10

NOTES ON ELECTRIC WELDING

The successful application of metallic arc welding to important work, depends on three main factors—design, materials and workmanship. Progress for the more general adoption of welding by this process has been retarded particularly in the past by the lack of certainty in the last factor—workmanship. In the last few years, however, improvements in methods and in the training of welders have advanced so much that, in this country and abroad, many large structures have been built almost entirely by means of welding, while electric welding plant is in constant use in most engineering shops and shipyards for construction and repair work.

It is proposed to consider the factors on which the making of a weld of good quality depends, and the best means of controlling these factors, and to discuss the standardising of the procedure to ensure the proper quality of the finished weld.

The soundness of a weld depends upon the adoption of a correct technique in depositing the metal, and it is the lack of well-grounded rules to control the process which has resulted in many failures in the past.

Materials. Parent Metal.—It is only proposed to discuss the welding of commercial mild steel as it is in this field that the majority of metallic arc welding is carried out. Wrought iron and low carbon cast steel may be satisfactorily welded, but require special welding technique and materials. The welding of high carbon and alloy steels often gives very erratic results and little information is available on the subject. Cast iron may be electrically welded, but this weld is more of a mechanical joint than a true weld. Special electrodes are sold by manufacturers for use when welding the above materials. A few notes on the welding of these materials are given in " Papers on Engineering Subjects," No. 4.

Electrodes.—There are three main types of electrodes on the market :—

(1) Covered or fluxed electrodes.
(2) Dipped or sprayed electrodes.
(3) Bare wire electrodes.

The second class covers the complete range between the first and third. From information available from reliable and unbiassed sources, and from the results of test, it may be said that to ensure consistent and satisfactory results only the best covered electrodes should be used. While an expert operator using special welding technique can obtain results from bare wire electrodes comparable with those obtained from covered electrodes, it is uneconomical and beyond the ability of most welders. The ductility of the weld is generally much less. The average figures for ductility and toughness obtained from specimens built up of weld metal, using covered and bare wire electrodes, are as follows :—

	Covered.	Bare wire
Elongation per cent. on 2 in. ..	15 per cent.	6 per cent.
Izod value	25 ft. lbs.	5 ft. lbs.

In the lightly fluxed or dipped electrodes, the covering merely acts as a flame producer making the arc steadier and easier of control, and has little effect on the quality of the weld metal which gives mechanical properties similar to that obtained using bare wire electrodes. A good covered electrode should have the following qualities :—

(1) The covering should be concentric with the core. This is important in controlling the direction of deposition of the weld.

(2) Covering must be uniform in composition and contain no impurities such as phosphorus, sulphur, nitrogen and water. At the temperature existing in the arc, water vapour is intensely oxidising, while the other impurities all tend to make the weld brittle.

(3) The most important function of the covering is to form a vapour around the arc to protect the metal from oxidation; frequently some agent is added to reduce any oxygen which may be present in the molten metal.

(4) The covering should be a poor conductor of heat and melt more slowly than the core.

(5) Slag formed by the covering should have a low point of solidification (800° C.) as it must remain molten until the weld has solidified to allow the metal to form its shape and exclude the slag.

(6) Slag should be of a viscosity such that it will not flow back in the direction of movement of the electrode and be driven into the weld.

With reference to (1) and (4), the covering forms a sleeve which projects beyond the end of the metal core. This forms a guide or barrel out of which the globules of metal are carried at high velocity by the gases formed. The direction of flow of these globules can be more easily controlled if this "gunbarrel" effect is obtained. With the bare wire electrode this effect is not obtained, the globule of metal just dropping off the end of the electrode as it melts. In the latter case the weld metal is therefore longer in the intense heat of the arc (between 2000° and 3000° C.) and has no protective vapour surrounding it. At this high temperature, chemical activity is very rapid and oxidation very likely to take place. The arc should be kept short or the covering will be burnt back and the end of the electrode will project beyond it. The advantages stated above will then be lost.

In cases where it is impracticable to heat-treat a weld after it is made, the quality of the weld metal will largely depend on the heat treatment it gets during deposition. This heat-treatment will depend on the temperature of the arc, the length of time the weld metal is kept at that temperature, and the heat conditions prevailing in the metal adjacent to the weld.

Heat Conditions.—The factors which govern the heat conditions to which a weld is subjected are :—

(1) The mass per unit length of weld metal deposited in one run.
(2) The mass of parent metal adjacent to the weld.
(3) The size of electrode used.
(4) The welding current.

The length of an electrode has been standardised amongst manufacturers at 18 in. It is assumed that 1¼ in. is lost per electrode, being the amount remaining in the holder. The useful welding length of an electrode is therefore 16¾ in. The sizes of electrodes in general use are as follow :—

S.W.G. .. .. 4, 6, 8, 10, 12 and 14.

For the purpose of indicating the mass per unit length of weld metal deposited per electrode, the following is an example of the notation used :—

A 10/9 weld is one made by a single run of weld using a No. 10 gauge electrode, such that 16¾ in. of the electrode are deposited in 9 in. of weld.

The influence of the mass per unit length of weld metal deposited in one run may be seen from the following Table :—

TABLE 1.

Size of Run.	Tensile Strength. Tons/sq. in.	Elongation. %	Izod Figure. Ft./lbs.
10/9	25·8	20·4	37
10/6	23·6	16·0	32
8/9	25·0	15·0	26
8/3½	30·1	6·7	3·5

Covered electrodes were used in making these test pieces which were built up entirely of weld metal.

In considering the properties of a weld the ultimate tensile strength must be considered in conjunction with the ductility and toughness. The ultimate tensile strength can be increased, but only at the expense of the other properties. Ductility is necessary to permit of cooling of the weld metal without cracking and to equalise stresses and this property cannot therefore be sacrificed in order to obtain a high U.T.S.

A test piece built up in heavy runs of 8/3½ is maintained at a red heat for a considerable period. Oxidation is rapid at this high temperature and brittle metal results, the test piece giving very low figures for ductility and toughness. The 10/9 test piece on the other hand never remains at a red heat for more than a few seconds and gives very satisfactory figures for these properties.

The Izod value of a metal may be considered as giving a good indication of the heat treatment to which the metal has been subjected, and this value for a weld test piece will therefore give us a fair idea of whether the heat conditions prevailing have been correct when making the weld.

The influence of the mass of metal adjacent to the weld may be seen from the following figures :—

TABLE 2.

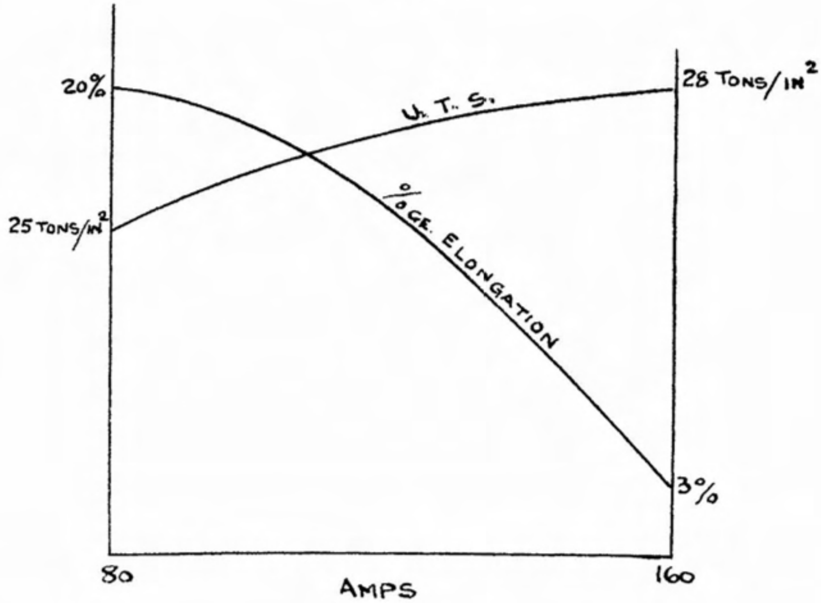
Size of Run.	Izod Values.		
	⅜-in. Plates.	½-in Plates.	⅝-in. Plates.
10/6	18	32	35·5
10/9	23	37	38
8/9	12	26	38

The test pieces were made by butt-welding two pieces of plate veed from one side with a 60° V. The notch was cut in the weld at the wide side of the V. In the test piece made from ⅜ in. plates welded with runs of 8/9 and 10/6 welds, the welds remained at a red heat long enough for oxidation to commence, the mass of parent metal adjacent to the weld not being sufficient to rapidly conduct away the heat. With ⅝ in. plates, however, the 10/9 and the 8/9 welds give identical Izod value, showing that the mass of parent metal is sufficient in either case to conduct away surplus heat. The size of the electrode influences the size of the deposit and its effect can be seen from Tables 1 and 2.

The following graph shows the influence of the welding current.

It is necessary to vary the current for the different sizes of electrodes and the thickness of the plates to be joined ; *e.g.*, a 10/9 weld on ⅜ in. plate using a particular type of electrode takes a current of 105 amps. If this weld is attempted on ⅛ in. plate with the same current the plate will be overheated and cut right through. Reducing the current to 60 amps. and making a 10/12 weld, a satisfactory weld can be made.

The current required for various sizes of electrodes and plate thickness is given in Tables 3 and 4. If too low a current is used



10/9 WELD.

the arc is hard to strike and difficult to maintain. There is little or no penetration as the globules of metal drop off the end of the electrode instead of being carried off at high velocity, and the parent metal is not sufficiently melted. Too high a current on the other hand will give bad results as the electrode becomes hot and the metal is oxidised before being deposited. The globules are shot off the end of the electrode at such a velocity that unless a very short arc is maintained, much splashing takes place.

Using bare wire electrodes a much higher current is required than when using covered electrodes. This is necessary because in the absence of any flux it is necessary to melt up all the metal and keep it molten for a sufficient time to allow slag and dirt to rise to the surface. If the operator is skilful, he will obtain clean looking welds on clean plates when using bare wire electrodes, but the weld will be brittle. If the plates are dirty or there is rust present, it will not be possible to float out or reduce it and a bad weld will result.

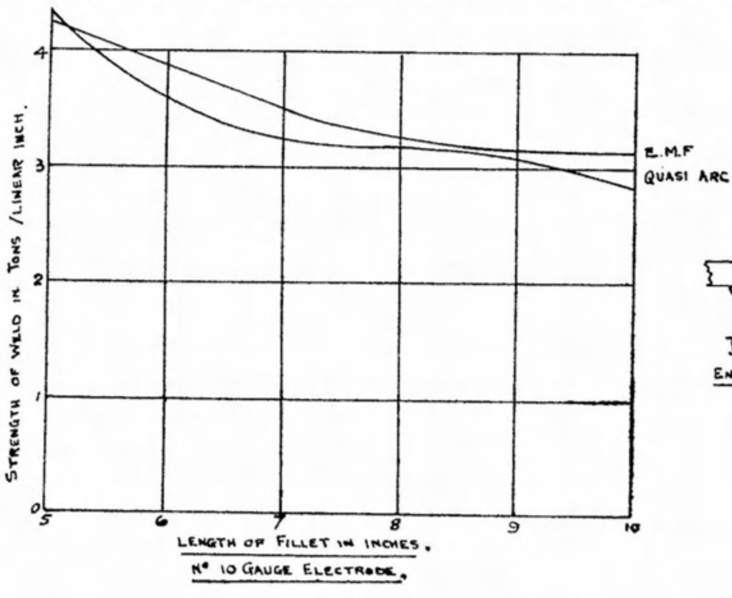
With the covered electrode it is claimed that the cleaning process is speeded up. The flux melts at about 900° C. before the metal has reached a temperature at which oxidation is very rapid, and completely covers the molten metal, excluding the air all the time welding is in process. The slag remains molten until after the metal has cooled to 900° C., and thus during the time the metal is above the critical temperature it is covered by this protective layer which tends to slow the cooling and avoids chilling. The slag has a strong reducing action, rust and dirt being quickly dissolved and absorbed.

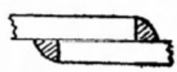
The current also affects the speed of welding and for the sake of economy the current should be as high as possible, but high current should only be used if the main heat of the arc can be absorbed by the plate itself. If the arc is played on to the pool of molten metal using a high current, overheated and very brittle metal will result. The advantage of increasing the speed of welding by increasing the current can only be taken in so far as the welding method adopted allows of the current being raised, without harming the quality of the weld. It is considered therefore, that to make a weld of good quality only the best covered electrodes should be used. The weld should be made of small runs so that the metal is not kept at a red heat longer than necessary, and the arc should be kept short so that the molten metal is surrounded by vapour to exclude the air and prevent oxidation. The welding current is dependent on the size of electrode and the size of electrode and current on the amount of parent metal adjacent to the weld available for conducting away the heat.

Two well-known covered electrodes on the market in this country are Quasi Arc and E.M.F. electrodes. These two types will be discussed in more detail later.

Using a Quasi Arc electrode and moving it forward steadily *without appreciable side movement*, the heaviest continuous weld obtainable from one electrode is deposited in 8 in. while 9 in. are obtained from an E.M.F. electrode. It will be seen that using the appropriate electrodes for the thickness of plates to be welded, the -/8 and -/9 welds are the most economical runs that can be made.

The diagram below shows the weld strength plotted against the length of fillet using these two electrodes in the 10 gauge size.



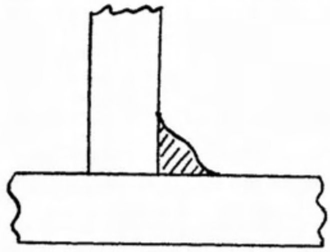


TESTS OF END WELDS

The 10/9 to 10/10 weld for E.M.F. and 10/8 for Quasi Arc electrodes give the best results. Below this the unit strength commences to fall off, while above these figures, the strength increases at the expense of the ductility. It is good practice to use a length of run of 8 to 9 in. per electrode and the use of large electrodes, except for special purposes is to be deprecated, better welds being made as a general rule with large plates by " building up " layers using electrodes not larger than 8 gauge. The figures indicate the method.

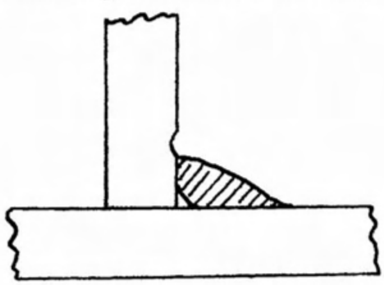
There are two main types of welds, viz., fillet welds and butt welds, and the appropriate method to adopt for these types is given below.

Horizontal Fillet Welds.—For small runs the contour of the weld is as shown (*a*). Penetration right into the corner of the fillet is



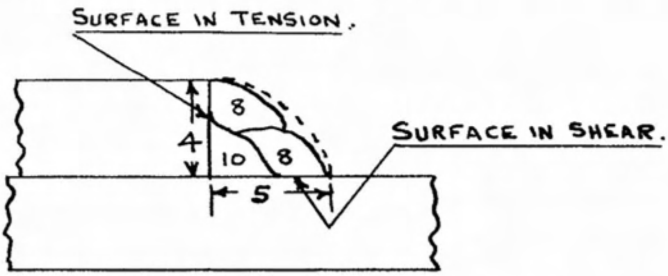
(a)

obtained. Apart from being bad practice, it is not possible to make a fillet weld in a single heavy run and secure good penetration into the corner of the fillet. The electrode has to be weared from side to side and the weld metal runs on to the horizontal plate. Lack of penetration into the corner of the fillet and heavy undercutting results. The strength of this weld will depend on the thickness of the metal at the corner of the fillet. This throat thickness of say a 6/6 weld is very little greater than that obtained from a 10/9 weld (*see* (*b*)). To secure penetration into the corner it is therefore



(b)

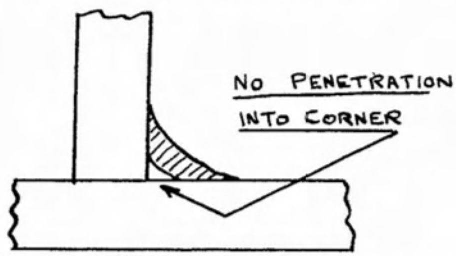
necessary in making large fillet welds that the weld be built up of a number of small runs. If possible, the contour of the finished weld should be such that the face under shear should be greater than the face under tension, generally in the ratio of 5 : 4, and the contour of the weld should be the arc of an ellipse.



Vertical Fillet Welds.—(*a*) Welded in upward direction. In making this weld the metal tends to flow back under the influence of gravity, and a small percentage is lost. Complete penetration into the corner of the fillet can be obtained.

(*b*) Welded in downward direction. This method of welding should *never* be used if it is possible to weld in the upward direction, as it is almost impossible to secure penetration into the corner of the fillet. The slag runs ahead of the electrode and is included into the corner, preventing good metal flowing.

The contour of this weld is as shown :—

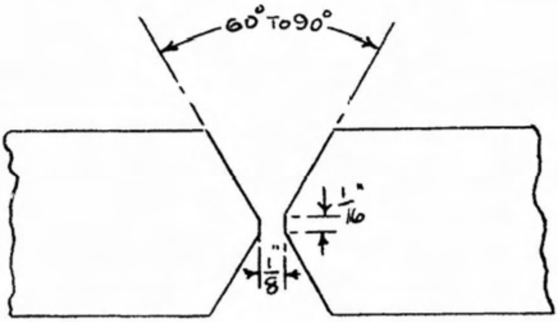


Overhead Fillet Welds.—A current, 10 to 15 amps. higher than that used when welding horizontally or vertically, should be used when welding overhead. This makes the arc easier of control and counteracts the force of gravity acting on the particles of metal being deposited. As short an arc as possible should, therefore, be kept to prevent "splashing." A fair percentage of metal is lost due to falling away, and this weld gives a lower unit strength than the other welds. The average strength of these welds of 10/9 size made under good conditions with E.M.F. electrodes is as follows :—

Horizontal	3·19 tons per linear inch.
Vertical, down	2·57 ,, ,, ,,
Vertical, up	3·10 ,, ,, ,,
Overhead	2·77 ,, ,, ,,

In making fillet welds, the electrode should be held at such an angle that the main heat of the arc is concentrated on to the heavier plate. This ensures that the heat will be conducted away uniformly, and the metal of the thinner plate will not be overheated. After a little experience, it will be found that there is a natural tendency to do this if an even weld is to be obtained.

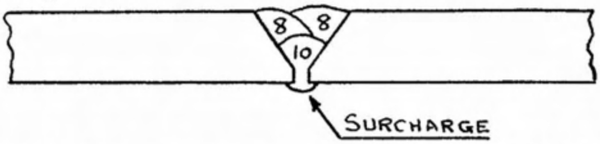
Butt Welds.—In joining plates up to $\frac{3}{16}$ in. in thickness by a butt weld, it is not necessary to vee the edges of the plates, but a gap of $\frac{1}{32}$ in. to $\frac{1}{16}$ in. should be left between the plates into which the weld metal is deposited. Plates above $\frac{3}{16}$ in. in thickness should be veed. The veeing should not be continued right through the plate, but should stop $\frac{1}{16}$ in. from the bottom of the vee, as theoretically the intensity of heat at a point is infinite and the lower edges of the plate will be burnt away. In general, plates should be prepared as shown in Tables 3 and 4. Large plates should be veed from both sides as shown, and the metal deposited equally on both sides.



This method is used where distortion is required to be kept to a minimum, and it will be seen that less metal has been deposited to complete the weld than if the plates were prepared with single vee from one side only.

In making butt welds on plates $\frac{5}{16}$ in. and above, it is necessary to commence with a small run of No. 10 gauge electrode at the bottom of the vee, and the remainder of the weld should be built up of 10/8 or 8/8 runs. This first run ensures complete penetration. (*See* Tables 3 and 4.) If a butt weld on heavy plate is made with a single heavy run, it is found that there is little penetration in the sides of the vee and the metal does not flow to the bottom of the vee. Bad distortion also occurs due to intense local heating, and the large mass of weld metal contracting on cooling.

If practicable, a small run on the back of the weld called the "surcharge" should be made to ensure complete penetration through the plates.



Tables 3 and 4 give the necessary data for making fillet and butt welds up to $\frac{3}{4}$ in. plate thickness.

Before successive runs are made it is essential that all slag should be removed by striking with a chipping hammer and brushing with a wire brush.

With reference to the mass of parent metal adjacent to the weld and capable of drawing heat from it, rough rules which have been found to give good results, are as follows :—

> "No electrode larger than No. 10 gauge shall be used, unless the area of section of plate metal within 1 in. of the arc and capable of drawing heat from it is in excess of 1·0 sq. in."

(It will be seen that this only allows the use of No. 8 gauge electrodes in butt welds on $\frac{1}{2}$ in. plate and over, and in fillet welds on $\frac{3}{8}$ in. plate and over.)

> "No electrode larger than No. 12 gauge shall be used unless the area of section of plate metal within 1 in. of the arc and capable of drawing heat from it is in excess of 0·35 sq. in."

(This only allows the use of No. 10 gauge electrodes in butt welds on $\frac{3}{16}$ in. plate and over, and in fillet welds on $\frac{1}{8}$ in. plate and over.)

Design.—In designing a structure to be joined together entirely by welding, if full advantage is to be taken of this means of fabrication, it is necessary to depart from the usual methods in designing for riveted construction. Welding cannot be considered merely as a substitute for riveting, and the substituting of welds for rivets —apart from being more uneconomical—may make a structure quite unsafe. A rivet is generally of more ductile material than the plates it joins, whereas the weld metal has, as a rule, less ductility than that of the plates. A weld joint, on the other hand, can be made the strongest part of the structure, instead of the weakest as in a riveted joint. On account of the difference in the nature of the two joints it is also unsound to combine welding and riveting, unless the behaviour of the two types of joints is carefully considered. An example of wrong combination is often seen in pipe and tank work where a riveted lap joint is also welded, although in this work (more especially where the pipes and tanks carry petrol or other highly inflammable substance) the welding is merely meant to act should the rivets leak. The weld being less ductile than the rivets, shock is mainly taken by the weld. A double-welded lap joint made under good conditions is 1·2 times the strength of the plate, while the efficiency of a single-riveted lap joint is only 60 per cent. The rivets, therefore, give little assistance to the joint and are a possible source of trouble due to leakage and corrosion.

It is reiterated here that in considering the design of an important welded structure, it should be specified that only the best covered electrodes should be used or the design will have to be appreciably altered. For instance, if bare wire electrodes are specified, butt welds, which will be subjected to a tensile stress, should not be used, owing to the extremely low ductility obtained from this type of electrode. If an attempt is made to butt weld pieces which are not free to move, as, for instance, welding a crosspiece into a heavy ring, or the web members into a truss rigidly assembled, the bare wire weld will either break as soon as it cools, or the member may be subjected to high initial stress, as the metal is not sufficiently ductile to take up the contraction on cooling. Without butt welds the most economical and weigh-saving joint is lost.

It is not possible to lay down any definite figures as to the saving of material that may be expected by the use of welding instead of riveting, but the following figures obtained from the Metropolitan Gas Company in Melbourne show the possibilities in this form of construction. This Company has over 12,000 tons of welded constructional work, including gasometers of 3,000,000 cub. ft. capacity, and their experience shows that a saving of weight of 12 per cent. in beams, 8 per cent. in columns and 18 per cent. in tension members with additional saving in connections may be anticipated, making in total a saving in weight of approximately 20 per cent. Tables 3 and 4 give average figures that may be used for design purposes for the strength of fillet and butt welds.

The figures are given for loading at right angles to the weld. Should the loading be along or in the direction of welding, the above figures should be used with caution, as due to the contraction of the weld, large initial stresses may be present. This will depend largely on the welding procedure and can be reduced to a minimum by correct methods.

A factor of safety of four is usually considered sufficient for general constructional work, but where alternating or sudden loading is to be expected, a factor of safety of six should be allowed.

The factor of safety has a big influence on the cost of the work as it will be seen that if a factor of safety of six is used instead of four, 50 per cent. greater length of weld of the same size, or more than twice the volume of weld metal for the same length of weld is required to give equal strength. Hence, in work where strength consideration is not of major importance, there is a considerable saving in expense by using a low factor of safety. It must be borne in mind, however, that in adopting these factors of safety it is assumed that the welds are made in accordance with the best practice. If a factor of safety of four is to be used, it is reasonable to require the deposited metal shall have properties little inferior to those of mild steel and this is obtainable if the correct procedure is followed.

An elongation of 20 per cent. and Izod value of 30 ft./lbs. can be obtained from properly deposited metal, but this may vary down to 3 per cent. elongation and 2 ft./lbs. Izod value if the metal is wrongly deposited.

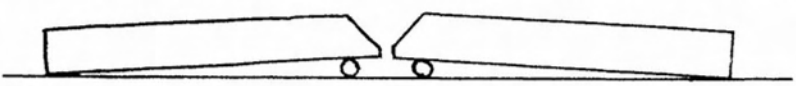
One of the principal advantages of electric welding is the ease and economy in which sections of a more or less complicated nature may be built up. The construction of sections which are now cast could be carried out by building up of mild steel plates welded together. The saving of weight for equal strength is considerable and the cost of patterns which, if only a small number of castings are required, is often as costly in labour as the castings themselves, is done away with. Of course, against this must be considered the cost of any jigs required for welding.

Another great advantage of welding in light work is that moisture may be excluded from the joints. In structures such as funnels, deterioration mostly takes place, due to corrosion in the laps of the plates. Rust forms and forces the lap apart, tearing the plates from the rivets. If butt welds are substituted for laps where possible and lap welds lightly welded their full length, all moisture is excluded from the joints and the life of the funnel considerably lengthened.

Distortion is the bugbear of welding and methods must be employed to keep it to a minimum. Distortion is caused by the contraction of the weld metal drawing the two sides of the weld together and can be controlled to a large extent, according to the method of preparation of the joints, but in the main, dependence must be placed upon the experience of the operator in handling similar structures. There are two methods of controlling distortion :—

1. The free method.
2. The fixed method.

The first consists in distorting the job before welding and allowing the contraction of the weld to return the job to its proper shape, and the second is to fix the job, so that it cannot distort, by clamping, or, more usually, by securely tack welding, so that it cannot distort. An example of the first method is as shown. The veed-ends of the



two pieces of plates to be welded are raised slightly before welding, so that the contraction of the weld pulls the plates into line. Another

TABLE 3.

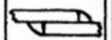
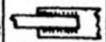
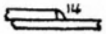
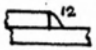
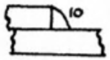
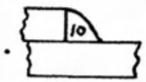
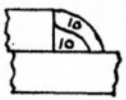
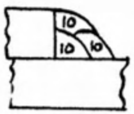
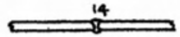
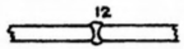
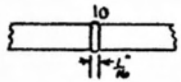
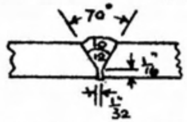
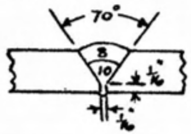
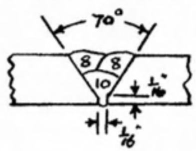
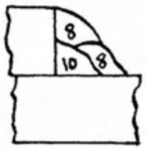
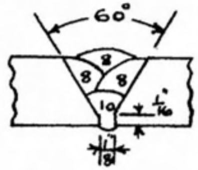
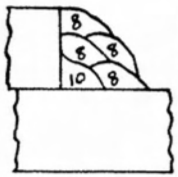
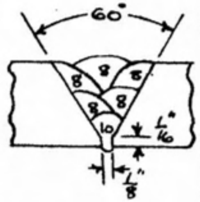
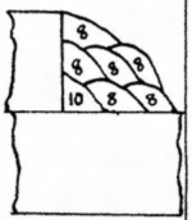
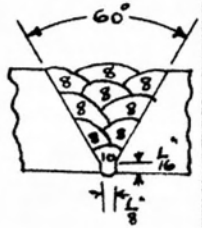
THICKNESS OF PLATES	TYPE OF WELD.	Nº OF RUNS.	SIZE OF ELECTRODE S.W.G.	CURRENT, AMPERES.	LENGTH OF RUN PER ELECTRODE.	STRENGTH IN TONS PER LINEAR INCH OF WELD. END WELDS.  U.T.S.	STRESS / F.S.4.	SIDE WELDS.  U.T.S.	STRESS / F.S.4.
1/16"		1	14	35	9"	0·85	0·2	0·8	0·2
1/8"		1 OR 1	12 OR 10	65 80	12" 14"	1·75	0·44	1·6	0·4
3/16"		1	10	80	10"	2·5	0·6	2·0	0·5
1/4"		1	10	80	8"	3·5	0·9	2·8	0·7
5/16"		2	10	80	8"	4·2	1·0	3·6	0·9
3/8"		3	10	80	8"	5·0	1·2	4·0	1·0

TABLE 4.

TYPE OF WELD.	Nº OF RUNS	SIZE OF ELECTRODE S.W.G.	CURRENT, AMPERES.	LENGTH OF RUN PER ELECTRODE.	STRENGTH IN TONS PER LINEAR INCH OF WELD. U.T.S.	STRESS / F.S.4.
	1	14	35	18"	1·6	0·4
	1 OR 1	12 10	65 70	12" 14"	3·2	0·8
	1	10	70	8"	5·0	1·2
	1 + 1	12 10	40 80	14" 9"	6·5	1·6
	1 + 1	10 8	80 100	10" 8"	8·2	2·0
	1 + 2	10 8	80 100	8" 8"	10·0	2·5

1/2"		1 + 2	10 8	80 100	8" 8"	6·5	1·6	5·2	1·3		1 + 3	10 8	80 100	8" 8"	13·0	3·2
5/8"		1 + 4	10 8	80 100	8" 8"	8·0	2·0	6·4	1·6		1 + 5	10 8	80 100	8" 8"	16·2	4·0
3/4"		1 + 6	10 8	80 100	8" 8"	9·6	2·4	7·2	1·8		1 + 8	10 8	80 100	8" 8"	19·2	4·8

CURRENT IS GIVEN FOR QUASI ARC ELECTRODES. IF E.M.F. ELECTRODES ARE USED THE CURRENT SHOULD BE RAISED APPROX: 20 AMPERES IN EACH CASE AND THE LENGTH OF THE RUN INCREASED BY APPROX: 12%.

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example is welding a patch into a tank side. The patch is dished so that the contraction in the weld will pull it out straight and there will be no danger of the weld splitting. An example of the second method is the welding of a flat on to a rolled joist. If the plate is securely tacked at intervals along its length and welding is carried out in short light runs so that the job never becomes really hot, no distortion will occur.

Allowing for and checking for distortion is largely a matter of experience, but as a general rule, in simple construction, if the job is securely tack-welded first and the welding is done in light runs, distortion may be reduced to a minimum.

Supervision.—If the constructional drawings specify the type and size of the welds, the type and size of electrodes to be used and the amount of deposition per electrode, the current for each size of electrode being standardised, then there is little doubt that good work can be obtained. Supervision is then only a matter of seeing that the instructions are carried out.

Although from a visual examination it is impossible to detect flaws buried in the weld, an idea of how the weld has been made can be obtained. The weld should be of an even contour throughout its length, slight variations only being allowed. If the weld is built up of a number of small runs, the separate runs on the top layer should be clearly discernible. There should be no gap between where one electrode finishes and the weld commences again. Undercutting should never be allowed, as it is a sure indication of wrong current conditions. Too high a current can generally be detected by the amount of splashing that has taken place. As most bad welding is due to wrong current conditions, correct supervision in this direction is most important. Heavy runs of welding should never be resorted to, heavy welds being built up of a number of small runs.