WELDING MEEHANITE METAL

contents

Welding of Meehanite Metal

High carbon materials, such as cast iron and Meehanite Metal have not normally been regarded as weldable materials, in the sense that mild or low carbon steels are. Despite this stigma, many hundreds of tons of cast iron are welded successfully each year, and provided this welding is done with a full understanding of the principles and problems involved, it can become a useful tool for repair, for salvage, and for construction purposes.

In general, welding techniques applicable to cast irons, containing graphite in the flake or the nodular form, are also applicable to Meehanite Metal. As Meehanite Metal is a controlled engineering product produced under exacting manufacturing conditions, it may be anticipated that the welding of Meehanite Metal is usually a simpler and more dependable procedure, than is normally the case with common cast irons. The procedures outlined in this publication are specifically designed for Meehanite Metal, and may or may not be applicable to other cast irons.

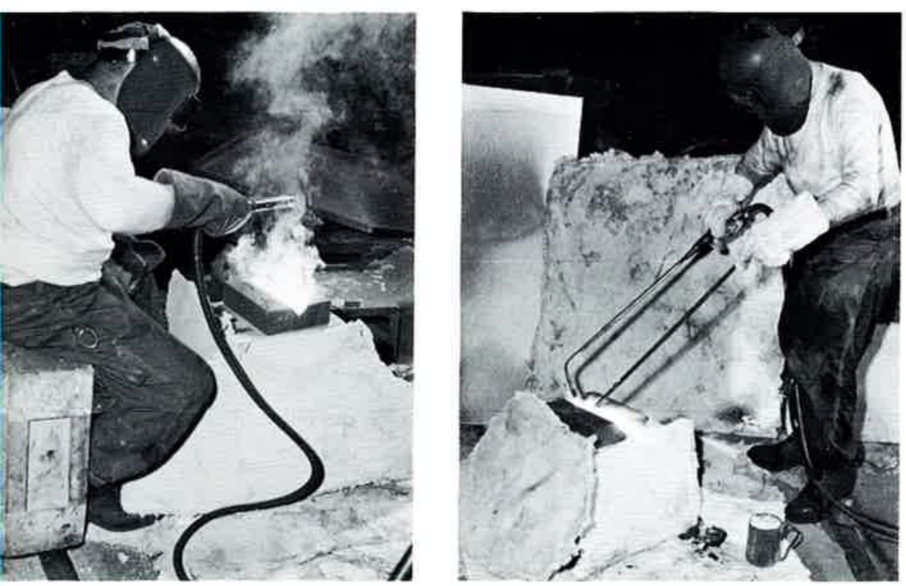


Fig. 1: *Welding is essentially a casting operation conducted on a miniature scale. Melting and pouring into a previously prepared metal mold, is conducted insitu, without benefit of both composition adjustment and slag and gas removal.*

Metallurgical Problems Associated with Welding

The welding of ferrous materials, which would include all steels and cast irons as well as Meehanite Metal, is fraught with difficulties, which result from the metallurgical nature of the fusion welding process. Welding is actually a miniature casting operation done under extremely difficult conditions, involving extremely rapid heating and extremely rapid cooling. Thus, all of the problems usually found in a normal casting process are present, and these problems are in fact, aggravated by the conditions that exist under welding conditions. It is in fact, a tribute to the skill and persistance of the metallurgical engineer, that such tremendous advances in the art of welding even easily weldable materials, such as low carbon steels, have taken place.

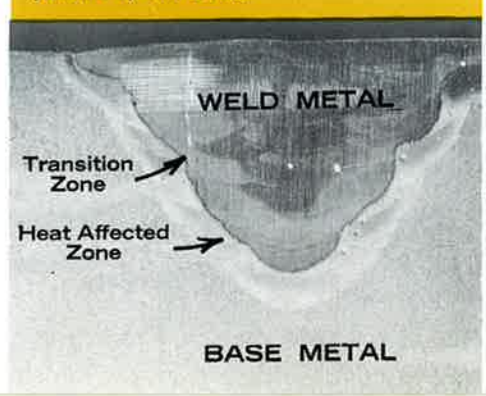
In the higher carbon steels, and particularly in graphite bearing materials, such as cast iron and Meehanite Metal, the hardening effect of carbon under the intense and rapid heating and cooling attendant with fusion welding, produce additional complications, which call for more exacting methods, and which preclude successful welding in many cases. Basically speaking, carbon or graphite in the metal being welded dissolves in the weld metal, causing hard brittle carbides or equally hard martensite in the weld, or adjacent to the weld during cooling. The rapidity of heating and cooling makes the control of this carbon solution effect an extremely difficult matter. Even complex heat treatments after the welding operation, do not completely solve all the problems that are involved. It may be understood from these remarks, that welding under controlled shop conditions, with proper facilities available, is always preferred to welding in the field where equipment is usually cruder, and where many of the complex metallurgical phenomena cannot be allowed for. It should also be realized, that there is no magic welding rod, or magical procedure that will allow unskilled operators with primitive equipment to weld cast iron or Meehanite Metals, with ease and dispatch.

In any welding operation, three primary zones must be considered:

(a) The casting or mother metal to be welded.
(b) The weld or filler metal.
(c) The heat affected or marriage zone.

Fig. 2: *Extensive carbidic area in a nodular weld indicating rapid solidification of the weld metal.*

Fig. 3: *Microstructures of metal-arc weld showing distinctive zones of influence of the weld.*



The Metallurgy of Welding Meehanite Metal

There are two types of welding employed in the welding of Meehanite Metal: Metal arc welding and oxy-acetylene welding. Other specialized methods, such as resistance welding, friction welding, gas shielded arc welding, Thermit welding, slag welding and etc., are too experimental in nature, and too specialized to be considered here.

Metal arc welding is rapid, convenient and relatively inexpensive, but does not produce the quality of weld possible with the slower less convenient oxy-acetylene process. In fact, the oxy-acetylene process, using the correct filler rods and fluxes can produce a weld in Meehanite Metal, which is completely indistinguishable from the part being welded from the standpoint of structure, color and physical properties. This is never possible with metal arc welding, where a good weld may be produced from the standpoint of physical properties, but where the color or chemistry of the weld area is always different from that of the part being welded.

Engineering Meehanite Metals may be divided broadly into the flake graphite irons, such as: GM60, GA50, GC40, GE30, GF20, AQ, HR, HE, CC, CR, and the nodular graphite or ductile iron types, such as: SH100, SP80, SF60, AQS, HS, HSV, WS, WSH and CRS.

Methods for welding all these materials are essentially the same, but it will be found that all the nodular types have inherently better weldability, and their higher strength values and ductility allow a weld, which is similarly stronger and more ductile. In oxy-acetylene welding, the nodular irons require special filler rods and fluxes, but under these conditions, welds may be produced with even better properties that may exist in the original part being welded. All welding methods applicable to nodular irons are recommended for flake irons. The only difference is in the character of the weld, which is far superior in the nodular iron. Certain types of Meehanite Metal produced for corrosion or heat-resistance, such as, HSV, HS, CR, or CRS require special composition rods for welding, so as to produce a weld metal essentially similar in chemistry to the mother metal. Corrosion resistant metals require specialized techniques, because of the inherent tendency of welded metals to accelerate corrosion rates.

In general, welding of parts without restriction, presents an entirely different problem to welding under restriction. This is because of contractions of the weld metal during solidification producing intensive areas of stress, where the welded parts are not free to move with respect to each other. As welding under constriction is such a difficult feat to perform, the examples given and the methods discussed in this booklet relate to welding without constriction, that is where the welded members are free to move in relation to each other.

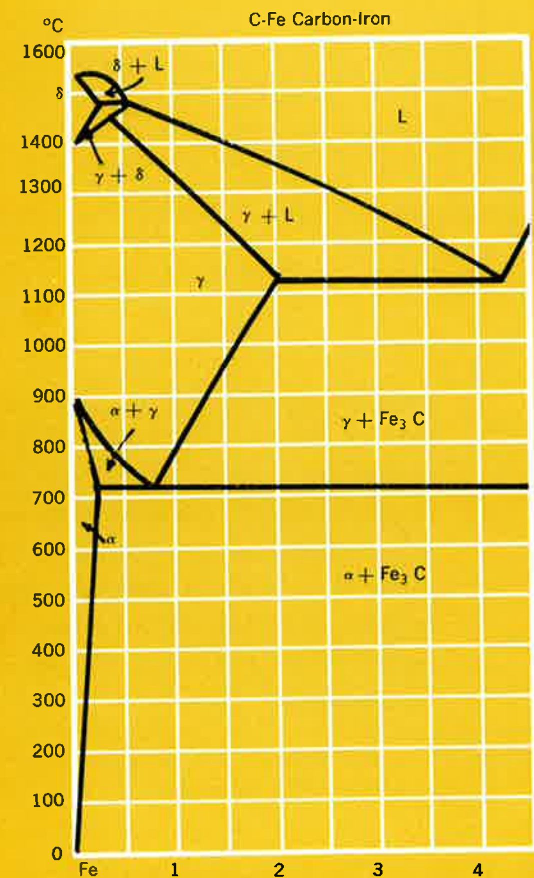
In welding Meehanite Metal, the filler or rod metal is melted into the parent metal. The heat affected zone will vary according to the rate of energy input during welding, which controls the depth to which heat will penetrate into the parent metal. As it takes heat to cause carbon solution, and this results in weld hardness, it follows that the hardness of the heat affected zone, depends a lot on the welding technique. With oxy-acetylene welding, heat or energy input may be controlled at will, resulting in a superior weld. With metal arc welding, energy input cannot be controlled with such ease so that the selection of the correct welding rods, becomes a major consideration.

Metal Arc Welding of Meehanite Metal

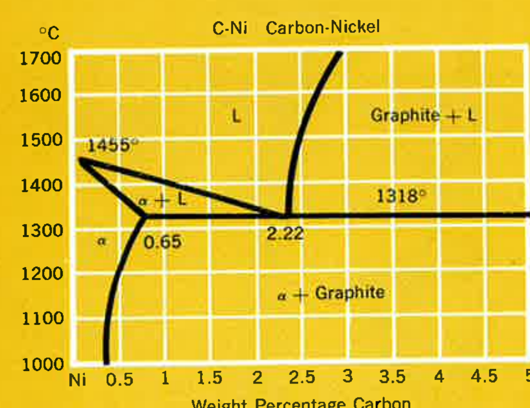
Because of the ever-present problem of controlling hardness in the weld, due to carbon solution, high nickel rods are recommended for most applications. Nickel may absorb considerable quantities of carbon without producing hardness, whereas, steel rods which also absorb carbon, would produce excessive hardness in the weld. The best nickel rod for the metal-arc welding of Meehanite Metal, is that containing approximately 55% nickel, and covered by ASTM specifications A398 - 56T. Chemistry specifications on these rods are:

Carbon	2.0 % max.
Manganese	1.0 % max.
Silicon	2.0 % max.
Sulphur	0.03% max.
Copper	0.50% max.
Nickel	45-60% max.
Iron	Remainder
Total other elements	1.0 % max.

There are other proprietary rods available, which may be used for welding Meehanite metal, but preference should always be given to the high nickel rod, particularly where weld hardness is a factor, and if any subsequent machining of the weld area is contemplated. Where large areas of weld are involved and machining is to follow, the pure nickel rod will be found more suitable. Where strength is more important, the 55% nickel rod is the most logical choice.



Dia. 1: *According to the iron-carbon phase diagram cementite or Fe_3C separates from the melt. This produces welds of high hardness.*



Dia. 2: *Where iron is replaced by nickel, graphite separates from the melt, as nickel carbide Ni_3C is extremely unstable.*

Preparation for Metal Arc Welding

The prime requisite for all types of welding is to adequately prepare the parts for the welding operation. Absolute cleanliness in freedom from greases, oils, rusts, paint, and other foreign materials, is essential. All areas to be welded should present absolute clean metallic surfaces. Where defect salvage repair is contemplated, the defect must be removed completely, so as to expose solid clean metal. Where component welding is involved, all surfaces to be welded should be freshly machined and ground. All joints and weld roots should be designed to facilitate the welding process.

Fig. 5: *Electric arc welding equipment.*

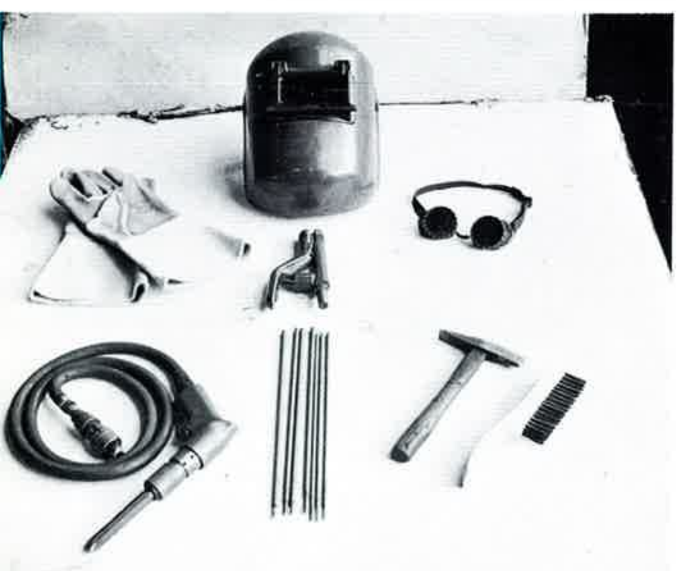
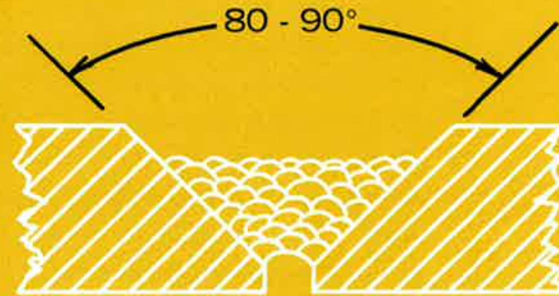


Fig. 6: *Butt joints are wider than those conventionally used for steel welding.*

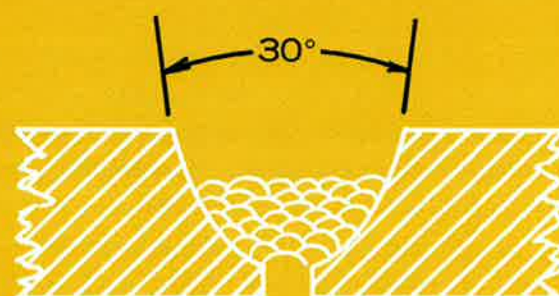


Root face 1/16" or less

Root gap 1/16"

Note staggered joints when over-lapping weld deposits.

Fig. 7: *For heavier sections the "U" type grooves are preferred.*



Root radius 3/16 - 1/8"

Root gap 1/8"

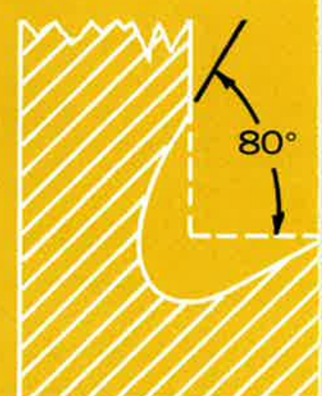


Fig. 8:

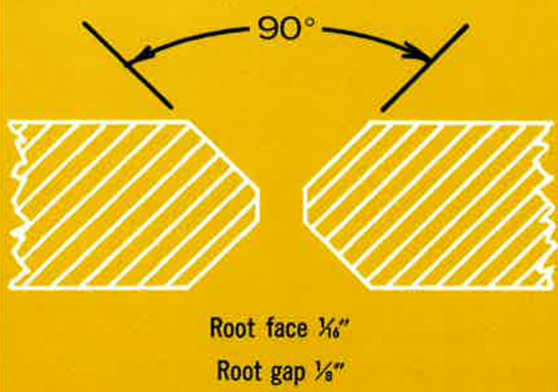


Fig. 9:

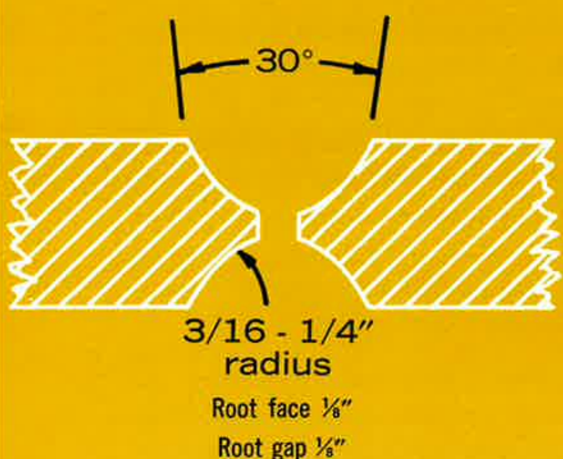


Fig. 10: *Corner defect position for downhand welding.*

Welding Technique

Welding currents should normally fall within the range recommended by the manufacturer. In the case of the 55% nickel rod, this would be:

	DC *(Reversed Polarity)*	AC
1/8 in. rod	80-100 amp.	90-110 amp.
5/32 in. rod	100-120 amp.	120-140 amp.
3/16 in. rod	120-150 amp.	130-160 amp.

Currents should be as low as possible, consistent with smooth operation, good bead contour, and securing a good wash. The electrode should be manipulated so that the width of the deposit is never greater than three times the diameter of the electrode being used. Large cavities are best welded by buttering and gradually filling the cavity towards the center of the repaired area. Slag should be completely removed from a bead layer by peening and brushing before a new bead is applied above it. When the weld is along a vertical or nearly vertical wall, it is desirable to reduce the current by 25% of that recommended for horizontal welding.

Repair welding requires a welding area, which allows easy manipulation of the welding rod.

A smaller electrode with an arc length of only 1/16" will keep the weld relatively cool, and will avoid alloying of the rod with the base metal. Low amperage alternating current reduces "arc blow" and improves arc control.

In general, deposit short straight beads and allow each to cool so they can be touched. Always direct the arc at a previously deposited bead.

Massive defective areas may be studded for added weld strength, but if salvage is attempted at all, it is best done by burn in welding, using molten metal.

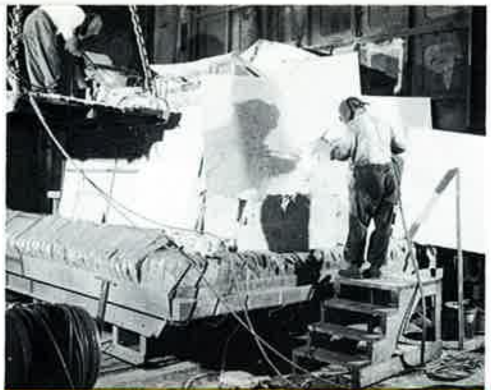


Fig. 11: ***Casting preheated, covered with asbestos to hold heat and protect the welder and ready for the welding operation.***

Fig. 12: ***Torch preheat is more convenient for small castings. Cover casting with asbestos after heating to prevent heat loss. Temperature of preheat may be measured by heat crayon.***

Post Heat and Preheat

In the welding of Meehanite Metal, two factors are prominent, viz:

1. The need to avoid excessive strain in the weld area, or in the casting itself, and
2. The need to prevent excessive hardness from developing in the weld.

As in any metallurgical process, these two conditions may be met by heating and cooling at rates, which are sufficiently low.

PREHEAT of a part to be welded will slow down the rate of heating during welding, and will tend to prevent excessive temperature gradients between the weld area, and the casting itself. The residual heat from a preheat will also slow down the rate of cooling after welding, so that it would appear that preheating of the part before welding is desirable. The practicability of preheat must be related to the size and mass of the part to be welded. As stresses in the weld area would result from the austenite to martensite transformation, the correct preheating temperature to minimize these stresses would be in the 400° - 450°F. range.

Where the casting is massive, heating is likely to be non-uniform, and where the casting is both massive and complex, such preheating is likely to do more harm than good. Further, the practical difficulty of working on a large mass heated to this temperature, must be borne in mind.

For complete freedom from hardness and stresses, the preheating temperature would have to be in the 1050° - 1250°F. range. For practical reasons, this would only be followed on extremely critical or complex weldments.

Local preheat in the weld area is often resorted to, in that it lowers the temperature gradient between the weld area and the part being welded, thereby reducing weld strain and martensitic hardness. Such preheat may conveniently be accomplished with an oxy-acetylene or other gas torch.

In general, most metal-arc welding is accomplished without a preheat treatment. Where the mass of metal to be deposited during welding is great, it is a good idea to reduce over-heating of the casting, by welding

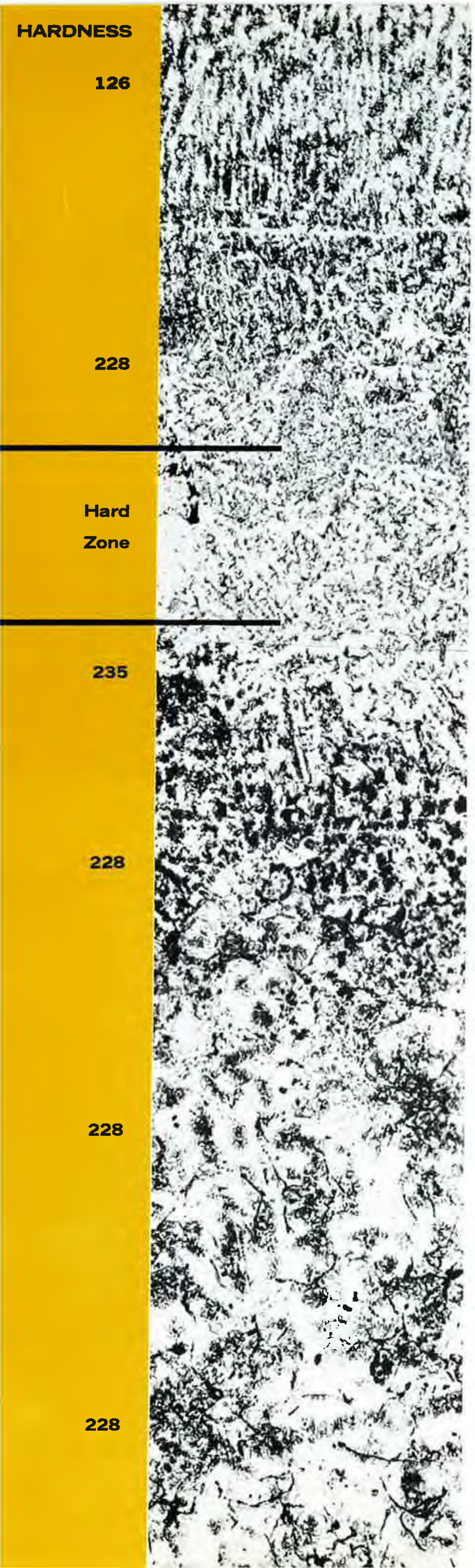
Fig. 13: Steel wheel with Meehanite Type "GA" hub, used for test welding.

Fig. 14: Martensite in the heat affected zone of this weld may be removed by suitable post heat treatment.

with a wandering sequence, allowing the area first welded to cool before welding again over this area.

POST HEATING is of benefit, particularly where machinability is a problem. Martensite in the marriage and weld areas may be removed by treating in the stress relieving range vis 1050° - 1200°F. Free carbides in these areas will only be decomposed by treatment at temperatures ranging from 1600° - 1800°F., and it is important to realize that such treatments in the case of flake graphite types of Meehanite Metal, will result in loss of strength, unless such treatment is followed by air cooling, to restore the pearlitic matrix normal in this type of metal. With the nodular types of Meehanite Metal, such treatment will be followed by slow cooling, where a ferritic matrix is desired, as in SF60 and HS, and air cooling where a pearlitic matrix is desired, as in SP80 and SH100. In the post heating of welds produced by the metal-arc process, it must be borne in mind that the composition of the weld area is different from that of the part which has been welded, and as such, will possess a different co-efficient of expansion. If any constriction is present, due to the design of the part, and the location of the weld area, it is quite likely that such post heating will result in weld cracking. Where this occurs, it is better to rely on adequate preheat and dispense with the post heat treatment.

Fig. 15: Cracked weld shown by radiograph may have been avoided by preheat before welding.



Strength and Structure of Metal Arc Welds on Meehanite Metal

While many examples may be given of successful welds using mild steel electrodes on Meehanite Metal, the general tendency for cracking when using rods of this type, is considerably greater, so that preference must be given to the recommended 55% nickel rods. Improper technique, i.e., welding in short runs and cooling in between would also increase the tendency towards cracking, but all factors being equal, the 55% nickel rods should be used wherever possible.

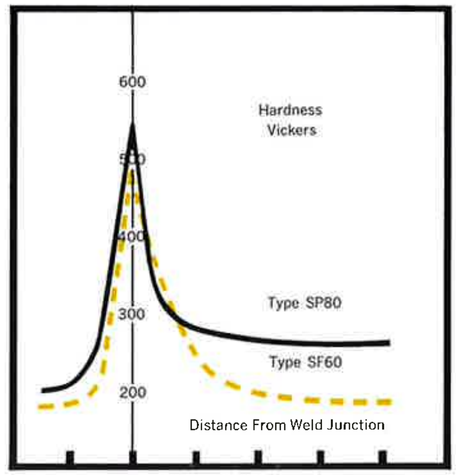
Tensile tests taken on Meehanite Type GA welded to steel, using nickel rods on a cold weld basis, gave 47,000 - 48,000 psi. This compares quite favorably with the base metal strength of 50,000 psi minimum. Structures taken from these welds indicate some cementite at the boundary, but a tendency for a pearlite or sorbitic matrix, rather than a martensite one. There is, however, sufficient martensite present to warrant drawing at 1050° - 1150°F., if machinability in the welds is required. From a consideration of various tests conducted over a period of time, it may be stated that a properly made weld will have a tensile strength of 80% of that of the base metal in flake graphite irons, and that failure will usually occur in the area adjacent to the weld, rather than in the weld itself.

Welds made on the nodular or "S" types of Meehanite Metal usually exhibit quite good strength properties and can be produced with measurable ductility values, although probably not as great a ductility as exhibited by the base metal. In the case of welding, this type of Meehanite

Fig. 16: *Mild Steel deposit on Meehanite Type "GC."*

Metal, mild steel rods may be used with greater facility, than the flake graphite types of Meehanite Metal, bearing in mind, however, that cracking of the weld is more likely and machinability of the weld will not be possible, unless the preferred high nickel rod is used. Typical physical tests on welds made on nodular Meehanite Metal or Ductliron, are shown herewith in Table I and Table II:

In general, it may be said that nodular iron welds made with 55% nickel rods by the approved technique, retain 90% of their strength in the ferritic condition, but only 30% of their original elongation. Welds on pearlitic base iron retain about 80% of their strength and 30% of their elongation. Post annealing, which has a prime function of promoting machinability increases elongation slightly, and in the case of pearlitic iron reduces strength by some 20% over that obtained in the annealed condition.



Dia. 3: *Typical hardness traverse on weld of ductliron using 55% Ni welding rod.*

TABLE I

MECHANICAL PROPERTIES OF NODULAR TO NODULAR WELDS USING 55% NICKEL RODS

TYPE OF METAL	CONDITION OF WELD	TENSILE	YIELD	ELONGATION %
SF60	Base Metal	68,000 psi	46,000 psi	21.0
	As Welded	65,000 psi	54,000 psi	8.0
	Post Anneal *(1600°F.-slow cool)*	67,000 psi	49,000 psi	11.0
SP80	Base Metal	98,000 psi	85,000 psi	3.0
	As Welded	80,000 psi	74,000 psi	1.0
	Post Anneal *(1600°F.-slow cool)*	65,000 psi	51,000 psi	8.0

TABLE II

MECHANICAL PROPERTIES OF NODULAR TO MILD STEEL WELDS USING 55% NICKEL RODS

TYPE OF METAL	CONDITION OF WELD	TENSILE	YIELD	ELONGATION %
SF60	As Welded	61,000 psi	47,000 psi	6.0
SP80	As Welded	69,500 psi	48,900 psi	3.0

Oxy-Acetylene Welding

Unquestionably, the ultimate in strength, color match and machinable hardness is possible only with gas welding, using appropriate filler rods. For welding all types of Meehanite Metal by this process, we recommend a cast filler rod having a composition range falling within the normal chemistry of the metal being welded. In the case of the nodular or "S" types of Meehanite Metal, we recommend a cast nodular rod, also falling within the compositional limits of the part being welded.

For the flake graphite types of Meehanite Metal, commercial fluxes consisting chiefly of Borax may be used, but for the nodular types, a flux known as Procaloy W should be used, as this is designed to reproduce the nodular type of graphite in the weld itself. Simple remelting of a nodular rod, will not by itself, retain a nodular structure in the weld.

The size of the rod relates to the amount of heat required to melt it and, therefore, to the thickness of the material being welded. For material thicknesses of up to 3/8", a maximum rod size of 1/4" is recommended and the welding tip should consume 15 to 30 cubic feet of acetylene per hour. For material thicknesses ranging between 3/8" and 3/4", the maximum size of the rod should be 5/16" and in this case, a tip consuming a volume of 30 to 60 cubic feet of acetylene per hour would be used. For sections over 3/4" the maximum size rod is 3/8" and, in this case, a welding tip consuming 60 to 110 cubic feet of acetylene per hour would be normal.

In no cases is it recommended that a layer should be greater than 3/8" thick.

Gas welding may be accomplished by either back hand or fore hand techniques, but, in general, the fore hand technique is preferred, in which the rod is pointed back towards the torch, and leads the progression of the weld. This fore hand method allows a better puddling action, with consequent working out of oxide slag inclusions and flux.

WELDING RANGE	TIP MARKING
⅛ to 3/16″	12A1
⅝ to ¾″	55A2
1″ and over	100A3

Typical torch tips and welding rod analysis

The working out of the flux is an important factor, particularly in nodular iron welds, where the applied flux is rather heavy, in order to ensure retention of the nodularity of the weld.

The character of the flame should be neutral. Where carbon contents are rather high, as in the nodular types of metal, or in the soft engineering flake types and where the carbon loss during welding is to be avoided, a slight excess of acetylene in the flame is recommended.

The flux is conventionally applied by heating the tip of the rod and dipping it in the flux. In the case of nodular iron welds, particularly those which are rather heavy, it is advisable to pour some flux into the area to be welded and maintain fusion sufficiently long for this flux to work to the top. This requires a good fluid weld and a slightly higher heat input, to avoid entrapment of the flux.

"V" grooves are prepared essentially as in metal-arc welding, but it must be borne in mind that welding on vertical sides is extremely difficult and overhead welding by this method is not practical. The preferred method of welding is to melt the sides of the "V" grooves ahead of the advancing puddle — this may be a matter of individual technique.

A typical nodular welding rod consists of

Total Carbon	3.60%
Silicon	2.80%
Manganese	0.35%
Sulphur	.02%
Phosphorous	.05%

with the graphite in the spheroidal form.

Nodular rods or "S" welding rods and Procaloy W flux may be purchased from the Casting Materials Co., New King St., White Plains, New York.

Fig. 20: ***A 50/50 mixture of oxygen and acetylene produces a neutral flame where the inside consists of a brilliant white cone 1/16 to ¾″ long and the envelope flame is faintly luminous with a delicate bluish color.***

Fig. 21: ***The carburizing or excess acetylene flame consists of three zones. Between the inner cone and the bluish outer envelope there is an intermediate cone of whitish color. The length of this intermediate cone variés directly with the amount of excess acetylene.***

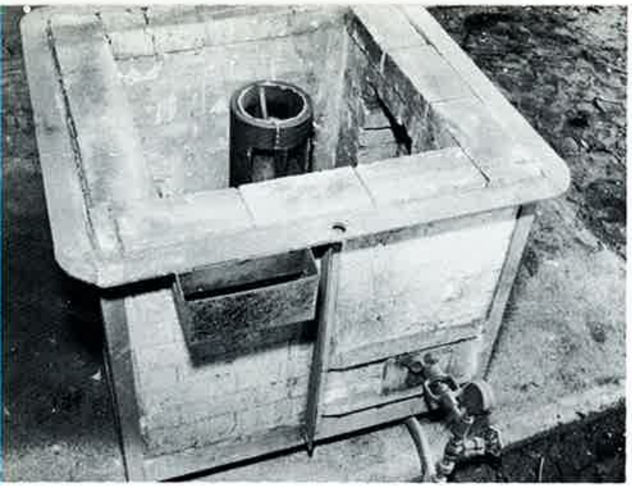
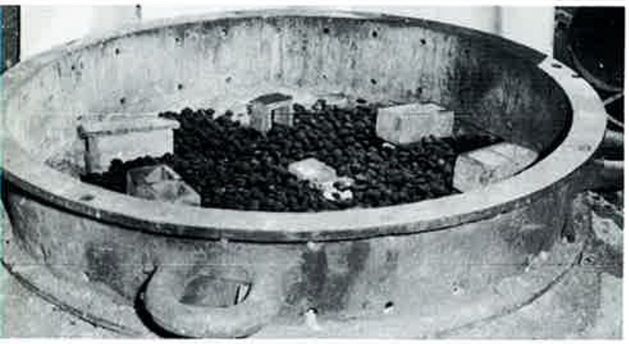


Fig. 22: *Simple oven for preheat of small castings covered with asbestos for preheat.*

Fig. 23: *Charcoal bed oven. Casting placed above burning charcoal and covered with asbestos paper.*



Pre-Heat

The same general laws governing the pre-heating of castings before welding is applied as in the case of metal-arc welding. As the gas torch can be manipulated over a wide area, it is, of course, possible to apply a certain degree of pre-heat using the welding torch itself. As it is also possible to control completely the rate of heat input, a skilled welder may often avoid the need for pre-heating.

Pre-heating may be accomplished by placing the casting in a conventional furnace, or by building a special furnace for the job. In any case, the casting should be completely covered with asbestos, or other heat insulation to prevent heat loss and to provide some degree of protection to the welder.

Where a large casting is involved, it is better to use more than one welder, in order to complete welding before the casting loses all of its pre-heat.

There appears to be some connection between the temperature of pre-heat and the relative density of the deposit. In general, higher density deposits result from a greater pre-heat.

As in metal-arc welding, the post-heat is controlled to some extent by the rate of cooling, which, in turn, is pre-determined by the amount of pre-heat which is given to the casting before welding.

Dia. 4:

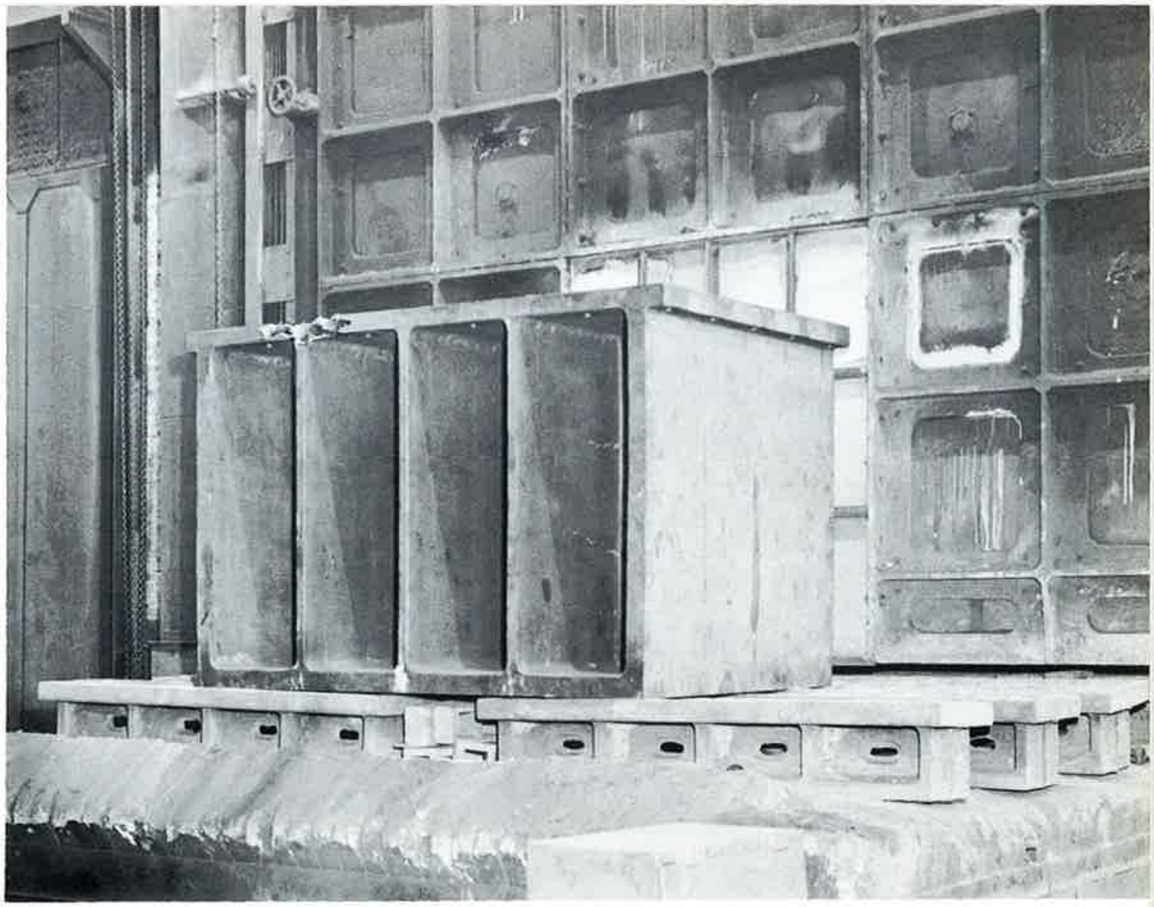


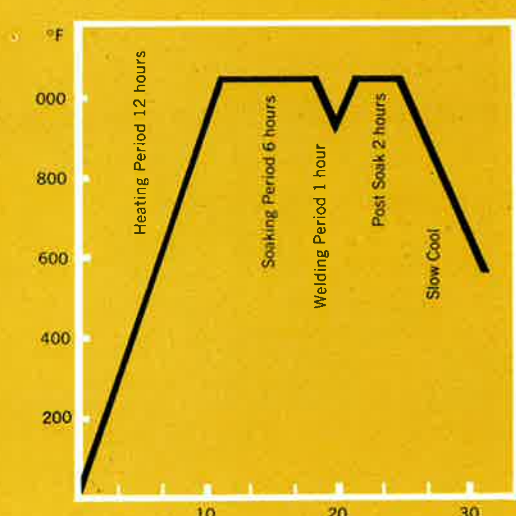
Fig. 24: *Large casting prior to preheat and welding on car of conventional stress relieving oven.*

Post-Heat

As the fusion process is not as rapid as is the case with metal-arc welding, the production of hard martensite, or primary cementite in the weld area is not as likely with oxy-acetylene welding. This is particularly true with a skilled operator, who maintains the correct heat input.

In addition to this, it is possible to slow down the cooling of the weld itself by passing the welding torch over the weld area after the deposit is complete. Because of this, post-heat for improved machinability is rarely required in an oxygen-acetylene weld made in the correct manner. The exception to this rule will be found in the highly ductile "S," or nodular types of Meehanite, where post-annealing at 1600°F., followed by a slow cool would be necessary to produce a completely ferritic weld structure.

Similarly, where high strength type "SH100" is involved, it may be advisable to normalize the resultant structure, to ensure a fully pearlitic matrix, having the required tensile strength.



Dia. 5: *Thermal cycle used for salvage welding large casting shown above.*

Structure and Strength of Oxy-acetylene Welds

Because oxy-acetylene welding involves a more controllable degree of heat input and because the composition and structure of the welding rod itself is designed to match the metal being welded, and because fluxes may be applied to promote nodularity in the weld metal, in the case of nodular iron welds, it is reasonable to assume that the final structure of the resultant weld is at least equal to that of the base metal and in many cases, it may actually be superior.

In general, both hardness values and strength of the base metal may be maintained with oxy-acetylene welding of flake graphite types of Meehanite Metal.

TABLE III'

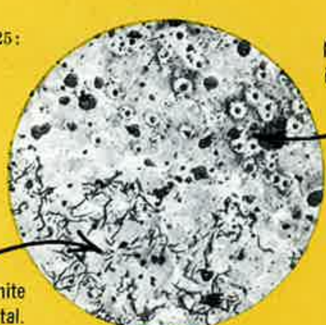
STRENGTH VALUES IN TYPICAL OXY-ACETYLENE WELDS OF FLAKE GRAPHITE MEEHANITE METAL

TYPE	BASE METAL TENSILE	TENSILE STRENGTH IN WELD	HARDNESS BHN	TENSILE STRENGTH AT JUNCTION	HARDNESS BHN
GA50	53,000 psi	52,000 psi	241	49,000 psi	255
GC40	41,500 psi	40,600 psi	228	40,000 psi	241
GE30	30,200 psi	34,200 psi	196	32,000 psi	187

In the case of the flake graphite types of Meehanite, it is possible to use a nodular welding rod with nodular flux for the weld and this will definitely produce a weld which is considerably stronger than that of the base metal.

The color match, also, will be sufficiently close that it would be difficult to detect the weld area, particularly in a high strength flake iron, such as type "GM60" or "GA50" Meehanite.

Fig. 25:



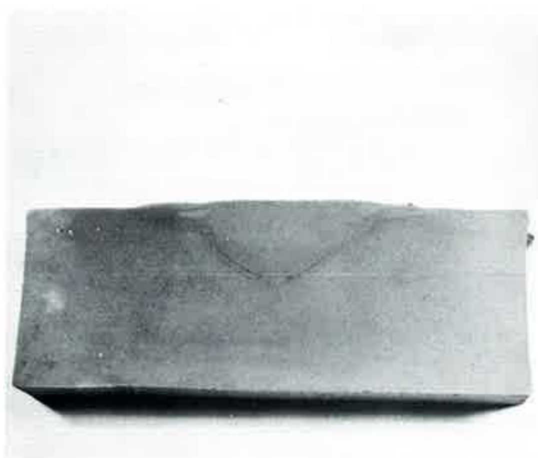
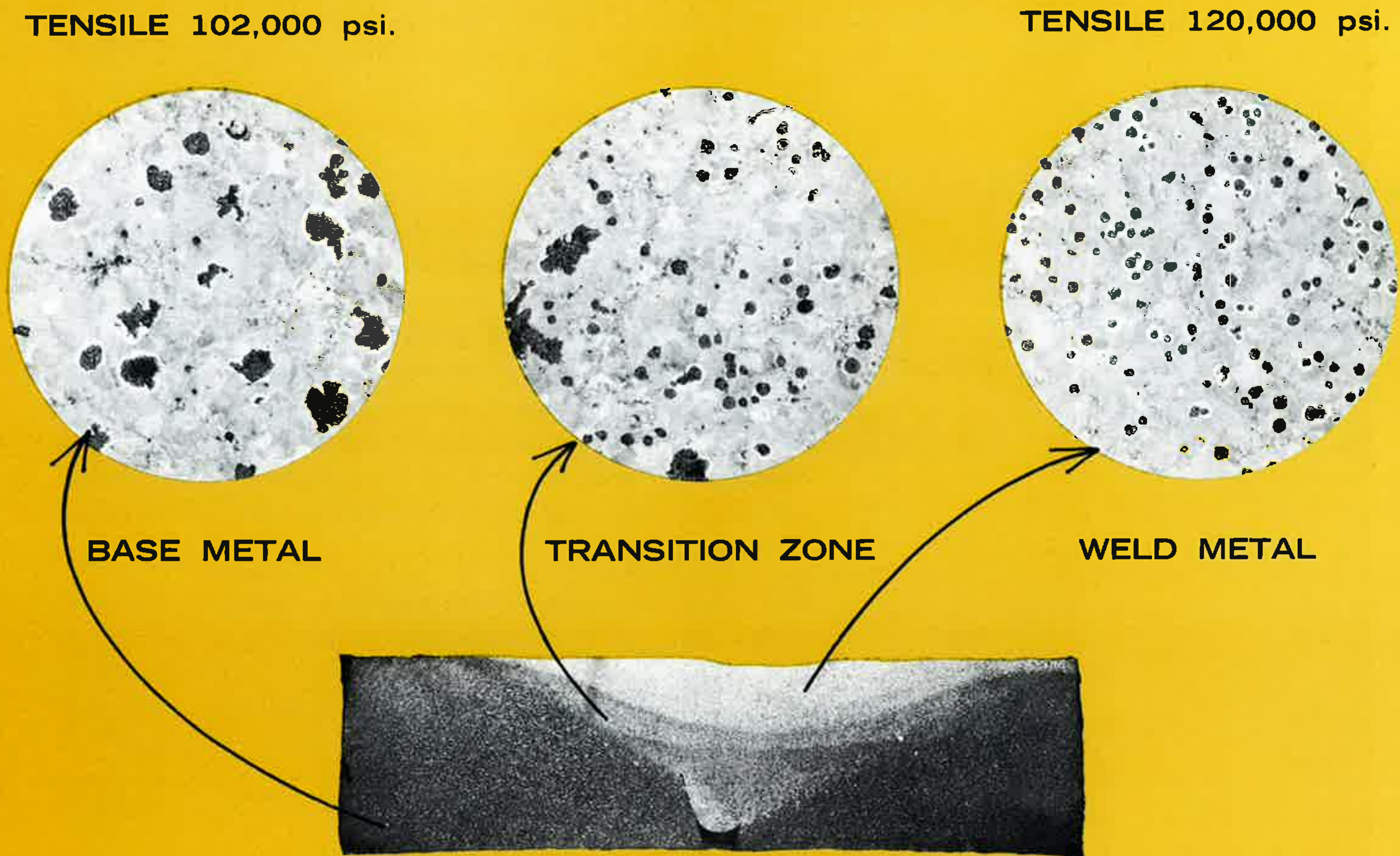


Fig. 27:



TEST WELD ON MEEHANITE SH100
USING "S" WELDING RODS AND PROCALOY W FLUX.
WELDED COLD BY THE OXY-ACETYLENE PROCESS

TABLE IV

STRENGTH VALUES IN TYPICAL OXY-ACETYLENE WELDS OF NODULAR OR 'S' TYPES OF MEEHANITE DUCTILIRON

TYPE	BASE METAL PROPERTIES			POST HEAT TREATMENT	WELD PROPERTIES		
	TENSILE	YIELD	ELONGATION		TENSILE	YIELD	ELONGATION
SF60	62,000	48,000	20%	Full Anneal and Slow Cool	60,000	45,000	16%
SP80	85,000	64,000	4%	None	82,000	61,000	3%
SH100	110,000	73,000	3%	Full Anneal Air Cool	120,000	72,000	2%
AQS	160,000	92,000	2%	Full Anneal Air Cool Draw	170,000	90,000	1%
HS	92,000	80,000	12%	Stress Relieve	85,000	70,000	10%

In all the above cases nodular iron rods corresponding to the chemistry of the base metal were used. Heat treatments are those conventionally employed on these types of Meehanite Metal.

Welding Repair by Burning

This is a specialized type of welding operation, usually applied to large castings and consists of using molten metal as the welding medium. The casting to be welded is prepared by building a refractory mold around the area to be welded and then pre-heating the whole casting. The refractory mold portion is provided with an outlet through which molten metal may be flowed and when the casting is pre-heated to a sufficiently high temperature, molten metal is poured into and through the refractory mold until the metal in the area to be welded begins to melt, under the action of the molten metal.

After a sufficient quantity of metal has been run through to melt to a depth of about ½" - 2", the drainage hole is plugged up and the cavity in the refractory mold is allowed to fill. This metal is then allowed to solidify and the welding operation is complete, after cleaning the casting and applying the post heat-treatment, where this is considered necessary.

This is a very useful type of weld repair and, in the hands of a skilled

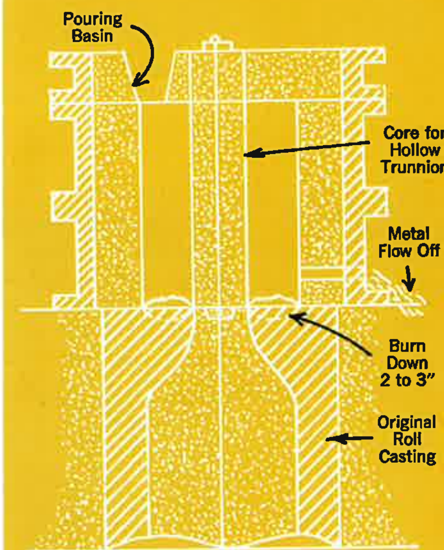
Fig. 29: ***Rubber roll after burning welding of new neck. Old broken neck in the foreground.***

Fig. 28: *Preheating marine cylinder prior to welding by burning. Repair approved by the Bureau of Shipping.*

foundryman, it can produce remarkable results. The danger of this process, as indeed in any welding process on complex castings, is that heating may be sufficiently uneven and severe to cause cracking of the casting. This danger can be minimized by an adequate pre-heating job. The weld area itself cannot be kept cool, because it is essential to heat this area up to the temperature of molten metal, if a successful weld is to be made.

One of the major advantages of this type of welding is that complex and massive shapes may be joined together with a weld that is every bit as strong, or even stronger, than that of the base metal. The exact technique usually varies, according to the particular foundry doing the welding job, but those that are skilled in this technique are able to do a very commendable job.

This method of welding may be used with the "S" types of Meehanite metal, as well as the flake graphite types.



Dia. 6: *Cross section of mold assembly for rubber roll repair.*

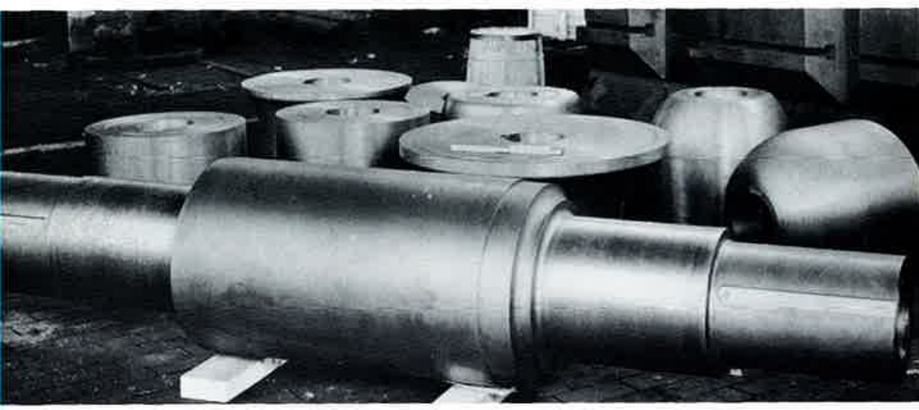


Fig. 30: ***Finished repaired roll after the machining operation.***

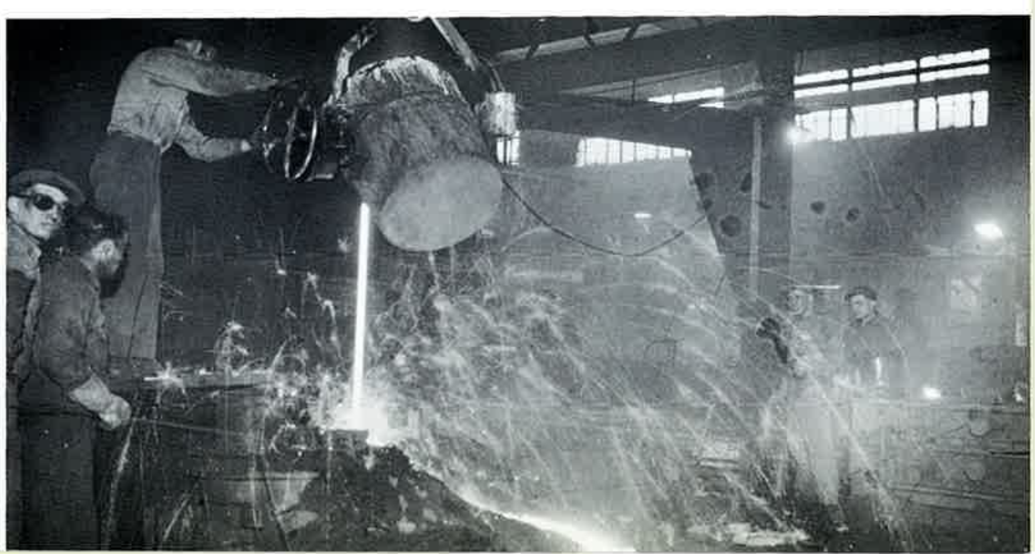


Fig. 31: *Pouring the molten metal during welding by burning. Note the flow-off of metal used for promoting incipient fusion in the weld area.*

Fig. 32: *Steel welded to Type SF Ductliron using 55% Nickel rod. Note that the base metal fractures under bend before the weld area.*

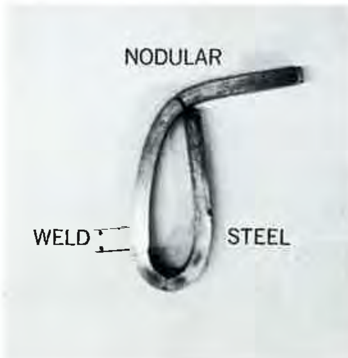


Fig. 34: *Type SF 60 missile access doors with welded steel lifting hooks and hinges to specification of U. S. Army engineers. Steel rods are for holding concrete filling.*

Other Welding Techniques

Because the more conventional techniques of metallic metal-arc welding and oxy-acetylene welding have been developed to their present state of perfection, some of the other methods previously practiced are not used to as great a degree today, however, it should be mentioned that Meehanite metal is capable of being welded by all of these methods viz brazing, resistance welding, flash welding, friction welding and Thermit welding.

Brazing

In brazing there are two main classes of alloys, namely, copper base alloys, or silver base alloys. With silver alloying a bond, stronger than the parent metal may be formed and as the flow point of the alloy is only 1100° to 1200°F., this avoids the danger of excessive hardening or excessive stresses resulting from uneven expansion. Because of the high cost, this method of brazing cannot be used where large cavities are to be filled.

A properly prepared surface is essential and, while most types of Meehanite require no special treatment, soldering may be enhanced by prior treatment in chemical solutions, which will effectively remove carbon from the surface.

Fig. 33: *Unusual nodular structure in the weld area using a specially coated nodular rod and welding by the metal-arc process. Further development of this technique and the inherent high weldability of the nodular types of Meehanite metal holds high promise for production welding techniques of the future.*

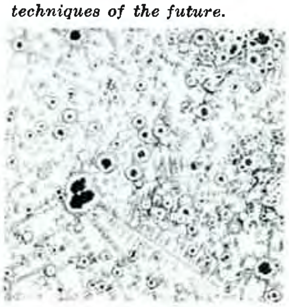


Fig. 35: *Meehanite Brake Drums with welded steel hub and bolts.*

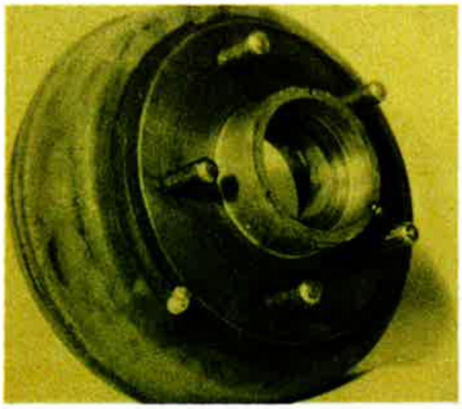
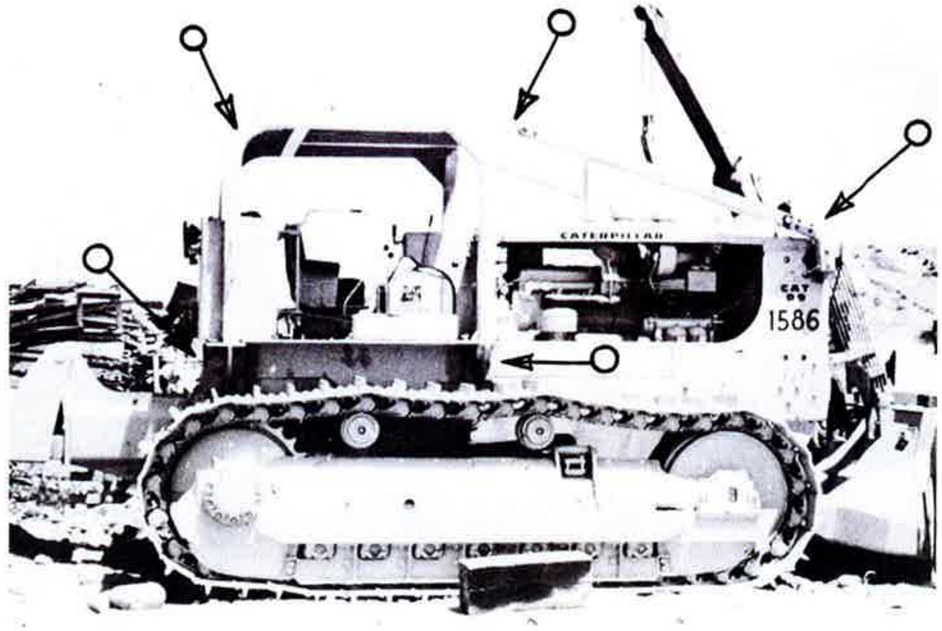


Fig. 36: *Steel canopy parts for industrial vehicles have been production welded onto nodular Meehanite corner brackets using 55% Nickel rods in the metal-arc welding process.*



The Kolene process would be typical. The surfaces to be joined are painted with a flux and the brazing alloys, in the form of a thin strip or wire, is placed on the surface, and the parts are heated together with jigs, to prevent sagging or separating. This brazing may be done by a torch or in a furnace, or even by resistance, where the parts are pressed under pressure between two carbon electrodes.

Copper base alloys require heating to 2000°F. or above, for sufficient fluidity for effective union.

Oxy-Acetylene Bronze Welding

Oxy-acetylene welding may be used with a bronze filler rod, rather than a cast iron filler rod.

The disadvantage of this is a very poor appearance, in that the color of the weld is entirely different and electrolytic corrosion may be a problem. The advantages are that the brazing temperatures are not as high, resulting in a savings in the case of labor and also less tendency for overheating the base metal. Tensile strengths of between 50,000 and 70,000 psi are possible.