteen inches long. This copper tubing may be attached to a handle, equipped with a petcock or spring valve, or it may be soldered to a burnt welding tip or otherwise attached to the welding torch, various types being illustrated in Fig. 65.

Method of Operation.—While the motor is running, the gasolene is turned off back of the carburetor, allowing the engine to die down from lack of fuel. If the car is equipped with a vacuum feed, this should be drained. *No gasolene should be in the line from the tank to the carburetor,* since a leaky inlet valve might allow the propagation of sparks into the gas line. It is the general practice to remove the valve cap, where the construction of the cylinder is such that this may be done. As a general rule, *better work may be accomplished by removing the spark plug only,* making sure that the piston is at the top of its stroke on each cylinder as it is cleaned. Then drop in a lighted match or hold a lighted wax taper into the opening, at the same time inserting the copper tubing with a few pounds pressure of oxygen. If there is a considerable flame, hold the pressure of the oxygen down (either on the valve of the burner or at the regulator) until most of the flame disappears, but if little or no flame, increase the pressure to twelve or fifteen pounds, moving the tube briskly back and forth across the cylinder.

Carbon which is very dry burns with more difficulty than that which is oily, and in this instance combustion is likely to be stopped before the carbon is completely consumed. It is necessary then to inject into the cylinder a small quantity of oil—preferably a very few drops at a time—in order to assist combustion, that is to make more fuel. Ordinary lubricating oil, kerosene or alcohol may be used.

To a large extent, *the necessity of using oil may be determined by the appearance of the spark plug.* If the carbon on it is hard and dry, oil is necessary. If on the other hand the plug is oily, the carbon in the cylinder will burn readily without the injection of oil. It may be said in passing that oil increases the temperature of the combustion chamber and if used in too large quantities there is some danger of warping or cracking the valves and piston.

Theoretically, when the burning is complete, which is evidenced by the stopping of sparks, the combustion chamber should be entirely clean. Practically, however, this is rarely so, since it is probable that some sand is present in the chamber, sucked through the carburetor. Graphite may also be in the chamber if it is used anywhere in the cylinders as a lubricant. If compressed air is at hand, the cylinders should be blown out after the burning is complete, and always *a swab should be used to wipe the piston top and valves.*

Due to the flying sparks and the nearness of gasolene and oily substances, it is advisable to have at hand a fire extinguisher to prevent any serious blaze.

Lead Burning.—The oxy-acetylene flame may be used for lead burning on batteries, a special torch being used. One of the dissolved acetylene companies has recently brought out such a torch. Oxygen may also be used with ordinary city gas or hydrogen for this purpose. The burning of lead is no different than the welding of the metals already taken up. No flux is required, but the edges should be filed or scraped clean. A strip of pure lead is used as the rod.

Soldering.—For soldering, acetylene without oxygen, burnt in a torch which is supplied by the dissolved acetylene companies, offers the advantage of giving a very concentrated flame.

Case Hardening.—The carbonizing flame of the welding torch may be used to case harden mild steel, as described in the Steel Chapter.

Babbitting.—Either acetylene alone or oxygen and acetylene used in the welding torch may be employed in heating bearings to pour babbitt. The concentrated heat is especially desirable in getting the bearing sufficiently hot to prevent holes in the babbitt as it is poured and cools.

Heating Uses.—For straightening frames, axles, steering knuckles, shrinking on bushings, etc., the oxy-acetylene flame is invaluable and is especially useful because of the portability of the equipment.

CHAPTER VIII.

HOW TO FIGURE COST OF WELDING.

Oxygen Consumption—Dissolved Acetylene Consumption—Torch Consumption Test—Acetylene Generator Consumption—Cost Card—Conclusion.

Oxygen Consumption.—The high pressure indicating gauge on the regulator will tell us very closely the cubic feet of oxygen used in welding or carbon burning. If the dial is calibrated in atmospheres, we remember that the cylinder is full at 120 atmospheres and that it contains 100, 150 or 200 cubic feet at this pressure, depending, of course, upon the size of the cylinder. Assume that the cylinder is a 100-foot one, and that the gauge reads at the start 90 atmospheres and at the finish 50. We have then used 40 atmospheres or one-third the contents of the cylinder, or 33⅓ cubic feet. One atmosphere with a 100-foot cylinder equals five-sixths cubic feet; with a 150-foot cylinder 1¼ cubic feet; and with a 200-foot cylinder, 1⅔ cubic feet. In keeping a cost record then, it would be desirable that the oxygen gauge be noted at the start and finish of a job and figured as follows:

Start.		Finish.		Atmospheres used.		Cu. ft. to Atmospheres.		Cu. ft. Used.
120	—	90	=	30	×	⅚	=	25

If a 200-foot cylinder is employed, the equation is the same except the difference in atmospheres is multiplied by 1⅔; with a 150-foot cylinder by 1¼.

If the graduation of the dial is in pounds, the cylinder is full at 1800. With a 100-foot cylinder, 18 pounds difference will represent one cubic foot; with a 150-foot cylinder, 13½ pounds; with a 200-foot cylinder, 9 pounds. We may find out the cubical contents used as follows:

Start.		Finish.		Pounds used.		Pounds to 1 cu. ft.		Cu. ft. used.
1800	—	1200	=	600	÷	18	=	33⅓

With a 200-foot cylinder the division, of course, will be by 9 and with a 150 one by 13½.

If the high pressure indicating gauge is calibrated in percentage, it is simply necessary to know the capacity of the cylinder and take the gauge reading as follows:

Start.		Finish.		Per Cent.		Cubical contents.		Cu. ft. used.
100	—	80	=	20	of	100	=	20

With a 150-foot cylinder, the number of cubic feet will be 30; and with a 200-foot one, 40.

Dissolved Acetylene Consumption.—The tank pressure indicating gauge on the dissolved acetylene cylinder cannot be used to figure contents since the gas is dissolved in a liquid and the pressure varies in accordance with the amount and purity of this liquid. The same size cylinder may in one instance record a pressure of 300 pounds and contain only 150 cubic feet and in the next indicate a pressure of only 150 pounds and contain 300 cubic feet. Likewise, the gas is more susceptible to temperature than oxygen, so the gauge reading on the acetylene regulator is merely helpful in recording when the tank is becoming empty. It is necessary with dissolved acetylene to find out contents by weight, 14½ cubic feet weighing one pound. The cylinder may be weighed when received and again when empty and the difference times 14½ will give us the cubical contents in feet. Manufacturers of dissolved acetylene check these weights carefully and since it would be impractical for the user to weigh the cylinder each time a job is started and again when finished, it is necessary for the user only to weigh the cylinder when full and when empty for the purpose of a test to ascertain the consumption of the welding torch and thereafter the cost record of gases may be kept by means of the oxygen gauge only.

Torch Consumption Test.—All torches do not consume the same relative quantities of oxygen and acetylene. The torch which is the most economical one to operate is the one which uses the least amount of oxygen, and the user can ascertain approximately the consumption of each gas in the ordinary run of work. Full cylinders of each gas should be used and the acetylene cylinder, which should be a fairly large one, say 225 or 300 feet, should be weighed before starting and a record made of its weight. At normal temperature (about 65 deg. Fahr.) the oxygen cylinder should register 120 atmospheres. Then the apparatus is used in the shop on the usual work. When we have used 200 feet of oxygen, disconnect the acetylene cylinder and weigh it and ascertain the cubic feet used by multiplying the difference in weights by 14½, as previously described. It is just possible that we have used 200 feet of acetylene or about that, but more likely it will be found that the acetylene consumption is less than the oxygen. At any rate, the ratio has been established and if reasonable care has been used in the test, we will have a general idea of whether the torch consumes 10 feet of oxygen to 7 of acetylene or 10 feet to 5, and thereafter we have only to determine the oxygen consumption by means of the high pressure gauge and estimate the acetylene consumption on the ratio basis established by the test. It is understood, of course, that this test is not technically correct—the welding shop is not equipped to establish a test of this character and the method described is simply one to give a general idea of relative consumption.

Acetylene Generator Consumption.—Establishing the number of cubic feet of gas delivered by a generator from a charge of carbide may be done by the aid of a meter; or in a general way, by first establishing the ratio of consumption of gases by the welding torch test just described—using dissolved acetylene, of course, to make the test—and then connecting the generator, freshly charged with a known quantity of carbide, and operating the torch until the generator is empty. As we already know the relative consumption of gases in the torch we have simply to keep an accurate record of the oxygen used to find out how much acetylene we are getting per pound of carbide and thereafter the cost record may be kept by means of the oxygen gauge, the same as with dissolved acetylene.

Cost Card.—In Fig. 66 is an outline of a cost card for the welding shop. Details will, of course, vary. Welding rods may be kept track of by number rather than by pounds, by first establishing how many rods there are to the pound. If gas torches are used for preheating instead of charcoal, their hourly cost of burning may be determined by the meter, and with the power cost for the air added, it is necessary only to substitute on the cost card for pounds of charcoal, hours, minutes and number of torches used. Overhead, which in repair work is unusually high and must include deprecia-

NO. 100

ARTICLE Rear Housing

OX. GAUGE START 120
" " FINISH 80
40

CU. FT. OX. USED .... 33 .. AT $.02 .... $.66
" " AC. " .... 33 .. " .025 .... .72

LABOR

	HRS.	MIN.	AT	
PREPARING		45	$.60	$.45
WELDING		30	1.00	.50
FINISHING	1	30	.60	.90

RODS.

LBS.		AT	
	STEEL	$	$
	CAST IRON		
1½	BRONZE	.60	.90
	ALUMINUM		

FLUX .... $.10
5 LBS CHARCOAL .... .25

TOTAL--

REMARKS

Fig. 66.—Cost card for welding shop.

tion of equipment, failure of welds, etc., is not safe to figure under 100 per cent, and cost of labor naturally depends upon many conditions. A competent operator of the oxy-acetylene flame can easily command a minimum of $25 per week; therefore, if the owner of the shop is the welder, as he so many times is in the small shop, he should figure that he must first pay himself at this rate.

Conclusion.—Is oxy-acetylene welding of automobile parts hard to master? Not if we pay attention to the fundamentals—torch adjustment, effects of contraction, quality of the apparatus and supplies. It is impossible to become a successful operator without these essentials. We cannot actually learn to weld by reading alone, but we can avoid serious errors by taking advantage of the experiences of practical men simply expressed. The reward for good welding is a very substantial one; to the workman, increased wages—higher than he could earn in any other mechanical line; to the welding shop, increased business at better prices; and to a shop employing the process on its own cars, a decided saving in the price of parts and the elimination of annoying and costly delays.

What not to weld will depend largely upon the skilfulness of the operator. Shafts and steering knuckles, for instance, require expert workmanship and should never be attempted until the workman knows he is competent to handle them; and this knowledge comes only from experience with many steel jobs. The cost of a new part must also be considered, except in cases where a new part is not easily procurable. If a new gear may be bought for three dollars and it is necessary to weld in three or four teeth, machine and case harden the gear, it can readily be seen that no saving in this instance is possible.

The proper use of the oxy-acetylene flame benefits all, since it reduces waste. Let us then employ it properly, not venturing to use it on commercial work until we are certain we understand how to use it.

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