Text-book Series No. 8

SHEET METAL WORK

1970

OVERSEAS TECHNICAL COOPERATION AGENCY

JAPAN

FOREWORD

In order to meet the growing requests for the services of Japanese experts in various fields from developing countries, the Overseas Technical Cooperation Agency entrusted with the mission of extending technical cooperation toward those countries by the Government of Japan, is making every possible effort to recruit qualified experts.

However, it is understood that one of the major difficulties encountered by the experts in carrying out training, demonstration, research and experiments abroad is the "language barrier" which sometimes resulted in ineffective implementation of the experts assignment project.

Therefore, in order to settle the difficulty and to obtain good result in the technical guidance by the experts, the Overseas Technical Cooperation Agency has started to publish a series of technical text-books.

This technical text-book on "SHEET METAL WORK" is the translated issue from the Japanese text-book prepared for the vocational training at the Vocational Training Institute by the Ministry of Labour, Government of Japan.

It is hoped that this book will be fully utilized not only by the experts but also by their counterparts and trainess of receipient countries and thereby will serve as an aid to the technical development in the developing countries.

March 1970

Overseas Technical Cooperation Agency

Tokyo, Japan.

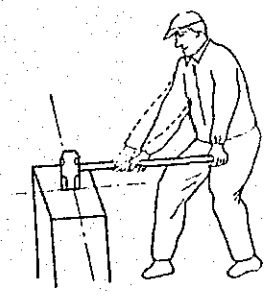
TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

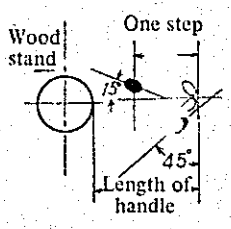
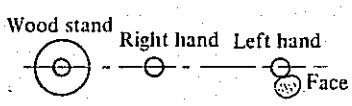
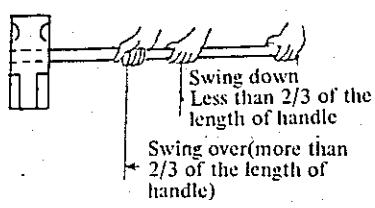
TABLE OF CONTENTS (Con'd)

FIG. 1

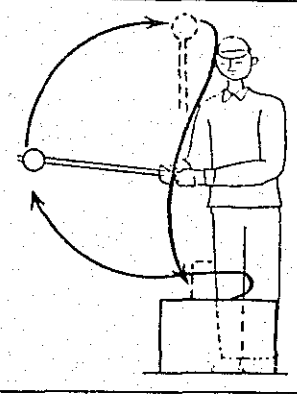
FIG. 2



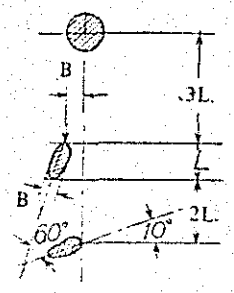
Work No.	No. 1
Type of work	Use of striker (1)
Main points	Correct pattern in the use of striker
Materials	Wood stand (for practice purpose) Diameter 300 x 450 – Height 500 mm
Tools	Anvil block, striker for practice purpose (10, 12 lb)

No,	Sequence of Work	Description	Related Information
1.	Position 	1. Face wood stand and stand at a distance equivalent to the length of the handle of striker. 2. Step the right foot forward and fix the position of the foot as shown in the sketch at left. (Maintain the angle of right foot to the center line of wood stand at about 15^{o} and that of left foot at 45^{o}). 3. Adjust the position of your feet so that the head of the striker will hit the center of wood stand horizontally.	1. A wedge should be driven deep to prevent the striker from slipping out from the handle 2. Generally, the length of handle is fixed at 90 cm but appropriate length is said to be that equivalent to the height from the ground to the arm pit of operator. 3. Select eigher 10 or 12 lb hammer depending on physical fitness.
2.	Holding of striker	1. Hold the end of the handle tight with the left hand in such a manner that the little finger comes over the handle tip (upper part of the right). See Fig. 2. 2. Place the right hand over the handle at the point a little further from the center of handle and grip it lightly. 3. Center line of the handle and the side face of operator should be on the straight line.	1. Position of the right hand on the handle should be adjusted depending on the statue of operator. 
3.	Take posture (Swing over)	1. Swing the hammer (striker) straight up to just above the right shoulder as shown in Fig. 2. At this moment the handle should touch the ear slightly and the right arm should be placed in such a manner as to hold the handle under arm. Left arm should touch the waist lightly. 2. Keep eyes on the position to be hit.	
4.	Strike (Swing down)	1. Swing down in a straight with the left hand kept at the side. See Fig. 2. 2. When making the swing down, stoop down a little so that the handle comes on a horizontal line at time of impact. 3. If right hand is extended forward or the body leans forward when the swing down is made, the hammer will miss the object.	1. Just before swing down both heels should be raised slightly and the body should be leaned forward slightly. 2. Hold the handle lightly with right hand and grip it rather hard with the left hand.
5.	Strike repeatedly	1. To swing over the hammer (striker) from the swing down position, shift right hand to a little further away and swing the striker up by utilizing the spring motion of reaction skillfully while straightening the body. While swinging up, retract right hand slightly. 2. Keep practicing on continuous blow by adjusting speed and force of percussion.	

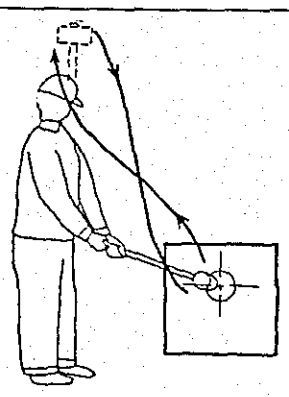
Remarks: When using a striker on anvil block, pay attention to the movement and instructions of the smith and swing it according to this instructions.



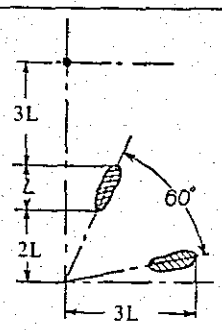
Work No.	No. 2
Type of work	Use of striker (2)
Main points	Correct pattern for spin blow of striker
Materials	
Tools	Striker (10, 12 lb) Anvil block for practice purpose

No.	Sequence of Work	Description	Related Information
1.	Take position 	1. Face anvil block and stand at a distance 3 time the length of the foot. 2. Shift left foot to the left for the width of the foot, pull back right foot and fix the position of feet as shown in the sketch at left.	
2.	Take posture	1. Grip the handle tip rather hard with once left hand. 2. Place right hand just in front of the left hand and hold handle lightly.	
3.	Swing over	1. Shift the right hand gradually so as to make the distance between the two hands about 10-15 cm. 2. The handle should be held in an almost vertical position. 3. The weight of the body should be shifted on the right foot at the same time.	
4.	Strike (Swing down)	1. Slide right hand toward this side gradually. 2. Shift the weight of the body to the left foot at the time of impact. 3. Watch the point (to be hit) closely.	

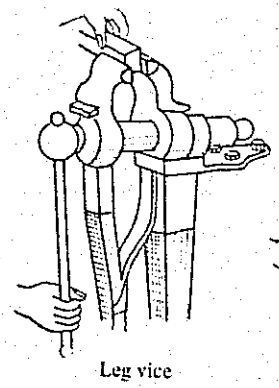
Remarks



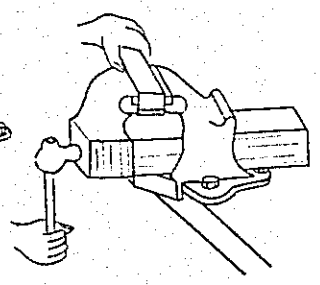
Work No.	No. 3
Type of work	Use of striker (3)
Main points	Correct pattern for side blow of striker
Materials	
Tools	Striker Anvil block for practice purpose

No.	Sequence of Work	Description	Related Information
1.		1. Face anvil block and stand at a distance 3 times the length of the foot. 2. Position right foot with toes pointing outward, shift left foot to the right and fix the position of feet as shown in the sketch at left.	
2.	Take posture	1. Hold the end of handle rather tight with the right hand. 2. Place the left hand about 20 cm ahead of the right hand and grip handle lightly.	
3.	Swing sideway	1. Shift the weight of the body to the right foot gradually. 2. This action should be in a natural form.	
4.	Strike the object	1. Keep eyes on the point (to be hit). 2. Shift the weight of the body to the left foot at this moment.	
5.	Strike continuously (repeatedly)	1. Motion of the striker should be smooth and in the pattern of ∞ by utilizing the reaction force of percussion, as shown in the sketch above.	

Remarks

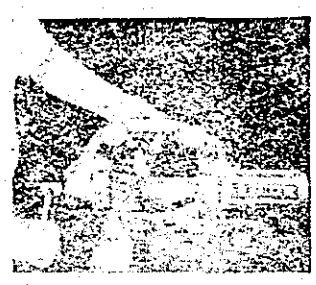


Leg vice



Parallel vice

Work No.	No. 4
Type of work	Use of vice (handling of vice)
Main points	Handling of vice
Materials	Test pieces, sheet metal, round bar, square bar (long bars and bars of special shape), rugs.
Tools	Leg vice, parallel vice, mouth piece

No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Select vice according to the type of work to be accomplished. 2. Keep the mouth piece clean.	Leg vice is suitable for rough work because of its rigid construction, and parallel vice is suited for precision work. The size of vice is expressed by the size of the width of opening (mouth).
2.	Open the mouth of vice	Stand facing the vice, hold the handle with right hand and turn it counter-clockwise. Open the mouth of the vice slightly wider than the material.	
3.	Squeeze mouth and clamp material 	1. Place material deep at the center of the mouth piece with left hand. 2. Turn handle clockwise and squeeze material at a right position. 3. Always keep the handle down. 4. Use special mouth piece for round bars or similar shaped materials. 5. When there is a possibility of one-sided sqeeze because of the shape of material, use a scrap metal of the same thickness as the material at the other end. 6. Add a splint when sqeezing a thin steel plate. 7. When inserting finished surface, use copper or lead mouth piece. Insert material deep into the mouth. 8. When placing a material of special shape on the vice, use mouth piece which is suitable for the shape or use hand vice.	1. Keep the mouth piece clean at all times. 2. Material of small diameter should not extend excessively over the mouth piece. 3. Do not hit handle of the vice with a hammer. 
4.	Turn handle back	Turn handle counter-clockwise with right hand and place left hand over the material to prevent it from falling.	
5.	Clean up	Clean and wipe off the vice with oily rugs after each use. Keep mouth closed.	

Remarks

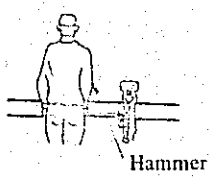


FIG. 1

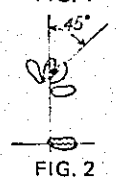


FIG. 2

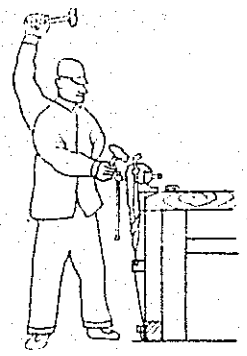
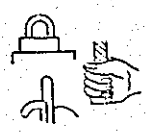
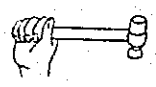
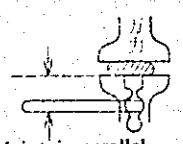
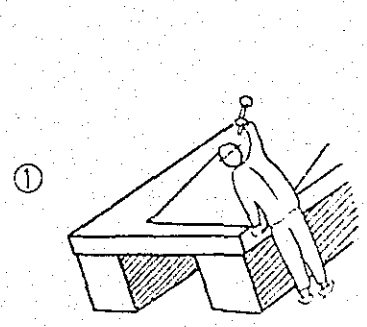


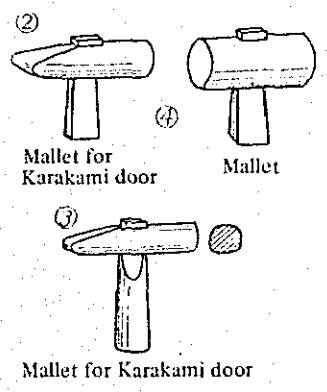
FIG. 3

Work No.	No.5
Type of work	Base requirements (basic work) of hammer swing
Main points	Swinging of a hammer
Materials	5/8" U-bolt, pad plate
Tools	5" leg vice, hammer (1 lb)

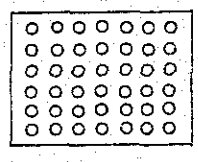
No.	Sequence of Work	Description	Related Information
1.	Make preparation 	1. Attach pad place to the leg vice, place U-bolt in the center of vice and tighten it down. 2. Hold the end of the handle of the hammer with right hand.	1. Make the handle of the hammer in appropriate length in proportion to the length of arm of operator. 2. Drive wedge propertly. 3. Make sure that the handle will not come in contact with oil or similar materials.
2.	Take position	1. Stand at left of the vice with a hammer held at a right angle as shown in Fig. 1. 2. Face half way to the right and slowly pull right foot back one step.	Position feet as shown in Fig. 2.
3.	Take a proper posture	1. Put the hammer against U-bolt at an angle of 20^{o} and adjust the position of the body. 2. Lean forward slightly. 3. Rest left hand at the waist. 4. Always watch the object.	
4.	Swing over 	1. Swing the hammer over until the flat head of it faces upward, without exerting an excessive strength while maintaining the hammer at 90^{o} to the arm. 2. Twist the upper half of the body to take the posture as shown in Fig. 3.	The hammer is swung only with the strength of arm for half swing The hammer is swung only with the strength of wrist for small swing.
5.	Swing down  Maintain parallel at time of percussion 3.0 x 2.0	1. Swing the hammer down aiming at the object. At that moment grip the handle tight. 2. Strike the center of U-bolt with the center of the flat head of the hammer with the line of percusiion maintained at an angle of about 30^{o}. 3. The hammer should have an inclination at an angle of 20^{o} when swung down. 4. At the moment of impact, the handle should be in parallel with the face of mouth piece of the vice.	
6.	Repeat above motion	Practice the above motion repeatedly until the balance of the body can be maintained without difficulty.	

Remarks





Work No.	No. 6
Type of work	Strain relieving
Main points	Strain relieving of thin plate
Materials	Mild steel sheet
Tools	Surface plate, mallet, mallet for Karakami door

No.	Sequence of Work	Description	Related Information
1.	Position plate	Place the plate in a diagonal position so that one corner will protrude to the outside of surface plate as shown in Fig. (1) above.	1. Two different types of mallet are available as shown in Fig. (2) above. Select the type suitable for the work to be performed.
2.	Strike the plate around strained portion 	1. Hold the plate securely with left hand as shown in Fig. (1) above. 2. Strike the strained portion with uniform strength at a regular intervals by keeping the mallet at a right angle to the sheet. The strained portion will be straightened gradually.	1. When there is a large curvature, stretch the sheet by bending it with hand in the opposite direction prior to the use of hammer. 2. Simple strain as shown below can be corrected without difficulty by striking the convexed surface. However, the strain of material generally has complicated aspects and the following basic works used in combination.  (1) The portion that was hit by a hammer becomes thinner slightly and increases its surface area. (2) When attempting to depress the convexed portion other than small convex, hitting the affected portion alone will only result in enlargement of the affected area. So, there is no alternative but to hit all around the affected portion. (3) When a paper sliding door hammer is used, care must be take not to damage the plate.
3.	Repeat the above motion	1. Continue this motion patiently until the strain is removed completely. 2. Toward the end of strain relieving work the strain of the plate changes considerably with each blow. Check the condition of the strain (expansion and contraction) closely by flipping the sheet up and down periodically.	When the sheet has any strains, flipping of the sheet on the surface plate will make a high metallic sound. As the strain is eliminated, the sheet produces a thick sound with wind pressure as if the sheet sticks fast to the surface plate. From the change in the sound and the movement of the sheet (when the strain still remains, the sheet makes undulating motion), degree of the strain remained may be easily detected.

Remarks (Note)

1. Strain in the thick plate may be relieved also by loosening the 3 rolls.
2. It is important that the hammer hits the sheet vertically (flat head of the hammer hits the sheet evenly). At first each blow may not pass the fixed locus and the hammer may swing in all directions and leave crescent-shaped dents on the sheet surface, thus making the material valueless. Efforts should be made to correct blows carefully and by taking proper posture.

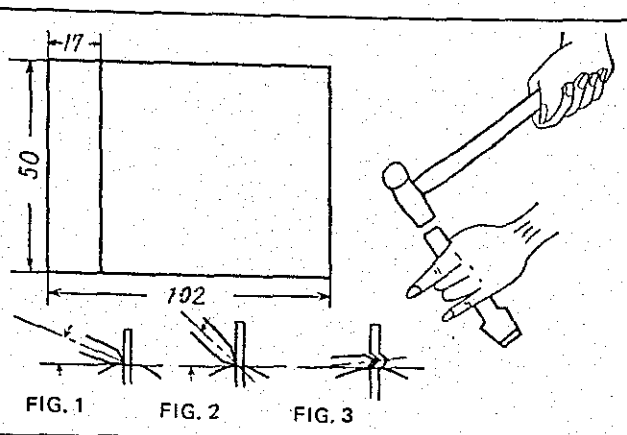
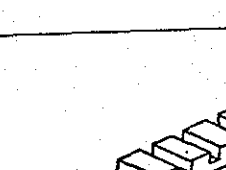
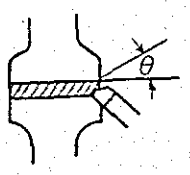


FIG. 1 FIG. 2 FIG. 3

Work No.	No. 7
Type of work	Chipping
Main points	Chipping of thin materials
Materials	Mild steel plate, 3 x 50 x 102 mm
Tools	Flat chisel, crosscut chisel, single hand hammer, marking-off pins, rules, leg vice

No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Mark off dimension lines with a rule and marking-off pins. 2. Make the vice hold material tight so that the marking-off lines come flush with the line of the mouth piece of vice.	
2.	Pick up chisel and hammer 	1. Hold the head of the chisel with the thumb, middle finger and third finger gripping the head and other fingers just placed over it lightly, as shown in the figure at left. 2. Refer to No. 8 for proper holding of the hammer.	Tool angle of chisel Material of work / Tool angle Copper, lead: 25 - 30° Cast, gun metal: 40 - 60° Mild steel: 50° Hard steel: 60 - 70° 1. Maintain bevel (chipping) angle at ½ of the tool angle. 2. If held like the one shown in Fig. 2, the chisel will cut in excessively. 3. If held like the one shown in Fig. 3, the material will slip away and become deformed.
3.	Take position 	1. Put the chisel against the right end of the material. Maintain the blade edge of chisel at an angle of 20 - 30 as shown in the figure at left. 2. Adjust the position of once feet according to the bevel (chipping) angle. Apply hammer to the head of chisel once to determine the position of feet.	1. Apply blade edge of the chisel to the material in horizontal direction. 2. Satisfactory chipping is obtained when cutting by chisel is made for 2/3 of the face and breakage by force is provided for the remaining 1/3.
4.	Chip material 	1. While striking the chisel in the manner as described in Work No. 8 move chisel gradually toward this side. During this process always watch the blade edge closely. 2. Use half swing at first and as the chipping work comes near finishing stage, shift to small swing. 3. Chipping should be made in such a manner that the chisel will cut off the material by forcing it against the mouth piece of vice.	1. When chipping a wide area, proper contact angle should be maintained, or the cut section will have irregularities. 2. When the chipping edge is greater, cut a groove with a crosscut chisel and chip it off with a flat chisel. 3. When chipping a hard material, blade edge should be cooled down with oil or water sometimes. 4. When chipping a hard material, the last portion of the chipped end often breaks away. So, the chipping for the last portion should be started from the opposite direction.

Remarks

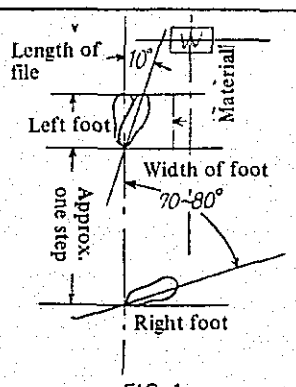
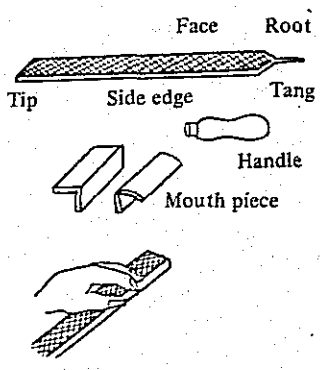
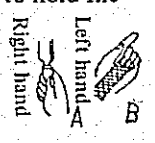
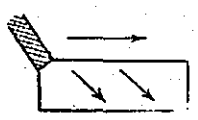


FIG. 1


FIG. 2

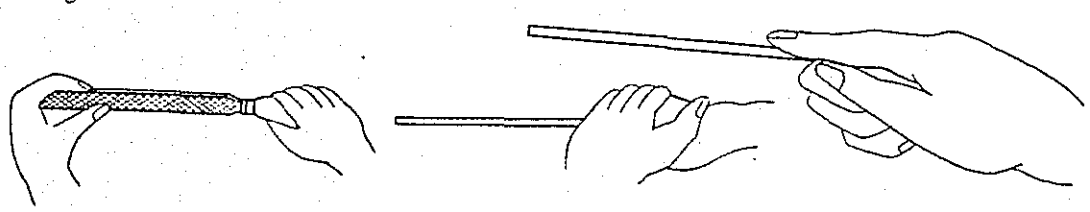

FIG. 3

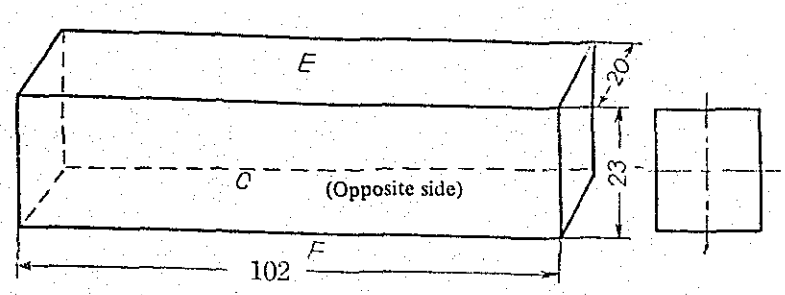
Work No.	No. 8
Type of work	Filing
Main points	How to use a file
Materials	Mild steel bar, 38 in diameter x 55mm
Tools	14" flat file (coarse), 14" square file (coarse), wire brush, 5" leg vice

No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Insert file deep and straight into the handle. 2. Put material on the vice properly in the manner described in Work No. 7.	 Place left hand over the file when a long one is used, as shown in the figure above.
2.	Take position	Take position as shown in Fig. 1 with left foot stepped to the left in the width of the leg of vice and to the back of work bench in the length of file, and the right foot one step back from the left foot and opened at an angle of 70 - 85° to the left foot.	
3.	How to hold file 	1. Hold file with the thumb place over it as shown in the figure at left. 2. Hold the end of file with the palm of the left hand as shown in the figure at left.	
4.	Take posture A B	Hold file as shown in Fig. 2. Do not exert too much strength to the left hand.	
5.	Push file forward .	1. Watch material closely and bend left leg slightly. At the same time, put the upper half of the body forward and thrust file forward horizontally by keeping left elbow close at the side of the body. 2. Put the weight of the body on the file evenly.	1. Straight forward method: (1) The method described at left is the straight forward method. Since the cutting edge has a certain angle to the direction of movement of the file, it provides smooth filing. (2) Use entire the length of the file. 2. Diagonal forward method:  With the diagonal forward method the file is moved from right to left. Because of the right angle which is formed by the cutting edge and the direction of the movement of the file, it provide a sharp cutting. Generally, both the straight forward method and the diagonal forward method are used in combination.  Scrape off black skin with a knife.
6.	Pull back file	While holding the file horizontally, slowly pull it back by weakening the strength without removing left hand from the file and regain original posture at the same time.	
7.	Repeat above action	Repeat the above action by maintaining the balance of the body. Practice at the rate of 30 – 40 strokes per minute.	

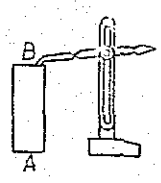
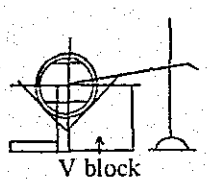
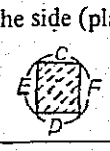
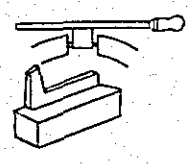
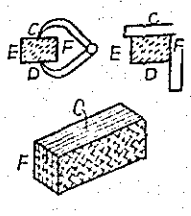
Remarks

Holding of a small file

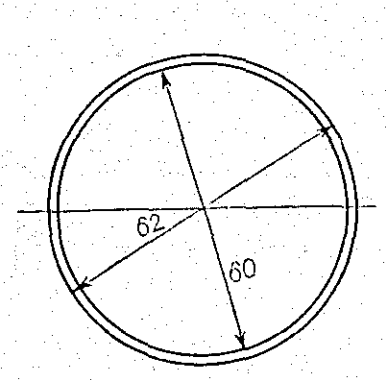


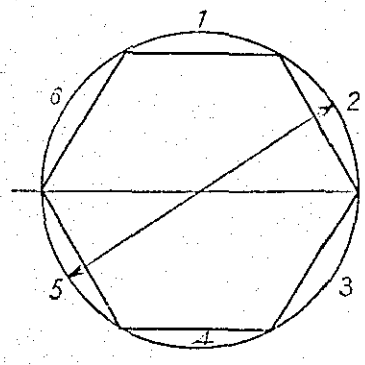


Work No.	No. 9
Type of work	Filing
Main points	Practice on use of file and hammer, right angle finishing
Materials	Mild steel, 1-1/4 x 4-1/8" in diameter
Tools	14" square bastard cut file, surface gage, hammer, chisel, rule, outside diameter calipers, square (or straight edge), V block.

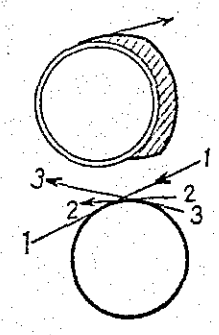
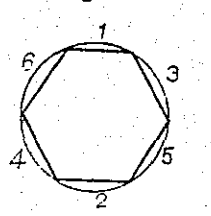
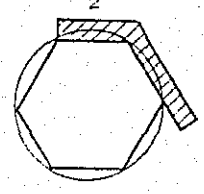
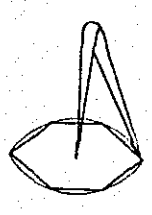
No.	Sequence of Work	Description	Related Information
1.	Finish the plane of both ends 	1. As both ends of the material cut with a saw band have not yet been given a finishing work, finish *plane A almost at a right angle to the side plane.* 2. Mark off plane B for the length of 102 mm with a surface gage and finish the end in the same manner as described in No. l.	Check of the plane is to be made with a surface gage as shown in the figure at left.
2.	Mark off end plane 	1. Determine the center of end plane and mark off parallel lines, each 10 mm long, at the upper and lower portions of both ends. 2. Turn it 90° and mark off vertical line with a square. 3. Mark off parallel lines, each at the point 11.5 mm above and below the center respectively.	
3.	Chip the side (plane) 	Chip a groove from plane C with a crosscut chisel and chip the plane off with a flat chisel leaving an 1 mm wide finishing allowance	Proper cutting depth by chisel is 1 - 2 mm.
4.	Finish plane C 	1. Finish plane C while paying attention so that finished surface will not result in a crown. 2. Finish the plane by checking it with a square. Work crosswise until smooth surface is obtained. 3. After giving adequate rough finish, use a medium cut file. 4. A square or straight edge should be used to check the plane finished with a file.	1. During the rough finishing work change the direction of file sometime so that a crown may be avoided. 2. When giving a rough finish work to a rectangle object, apply file sideway or horizontally.
5.	Finish planes D, E and F 	1. After finishing plane D, check the level with an outside diameter calipers or a surface gage and correct irregularities. 2. Finish planes E and F with a file to make them at a right angle to planes C and D. 3. Make all filing trace (grains) arranged in parallel (referred to as KEEPING VERTICAL FILING TRACES). 4. Finish plane F with a smooth-cut file. Finishing work should be given in such a manner that the upper grain (trace) and lower grain (trace) will show distinctly.	Quality of material finished may be determined by the arrangement of file trace (grain).

Remarks
1. Shave (scrape) off black skin with the small blade of the file.
2. When there is a possibility of filling up of file blade with filing chips, fill blade up with chalks (only for smooth-cut file and dead-smooth-cut file).
3. When using a new file, start it with soft metals.
4. Brush off file sometimes (Use brush in the direction of alignment of cutting blade).

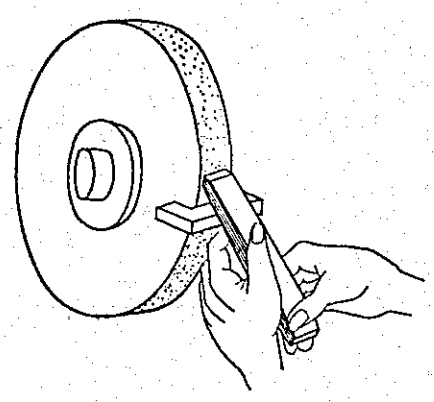




Work No.	No. 10
Type of work	Filing
Main points	Round finishing Thin materials Hexagon finishing
Materials	Mild steel, 65 x 65 x 6 mm
Tools	Compass, center punch, single calipers, marking-off pin, green bamboo, hammer, rule, 12" flat file (bastard cut), 10" flat file (medium), V block, 120 gage

No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Determine the center with a single calipers from angle line and punch a marking. 2. Mark off two circles, each having a diameter of 62 mm and 60 mm respectively. 3. Cut off four corners with a hacksaw. Care should be exercised not to cut into the mark-off line.	When making an oblique angle cutting, make a right angle cut first.
2.	Make round finishing 	1. Give a finishing touch with a file by maintaining a right angle of the mark-off line to the plane. 2. Correct roundness by ascertaining the dimension from the center with a single calipers. 3. To maintain a right angle of the finished face to the side plane, place V block over the surface plate, put finished face against the side face of V block and file off the portion which is higher than others. 4. After obtaining approximate roundness, work in the direction of roundness with a medium file by moving it from 1 - 1 to 2 - 2 and then to 3 - 3 as shown in Fig. B.	When the file is used from the side from the beginning of finishing work, it makes the work hard to obtain roundness. It is also hard with thin materials to obtain a right angle because it requires finishing work by using only one side as a basis.
3.	Make hexagon finish   	1. Divide the 60 mm circle which was previously marked off into six equal parts. 2. Start finishing work from the place No. 1 followed by opposite side. Before shifting to the other side, ascertain the level (smoothness) of finished plane with a surface gage. 3. Shift to the next plane and finish it by using 120 gage on the plane having obtained smoothness as a basis.	

Remarks



Work No.	No. 11
Type of work	Grinding of flat chisel
Main points	1. Use of grinder 2. Grinding of cutting tools
Materials	
Tools	Grinder, gage, score, goggles, flat chisel

No.	Sequence of Work	Description	Related Information
1.	Take position	1. Stand to one side, not in front of the grinder. 2. Goggles must be worn at all times.	1. Regulation calls for the installation of shield at all times. 2. Irregularities on the grinding surface of emery wheel should be smoothed off with tools. 3. It is important to check emery wheel closely to detect any cracks. 4. Proper clearance between the emery wheel and the rest should be maintained (2 - 3 mm).
2.	Switch on grinder		
3.	Apply blade to emery wheel	1. After constant speed has been obtained. 2. Put the chisel on the rest and hold it tight with both hands. 3. Check the angle of the chisel to the emery wheel (its relations with tool angle) closely.	Standard tool angles are 25 - 30° for copper and lead, 40 - 60° for brass, and cast iron, 50° for mild steel and 60 - 70° for hard steel.
4.	Start grinding	1. By maintaining a close check to obtain correct tool angle and tool line. 2. Don't forget to immerse tools sometimes so that the tool blade will not become blunt.	1. Hold the tool to the light and check the condition of the blade. 2. Rise in the temperature, which may cause dullness of the blade, this can be detected by watching the change in the color of the tool.

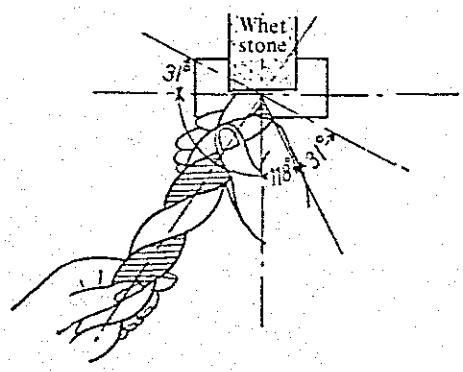
Remarks

(Inspection)

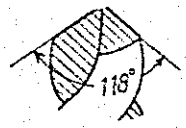
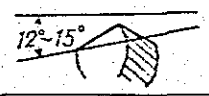
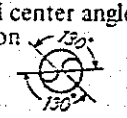
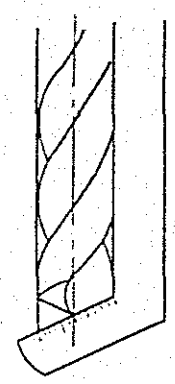
Check with gage and score to see that proper tool angle has been obtained and the blade line is at right angle.

(Note)

1. When grinding round material like a mark-off pin, apply it to the grinder by turning it around to obtain better result.
2. Grinder may also be used for cutting a small work in place of a hand file.

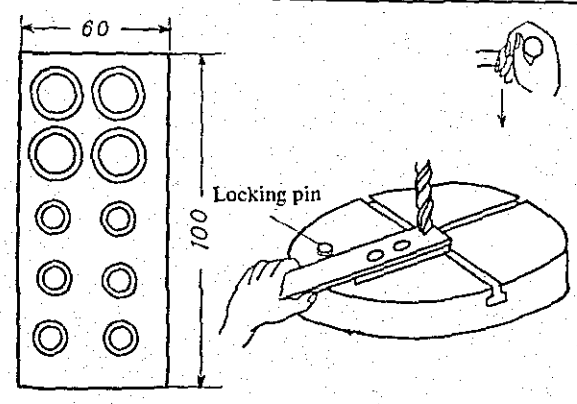


Work No.	No. 12
Type of work	Grinding of drill heads
Main points	Hand-held grinding
Materials	
Tools	Drill gage, tool grinding machine, drill head of various types

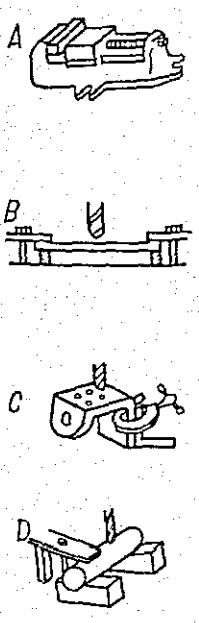
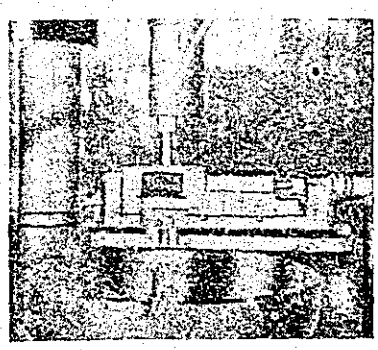
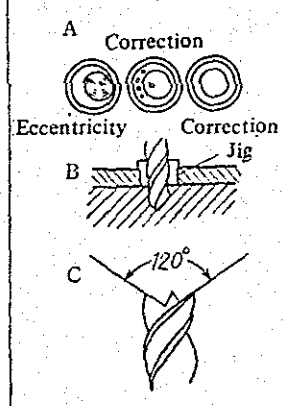
No.	Sequence of Work	Description	Related Information
1.	Grind front side 	1. Grind front side first to obtain correct center angle of cutting edge, as shown in the figure at left. 2. When the grinding surface of emery wheel has irregularities, correct them before proceeding with grinding a tool.	Improper blade tip often weakens cutting edges and causes breakage even when proper tool angle and inclined angle are provided.
2.	Grind tool angle portion 	1. When grinding the cutting edge, hold the drill head as shown in the figure above. 2. By rasing it with right hand above the contact point, grind it to provide a tool angle of 118°.	In this case, lower the drill head slightly with the left hand while turning the drill head counter-clockwise with left hand.
3.	Grind inclined angle portion 	Grind it to provide an inclined angle of 12 - 15°.	If the inclined angle is too great, it results in weakened cutting edge and it is too small, on the contrary, the cutting edge becomes dull.
4.	Grind center angle portion 	Grind it to provide a center angle of 130°.	If the center angle is too small, cutting force becomes weakened.
5.	Grind blade length 	1. Grind blade length correctly. 2. Make uniform grinding by measuring it with a drill gage.	When there is a difference in the blade length, the bore to be drilled will become larger than intended.

Material of work	Angle of cutting edge	Angle of relief
General (ordinary materials)	118	12-15
Hard steel	118	7-10
Brass, gun metal	90	5-10
Copper	90	3-8
Fiber	90	0-5

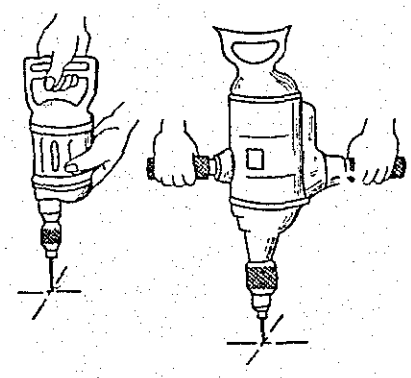
Remarks



Work No.	No. 13
Type of work	Drilling by drill press
Main points	How to start drilling How to drill a hole
Materials	Mild steel, 100 x 60 x 13 mm
Tools	Drill head (5.8mm), single calipers, drill chuck, sleeve hammer, socket, drift, compass, center punch, rules

No.	Sequence of Work	Description	Related Information
1.	Make preparation 	1. Make off the dimension to be drilled. 2. Always mark off waste lines (auxiliary mark-off) at the portion to be drilled. 3. Punch at the hole mark and waste mark. Use a larger punch correctly for the center portion. 4. When installing a work, place a thick anvil block under the work depending the shape of work so that the tip of drill head will not cut into the table. (See Figure B at left). 5. Attach a drill head securely. 6. Determine revolution and feed speed according to the material and the size of drill head. 	Waste mark-off should be used as the target of correct drill hole. Small punch often causes slipping of drill tip. 1. Use locking pin for a long material to prevent it from turning around, as shown in the figure above. 2. It is a dangerous practice to hold a small work with hand. Use table vice as shown in Fig. A at left. 3. Also see Fig. C and D at left.
2.	Start drilling 	1. Adjust the center of the drill head to the center punch hole and switch on the drill. 2. Initial drilling should be made lightly to correct eccentricity of the hole. 3. After correcting the eccentricity, start drilling at a regular feed speed. 4. At the final stage of drilling slow down feeding, or there will be a cut-in (or the drill head breaks out sometimes). 5. When the drill head swings or when there are porosity in the material, use a guide jig as shown in Fig. B at left. 6. Drill head used for thin materials should be ground as shown in Fig. B at left.	1. Correction of eccentricity can not be accomplished unless the size of hole becomes the same as that of the drill head. 2. When the extent of eccentricity is greater, cut a groove and correct the hole with a punch or hole correction chisel. 3. Use cutting oil depending on the material. 4. When a large hole is to be drilled, make a base hole first. 5. Use a jig for diagonal holes. 6. Use V block for round materials. 7. When drilling staggered holes, seal other holes with filler metal. 8. Drill head used for thin materials should be of the type shown in Fig. C at left, otherwise the drill head slips away and would not make a true circle because of lack of guide portion at the center.

Remarks Desirable drilling: If proper cutting edge and the second are obtained by proper grinding and appropriate revolution of drill head and feeding is provided, chips of uniform size (roughness) will come out from the groove at the side in an uniform pattern in the case of cast iron. In the case of mild steel, twisted chips will come out uniformly and continouously.



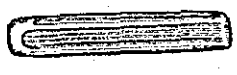
Work No.	No. 14
Type of work	Drilling by electric drilling machine
Main points	Use of electric drilling machine How to drill a hole
Materials	Mild steel; 2 sheets 3 x 40 x 150 mm 2 sheets 5 x 40 x 150 mm
Tools	Electric drilling machine, drill head (¼", 11 mm), chuck handle, pad plate

No.	Sequence of Work	Description	Related Information
1.	Attach drill head	1. Do not use drill head other than designated. 2. Tighten it securely with a chuck handle. 3. Plug in the extension cord.	1. Marking-off and center punch hole should be made in the same manner as described in No.13. 2. It is important that the drill head be sharpened well and ready for use (Refer to No. 12). 3. If inserted too deep, the drill head breaks off. Drill head should be inserted in such a manner as to leave the mark out of chuck. 4. Switch on to check the vibration of drill head. If not satisfactory, correct and try again.
2.	Set the tip of drill head at the punch hole (center of hole)	1. Secure material so that it will not move around. 2. Press it down slightly with drill head. 3. Maintain the balance of the body.	1. Small materials should be held rigidly in particular. 2. Place a pad plate beneath the material.
3.	Switch on the drill		
4.	Start drilling	1. Hold it securely so that the drill head rests on the plate surface vertically. 2. Press it down with uniform strength and not too hard. 3. At the final stage press it down lightly by weakening the strength so that the chuck will not hit the plate. 4. Care should be exercised not to break the drill head because the drill body is very unstable.	1. If pressed down excessively, revolution of drill head will be less than that required and results will not be satisfactory.

Remarks

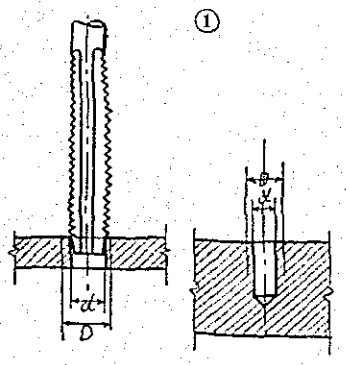
(Inspection)

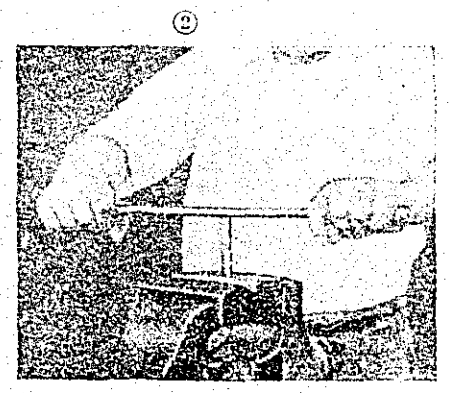
Check and see that the hole is at right angle to the material and it is not eccentric.



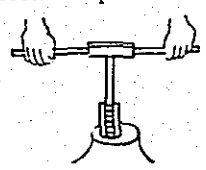
(Note)

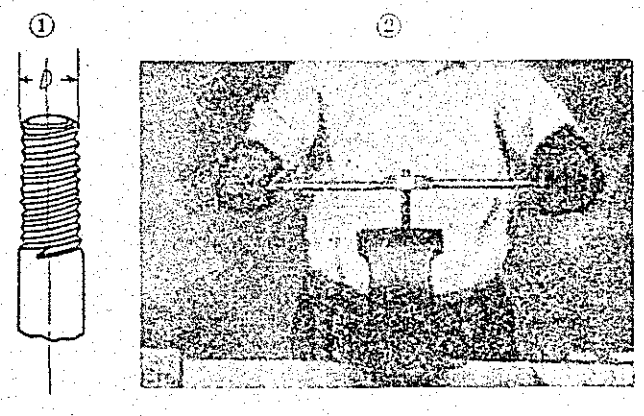
1. Precautions to be taken in general:
   (1) Check thoroughly to see that the extension cord is not frayed or plug is not damaged.
   (2) Extension cord should never be immersed in the water nor should it be placed under heavy material.
2. The type shown in the sketch above at left may be used with drill head up to 6.5 mm (¼") in size and is used on single phase 200 W. For larger drill head, the type shown above at right may be used for drill head up to 13 m/m (½") and is operated on single phase 500 W. Special large type may be used with drill head up to 32 m/m (1-1/4") and is operated on three phase 1,200 W and in this case the drill head is installed with a Mohr's taper socket and not with a chuck.
3. When drilling a hole in thin plate or mild (soft) material, a piercing punch like the one shown above at right is sometimes used. A hole 1/8" in diameter may be pierced with this punch.



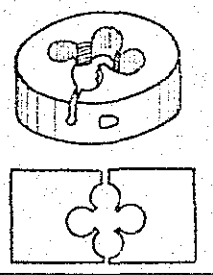
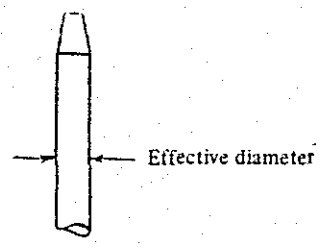


Work No.	No. 15
Type of work	Tapping
Main points	How to place a tap
Materials	Perforated mild steel plate (by Work No. 13)
Tools	Tap (6 mm, 3/8") tap wrench, square, vice, oil brush

No.	Sequence of Work	Description
1.	How to place a tap 	1. Base hole for the tap should be of a proper size. 2. Blind hole should be deeper than the depth of tap by 4 to 5 mm. 3. Use tap wrench of appropriate size depending on the size of tap. If tap is first used on tube, the tap will break out. 4. First hand tap should be used at first. 5. Turn first hand tap several times to see if tap is held at right angle. 6. Turn the tap to 270° and then turn it back to 90°. Repeat this while crewing in the tap. 7. Use cutting oil of appropriate type depending on material. 8. Twist of tap hole should be corrected by the first hand tap because it can not be corrected by the second hand tap. 9. Tap wrench should always be handled with both hands, not with one hand. 10. When tapping a blind hole, rake out chips sometimes. 11. For the taps of larger size, use drill press and press down taps with the center to get better results.
2.	How to take out (screw out) a broken tap 	1. When there is a fairly long portion sticking out above the hole, turn it with a tap wrench or make a new head and turn it with a tap wrench. 2. When the end of the tap sticks out above the hole by about one thread, turn it back slightly in the direction of loosening by hitting it with a chisel or punch. 3. Anneal the broken tap if possible, drill a small hole on the tap through (from) the bottom of tap hole and pull (screw) out the tap. (Drive a bolt in and turn it back with a monkey wrench).
3.	Types of tap available	Hand tap Machine tap Nut tap Taper tap Expansion tap Gas tap Adjustable tap Tapper tap Still-bolt tap Inserted-blade tap

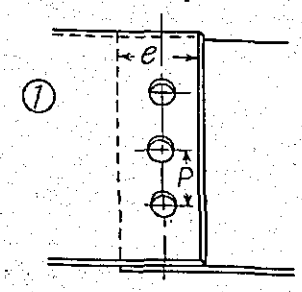


Work No.	No. 16
Type of work	Tapping
Main points	Use of dies
Materials	Round mild steel bar Cutting oil
Tools	Die, die stock, files, vice and oil brush

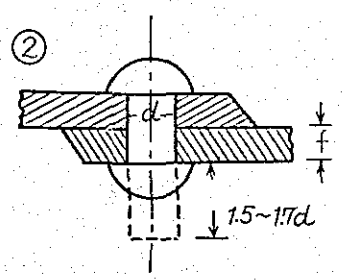
No.	Subject	Description
1.	Construction of die 	1. A die has four or five teeth, half of which act as guide teeth. 2. When setting it on die stock, keep the guide teetch facing up. 3. When using it for thread cutting, keep the guide teeth facing down. 4. Button tool has a screw which controls the bore size. By adjusting this screw, rough finishing of thread may be accomplished.
2.	How to cut threads	1. Thread cutting with a die may be accomplished in the same manner as for tapping. 2. To cut the thread, put the die on die stock, put it against the end of round bar, turn die stock slowly so that the bar may come into the guide face, and cut threads while maintaining die horizontally and at a right angle to the round bar. 3. Care should be exercised not to confuse front of die with its back. 4. Diameter of the round bar to threaded would match with the designated dimension of die. 5. End of the round bar should be beveled slightly with a file to provide a good bite for the die. 6. Male thread and female thread should fit well by their effective diameter. 7. When cutting threads, use seed oil for steel as a cutting oil. No seed oil should be used for cast iron. Use petroleum for hard materials as a cutting oil. 

Remarks

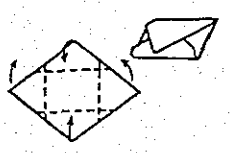
Length of overlap and rivet space



Diameter and length of rivet



Work No.	No. 17
Type of work	Annealing of mild steel rivet
Main points	Single annealing of mild steel rivet
Materials	Mild steel rivet 6 mm Scrap iron sheet, coke
Tools	Fire bed (pot), fire hook, pliers

No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Build a fire in the fire bed. 2. Select rivet, determine the length of rivet and cut it to the length.	1. Determination of the diameter of rivet: Size of rivet should be determined according to the thickness of material to be rivetted. If the size of rivet is too small for the plate, it will result in a weak rivetting and if too thick (large), on the contrary, it will hamper rivetting operations. Appropriate size of rivet depending on the thickness of plate has been determined as follows as a result of experiments. $d = \sqrt{5} \times t - 0.4$ (m/m) 2. Length of rivet $l = T + 1.5 + 1.7d$ Where T is the thickness of plate when clamped (thickness of plate t x number of plate) (Refer to Fig. (2) above)
2.	Wrap rivet with iron sheet	1. Fold the sheet in four (from four corners) and fold four edges one above another with a pair of pliers while exercising care not to cut the hand.	
3.	Heat rivet	Put rivet in the fire bed in such a manner as if to cover it up with coke by using a fire hook. 	
4.	Take rivet out and bury it in the ashes	1. When the rivet shows a luminous white color, take it out.	1. As a simple method to prevent oxidization of rivet by direct contact with flame and to heat a large quantity of rivet at one time, rivets are often wrapped with scrap iron sheets. In some cases, however, rivet are put in a small box or a piece of pipe.
5.	Take (unwrap) rivet out	1. Take rivet out of the ashes after it is sufficiently cooled down. 2. Unwrap iron sheet cover with a pair of pliers and take rivet out.	1. Though the appropriate beating temperature for annealing mild steel rivet is about 650°C (red), the rise in the temperature of rivet when wrapped in the iron sheet is much slower than that for the wrapping material. Therefore, heating should be continued until the wrapping material becomes luminous white in white color (about 1,200°C). 2. Appropriate heating temperature for brass and duralumin is also about 650°C but these materials should be cooled (quenched) quickly in the water (annealed in the water). 3. Overheated rivet is fragile and is not to be used.

Remarks (Note)

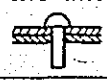
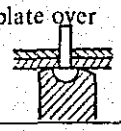
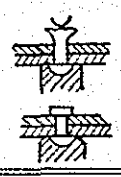
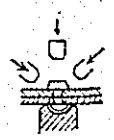
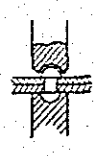
1. Material of rivet should be the same as that of the plate to be rivetted in principle.
2. Rivet of soft material such as copper and aluminum should be used cold but brass, duralumin and steel rivets should be annealed prior to their use.

(Question)

1. What would be the appropriate diameter of rivet for the plate of 3, 5, 7, and 9 m/m in thickness?
2. What would be the appropriate pitch when the thickness of plate is 3 m/m and the bore is 6 m/m in diameter? Use following formula.

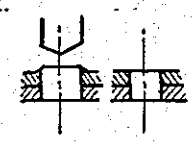
$$P = \frac{\left(\frac{\pi}{4} d^2\right) \times 0.8}{t} + d$$

Work No.	No. 18
Type of work	Rivetting with mild steel rivet (cold operation)
Main points	Cold rivetting operation with mild steel rivet
Materials	Perforated mild steel plate (by Work No. 14) Annealed 6 mm mild steel rivet (by Work No. 17)
Tools	Single hand hammer, pad plate, snap, Pile

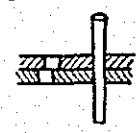
	No.	Sequence of Work	Description
A Flat crush	1.	Force the rivet into the hole 	1. Force the rivet into the hole from underneath without turning the plate up.
	2.	Place the plate over the pad 	1. Place the plate on the pad so that the rivet stands vertically and fit the rivet head to the hole on the pad.
	3.	Crush the rivet with a hammer 	1. Hit the rivet with uniform force so that the center of the hammer will come to perpendicular to the leg of rivet. 2. Finish up the shape gradually.
B Spherical head finish	1.	Force the rivet into the hole	1. In the same manner as in paragraph A.
	2.	Place the plate over the pad	1. In the same manner as in paragraph A.
	3.	Crush rivet with a hammer 	1. Hit hard for the first two or three blows so that the center of the hammer will be perpendicular to the leg of rivet. 2. Finish it up gradually by hitting around the leg of rivet diagonally.
	4.	Finish with a snap 	1. Apply snap to the center of the leg of rivet. 2. Hit hard while examining the shape.

Related Information

1. When rivetting two plates together, the rivet hole may be drilled by laying the plate on above another or it may be drilled separately by copying the hole of another plate. Holes drilled separately without using a jig do not match each other sometimes. In this case, hold plate with an erection bolt and finish the hole with a drill or a taper reamer.
   Care should be exercised when using a bolt because it often breaks out.
2. The hole made by a drill often has some burr as shown in the figure at right.
   Remove the burr with a drill head or file.
   Slight bevelling at this time will also bring a better result.

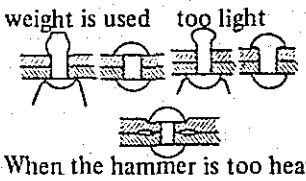


3. To prevent disagreement of holes in the laminated plate because of contraction, insert pile in the neighboring hole. See figure below.



4. If the hammer to be used is of improper weight, it will result in an unsatisfactory finishing work as shown below. It is important, therefore, that a hammer of appropriate type is selected.

When the hammer of proper weight is used | When the hammer is too light



When the hammer is too heavy

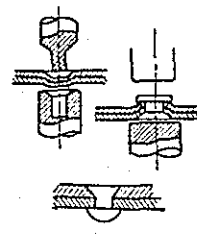
Remarks

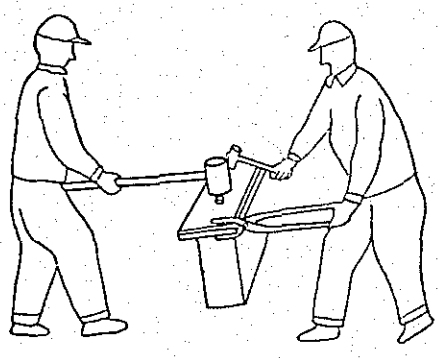
(Inspection)

Check to see that the rivet is not twisted. Check and see that the leg of rivet is satisfactory finished. Check to see that the centers of the upper and bottom head are in a straight line and there is no play between each plate.

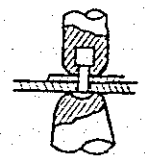
(Note)

Countersunk head rivet may also be possible by making a dish in rivet hole in advance with a drill, but it is not practical with thin materials. Therefore, head-out countersunk rivet is often made by drilling a small hole in advance as shown in the sketch below.





Work No.	No. 19
Type of work	Rivetting with mild steel rivet (Heat treatment)
Main points	Rivetting by heat treatment
Materials	10 mm mild steel rivet Perforated mild steel plate (by Work No. 14) Coke
Tools	Single hand hammer, striker, fire tong, fire hook, pad plate, puller, round snap, fire bed (pot)

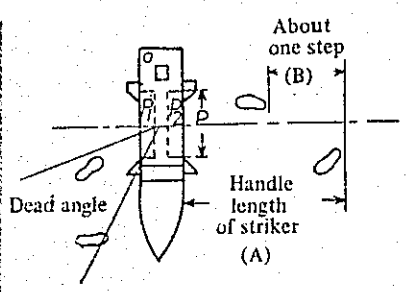
No.	Sequence of Work	Description	Related Information
1.	Heat up rivet	1. Place it in the fire bed gradually. 2. Heat half of the tip of rivet evenly. 3. Watch carefully the degree of heating--color (yellowish red) so that there will be no overheating.	1. Appropriate heating temperature for mild steel is from 800° to 900°C. If overheated, it will become brittle and tend to become corrode after rivetting. It is important, therefore, to give utmost attention to this point. For the portion subject to pressure, which requires special strength, rivet should be heated to 1,000° - 1,100°C. 2. Because of the intensity of coke fire, it is difficult to have the inside and outside of the rivet heated equally. Care should be taken when placing the rivet in the fire bed.
2.	Force the rivet into the hole	1. Remove scale thoroughly. 2. Insert the rivet in the hole promptly while having the partner hit the rivet lightly.	1. Since this process requires a prompt combined work, there should be a coordinated work with sufficient signals exchanged.
3.	Place the rivet head on the pad	1. Place the rivet head in the cavity of pad.	
4.	Pull rivet out 	1. In such a manner that the base material will stick to it closely.	
5.	Hit alternately	1. Hit hard for the first two or three blows on the center of rivet vertically. 2. Shape it up gradually.	
6.	Finish with a snap	1. Align the center correctly.	

Remarks (Inspection)

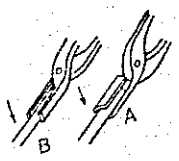
Check and see that the rivet is not crooked. See if the leg of rivet is finished satisfactorily. See if the centers of the upper and bottom heads are in a straight line. See if there is any play.

(Note)

When rivetting in a long line, it is advisable to rivet every other hole like No. 2, 4 and 6 in that order and then start rivetting skipped hole afterward.

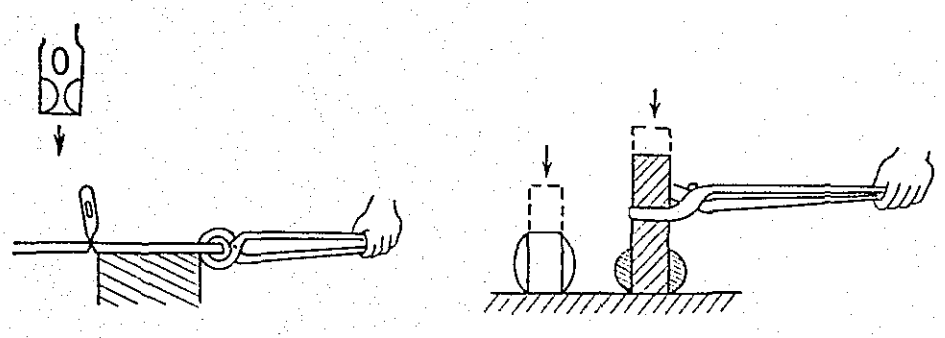


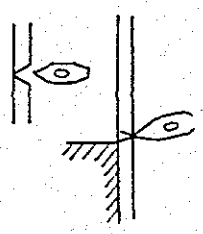
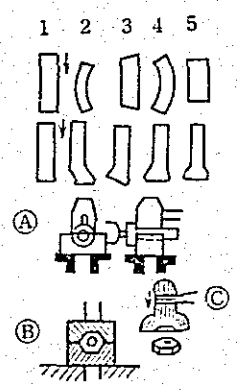
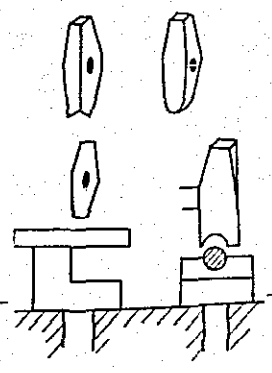
Work No.	No. 20
Type of work	Fundamentals of fire work
Main points	Posture of the smith Handling of fire tong Hammer blow
Materials	Cutting tool of various type (scrap materials)
Tools	Anvil block, striker of various types, large fire tong, single hand hammer

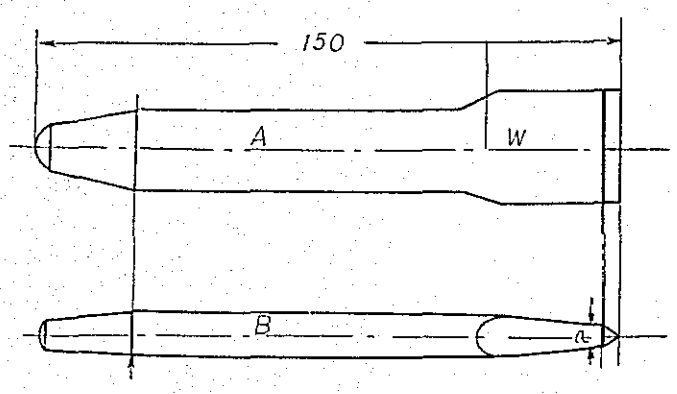
No.	Sequence of Work	Description	Related Information
1.	Position	1. Position of right foot varies depending on the length of material as shown in the figure above at right. 2. Position of left foot should be at half step back at a right angle. 3. Take a half-sitting posture as shown in the figure at left.	1. Smith is responsible for finishing it in required shape with the help of smith helper. 2. It is important for the smith, therefore, that he gives appropriate signals to the smith helper to have good communication between them. 3. Forward corner of the anvil block (position of smith helper) is called (front ken). 4. Position of the smith is called (rear ken). 5. Pointed end at right is called crows bill. 6. Top surface of anvil block should be used for flattening work. 7. Front and rear ken are used for making angles and bending. 8. Crow's bill is used for bending of the work.
2.	Take a posture	1. Hold the single hand hammer with right hand (See figure above). 2. Hold fire tong tight with left hand.	
3.	Pick up the work 	1. Hold material with a tong by pinching it from above and bottom as shown in Fig. A at left. 2. If held like the one shown in Fig. B at left, there is a possibility of flying over of the work when hit by hammer. 3. Fire work should be done in the center of anvil block.	
4.	Strike material	1. Supposing the strike made by smith helper sounds like "Tinkle, tinkle" and that by smith sounds like "Tap, tap": 2. Work should be harmonized in a tune something like, "Tinkle, tinkle, tap, tinkle, tinkle, tap; tinkle, tap; tinkle, tinkle, tap; tinkle, tap" 3. Show the position to be hit to the helper with a single hand hammer while beating time with the hammer. 4. Depending on the speed of the beat, smith helper adjusts his speed or strengthen his blow. 5. Smith gives instructions to the smith helper with his single hand hammer, not by works. 6. For ceasing the operation, lay the hammer to the side.	

Remarks

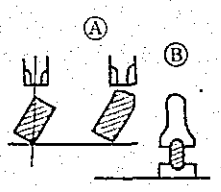
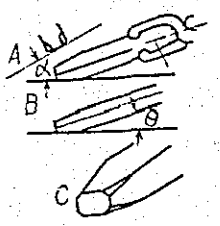
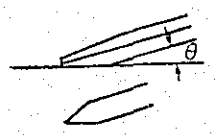
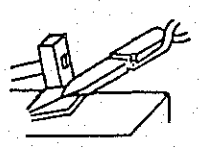
Subject	Fire Work (cutting, swaging)	Work No.	No.21

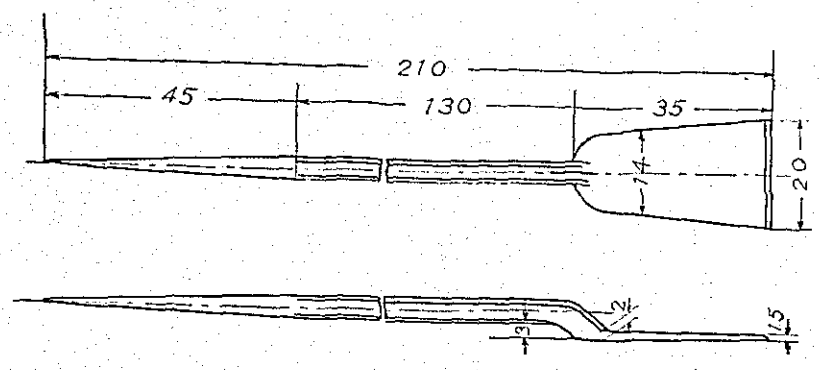


No.	Subject	Description
1.	Cutting down 	1. Cutting of heated material is done by first cutting in from the surface with a handle chisel once and then knocking it lightly with a hammer at the edge of front ken. 2. If a cut-in is made, flat cutting edge can not be obtained. 3. Cut-in on the surface should be made on the upper surface of anvil block. 4. Pay attention to the way the handle chisel is applied.
2.	Swaging 	1. Swaging is a work in which a small thin or narrow material is made broader or larger, or in which pins, rivets or bolt heads are made. 2. Blow the hammer down on the anvil block to make the work in the shape shown in No. 2 and then flatten it like the one shown in No.3. Strike it with the hammer to make it in the shape shown in No.4. 3. When making a bolt head, heat the portion to be expanded and swage it in the order of 1-2-3-4-5 as in the previous case. 4. Then correct the head and neck with a round tap (See Fig. (A)). 5. Then make a hexagon head with a shaping tap (See Fig. (B).) 6. Finish the head with a tap as shown in Fig. (C).
3.	Round chisel and set hammer 	1. Round chisels are available in two types, concave and convex types. Each type is used for its specific purpose. 2. Set hammer has two types, flat and round types. 3. Flat set hammer is used for cutting flat materials or square bars. 4. Round set hammer is used to cut round bars. 5. Use both flat and round set hammers by placing a set hammer stand on the anvil block or honeycomb and cut off the work at a right angle to the cutting line.

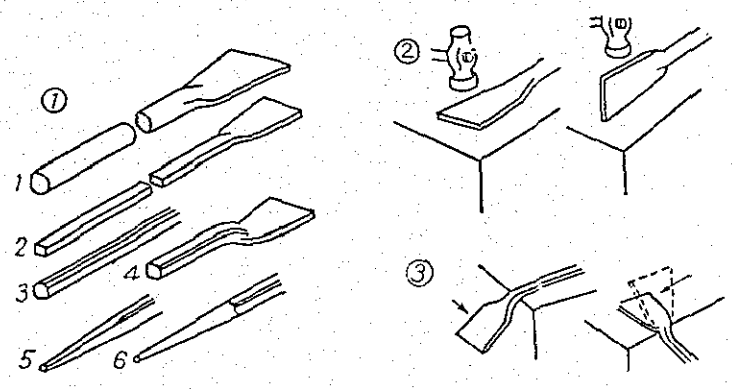
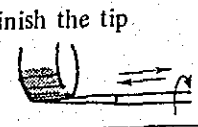


Work No.	No. 22
Type of work	Fire work (making flat chisel)
Main points	Use of striker and flattening tool
Materials	Hard steel 12 x 25 x 120 mm
Tools	Complete set of fire work tools

No.	Sequence of Work	Description	Related Information
1.	Make preparation	Obtain fire work tools and then build a fire.	Some chisels are oval in shape. When the chisel of this shape is used, procedures described at left may be omitted.
2.	Bevel corners 	1. Heat material to 900°–950°C and bevel corners with a striker and flattening tool as shown in Fig. A at left. 2. With the use of round tap and fullering tool, make the whole material round by working in the direction of diagonal line as shown in Fig. B at left. 3. Smith helper should strike the flurring tool correctly.	
3.	Make the head 	1. Have the smith helper hit the wider portion at the front ken of the anvil block to make the head. 2. Smith holds the work by maintaining an angle of (θ) only in this case (10°–15°). 3. The smith helper swings down his sledge hammer at an angle of α by sliding his hand down, and not horizond. 4. Narrow portion should also be treated by fire in the same manner as shown in Fig. B at left. 5. Cut the angle with flattering tool in the manner described in Work Sequence No. 2 to make it as shown Fig. C at left	1. As the proverb says, "Strike the iron while it is hot" excessively low temperature will result in a blue shortness, thus causing the material to become more fragile than the work treated cold. 2. Heating should be made as less frequently as practical, otherwise the composition of molecule will become coarse and weak.
4.	Finish tool edge 	1. The tip of tool edge should also be extended and flattened evenly on both top and bottom sides with a slight angle of (θ) in the same manner as described in Work Sequence No.3 2. Width of tool edge should be 30–35 mm and the width of portion a should be 3–4 mm. 3. Smooth out tool edge with a flattering tool to make the surface even.	
5.	Grind tool edge 	1. Grind both sides of tool edge uniformly as shown in Fig.A at left. 2. If ground like the one in Fig.B, it will result in a weak tool edge and it will not provide satisfactory chipping.	
6.	Hardening 	1. Heat it well and flatten tool edge both left and right from the center with a square tool. (See the figure at left. Use rear ken.). 2. Give it a shape by working left and right alternately. 3. Work it from both top and bottom surfaces alternately. Care should be taken so that the tool edge will be of uniform chickness. 4. Tool edge should be made somewhat thinner than the root. 5. Make the side round with a single hand hammer.	

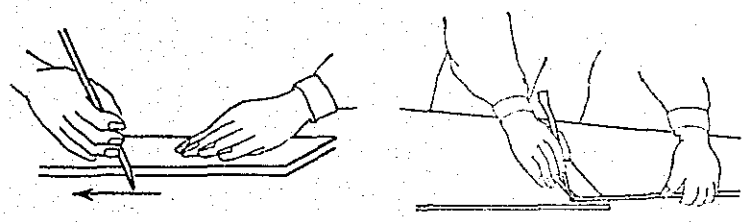


Work No.	No. 23
Type of work	Fire work (making marking-off *pins*)
Main points	1. Heating of material 2. Extention, chaping, expansion and bending of material
Materials	Hard steel, 7 x 110 mm, coke
Tools	Navil block, hammer, gad tongs, round tongs, fire bed, scale outside calipers

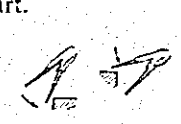
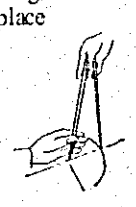
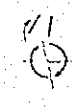
No.	Sequence of Work	Description	Related Information
1.	Make preparation	1. Prepare fire making tools. 2. Clean up fire bed and build a fire.	1. How to prepare a fire bed. Clean wind hole thoroughly, place a rostral, place coke over it in an uniformed thin layer and place kindling coal in the center. Then open the damper in the blasting duct slowly to about ¼, make such a thin layer of coke over the kindling coal that the kindling coal can still be seen and open the damper to ½. Slowly open the damper until it is fully opened while watching the spreading of fire.
2.	Heat material	1. Rake out intensified portion of the fire with a fire rake, place material on it and cover the entire portion to be heated with red hot coke. 2. Turn material over sometimes to give uniform heating. 3. Check the condition of material being heated – color (yellowish red) and pay attention so that the material will not be overheated.	2. Make a narrow fire bed for small materials. 3. Coke for this purpose should be the type18-9g.
			1. Heating temperature varies with the materials to be heated. Appropriate temperature is 1,200°C for wrought iron (white), 1,100°C for mild steel (light yellow), 900 –950°C for hard steel (yellowish red) and 1,100 –1,200°C for high speed steel. 2. Sudden application of heat will not result in uniform heating and prolonged application or excessively high temperature will degrade the material. Since appropriate finishing temperature is 800°C (red), treatment with the temperature lower than this will result in an unsatisfactory work. Once it is heated, try to finish the work before the material get cooled down, otherwise it must be reheated again. Heating of material in a number of times will exhastion of material. So efforts should be made to finish as quickly as possible.
3.	Shape up head (1) - Fig. 1	1. Take it out quickly and expand with a single hand hammer. 2. Give it a shape in the manner shown in Fig. (2). 3. Use center portion of anvil block.	
4.	Extend belly portion (1) - Fig. 2 & 3	1. Turn material over and strike each surface alternately. 2. Care should be exercised so that material will not be overheated and melted.	
5.	Bend the head (1) - Fig. 4	1. Bend it by utilizing the corner of front ken as shown in Fig. (3). 2. Bend it in opposite direction by utilizing the corner of rear ken.	
6.	Shape up the tip	1. Strike it in the order of ▨ ⬭ ◎	1. Care should be exercised so that the tip will not become too thin because it will result in crumple and cracks.
7.	Finish the tip 	1. Since it is impossible to give a complete round finishing by fire work alone, finishing work should be done with a grinder by turning the pin in longitudinal direction.	

Remarks (Inpsection)

Check and see that proper dimentions are maintained. Check for irregularities on fire worked portion. Check for cracks.

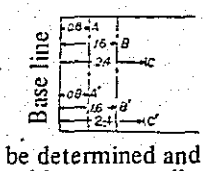


Work No.	No. 24
Type of work	Marking-off
Main points	Marking-off with mark-off pins and compass
Materials	Thin mild steel plate, galvanized iron sheet, tin plate
Tools	Rules, scale, mark-off pin, compass

No.	Sequence of Work	Description
1,	Hold mark-off pin	1. With four fingers of right hand as shown in Fig. (1) above.
2.	Hold down rule	1. Align the line of rule with the point correctly. 2. Spread fingers and hold it down rigidly to prevent it from shifting.
3,	Draw lines 	1. Keep eyes on the point of marker-off pin. 2. Draw lines from left to right and from bottom to top. 3. Keep the point of mark-off pin stuck to the side of rule as shown in the figure at left and draw a line at a stroke by tilting the pin slightly as shown in Fig. (1) above.
1.	Spread compass leg apart. 	1. Spread it a little wider than the dimension to be drawn with both hands. 2. Adjust graduations after fixing the leg firmly, which will be used as a base. 3. Minor adjustment can be made by padding it against wood portion as shown in the figure at left.
2.	Set the base leg at the center and place left hand along it. 	1. Set it at the center accurately. 2. Hold it securely with five fingers of left hand as shown in the figure at left.
3.	Turn it around 	1. Turn it around at a stroke while pressing it with the palm of right hand. 2. Turn it around by 180° in the same direction by shifting it twice.
4.	Check the result	1. Check diameter and radius thoroughly with a scale.

Related Information

1. How to take measurements: To take a measurement to determine the point for making-off, place a carpenter's square as shown in Fig. 2 above, set the graduation of scale to the base line with the left edge of the plate used as a basis and mark-off point A along the line at extreme right of the scale. After determining points A, connect them with a straight line and obtain parallel lines. In the same manner, B-B, C-C' may be determined and parallel lines may be obtained. In this way, equally spaced parallel lines may be marked off without making errors.

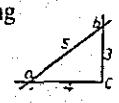


Making-off of dimensions should alway be done by watching (setting) graduations with the base line ans at the right end of scale as described above.

When the left edge of the plate is not straight, a base line must be drawn in advance.

2. To check the straightness of each edge of carpenters square, scale and rule, draw a line and then draw another line from the opposite direction. If the two lines match each other perfectly, lines are straight. If the result is the one like shown below, it indicates that edges are not straight.

3. To check the accuracy of right angle of carpenter's square, draw line on the extension of both sides as long as practical, determine the distance on both sides at a radio of 4 to 3 from the top as shown in the figure at right. If the distance a-b equals to 5, it shows the accuracy of right angle.



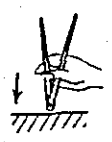
4. Graduations on carpenters square are shown both on front and back. Those on front side show true scale and those on the back are extended (expanded) scale. Relationship between the two is shown in the chart at right and its ratio is 1 : 2.

Length of one increment on back side

5. The point of mark-off pin must always be sharp in a cone shape. If the pint is dull and round, accurate marking can not be expected. To sharpen the point, work it on the grinder first and then with oil and a grind-stone. Since it has a tendency to become dull during grinding work, it is important that the point is quenched sometimes.

1. Calking of compass must always be tight and when loosen it must be retightened again.

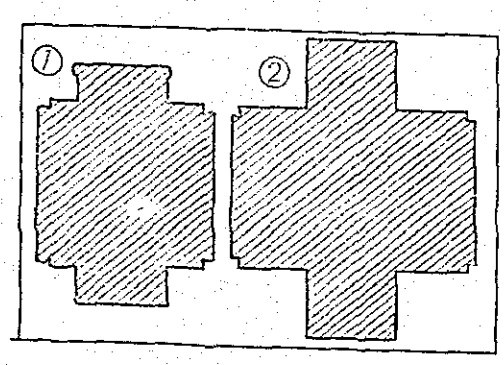
2. Minor adjustment should be given in the manner shown in the figure at right.



3. When marking off a small circle, it is advisable to turn the compass back with the same hand instead of shifting hand.

Remarks (Inspection)

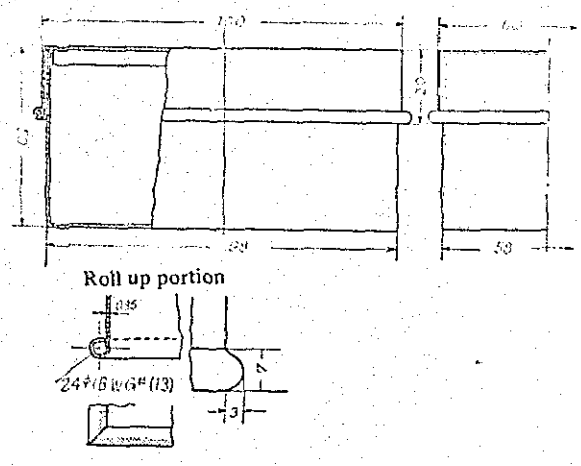
Check and see that the line is drawn thin, distinct, and that parallel lines are equally spaced, and that diameter and radius are accurately maintained.

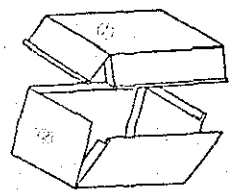


Work No.	No. 25
Type of work	*Sheet cutting for a small box* (Subject No. 1)
Main points	1. Marking-off of galvanized iron sheet. 2. Fundamental cubic deployment sheet cutting method 3. Lap edge, bend edge, roll edge
Materials	Galvanized iron sheet, BWG No. 28, 0.36 x 220 x 300 mm
Tools	Scale, carpenter's square, compass, marking-off pin

Subject No. 1 Small box

Scale 1 : 1





1. Use galvanized iron sheet BWG No. 28 (0.36 mm thick)
2. Joints should be soldered.
3. Width of lap edge should be 5 mm.
4. Width of roll up edge should be $2.4 \times 3.14 \times 3/4 + \frac{2.4}{2} \fallingdotseq 7$

No.	Sequence of work	Description	Related information
1.	Determine the portion to be separated		1. Attention should be given to the following points in sheet cutting. (1) Try to eliminate waste as much as possible in sheet cutting. (2) Try to make the sheet for easy work. (3) Try to make the length to be welded soldered, brazed as short as possible. (4) Grain of sheet when bending. (5) Strength and appearance of finished item. 2. If the right angle is not accurately drawn in marking off dimensions, satisfactory product can not be expected even when other dimension are correctly drawn.
2.	Determine position (arrangement)		
3.	Mark off deployment chart	1. In right sequence. 2. Pay particular attention when marking off right angle. 3. Mark off distinctly so that there will be no need for redrawing.	
4.	Check dimension	1. Check right angle and dimension closely against shop drawing.	
5.	Provide work edge	1. First determine the side where the lap edge should be provided, and then mark-off accurately. 2. Mark off bend edge and roll up edge accurately. When marking off a roll up edge, pay attention so that the joint of roll up will be at an angle of 45°.	

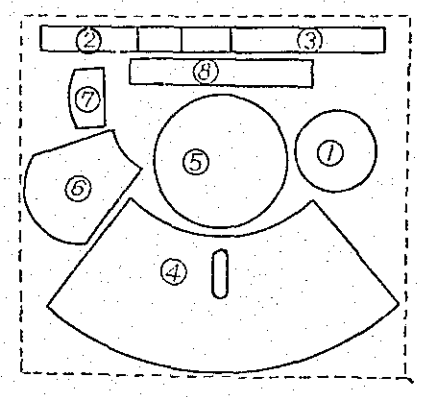
Remarks

(Note)

Two methods are used for sheet cutting. One is to mark off directly on the sheet by deploying with actual size as has been described above and the other is to copy template drawn or marked off on a thick paper or thin metal plate and clipped out. Use of template is convenient for determining economical arrangement (lay out) in cutting sheet when the said item is required in large quantity.

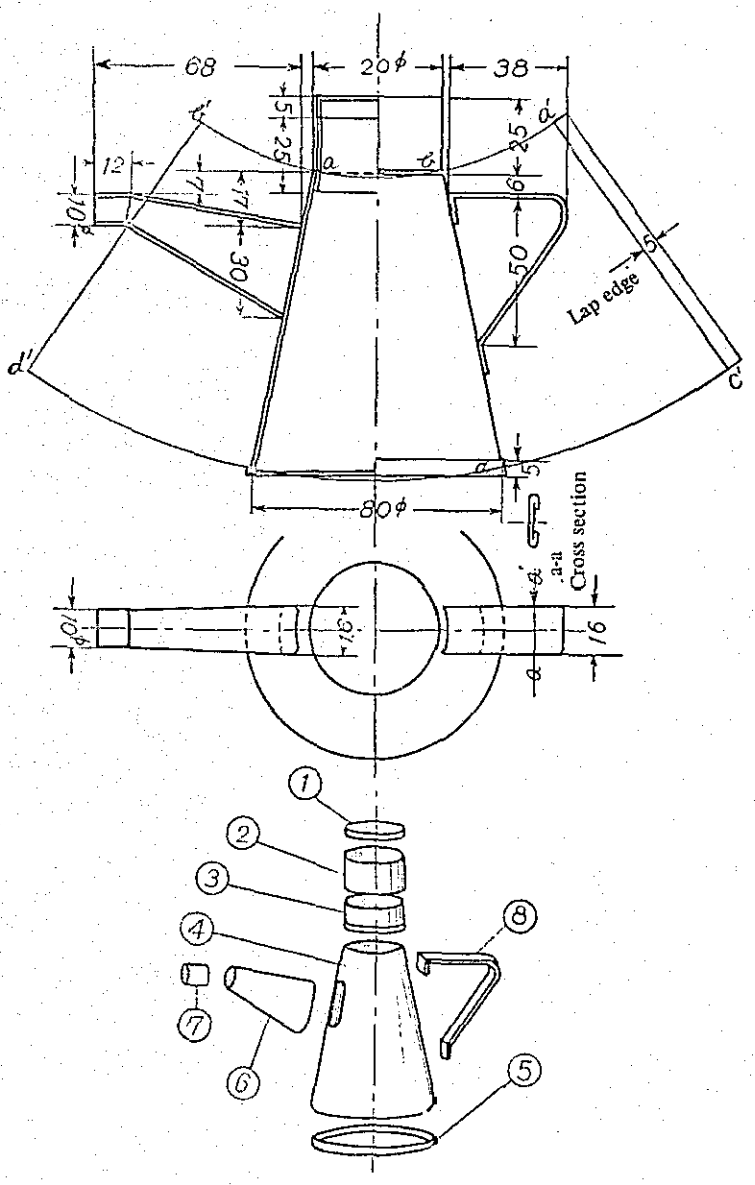
(Question)

How many sets of sheet can be cut from one sheet metal of standard dimension (90 cm x 180 cm) ?

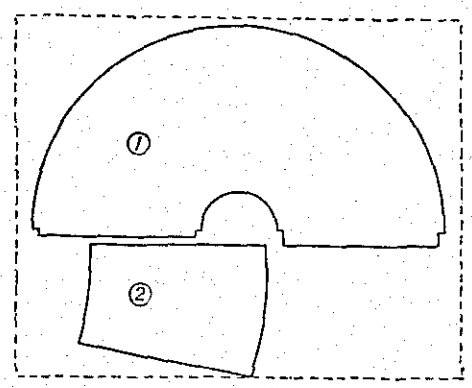


Work No.	No. 26
Type of work	*Sheet cutting for oil feeders* (Subject No. 2)
Main points	Fundamental deployment method for cylinderical cone. Sheet cutting. Marking off of tin plate
Materials	*Tin plate* BWG No. 30 0.305 x 300 x 300 mm
Tools	Scale, carpenter's square, compass, mark-off pin

Subject No. 2 Oil Feeder Scale 1 : 2

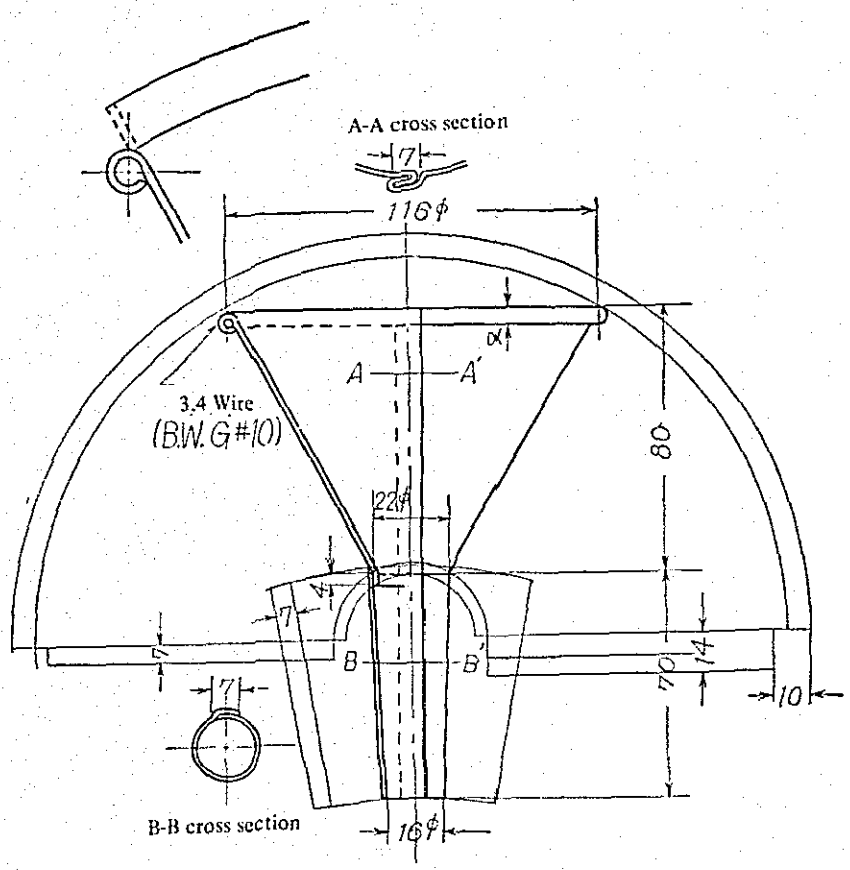


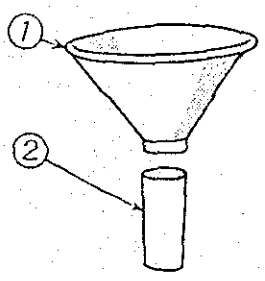
1. Use tin plate BWG No. 30 (0.305 mm)
2. Joints should be soldered.



Work No.	No. 27
Type of work	Sheet cutting for a funnel (Subject No. 3)
Main points	Fundamental sheet cutting method for cone shape items. Marking off of curved edge roll
Materials	Tin plated iron sheet, BWG No. 30, 0.305 x 200 x 250 mm
Tools	Scale, compass, marking-off pin

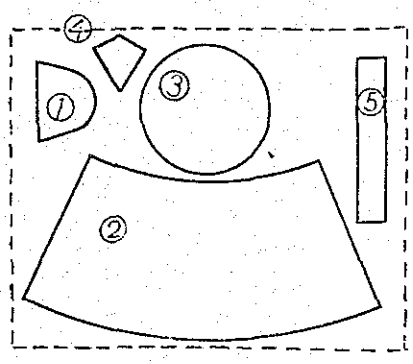
Subject No. 3 Funnel **Scale 1 : 2**





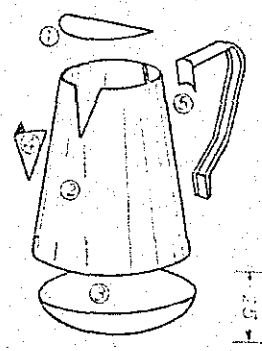
Use tin plated iron sheet, BWG No. 30 (0.305 mm).

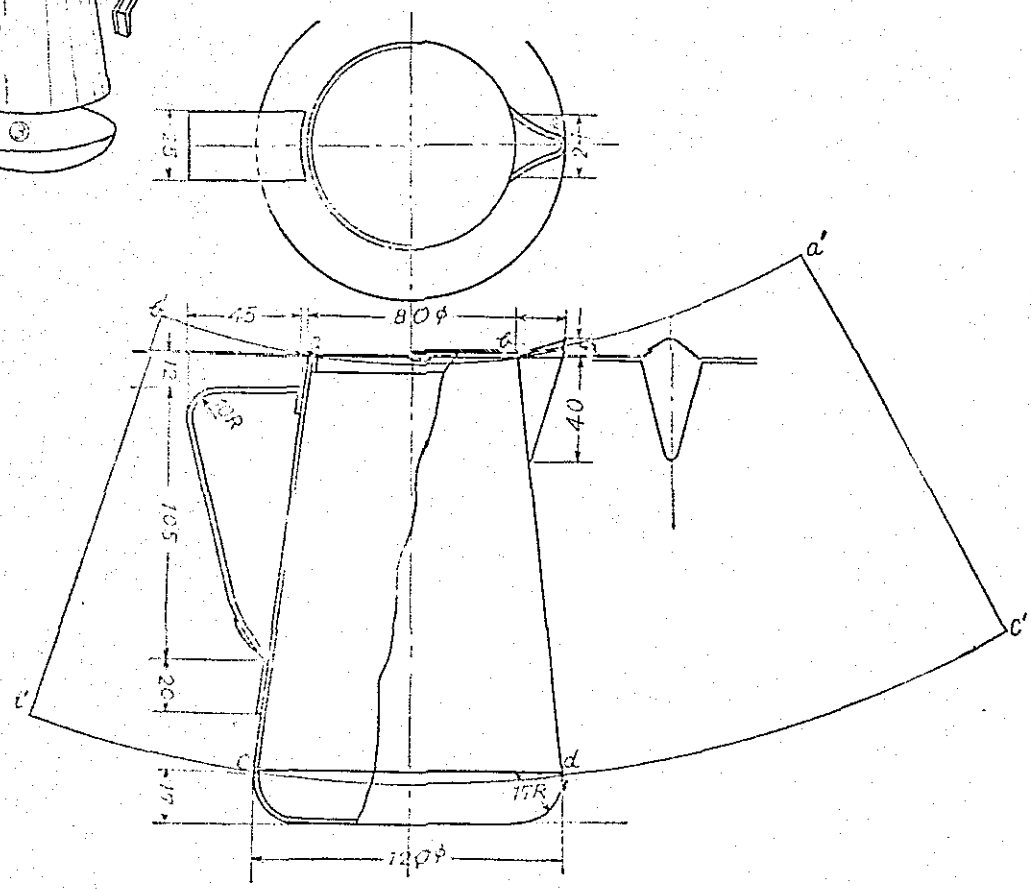
Joints should be soldered.



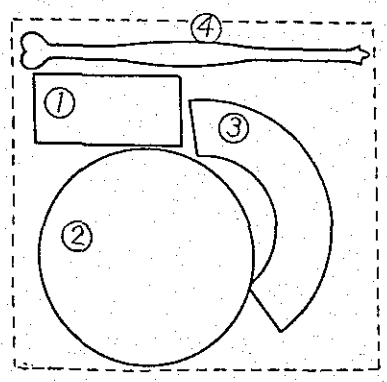
Work No.	No. 28
Type of work	Sheet cutting for oil feeder (Subject No. 4)
Main points	Fundamental sheet cutting method for cone shape choking work. Marking off on mild steel sheet
Materials	Mild steel sheet 0.8 m - 1.0 x 400 x 400 mm
Tools	Scale, carpenter's square, compass, mark-off pin

Subject No. 4 Oil Feeder Scale 1 : 2



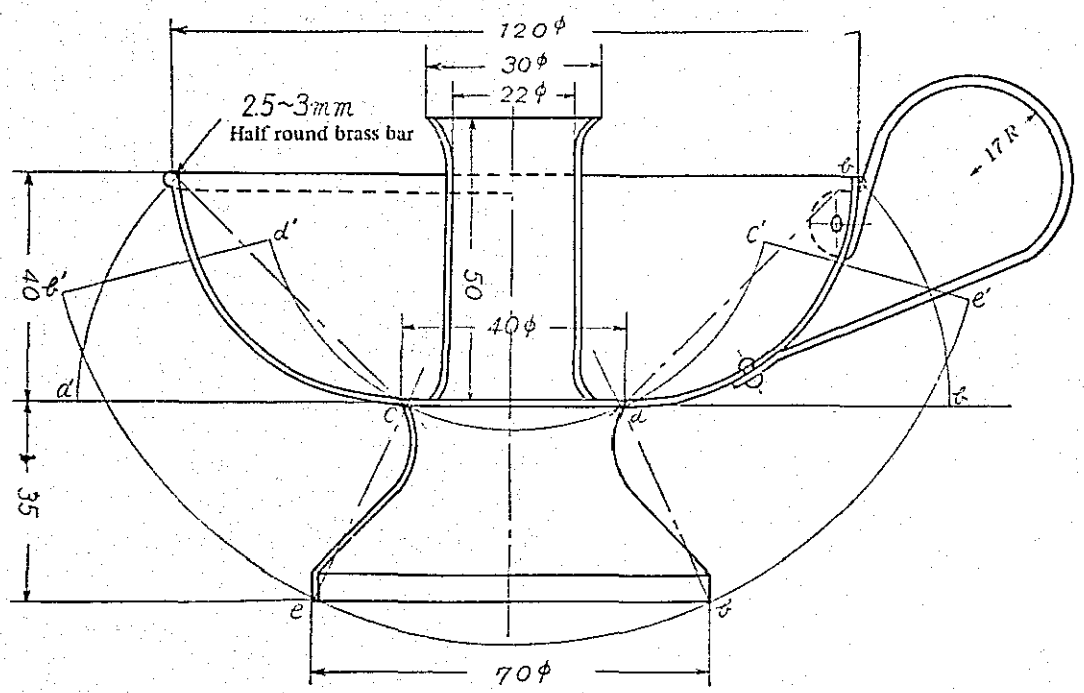


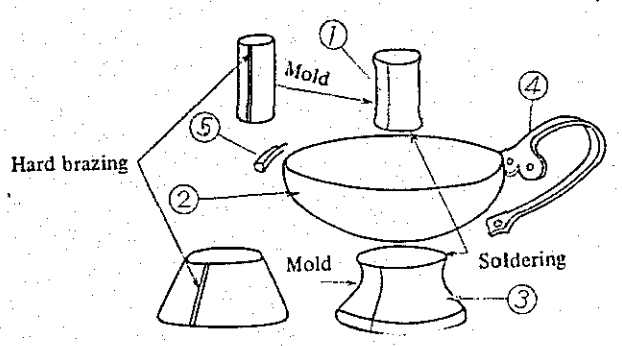
All joints of mild steel sheet having a thickness of 0.8–1.0 mm should be welded.



Work No.	No. 29
Type of work	Sheet cutting for candle stand (Subject No. 5)
Main points	Sheet cutting for choke work Marking off on brass sheet
Materials	Brass sheet, 0.7–0.8 x 210 x 240 mm 1.5–2.0 x 30 x 240 mm
Tools	Scale, compass, marking-off pin

Subject No. 5 **Candle stand** **Scale 1 : 1**





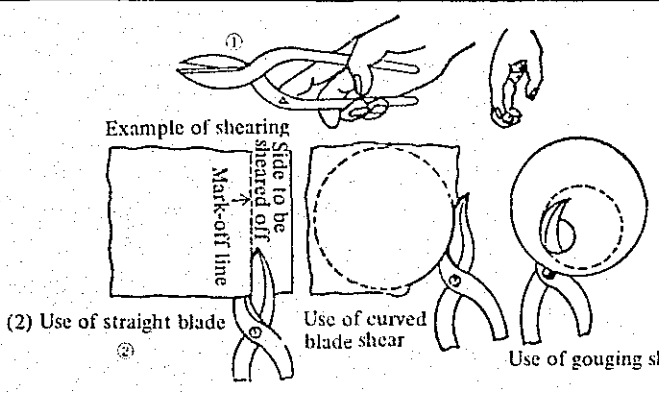
For (1), (2), (3), use 0.7–0.8 mm brass sheet.

For (4), use 1.5–2.0 mm brass sheet .

Remarks

(Note)

To obtain accurate sheet cutting for bell shaped items like the above, radius of marking off must be determined by calculating surface area of the bell shaped portion. However, when the depth of bell shape is smaller than that of a hemisphere, there is not a great difference between the result of calculation and that of the expedient shown in the shop drawing. Therefore, the expedient may be used for practical purpose.

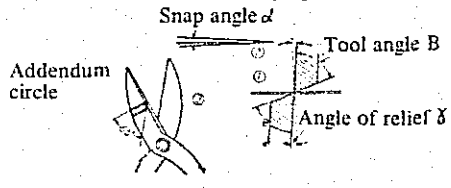


Work No.	No. 30
Type of work	Use of hand shears
Main points	Use of hand shears Various cutting (shearing) methods
Materials	Mild steel sheet, various scrap materials. Use materials mentioned in Subjects No. 1, 2, 3, 4, 5, 6, and 7 as necessary. (No. 25–29)
Tools	Straight blade shear, curved blade shear, gouging shear

No.	Sequence of Work	Description
1.	Hold shear	1. Use five fingers of right hand skillfully as shown in Fig. (1), hold one leg with the first joint of the thumb and with the root of index finger, support the center of curvature of other leg with the tip of the index finger and hold the lower portion of the leg with the remaining three fingers. 2. Use index finger like a spring. Place the belly of the index finger at the center of curvature of the leg and support the leg by bending the finger outward. 3. Give the most strength to index finger among the three fingers which hold the lower leg.
2.	Spread legs	1. As if to push them out with the belly of index finger.
3.	Put the sheet between the blades	1. Match the blade with mark-off line accurately. 2. Hold sheet securely with left hand by keeping the portion to be cut off at right hand side.
4.	Shear the sheet	1. Use full length of blade and avoid using the shear in such a manner that the cutting process comes to an end in the half way of the sheet. 2. Avoid making rumples and warps in the portion other than that is to be sheared off.

Related Information

1. Shears are manufactured in three different types: They are straight blade, curved blade (of which the one having a narrow blade width is specially called as slim blade) and gouging blade shears. Each type is used for difference purposes as shown in Fig. (2) above. In the case of curved blade shear, one tend to think that the shear is used along its curvature. But in actuality, it is used in the way shown in the figure to obtain better result.
2. Straight blade and curved blade of the size 24-27 cm are very handy. For cutting of thick plate having a thickness of 1-2 m/m, shears having a total length of 30-60 cm are often used.
3. Rivet of the shear should be tightened slightly to provide easy handling, otherwise the blade would not open (spread) easily. So, the rivet should never be tightened by striking it with other object.
4. As shown in Fig. (1) below, blade has a tool angle and angle of relief. Without an angle of relief, a friction is created between the two blades rendering it difficult to cut the sheet.
5. If the snap angle shown in Fig. (2) below is too great, the material will slip away making if difficult to cut the material. If the angle is too small, on the contrary, an extra strength is required to shear the material. For this reason, the point about 1/3 from the tip is made arc shaped instead of making the entire blade linear as shown in 3, to provide a snap angle to a certain degree from the beginning to the end of shearing operation.

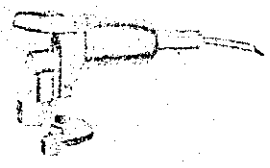


Remarks

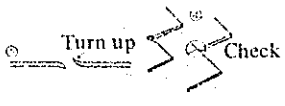
(Inspection)
Check to see that shearing is made accurately at the mark-off line and that there are no warps or rumples.

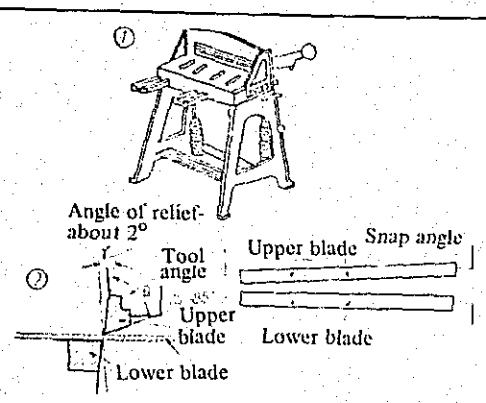
(Note)

1. Though it may not be possible to maintain sharp edges at all times because of the wear caused by shearing of the metal, it is still important to keep practicing until efficiency is attained to cut a thin paper by clenching sharp edges like this.
2. Electric snip (shear) shown below is very handy because of its efficient shearing ability. Standard type is manufactured for shearing the sheet having a thickness of 1.5 mm, but a larger type is capable to shear the sheet having a thickness of about 4.5 mm.



1. Care should be exercised to avoid excessive cutting. If cutting is made like the one shown in Fig. 4 below, the plate start splitting from that portion. Punch or drill a small hole as shown in the figure at left and then use shear working with the tip of blade to obtain satisfactory result.
2. Use the tip of blade for small work.
3. An excessive clearance between the blades when they come together will result in turning up of cutting edge as shown in Fig. (5). Particular care should be exercised when shearing a thin material.





Work No.	No. 31
Type of work	Use of foot shear (cutter)
Main points	Use of foot shear (cutter)
Materials	Mild steel plate
Tools	Foot shear (cutter), scale

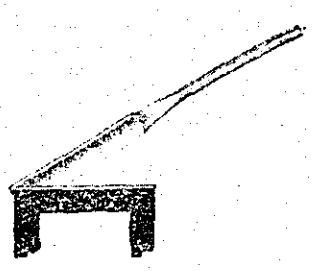
No.	Sequence of Work	Description	Related Information
1.	Insert the metal sheet	1. Insert the metal sheet with larger portion facing toward you. 2. Align mark-off line with the blade line accurately.	1. This machine is usually capable to shear the sheet having a thickness of about 1 mm but the larger type is capable to shear up to 2 mm. 2. Like hand shear, this machine has an angle of relief of 2, and appropriate tool angle for this machine is 75–85°. 3. Clearance between the upper blade and lower blade must be adjusted depending on the material and thickness of the metal sheet. 4. Machines equipped with a sheet holder provide convenience in working because of stabilized sheet position.
2.	Step on	1. Never place the foot over the pedal until this stage. 2. Hold the sheet securely so it will not move around. 3. Pay particular attention to avoid injury to the finger tip.	1. When shearing extremely thick materials or bulky materials, several people have to step on the pedal.

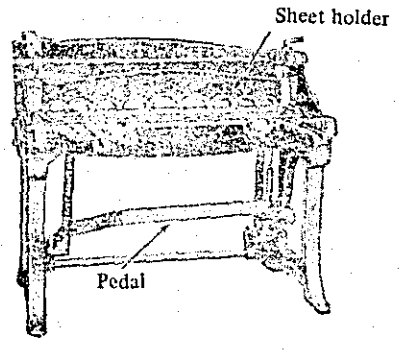
Remarks

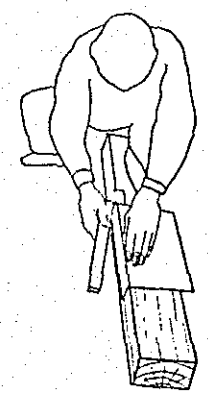
(Note)

1. When shearing many pieces of the same width, use a rule according to the dimention.
2. Blade construction of pushing shear (figure below) is almost similar to that of foot shear (cutter) and is manufactured in blade size ranging from 3 cm to 180 cm. It is used sidely because of its light weight.

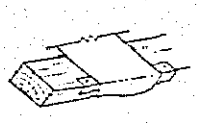
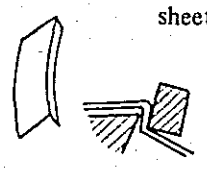
Foot shear equipped with a base metal holder







Work No.	No.32
Type of work	Rectilinear bending of sheet
Main points	Use of clappers and bending stand, Rectilinear bending of sheet
Materials	Thin mild steel plate Apply Subject No.1, 2-(8) and 4-(4), (5), as necessary
Tools	Bending stand, clappers

No.	Sequence of work	Description	Related information
1.	Hold sheet down 	1. Hold it securely with left hand and keep the shorter section of the sheet at right. 2. Match mark-off line with bending stand. 3. Hold it down securely with all five fingers of left hand (See figure at left)	
2.	Pick up clapper 	1. Hold it securely with four fingers placing the wrist just over the end of clapper. (See figure at left).	
3.	Hit the edge 	1. Bend both ends at the point 3.3 cm from the edge (See figure at left).	This prevents the sheet from shifting and provides accurate bending.
4.	Match mark-off line	1. Match mark-off line with bending stand once more.	
5.	Make forward movement while bending	1. Watch closely the forward portion of marking-off line as well as the line of beinging stand and pay close attention so that both lines will not run off each other. 2. Start from this end.	1. Care should be taken because the sheet tends to warp like the one shown in the figure. 2. Do not strike the sheet like this. 

Remarks

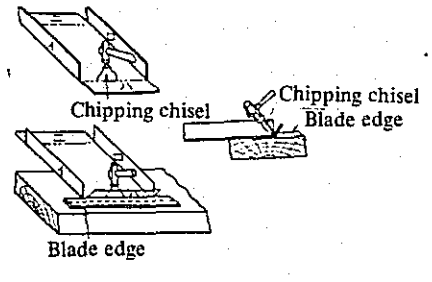
(Inspection)

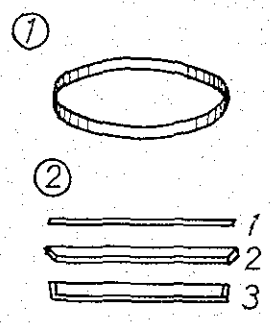
Check closely with square and rule to see that bent line forms a perfect straight line, that bend is made uniformly at a right angle, that curvature (radius) is uniform and that the sheet is not damaged.

(Note)

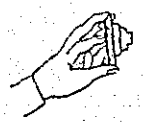
1, When bending a sheet for oblong box (Subject No.1), portion A and B may be bent with bending stand and clapper, but portion C and D can not be bent with these tools. In this case, make a crease with a chipping chisel and then place the crease on the edge of knife blade or base sheet metal, strike the crease and bend gradually by using chipping chisel chisel diagonally.

2. Even when bending stand is used, crease made with chipping chisel in advance will prove convenience in the work.





Work No.	No. 33
Type of work	Curve (line) bending of thin plate
Main points	Edge bending of flat sheet Use of blade
Materials	Subject No. 2- (1), (5)
Tools	Mallet, blade, vice, or wood stand, surface plate

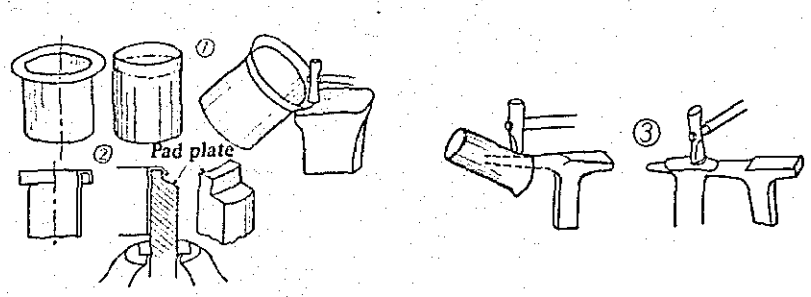
No.	Sequence of work	Description	Related information
1.	Put blade against the plate 	1. Hold the plate in a slant position and put mark-off line against the blade portion of blade. 2. Hold the plate with five fingers in such a manner that the warped portion faces outward (See figure at left).	1. This method is used for shallow bending, and choke method is used for deep bending.
2.	Strike the sheet 	1. Watch mark-off line from above diagonally. 2. Strike the sheet twice with a mallet while turning the sheet around and turn the sheet back, then strike it once lightly (See figure at left). 3. Start bending gradually from obtuse angle to make it a right angle.	1. For thick plate, strike with a hammer from the end gradually. Care should be exercised so that corners will not be damaged. 2. Avoid abrupt bending because it will cause warps and rumples and finishing will not be satisfactory.
3.	Correct warps	1. Strike the outside edge slightly over the surface plate.	

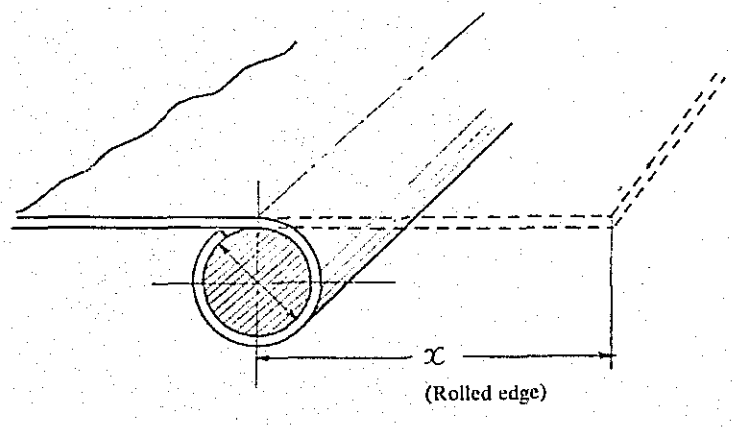
Remarks

(Inspection)
Check to see that bending is made smoothly and correctly at the mark-off lines, that there are no rumples, that warps have been corrected and that corners have not been damaged.

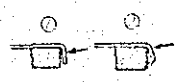
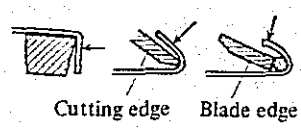
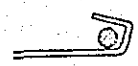
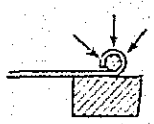
(Note)

1. To make the edge of cylinder: When bending the edge of a cylinder or the curved edge of similar product outward riection, bending should be made gradually while turning it around with a iron stand (in the direction opposite to the edge bending of the sheet).
2. Edge turn-up: When bending the flanged portion of a cylinder or the portion of similar shape, strike the edge with a mallet or slide door hammer while turning the material around slowly on the pad, as shown in the figure below.
3. When shaping up the cylinder such as enlarging the skirt, work it with pad plate like the one shown in Fig (3) below as a substitute of cylinder (Subject No.5–(3), (1)).





Work No.	No. 34
Type of work	Edge rolling of stright sheet
Main points	Edge rolling of straight sheet
Materials	Thin mild steel plate, wire Subject No. 1-(1)
Tools	Bending stand, clapper, mallet, scale, mark-off pin or pencil

No.	Sequence of work	Description	Related Information
1.	Bend the sheet at mark-off line 	1. Bend the sheet on bending stand as shown in Fig. (1), (2) below to form around roll and not to make it angular.	1. A thin mark-off line may be drawn with a pencil. 2. In another method, bend is made only once and finishing work is done with the use of blade edge as shown in the figure below. 
2.	Place core bar 	1. Hold the plate securely with left hand and place a core bar with right hand (See figure at left).	
3.	Strike while rolling the edge 	1. Start from this end and strike the roll lightly with a mallet. 2. Keep striking until the roll clamps the bar tightly (See figure at left).	
4.	Turn sheet over and strike 	1. Turn sheet over, put the rolled portion against the bending stand and hold the sheet down securely with five fingers. 2. Strike it with the clapper at stroke (See figure at left).	
5.	Finish it	1. Turn it over again and strike from above 2. Repeat it until the roll tightens the core rigidly.	

Remarks

(Inspection)

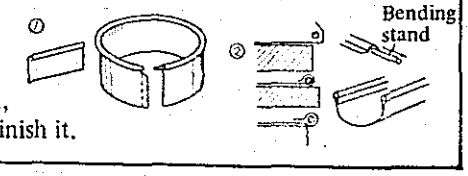
Check to see that the bend is straight matching with the mark-off line, that no angles are made at the rolled portion and that the roll is tight and rigid.

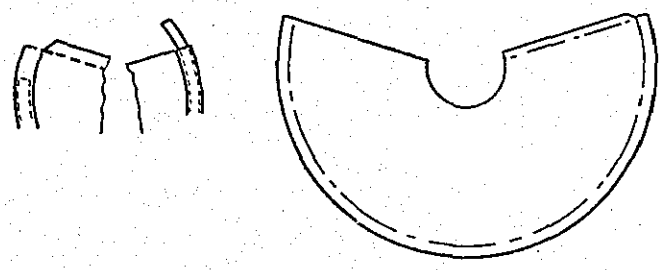
(Note)

Width of roll edge may be obtained from the following equation : $X \fallingdotseq \pi d \times 3/4 + 3/4 \fallingdotseq d/2$

Empty (Void) roll is a hollow roll made without having a core bar in the roll and the core bar is pulled out after edge roll is made. For this roll, a rather thin core bar should be selected. If the core bar is waxed and is not rolled too tight, subsequent pull out will be much easier.

When the work shown in the figure at right has to be done, rolling should be made as a flat sheet. Core bar should be of the same length as that of edge and should be pulled out slightly at the side opposite to the lap edge. Then bend the sheet to in loop shape, joint both ends together, laying one edge over another, insert the extending wire into the hole in the opposite end and solder the joint. This provide strong joint for rolled edge. To make an eaves- trough, first make an edge roll (empty roll as shown in Fig(2) at right), bend it in curvature and finish it.





Work No.	No. 35
Type of work	Edge rolling of curved line
Main points	Edge rolling of curved line of flat sheet
Materials	Thin mild steel sheet, core bar, Subject No. 3-(1)
Tools	Curve line bending stand (or blade), mallet

No.	Sequence of work	Description	Related information
1.	Bend at mark-off line	Give it roundness and avoid making angular portion.	
2.	Insert core bar	Core bar should have been bent in advance to accustom to the mark-off line.	Core bar should be pulled out slightly from the end opposite to the lap edge as shown in Fig. 34 (1).
3.	Strike while wrapping the core bar	Start from this side and strike lightly to make rumples even.	In the same manner as shown in No. 34.
4.	Turn material over and keep striking		
5.	Finish it up	Repeat the above action until the roll is tight and rigid.	

Remarks

(Inspection)

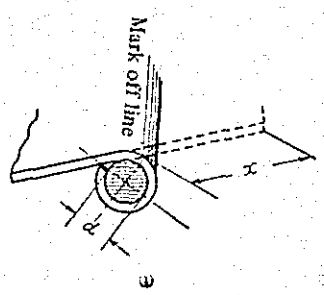
Check to see that the curve line is made smoothly matching the mark-off line, that no angular portions are made, that no large rumples are made and that the roll is tight and rigid.

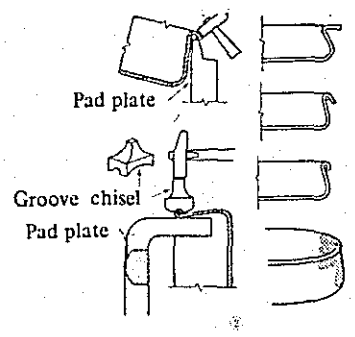
(Note)

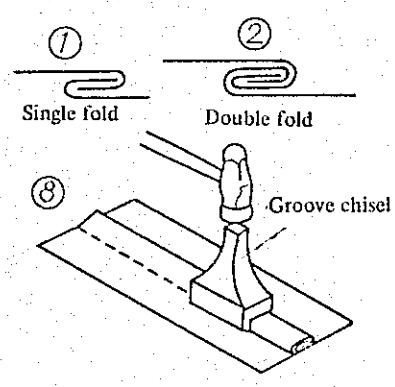
1. Width of roll edge in this case, because of its cone shape, may be obtained form the following equation by providing the base line (mark-off line) as an expedient as shown in Fig (1) below. $\div x\pi d \times \frac{3}{4}$

2. Edge rolling of cylinder.

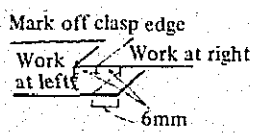
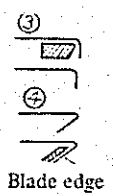
   When edge rolling is to be made in an outward direction from the curvature as shown in the figure at right, bending should be made as shown in lower Fig. (1) in No. 33 and finished in the order shown in the figure.







Work No.	No. 36
Type of work	Clasp joint of thin plate
Main points	Clasp joint of thin plate Use of blade edge Use of groove chisel
Materials	Thin mild steel plate (28-30 No.)
Tools	Bending stand, blade edge, clapper, scale, marking-off pin, single hand hammer

No.	Sequence of work	Description	Related information
1.	Mark of clasp edge 	1. Mark it on the end of each plate for the width of 2 cm (see figure at left).	1. Double fold (Fig. 2 above) is not commonly used, but it is made by folding a single fold by 90° (Fig. above) once more. 2. The length of clasp edge varies depending on the Work. 3. To avoid the joint with left edge placed front, layout should be made so that the plate at right comes over the other.
2.	Bend the plate 	1. Match mark-off line with the edge striking stand correctly and bend both plates at 90°. (See Fig. 3 at left). 2. Insert blade edge and strike the edge lightly to bend further (See Fig. 4 at left).	
3.	Clasp both plates	1. Make sure that each plate clenches one another securely.	
4.	Strike the edge 	1. Place the clasped portion on the bending stand and strike it from above at a slight ly angle. (See figure at left).	1. Care should be take when working on a long material because the center portion often slips out.
5.	Clamp it down with groove chisel 	1. Start from the other end and strike lightly along the line (see figure at left and Fig. (8) above)	1. Chipping chisel may be used for this purpose.

Remarks

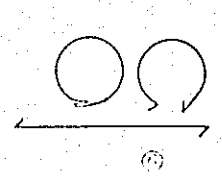
(Inspection)

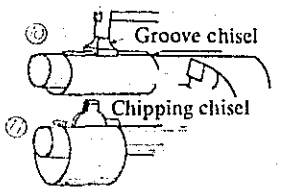
Check to see that clasp edge is uniform and clamped tight and rigid.

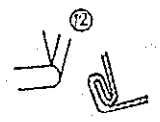
(Note)

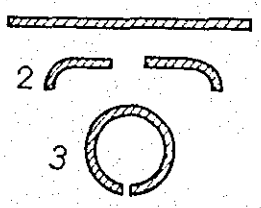
1. When making a cylinder like a smoke stack by means of clasping, bend both ends of the sheet metal as shown in Fig. (9) below, double up the sheet in curvature so that both ends engage and clamp the joint around the core bar by using either a groove chisel as shown in Fig. (10) or chipping chisel as shown in Fig. (11).

2. Shown in Fig. (12) below may be considered to be an examples of clasping.

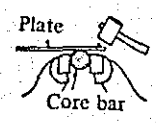








Work No.	No. 37
Type of work	Curvature (curve) bending of thin plate
Main points	Curvature (curve) bending of thin plate
Materials	Thin mild steel plate Apply techniques in Subject No. 2, 3, 4 and 5, as necessary
Tools	Clapper, pipe, mallet

No.	Sequence of work	Description	Related information
1.	Bend one end of the plate 	1. Place it over the pipe horizontally and strike with a clapper or hammer gradually starting from the end while paying attention so that no angular are formed. 2. To make a smooth curvature, strike the plate at the point slightly far away from the contact point of plate and pipe.	In the case like the smoke stack making by means of clasping, long materials should be rolled almost completely to the end and then rolled back in the opposite direction.
2.	Bend other end 	1. In the same manner as the above.	
3.	Push both ends down with both hands 	1. Bend the plate starting from the right end as if to slide it down from left to right.	When working on a short material using only a mallet, bend both ends first and then bend the center. 
4.	Finish it in desired roundness	1. Strike lightly with a clapper.	

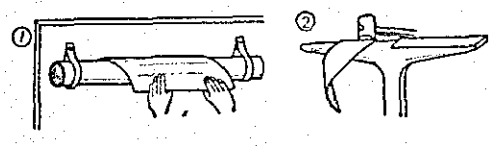
Remarks

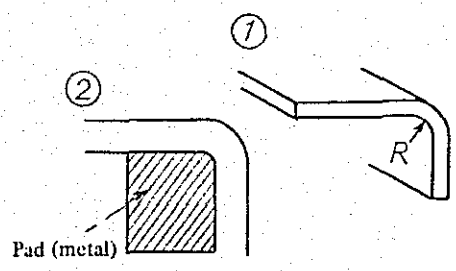
(Inspection)

Check to see that the surface has any angle or irregularities and that correct curvature has been obtained.

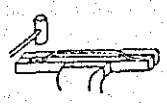
1. When making a long cylinder or semi-cylinder (half-cylinder) like smoke stack or eaves-trough, provide a set-up as shown in Fig. (1) below, insert one end of the sheet metal to be curved between core bar and wood plate and bend the other end down with both hands. This provides curvature of desired size in the sequence almost similar to the above-mentioned process.

2. When the slope of cone is great, put it over the end of break as shown in Fig. (2) below, work gradually from both ends toward the center in the same manner as the above.





Work No.	No. 38
Type of work	Bending of thick plate
Main points	Bending of thick plate using a pad metal
Materials	Mild steel plate 2 mm thick
Tools	Marking-off pin, scale, square, mouth piece, pad metal, mallet, vice, rugs

No.	Sequence of work	Description
1.	Mark-off bend line	1. Mark off bend line accurately in accordance with specified dimension.
2.	Place the plate on vice	1. Place it between the mouth piece and pad (metal) and align mark-off line with the edge of pad metal correctly. 2. Wipe off the contact point well to prevent damage to the material.
3.	Strike with mallet 	1. Strike near the mouth piece. 2. Bend both ends first as shown in the figure at left and proceed with the work by checking the angle.

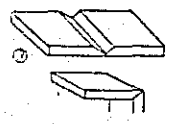
Related information

1. Bending radius:

   When bending a thick plate, any attempt to make a sharp bend may weaken the bend portion depending on the material of the plate. There must be an appropriate bending radius (R) according to the thickness and type of materials. When R is not shown on the drawing, a large R may be provided for the materialof low viscosity and a small R may be provided for the material like brass.

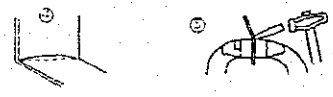
2. The R provided at the corner of core bar in advance as shown in Fig. (2) above result in a convenient finishing work.

3. When angularity is required for specific thick material, provide a deep groove at the crease with a scratch scraper or a triangle file as shown in Fig. (3) at right, place it on the vice and bend it by striking slightly.



1. Particular care should be exercised in this case as the bending line often warps as shown in Fig. (4) at right.

2. If a metal hammer is used directly on the metal instead of a mallet, the portion hit tends to have scratches and the materials often break at that portion. Therefore, use only a mallet or hammer made of soft materials such as lead or aluminum or use a pad made of lead, aluminum or fiber which is placed like the one shown in Fig. (5) at right and strike the material from over the pad.



3. Use squill vice (C clamp) to hold down a long material.

Remarks

(Inspection)

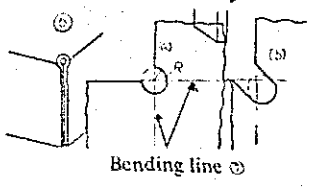
Check to see that the bent is straight matching the mark-off line, that R is properly made and that the plate has no scratches.

(Note)

1. When the bent is to be made at a right angle, there must always be a hole drilled at the corner to prevent cracks, as shown in Fig. (7).
   For this purpose, method (a) and (b) may be used. When the R is great, however, these two methods may cause a sharp angle. In that case, method (6) is more desirable.

Crack-proof radius (m/m)

Plate thickness	0.3–0.6	0.6–1.6	1.6–2.5	2.5–3.2
Crack-proof radius	1.0	1.5	2.0	3.0



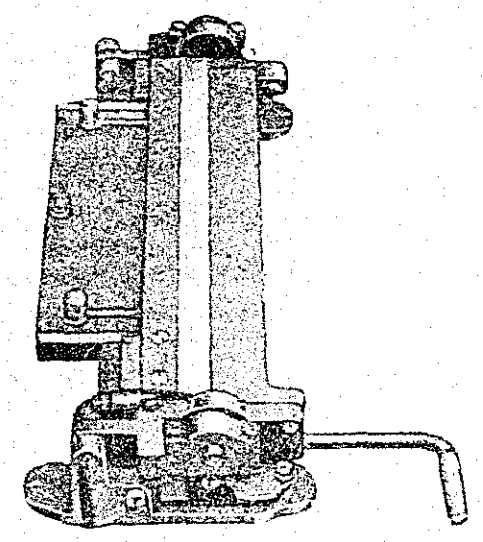
2. Table of bending radius (m/m)

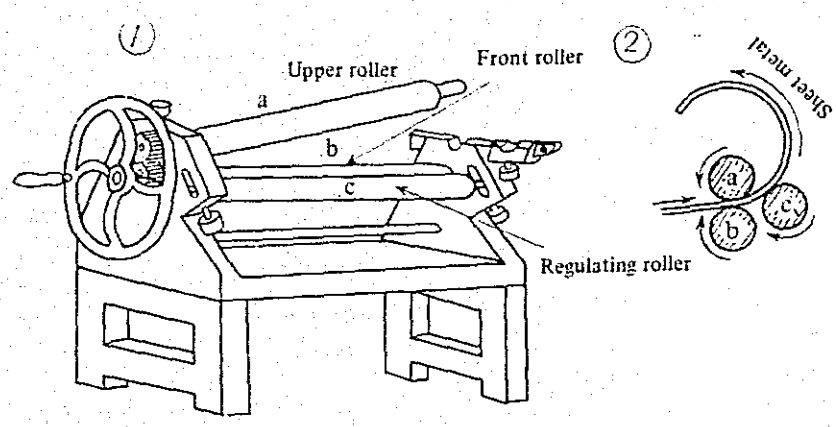
Plate thickness	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.2	1.5	2.0	2.5	3.0	3.2
Brass, aluminum, duralumin	1.0			1.5				2.5		4.0		6.0	
Superduralumin	1.5		2.0			3.0			4.5		6.0	7.5	10.0
Mild steel	1.0			2.0			3.0		4.0		6.0		8.0

Work No.	No. 39
Type of work	*Bending of thin plate with manual (hand) bending machine*
Main points	
Materials	Thin plate
Tools	Scale, manual (hand) bending machine

No.	Sequence of work	Description	Related information
1.	Adjust rule (gage)	1. Adjust both ends accurately to the specified dimension using a rule. 2. Tighten thumbscrew down.	
2.	Insert plate	1. Insert plate to the full length of the gage.	
3.	Raise handle	1. Exert strength at the last stage.	
4.	Return (lower) handle	1. Move it along with the handle while holding it down.	
5.	Pull out plate		

Remarks





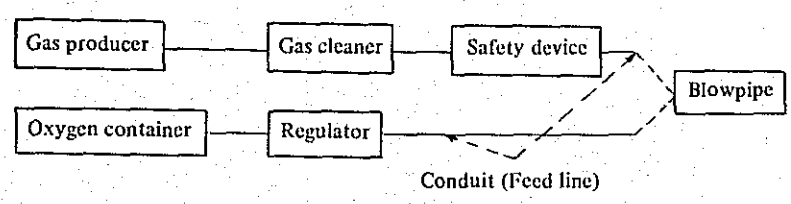
Work No.	No. 40
Type of work	Curvature (curve) bending of thin plate with manual (hand) 3 rolls
Main points	Use of manual (hand) 3 rolls
Materials	Thin mild steel plate, thickness x 3' wide x 3' long
Tools	Manual (hand) 3 rolls, scale

No.	Sequence of work	Description	Related information
1.	Insert plate	1. Place it at a right angle to the roller.	
2.	Adjust front roller	1. Put the plate in the roller and turn the roller slightly so that it may bite the plate lightly.	
3.	Adjust regulating roller	1. Turn roller slowly while checking the clearance.	1. By adjusting the regulating roller diagonally to the upper roller, a gently sloped cone shape may be obtained.
4.	Bend the plate	1. Turn handle slowly and at a constant speed.	
5.	Pull out plate	1. Raise upper roller and pull out the plate.	1. Some upper rollers can be raised and others can be pulled out.

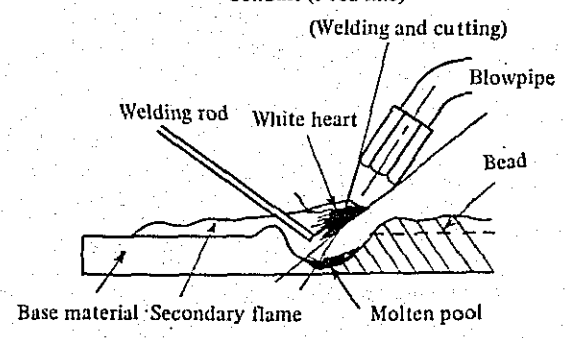
Remarks

Subject	Gas welding	Work No.	No. 41

(A)

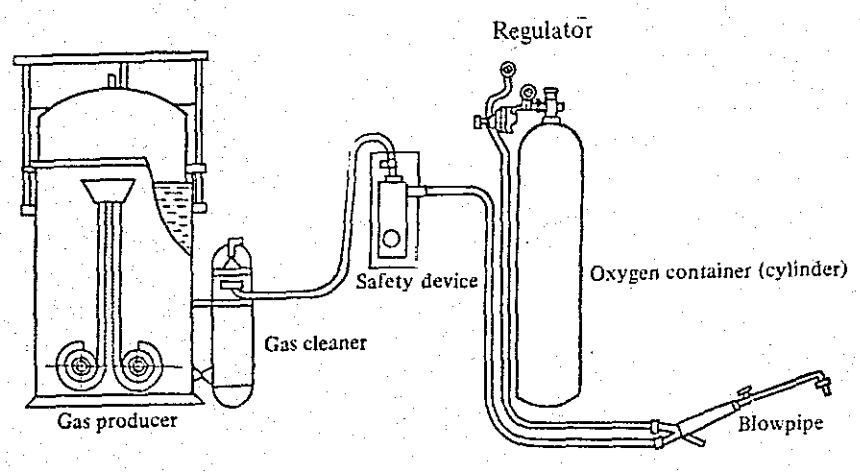


(B)



No.	Item	Description
1.	What is welding?	To heat and melt the weld joint of metal locally and make it an integral part of the base material having the quality similar to that of base material with or without the use of a welding rod.
2.	What is gas welding?	To join the metal by utilizing energy of high temperature produced by combustion of gas as its heat source for welding.
3.	Type of gas flame	Gases available are acetylene, hydrogen, propane, coal gas, etc. of which acetylene is most widely used because it provides the highest temperature and most appropriate conditions for welding. Hereafter, all references to gas will imply acetylene (Each of the foregoing gases is used along oxygen to obtain maximum available temperature).
4.	Welding operation	If a good welding work is to be accomplished, there must be equipment of perfect condition. For gas welding, in particular, blowpipe is most important and the flame produced by the blow-pipe may also be said as one of the most important tools. The welding rod, which is the metal to be added, must be carefully selected. Since acetylene is a very unatable and explosive gas and its ray (beam) is very harmful, attention should be given to its flame during the operation as well as to the spatter of molten metal.:tal.
5.	Attitude of operator	1. Pay close attention so that uniform welding can be accomplished. 2. Never perform irresponsible and careless welding. 3. Be serious, make utmost efforts and always keep in mind the team work in doing the work. 4. Be always eager to study and try to increase your knowledge and strive for the improvement of techniques. Don't pretend that you know everything. 5. Do your best in performing the work and accomplish perfect and complete welding both in quality and appearance. 6. Always keep in mind that safety comes first in all works. Observe all regulations and rules and attend the work with the sense of responsibility so that appropriate inspection and the procedures could be accomplished before and during and after the work.

Subject	Acetylene welding equipment	Work No.	No. 42



No.	Item	Description
1.	Gas producer	The device which produces acetylene gas by reaction of carbide with water.
2.	A. Automatic water feed type gas producer B. Automatic immersion type gas producer	Acetylene gas is produced when water is added to the carbide in the charger, and is sent to the gas chamber and raises it. At the same time, the arm of a lever installed on the gas chamber, which controls water cock, moves up and down with the gas chamber, thus controlling the volume of water being fed. Water is maintained at a constant level. The carbide charger attached to the gas chamber moves up and down to produce gas. When the quantity of gas exceeds a certain amount, the cage and water are separated and the production of gas ceases. When the gas runs out, the gas chamber moves downward causing the charger to come into contact with water to produce gas.
3.	Gas cleaner	Cleaner is a cylindrical steel unit and the cover on its top is provided with a rubber gasket to prevent leakage of gas. A perforated plate is placed horizontally at the height of 40 to 50 mm from the bottom and a piece of felt cloth is laid over it. With the addition of cleaning agent, this unit removes impurities from acetylene gas.
4.	Safety device	Due to the failure of blowpipe or others components parts, oxygen may counterflow into the acetylene pipe (conduit) and mix with acetylene, thus causing the possibility of explosion. This unit is located between the gas producer and the blowpipe and is designed to vent counterflowed oxygen and mixed gases to the atmosphere.
5.	Blow-pipe	Low-pressure acetylene is drawn in bb high-pressure oxygen and both are mixed in this unit and ignited to obtain a flame (heat source) required for welding. Blowpipes are manufacture in two different types; variable pressure type (B type, French type) and invariable pressure type (A type, German type).
6.	Oxygen container (Cylinder)	Oxygen container is usually called an oxygen cylinder or bombe. Charging pressure is 150 kg/cm² at 35°C. The size of container available are as follows:

High pressure gas vessel	5,000 l	6,000 l	7,000 l
Inner container	33.5 l	40 l	46.6 l

Type of gas contained	Oxygen	Hydrogen	Acetylene	Propane
Color of container	Black	Red	Brown	Gray

7.	Oxygen regulator	Oxygen in the cylinder is charged at the pressure of 150 kg/cm² at 35°C. This device decreases the pressure of oxygen to around 1 kg/cm², the required pressure of oxygen for welding.
8.	Conduit	Tubes which supply oxygen or gases from acetylene container or producer to the blow-pipe are called conduits. Steel pipe is used where gas producing room is located far from the plant (shop) and rubber conduits are used for other places. The conduit for oxygen is black in color and that for acetylene is red.

Remarks

Dissolved acetylene:

The container (cylinder) is fully stuffed with porous materials such a charcoal, asbestos, silicious marl, all of which have acetone absorbed in them. 1 liter of acetone at the pressure of 12 kg/cm² at 15°C is capable to dissolve 300 liters of acetylene. Capacity of cylinders are 15 l, 30 l, and 50 l, but the 30 l capacity is most commonly used. Charging pressure is 15 kg/cm² at 15°C.

Subject	Preparations and precautions prior to the welding operation	Work No.	No. 43

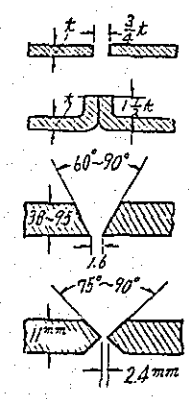
1. Requirements for welding operation

1. General
   (1) Select blowpipe having the capacity suitable for the thickness of the plate.
   (2) Determine quality and the size of welding rod to be used.
   (3) Determine the travel pattern of blowpipe and welding rod.
   (4) Select flux of proper type depending on the type of base materials.
   (5) Determine welding procedures by taking into account the direction of movement.

2. Preparation of base materials
   (1) Provide the edge with appropriate shape and clean the edge thoroughly.
   (2) Make necessary preparation against expansion and contraction (distortion).

3. Precautions to be taken during the work
   (1) Edge should be sufficiently melted.
   (2) Molten pool should always be maintained in molten condition. Welding should be done within natural flame and the white heart should not come into contact with molten metal.
   (3) Maintain the condition described in (2) until the completion of operation and do not remove the flame from molten metal during the operation.
   (4) Melt-in the welding rod at an appropriate time.

4. Care to be taken after the work
   (1) Welded joint must be uniform along the entire face.
   (2) Welded joint must have been joined by deposited metal and not by agglutination.
   (3) Welded joint must have the quality equivalent to that of base material or higher quality.



2. (Defects) likely to occur at the welded joint.

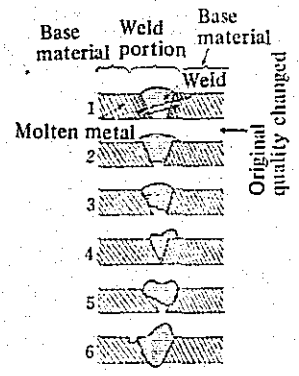
1. *Insufficient* penetration
   In the process like the bridge spot welding, for example, there are cases when molten metal remains only on the surface of the welded joint and does not penetrate into the bottom, thus making the welded joint fragile and easily broken even when hit slightly. This occurs when both edges of melting material have not been welded to their full thickness. This defect is often seen when welding thick plates where beveling is not provided or when root opening is not properly maintained in proportion to the thickness of material.

2. Overlap
   Overlap occurs when melting metal remains and sticks to the unmolten metal surface. This occurs when only the surface of metal melts and the molten metal flows into the portion, the bottom of which has not yet been melted or when the molten metal flows over the previously melted metal while it is in the process of solidification, or when one of the weldment is melted and the other is not melted. Even the experienced welder should be fully aware of this possibility.

3. Inadequate thickness
   This occurs when the padding (extra pad) in the welded joint is inadequate. This causes inadequate strength in the welded joint.

4. Undercut
   One side or both sides of the weldment are eroded because of overmelting, leaving one or two strips of grooves (called the secondary) and weaknes the strength of the welded joint.

5. Blowhole
   Porosity made at the welded joint, which are created when molten metal solidifies before the gas generated inside the molten metal escapes to outside. Strength of the welded joint weaknes as the number of porosity increases. This is caused when a rapid cooling occurs in the molten metal or when the removal of oxides is not sufficient.



Gas welding rod for mild steel JIS Z3201-1963

Type of welding rod	Treatment of test piece	Tensile strength (kg/mm²)	Elongation (%)	Type of welding rod	Treatment of test piece	Tensile strength (kg/mm²)	Elongation (%)
GA-46	SR	46	20	GB-43	SR	43	20
	NSR	52	17		NSR	44	15
GA-43	SR	43	25	GB-35	SR	35	20
	NSR	44	20		NSR	37	15
GA-35	SR	35	28	GB-32	SR	32	15
	NSR	37	23		NSR		
GB-46	SR	46	18	SR - When the stress is relieved NSR - When the stress is not relieved			
	NSR	51	15				

Size of welding rod and allowable error (Unit: mm)

	Size							Allowable error
Diameter	1	1.6	2.0	2.6	3.2	4.0	5.0	6.0	+ 0.1
Length	1000								+ 3

Relationship between the size of welding rod and the thickness of the plate

Thickness of base material (t)	Diameter of welding rod (D)
Less than 2.5	1.0 - 1.6
2.5 - 6.0	2.6 - 3.2
5.0 - 8.0	3.2 - 4.0
7.0 - 10.0	4.0 - 5.0
9.0 - 15.0	4.0 - 6.0

(Note) Calculation of approximate size: $D = \frac{1}{2}t + 1$

Subject	Precautions to be taken during welding operations	Work No.	No. 44

I. Rules to be observed by welders:

As the acetylene is a dangerous gas because of its instability and explosiveness, those performing welding work must always abide by the provisions of Article 395, Labor Safety and Sanitation Regulation.

Article 395, Labor Safety and Sanitation Regulation (Except)

1. Goggles and protective gloves shall always be worn during welding operations.
2. No spark producing tools shall be used nor shall be any acts to cause percussion to gas producer while it is in use.
3. Soapsuds or other safe means shall be used to check the leakage of gas in the welding equipment.
4. Prior to the start of welding operation, each part (piece) of the welding equipment shall be inspected and a mixture of air and acetylene, if found in the gas producer, shall be removed.
5. For heating the water in the welding equipment to prevent it from being frozen, only hot water or steam or other safe means shall be used.
6. No articles shall be placed on the air (gas) chamber of gas producer.
7. When the gas producer is not in use and there is a possibility of generating gas by the remaining carbide, water in the chamber shall be maintained at an appropriate level.
8. Acetylene and carbide shall be removed completely from gas producer prior to repair, any additional work, transportation or storage of the unit or when the operation of the unit is discontinued for breaks.
9. Gas producer for mobile welding equipment shall not be placed where the temperature is high, or where ventilation is poor or where vibration is frequent.
10. Safety device shall be located at the place which provides an easy access to the unit to acertain water level during welding operation. Water level shall be checked at least once a day during the operation.
11. Door to the gas producing room shall not be left open during the operation.
12. Smoking or use or open flames or spark producing devices shall not be allowed within 5 meters of the gas producer or within 3 meters of gas producing room.
13. When opening carbide containers, any act which might cause percussion or which might produce sparks shall be avoided.
14. Charging of carbide in the producer for mobile welding equipment shall be done outdoors and at the plade where it can be accomplished safely.
15. Carbide slag shall be placed in slag containers until the hazard of gas is eliminated or it shall be disposed of at the safe location.
16. No welding operation shall be performed near storage area of explosives, flammables or storage area of large quantity of combustibles.
17. When welding or cutting is to be done on the container of alcohol, gasoline, tars, grease, sulfaric acid, these materials shall be removed from the containers completely and the inside of the containers shall be inspected prior to the work.

II. Prevention of Accidents and Safety procedures

1. Clothing

1. Slovenly appearance can cause an accident. Clean and tidy clothing should be worn at all times while performing the work.
2. Work without clothing should never be allowed even in the hot weather.
3. Attention must be paid to the sparks or pieces of molten metal flying onto the colar or into the pocket or on the pants, which may cause a severe burn.
4. Attention should also be given to greasy or oil stained clothing because of potential hazard of catching on fire.
5. Shoes should be worn at all times, if possible, to protect feet from flying sparks and molten metals.

2. Protective equipment

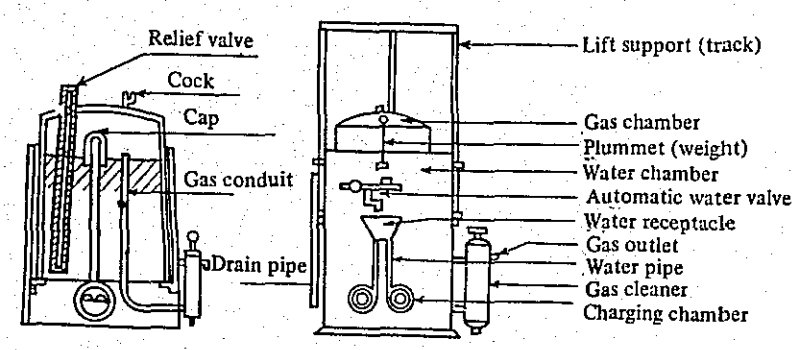
1. Welder and his assistant should always wear goggles during the operation. Intense glare of rays and flying sparks may cause injury to the eyes.
2. Protective gloves should be worn to prefent burns in the hand.
3. Apron, gauntlet (hand cover) or leggings should be used to prevent burns depending on the type of operation.

3. Precautions against poisoning (toxication)

Since some metals used for welding, particularly the lead, zinc and brass and other materials, give off harmfull gases, welding should be performed at the well ventilated location, and gas mask should be worn during the operation.

4. Precautions against fire or explosion

1. Welding and cutting operation should be performed at the safe location where no combustible materials are present in close vicinity of work site. Particular attention should be paid to the materials around mobile welding equipment.
2. Fire extinguishers should always be kept nearby during the operation, and when the work is over, work site should be cleaned thoroughly to eliminate fire hazards.
3. Gas cleaner should be installed as close to the gas producer as possible. When changing the cleaning agent, rubber gloves should be worn and particular attention should be given to the presence of open fire.
4. Particular care should be exercised that blowpipe is not used for pulling or knocking other articles in place of tools or that a burning blowpipe is not swung around.



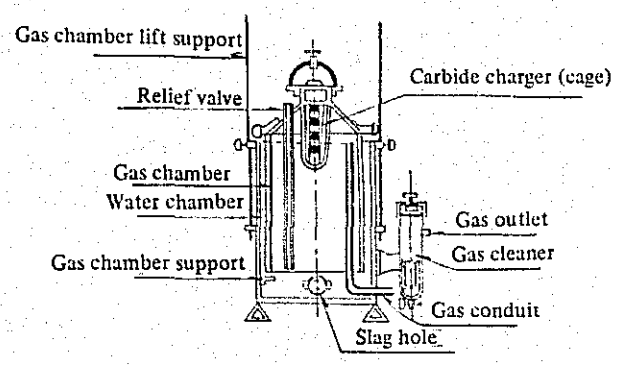
Work No.	No. 45-1
Type of work	Preparation of welding equipment
Main points	Handling of water feed type gas producer (fixed type)
Materials	Carbide, water
Tools	

No.	Sequence of work	Description	Related information
1.	Start operation		
	(a) Inspect gas chamber	1. Move gas chamber up and down slightly. 2. Inspect the clearance between water chamber and gas chamber, lift support and wheels.	When the gas chamber stuck, gas pressure increases, thus making the acetylene to counterflow and overflow at the water pipe and creating a hazardous condition. Also, if vertical movement (lifting) is not smoothly carried out, pressure of gas can not be maintained at a constant level, thus making it impossible to provide stabilized flames. This hawpersperation greatly, therefore, an effort should be made to secure smooth lift (up and down) operation.
	(b) Fill the chamber with water	Fill to the marked line.	If the supply of water is in excess, gas generates and the chamber rises itself. Increase in the pressure of gas causes water to overflow at the water chamber and flow into the water receptacle which in turn feeds excessive water to the charging chamber, resulting in excess generation of acetylene. If the supply of water is not adequate, feed of water can not be maintained properly and generation of gas is not satisfactory.
	(c) Charge carbide	Charge carbide about half full of the charging pan. (In the order of large, small, large, small or by taking into account the amount of work to be accomplished).	If charging of carbide is not done properly or when excessive amount is charged, the water fails to penetrate into the bottom, thus resulting in poor generation of gas or the generation of excessive heat by carbide. Care should be exercised when recharging the carbide, for the charging pan sometimes would not be easily drawn out because of expansion (swelling) of carbide.
	(d) Feed water	Feed water slowly.	Feeding a large quantity of water at one time will cause the carbide to generate a large quantity of gas at one time and produce excess heat. It will also produce foul acetylene, which may turn to a dangerous gas, or causing excess production of gas switch results in overflowing at the relief valve.
	(e) Vent a mixture of gas	When the gas chamber rises 1/3 of its track, open cock on vent valve and lower the chamber to the bottom. When lowered to the bottom, close cock on vent valve.	As a mixture of air and acetylene is the most explosive and dangerous gas, this procedure must be kept in mind at all times.
	(f) Check for leadage of gas	Check the unit with soapsuds by paying particular attention to the charger, all cocks and connection.	
	(g) Transfer gas to cleaner	Open cock on the connection to the cleaner.	This is done when the gas cleaner is ready.
2.	Completion of work		
	(a) Close cock	Slowly and carefully.	
	(b) Remove carbide	Carbide in the process of reaction should be placed in a storage container, after moisture has been eliminated.	
	(c) Clean up equipment	Wash out slag thoroughly. Check gas conduit closely in particular to see if any slag is left.	Slag can be easily washed out when it is wet but as time elepses, it turns to white in color and solidifies itself, thus making the removal difficult and presenting unpleasant appearance.

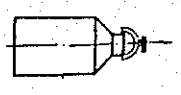
			Work No.	No. 45-2
			Type of work	Preparation of welding equipment
			Main points	Handling of water feed type gas producer (fixed type)
			Materials	Carbide, water
			Tools	
3.	Recharging of carbide			
	(a) Close cock	Close cock on the connection to the cleaner.		
	(b) Fill the chamber with water	Fill to the marked line.	If there is a shortage of water in the water chamber after the water has been fed to the charger, the cap may float over the water.	
	(c) Change carbide	1. Open the cover slowly and wash chamber and plate thoroughly with water. 2. Check and see if any slag remains in the gas conduit and water inlet. 3. Charge carbide 1/2 full of the plate.	Remove un-activated carbide and dump it into slag containers. Slag in the container should be disposed at the safe location or beried after it became completely free from reaction. It should never be discarded carelessly.	
	(d) Feed water	Slowly.		
	(e) Open cock	Open cock on the connection to the cleaner.		
	(f) Check equipment	Check equipment closely to see if there is any leakage of gas.		

Remarks

As the acetylene is a very unstable and dangerous gas having a wide range of inflammable and explosive characteristics, instructions on the use of gas producer must be strictly observed and no person other than the operator should be allowed to handle the equipment.



Work No.	No. 46
Type of work	Preparation of welding equipment
Main points	Handling of immersion type gas producer (mobile type)
Materials	
Tools	

No.	Sequence of work	Description	Related information
1.	Start operation (a) Check gas chamber	1. Operate gas chamber up and down slightly. 2. Check clearance between water chamber and gas chamber and the lift support and wheels.	If the gas chamber stuck, pressure of gas increases and the water in the water chamber overflows, thus presenting a possibility of explosion.
	(b) Fill the chamber with water	Fill to the marked line.	Excessive feeding of water will cause water in the chamber to overflow when gas is generated. This water is white in color and contains dissolved carbide. When dry, it presents very unpleasant appearance and is hard to remove.
	(c) Place carbide in the cage	1. About half full of the cage. 2. Make the mass in appropriate size when placing in the cage.	Extremely small mass of carbide will fall thorough the mesh and excessively large masses will remain over the mesh and will not fall down continuously.
	(d) Hung cage and place the cover	1. Place carefully. 2. Do not cause friction or percussion.	
	(e) Remove a mixture of gas	When gas chamber rises to 1/3 of the lift, lower it to the bottom.	A mixture of air and acetylene is highly explosive and is very dangerous. It is most important that this mixture is removed at all times.
	(f) Check for leakage of gas	With soapsud.	Open flames should never be used.
	(g) Transfer gas to cleaner	By opening cock.	
2.	Completion of work (a) Remove (discharge) remaining gas	Slowly and intermittently.	Since the acetylene is a highly flammable and dangerous gas, it should be discharged slowly and intermittently and not at one time.
	(b) Take carbide cage out	Remove top cover carefully and take the cage out without causing friction or percussion.	Though the remaining gas and water in the water chamber have been already removed, air might have penetrated in the gas chamber and a mixture of gas may have been formed or the air may come in when the cover is removed and form a mixture of gas, thus creating highly explosive and dangerous conditions. Special care should be exercised during this process.
	(c) Dispose remaining carbide	Carbide which has been in contact with water will generate acetylene as long as it contains moisture. It should be placed in a storage container after it is completely free from moisture.	Placing the remaining carbide in a sealed can immediately after the operation is a very dangerous practice because it might be full of acetylene when opened again for use in the following operation.
	(d) Remove gas chamber from water chamber	Carefully remove gas chamber from water chamber.	
	(e) Drain water	Drain water slowly by turning the screw at the slag hole.	Sudden opening will result in a gush of both water and slag at the same time and will present unpleasant appearance.
	(f) Clean up equipment	Wash slag out thoroughly and check to see if any slag remains in gas pipe (conduit) and relief valve.	The slag, if left in the gas generator (producer) even in a small quantity, will turn to white in color and will not be easily removed. Besides, it presents unpleasant appearance.
	(g) Place equipment in storage 	1. Check all parts carefully and closely. 2. Place gas chamber in water chamber and place the cage in the gas chamber, then hand tight the cover. 3. Place equipment in storage.	Check all parts carefully, particularly the gas pipe (conduit). assemble and store them in the location so as to be readily available the following day. When the store room is not available, they should be placed at the safe location with gas chamber and water chamber being separated each other. In this case, gas chamber should be placed on side as shown in the figure at left.

Remarks

FIG. A

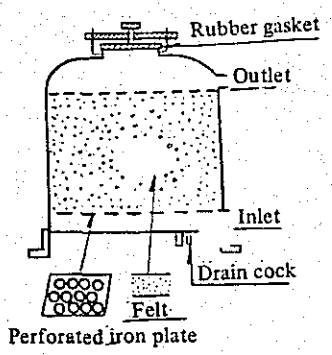
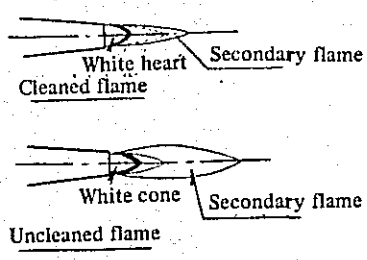


FIG. B



Work No.	No. 47
Type of work	Preparation of welding equipment
Main points	Handling of gas cleaner
Materials	Cleaning agent
Tools	

No.	Sequence of work	Description
1.	Open drain cock	Drain extra water
2.	Charge cleaning agent	1. Charge prescribed amount. 2. Make a thin layer in the center and a thick layer in the surrounding area. 3. Use rubber glove when charging the agent.
3.	Discharge a mixture of gas	Open inlet and outlet cocks for 5~10 seconds.
4.	Transfer gas to safety device	When safety device is ready, open outlet-cock.
5.	Check equipment	Check for gas leakage with soapsuds.

Amount of cleaning agent required (kg)	5	10	15	20	30	40	50	60
Amount of acetylene cleaned in one hour (liter)	600	1,200	1,800	2,400	3,000	3,800	4,700	5,600
Thickness of layer of cleaning agent (cm)	25	25	25	25	28	30	30	30
Height of cleaner (cm)	32	33	34	35	39	42	42	42
Diameter of cleaner (cm)	20	28	35	40	45	50	55	60

Cleaning agent	
1. Heratol	2 kg for 100 kg of carbide
2. Catalysol	Same as above
3. Akazin	
4. Frankolyn	

Related information

1. If the cleaning agent is compacted too hard, passage of gas is hampered, and if the compaction is too loose, satisfactory performance of cleaner can not be obtained. Compact agent properly.

1. Method used to determine the efficiency of cleaning agent:

   Place a test paper coated with dissolved sulfate of silver at the outlet of cleaner. In the pass turns black within a few seconds, it indicates unsatisfactory performance.

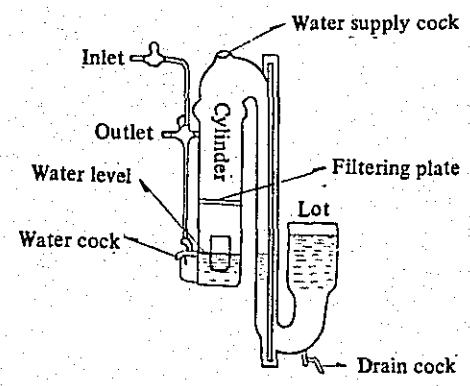
2. As shown in Fig. B. there is a clear distinction between the flame of cleaned gas and that of uncleaned gas. In other words, the flame indicates whether gas has been cleaned or not. When the secondary flame appears longer in size, it indicates that the cleaning effect is deteriorating. (Refer to remarks).

Remarks

1. Impurities contained in acetylene are very fine particles of lime, water, hydrogen sulfide, phosfate hydrogen. All of these imparities cause harmful effect during the welding operation, but phosfate hydrogen, in particular, presents a posibility of spontenuous combustion when its content in the mixture exceeds 0.02% and of explosion when exceeds 0.06%. Use of uncleaned acetylene also make sit difficult to controli flames.

2. (a) Since the cleaned gas, after having been removed of imporities, burns near complete combustion and the flame cone presents white color but the secondary, on the contrary, is very beautiful in purple color.

   (b) Uncleaned gas, because of its impurities, fconsumes extra oxygen to burn these impurities. This is the secondary flame and the color of flame.is indistinct.



Work No.	No. 48
Type of work	Preparation of welding equipment
Main points	Handling of safety device (water sealed type)
Materials	Water
Tools	

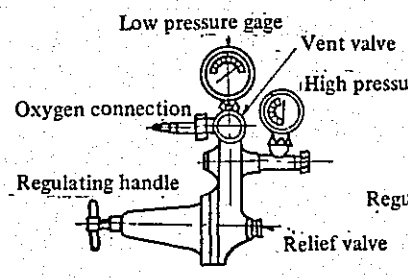
No.	Sequence of work	Description	Related information
1.	Fill water	Fill water to the level slightly above the mark.	Check all parts completely and wash inside of the unit thoroughly with water to remove rust before filling clean water.
2.	Set up (install) unit	1. Set the unit in vertical position at the location where water level can be seen easily during the operation. 2. Avoid locating it near gas producer or oxygen cylinder.	1. Safety device when inclined make it impossible to perform satisfactorily the control of water level. Moreover, the performance of the unit as a safety device can not be expected in an emergency. 2. Inspection of the unit can be made easily in the even of shortage of water due to counterflow or backfire.
3.	Determine water level (mark)	1. Close outlet cock and open inlet cock to the gas flow and then open and regulate water level control cock until water level rises to the prescribed mark. 2. Check water level periodically and maintain the level at the prescribed mark at all times.	
4.	Remove a mixture of gas	Open outlet cock (4–5 seconds)	
5.	Transfer gas to blowpipe	When blowpipe is ready, open gas inlet and valve cock fully.	
6.	Check equipment	1. Check for gas leaks with soapsuds. 2. Check conduit connection, inlet and outlet cocks, and water cock carefully.	

Remarks

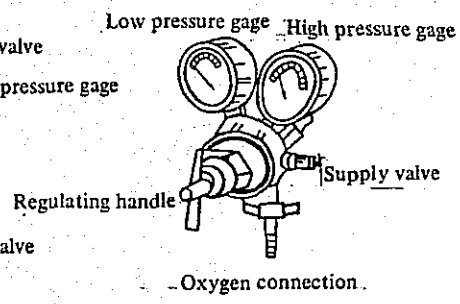
Precautions in handling the unit:

1. One safety device should be provided for each blowpipe. When this is not practical, provide one safety device for main conduit on the manifold, which is the closest to the blowpipe.
2. When the gas storage and gas producer are installed at the separate location, a safety device should be provided between these two units.
3. Water level should be checked at least once a day.
4. Frozen water in the equipment should never be thawed by use of open fire. Also, smoking should never be allowed while handling the equipment.
5. When the safety device is actuated by back fire or counterflow, blowpipe flame should be put out immediately and the cock on the inlet pipe of the safety device should be closed. Then remove rubber hose from the blowpipe and check it to determine the cause of backfire or counterflow. After acertaining that there is no defect in the hose, clean the hose thoroughly, add water and resume operation.

Type A (German type) regulator



Type B (French type) regulator



Work No.	No. 49
Type of work	Preparation of welding equipment
Main points	Handling of regulator
Materials	
Tools	

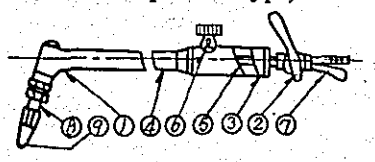
No.	Sequence of work	Description	Related information
1.	Open oxygen valve slightly	1. Open handle (Turn handle) slowly with both hands. 2. Make one or two turns to discharge oxygen to remove dust from mouth piece.	Since the oxygen is a combustion support agent, fast discharge of it creates a very hazardous condition. Also, the dust, if allowed into the regulator, will cause mechanical mulfunction.
2.	Install (set up) equipment	1. Safety device should not face toward the shoulder of oxygen cylinder. 2. Screw in 5 or more threads and then tighten it down. 3. Set the device in an inclined position so as to provide easy reading during the operation.	1. If the discharge of oxygen is directed at the cylinder when the relief valve actuated, it creates a dangerous condition. 2. Screwing less than 5 threads will damage threads and at the same time it makes it impossible for the unit to withstand the pressure when oxygen valve is opened simultaneously.
3.	Loosen regulating handle (Turn back Regulating handle)		
4.	Open oxygen valve		
5.	Check equipment for leakage	With soapsuds.	Any leakage results in the loss of a large amount of gas because of its high pressure.
6.	Regulate pressure	1. To the required pressure. 2. Turn handle clockwise slowly.	
7.	Close vent (supply) valve		
8.	Attach (connect) oxygen hose	Secure hose tightly with clamps.	
9.	Start operation	When blowpipe is ready, open supply valve.	
10.	Completion of operation	1. Close oxygen valve. 2. Turn loose the regulating handle. 3. Check equipment.	If oxygen is not completely discharged (removed) from the regulator after work is completed, it may cause mulfunction of gage.

Remarks

Handling instructions:

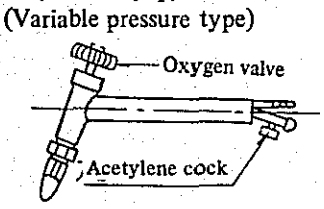
1. No grease or lubricant oil should be used for any part of the equipment (grease and oil will oxidize and cause spontenuous combustion). Use glycerin when lubrication is required.
2. Prior to installing the regulator, blow off the dust from the valve of oxygen cylinder so that the dust would not enter regulator.
3. Operate valve slowly.
4. Always keep regulating handle loose when replacing the regulator.
5. No attempt should be made to disassemble the regulator. When work is suspended temporarily, close supply valve lightly.

Type A
(German type)
(Invariable pressure type)



1. Torchhead 2. Cock 3. Grip hadle
4. Outer tube 5. Inner tube 6. Regulating valve
7. Hose connectiin
8. Flame body
9. Flame tip
(Welding tip)

Type B
(French tyep)
(Variable pressure type)



Work No.	No. 50
Type of work	Preparation of welding equipment
Main points	Handling of blowpipe
Materials	
Tools	

No.	Sequence of work	Description	Related information
1.	Attach welding tip	Tighten it up rigidly.	If not tightened rigidly, backfire or couterflow may occur.
2.	Connect oxygen hose	1. Insert hose up to the roof of connection (Tighten it up with a clam). 2. Open supply valve on regulator.	If not tightened securely, it may come loose because of high pressure of the oxygen.
3.	Examine suction	1. Open gas cock first and then open oxygen cock. 2. Put a thin paper at the opening to see suction.	
4.	Connect gas hose	Securely so that it would not come off.	
5.	Open cock on safety device		
6.	Discharge a mixture of gas from pipe (conduit)	Fully open valves for both gases for 5-10 seconds.	
7.	Light blowpipe	Refer to No. 51-1 (Variable pressure) Refer to No. 51-2 (Invariable pressure)	
8.	Shut off	Refer to No. 51-1 (Variable pressure) Refer to No. 51-2 (Invariable pressure)	
9.	Check equipment	1. Check to see if there is any leakage at oxygen or gas connection. 2. Check to see if there is any leakage at oxygen valve or acetylene cock.	Do not drop blowpipe on the ground or avoid using it for pulling tools or for striking equipment in place of other tools.

Thickness of steel plate mm	Flame head No. (Capacity) of Type A (German type)	Flame head No. (Capacity) of Type B (French type)
1–1.5	1	50–100
1–2.0	2	100
2–3	3	200
3–5	5	300
5–7	7	500

Remarks

Instructions on blowpipe handling:

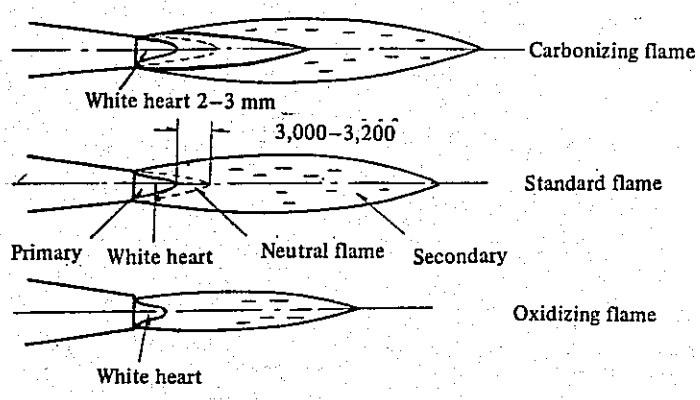
1. Handle blowpipe carefully.
2. Do not let the burning blowpipe loose from your hand.
3. When cleaning the blowpipe, blow in oxygen from the end of flame tip.
4. Do not enlarge the diameter of flame tip. Use copper or brass wire carefully to remove dregs (slag).
5. Cool down if flame tip become overheated (by discharging oxygen slightly).
6. Attach flame tip securely.
7. If the blowpipe does not light satisfactorily on first try, always make a careful check and correct defect, if any, before relighting.
8. Follow proper sequence for lighting and extinguishment of flame.

Invariable low pressure blowpipe (Type A)

Mostly used in Kanto area. Discharge rate of gas and the size of flame tip are standardized and does not provide free control of flame size (capacity). But by changing the flame tip, one blowpipe can be used for rarious purposes. The size of flame tip is expressed by the thickness of the plate it can weld (m/m).

Variable low pressure blowpipe (Type B)

Mostly used in Kansai area. Supply of oxygen can be controlled and the amount of acetylene drawn can be controlled according to the size of flame tip being used. The size of flame tip is expressed by the amount of acetylene consumed per hour (liter).



Work No.	No. 51
Type of work	Control of flame
Main points	How to make standard flames
Materials	
Tools	

No.	Sequence of work	Description	Related information
		1. Variable pressure type blowpipe (JIS B 6801–1960)	
1.	Light blowpipe	1. Open cock (valve) 2. Discharge oxygen slightly and light blowpipe.	1. When lighting the blowpipe, make sure no hazardous condition exist around the operating area. 2. Do not light the blowpipe at the location where gas may have been accumulated.
2.	Regulate flame	1. Discahrge oxygen until the oxidizing flame almost overlaps white cone. 2. Maximum temperature is obtained from the point 2 to 3 mm from the white cone.	Carbonizing flame-Caused by an excess supply of acetylene and is general black in color. Oxidizing flame-Caused by an excess supply of oxygen and is the standard flame with a small and indistinct white cone. Standard flame-Produced as a result of complete combustion of a mixture of oxygen and acetylene with distinct white cone.
3.	Extinguish flame	1. Close acetylene valve. 2. Close oxygen valve.	
		2. Invariable pressure type blowpipe (JIS B 6801–1960)	
1.	Light blowpipe and regulate flame	1. Open acetylene control valve fully. 2. Light blowpipe by opening the valve to 70–80 and then open valve fully. 3. When there is a carbonizing flame, regulate it by closing regulating valve. 4. Where there is an oxidizing flame, regulate it with regulating handle. 5. If the above is not adequate, make standard flame by operating both the regulator and regulating handle.	1. Breathing of flame: (1) Caused by the presence of acetylene or water in rubber hose. (2) Mulfunction of safety device. 2. Roaring noise at time of lighting: (1) Incomplete removal of unpurified gas. (2) Inadequate supply of acetylene. (3) Extremely low pressure of oxygen. (4) Enlarged and distorted flame tip, accumulation of slag. 3. Discontinuity of flame (intermittent flame): (1) Excessive pressure of oxygen. (2) Accumulation of slag in the nozzle. 4. When the blowpipe make crackling and popping noises during operation and then returns to normal condition or when flame blows out itself, their causes would be: (1) Overheat of flame tip and the accumulation of slag. (2) Incomplete control of supply and pressure of gas. 5. Continuous roaring noise: Overheat of flame tip and the accumulation of slag.
2.	Extinguish flame	Close valve.	

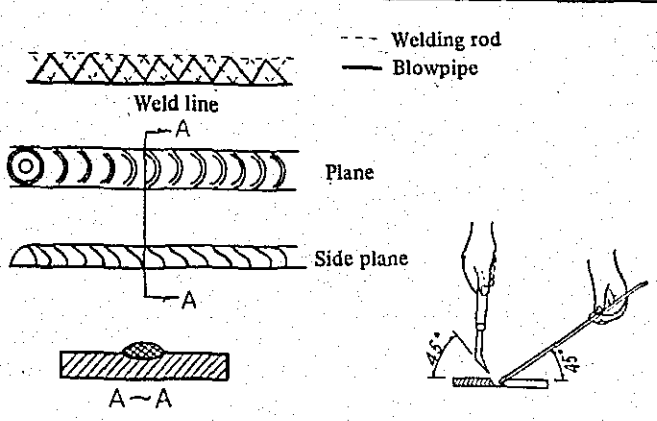
Remarks

Importance of flame:

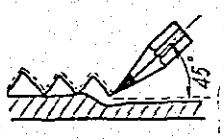
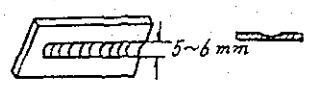
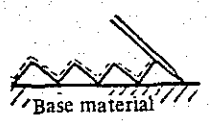
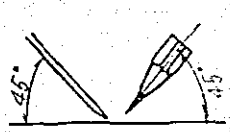
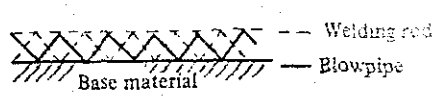
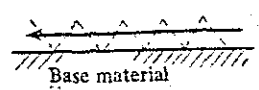
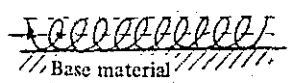
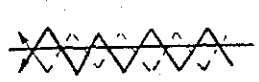
In welding operation the flame plays the most important role. The flame may be likened to a tool for handicraft work. As good work requires good tools and excellent skill, good welding requires good flames and excellent skill. To provide complete welding equipment is to obtain a good flame. To make a good weld is to make the best use of a good flame.

Reasons for using neutral (standard) flame for welding:

When the welding is done by keeping the white cone from coming into contact with the molten metal, the metal remains in neutral condition without being affected by chemical reaction of flame during the operation. This flame is called the standard flame is mostly used in welding.

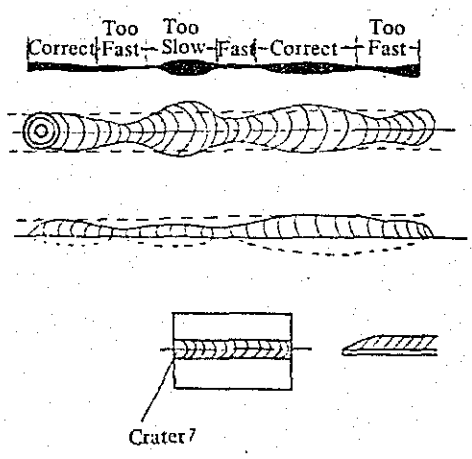


Work No.	No. 52-1
Type of work	Placement (How to make) of bread
Main points	Movement of blowpipe and welding rod
Materials	One mild steel plate (1-2) x 100 x 200 mm Welding rod 1.2-2.0mm *in diameter*
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Draw weld line. 2. Position plate horizontally. Refer to No. 43-1	
2.	*Posture*	1. *Take position in front of welding bench.* 2. Hold blowpipe lightly in natural posture so as to be able to endure prolonged operation.	*Because of its weight, rubber hose should be laid over the* lap.
3.	Maneuver blowpipe 	1. Move blowpipe up and down in the pattern of sawteeth while making molten pool. 2. Maintain 2-3 mm space between white heart and base material. 3. Maintain the angle of blowpipe at 45° 4. Maintain it at 90°from the side. 5. Maintain the width of bead at 5-6 mm so as to make a shallow cavity in the base material.	1. If the angle of blowpipe is too great for a thin plate, it will often cause holes in the plate. 2. If the movement speed is too slow, it will often cause holes in the plate. 
4.	Maneuver welding rod 	1. Hold the rod lightly with left hand. If the rod is too long and the tip swings, bend the rod in half to appropriate length. 2. Maintain the angle at 45° 3. Practice backward movement while moving the rod up and down slightly in the pattern of sawteeth.	
5.	How to maneuver blowpipe and welding rod 	1. Hold blowpipe with right hand without lighting it and hold rod with left hand. (See above sketch.) 2. Maintain the agnle at 45°and move it up and down slightly in the pattern of sawteeth. 3. Move blowpipe straight ahead and move rod alone up and down. 4. Move blowpipe eliptically and rod straight backward. 5. Swing blowpipe and rod sideway alternately. 6. Keep practicing until both hands can move skillfully.	②  ③  ④  ⑤ 

Work No.	No. 52-2
Type of work	Placement (How to make) of bread
Main points	Movement of blowpipe and welding rod
Materials	One mild steel plate (1-2) x 100 x 200 mm Welding rod 1.2-2.0mm in diameter
Tools	

No.	Sequence of work	Description	Related information
6.	Place (make) bead	1. Maintain 2-3 mm space between base materials and heart cone. 2. After the plate has been melted and molten pool has been formed, melt in the welding rod. 3. Move blowpipe and rod up and down in the pattern of sawteeth. 4. Maintain standard flame during operation. 5. Keep heart cone (flame cone) away from material. 6. Melt in rod at the end (tip) of molten pool.	Refer to 5-(2). When 5-(2) is accomplished satisfactorily, practice 5-(3) and 5-(4) alternately.
7.	Check bead	1. Bead should be made without making base material thin or without overlapping but with uniform ripple and even surface. 2. Width of bead should be approximately 8mm. 3. Bead should be made in such a manner as to allow melting metal to penetrate to the bottom. 4. Refer to No. 3-2 (Defects most frequent with the welded joint) (Basic Knowledge).	



How to remove flame from the end of bead:

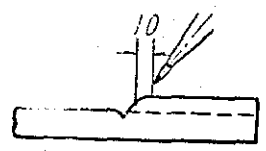
End of bead tends to become depressed by excessive heat. Therefore, after welding is completed and flame is taken away from the weld, direct flame again to the finished portion and melt in the rod to make the height of bead even.

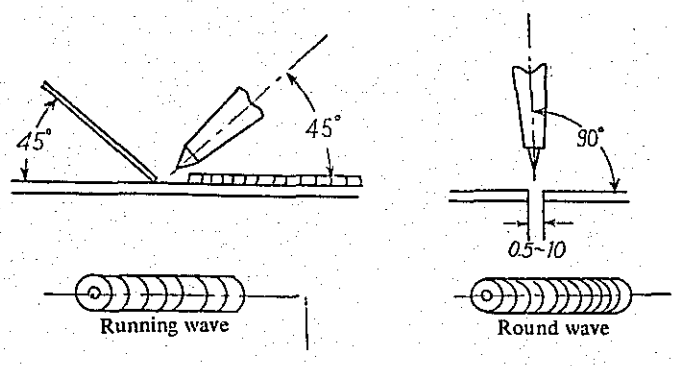
Remarks

How to join the bead:

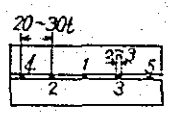
Sometimes it becomes necessary to join two pieces of welding rod together during operation or to stop operation temporarily to regulate flames. When operation is resumed and bead is to be made and joined with the previous bead, the following care should be taken.

1. Start heating the plate from the point 10 mm this side of the crater, and when the surface begins melting, move blowpipe forward and melt in the rod slightly. Move forward gradually and melt deep into the highest portion of bead to make a molten pool and continue operation as before.
2. If a white glittering oxide forms on the surface, remove it by raking with welding rod.





Work No.	No. 53
Type of work	Flat butt welding
Main points	Forward welding method
Materials	Two mild steel plates, (1-2) x 100 x 150 mm Welding rod 1.2-2.0 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 3-1. 2. Place the plate horizontally. 3. Maintain root opening at 0.5–1.0 mm.	
2.	Posture	Refer to No. 52-1-2 (Posture).	
3.	Make tack weld 	1. Make tack weld symmetrically on both sides of centerline. 2. Weld should be spaced 20-30t apart. 3. Hold blowpipe almost at right angle. 4. Melt the metal slightly to the back side with the cavity at the center. 5. Length should be 2-3 mm.	Tack welding determine: dimensions and configuration of the material. Therefore, omission or negligence of tack welding should not be allowed.
4.	Relieve strain	1. Relieve strain by hitting the material. 2. Use counter stress method.	Since the stress (strain) is caused by the heat of welding, it can be corrected by peening around the weld.
5.	Start welding 	1. Maintain the angle of blowpipe and rod to the base material at 45° respectively. 2. Melt edges uniformly and completely (to the extent that a hole could be made through the bottom). 3. Refer to No. 52-2 (Beat tube). 4. If the welding is started from the end of material, it may result in cracks at the starting point of welding. Sequence should be in the order of A-B, A-C. 5. Width of bead should be about 6 mm. 6. Circular (round) wave should be made for eleborate welding but running wave should be satisfactory for normal operation. 7. Care should be taken not to cause overlapping.	Cracks can be prevented by changing the direction of heat created by welding. Increase in the deposit metal will result in a greater stress. Prolonged welding time will also result in a greater weld stress. Increased heat at the weld will also cause a greater weld stress.
6.	Check the weld	Refer to No. 52-2-7. Refer to No. 43-2.	

Remarks

Cautions to be taken when welding has to be started from the end of material for some reasons:

Edges (Ends) of both plates, the starting points of welding, are liable to fall down when melted. As soon as the surface begins melting, melt in the rod on that portion (end) alone promptly, then melt it at the point about 5 mm from the starting point until a hole is made through the bottom, in such a manner as to thrusting the white heart of the flame.

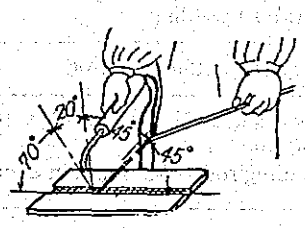


FIG. A

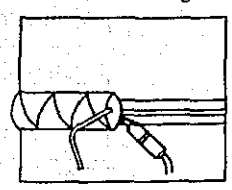
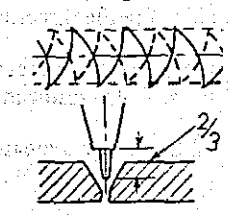


FIG. B

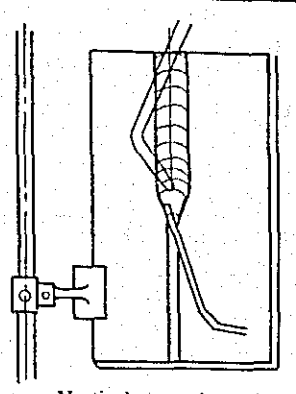
Work No.	No. 54
Type of work	Flat butt welding
Main points	Backward (backhand) welding method
Materials	Two mild steel plates, 6 x 50 x 150 mm Welding rod 4 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation 	1. Refer to No. 43-1. 2. Bevel the edge of each plate in V shape. At an angle of 30–35°. 3. Place the paltes horizontally. 4. Root opening should be 1-1.5 mm.	
2.	Posture	1. Take stable posture in front of welding bench. 2. Refer to Fig. A. 3. Refer to No. 52-1-2.	
3.	• Make tack weld	1. Tack weld should be spaced at 100-150 mm. 2. Melt the plate well to the root.	
4.	Start welding 	1. Maintain the angle of blowpipe at 70° and the rod at 45°. 2. Move blowpipe and rod alternately in the half moon pattern. 3. Thrust white heart to the depth of 2/3 of the bevel. 4. Melt the plate well to the root. 5. Speed of movement should be such that two reciprocating motions can be made per second. 6. Melt welding rod when the rod and blowpipe cross each other.	
5.	Check the weld	Refer to No. 52-2-7. Refer to No. 44-2.	

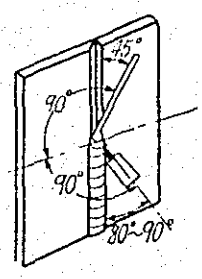
Remarks

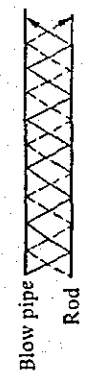
Advantages of backward (backhand) welding:

1. Because of its well penetrating heat power, it eliminates the possibility of insufficient penetration and provide satisfactory weld joint.
2. Because of its small included angle compared to that required for forward welding, it has advantages,from an operational and economical point of view.
3. This method (process) is suited for heavy plate of 3 mm thick or more but presents a possibility of making a hole with the plate thinner than the foregoing.
4. After thoroughly rehearsing the operation of blowpipe and welding rod, practice bead welding over the plate before making but welding.



Vertical upward welding



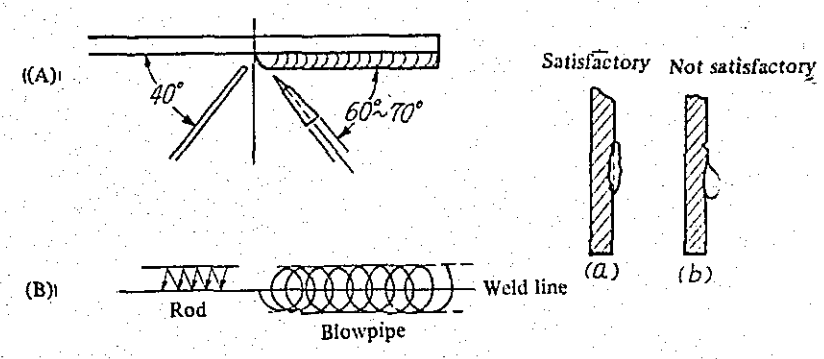


Work No.	No. 55
Type of work	Vertical butt welding
Main points	Upward welding
Materials	Two mild steel plate, 4.5 x 5 x 200 mm Welding rod 2-3 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 43-1. 1. Root opening is 1/2 of the thickness of plate. 3. Tack weld spacing is 100 - 150 mm. 4. After tack welding, set the plate in vertical position.	
2.	Posture	Take stable posture facing parallel to base material.	
3.	Start welding	1. Maintain the angle of blowpipe at 80°and the rod at 45°. 2. Make a small hole 5-6 mm in diameter with blowpipe and them immerse the rod in the molten pool and melt in. 3. Repeat the foregoing three actions while pushing the falling molten metal up with the power of flame. 4. Welding speed should be about 3/4 of that required for horizontal welding.	This method is generally believed to be difficult because of drooping molten metals during operation. Attention should be paid to this point during operation.
4.	Check the weld	1. Refer to No. 52-2-7. 2. There should not be any drooping of molten metal. 3. Refer to No. 43-2. 4. There should be a beautiful corrugated bead also on the backside.	

Remarks

After thoroughly rehearsing the operation of blowpipe and rod, practice vertical upward bead welding over the plate before making butt welding.

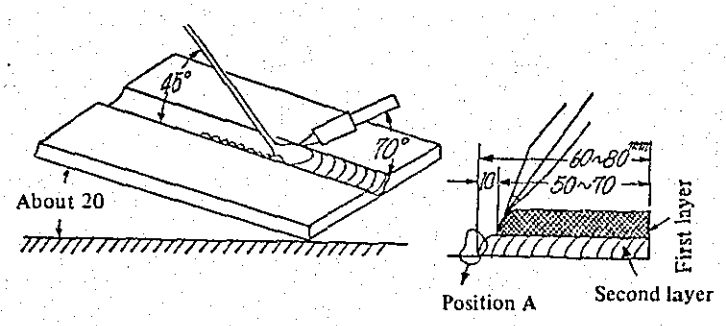


Work No.	No. 56
Type of work	Horizontal butt welding
Main points	Square groove welding
Materials	Two mild steel plates, 4.5 x 50 x 200 mm Welding rod 2 mm in diameter
Tools	

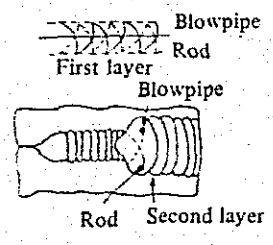
No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 43-1. 2. Root opening should be 1/2.	
2.	Make tack welds	1. Should be spaced at 100-150 mm. 2. Lay the plate down.	
3.	Start welding	1. Maintain the angle of blowpipe at 60-70°and that of rod at 40°against base material. See Fig. A. 2. Move blowpipe in the elliptical pattern and the rod slightly up and down but not to bring it down to the weld line. Keep it above the weld line. 3. Push up molten metal with flame, which often falls down. 4. While making a small hole in the root.	Hanging molten metal often causes erosion.
4.	Check the welds	1. Refer to No 52-2-7. 2. Make the weld uniform both at the upper and lower portions, as shown in Fig. C-a. 3. Fig. C-b shows an unsatisfactory weld which is hanging down.	

Remarks

After thoroughly rehearsing the movement of blowpipe and rod, practice on bead making on the plate before proceeding with butt welding.

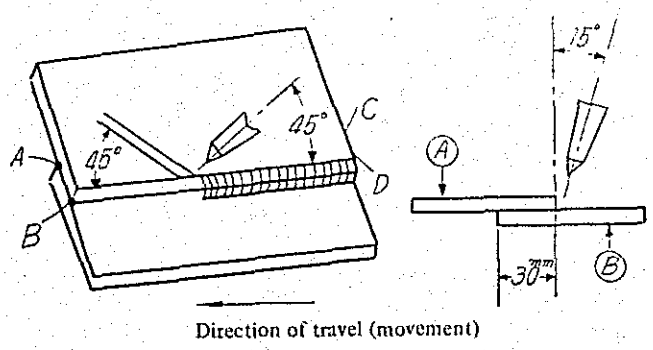


Work No.	No. 57
Type of work	Double layer bead welding
Main points	V groove welding for thick plate
Materials	Two mild steel plates, 9 x 100 x 150 mm Welding rod 3 mm in diameter
Tools	

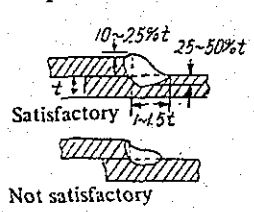
No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 43-1. 2. Bevel the edge in V shape.	
2.	Make tack weld	After tack weld has been made, raise the left end of the plate so the angle to the horizontal line would be approx 20°. Refer to No. 56-2.	
3.	Start welding 	1. Maintain the angle of blowpipe at 70°and that of the rod at 45° 2. Stop the first layer at about 60 mm and return to the starting point, make the second layer for 50 mm, leaving about 10 mm unwelded. 3. When the second layer has been completed, melt the remaining 10 mm on the first layer well in the manner described in the foregoing paragraph 1 and finish the weld by repeating the above procedure.	End of the bead often has defects such as craters and blowhole (porosity). Therefore, it is not advisable to bring the joint of bead on the same line. Also, if the first and second layers are piled up one another, the flame will not reach position A when the bead is continued on the first layer, resulting in poor melting. When making the second layer, scrape and remove oxidized film or oxide while making weld, which often get into the layer.
4.	Inspect welds	Refer to No. 53-2.	

Remarks

This process is used when it is not practical to make bead with one process because of the thickness of base material.

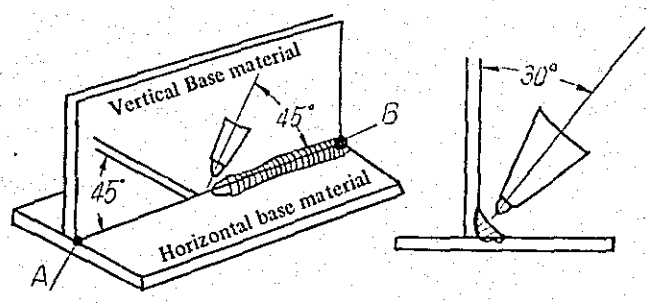


Work No.	No. 58
Type of work	Horizontal fillet welding
Main points	Lap joint
Materials	2 mild steel paltes, (3-4) x 50 x 200 mm Welding rod 2-3 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 44-1. 2. Width of lapping should be about 30 mm.	
2.	Make tack weld	Tack weld at four corners of overlaying plate in the order of A, B, C, D.	
3.	Start welding	1. Maintain the angle of blowpipe and that of the rod at 45 to horizontal plane and 15 to the vertical plane. respectively. 2. Swing blowpipe left and right slightly. 3. Move rod up and down lightly in the pattern of sawteeth. 4. Care should be taken not to cause over-melting of upper edge or erosion of palte. 5. Care should be exercised so that the underside of molten metal would not result in overlapping. 6. Direct flame toward the way which allows melting of the underside. Since the upper edge is liable to be melted by the remaining heat, it should be protected by the rod during the operation.	It is necessary to give careful attention to the angle of blowpipe. In the case of lap joint, the overlaying base material is often subject to erosion. Thermal expansion sometimes cause crevice (opening) at the joint of the plates during the welding operation. Use a hammer to eliminate crevice (opening).
4.	Inspect welds 	Refer to 43-2.	

Remarks

In this practice the welding rod is melted in while the edges and the surface of the palte are being melted.
A particular attention should be given to the portion being melted.

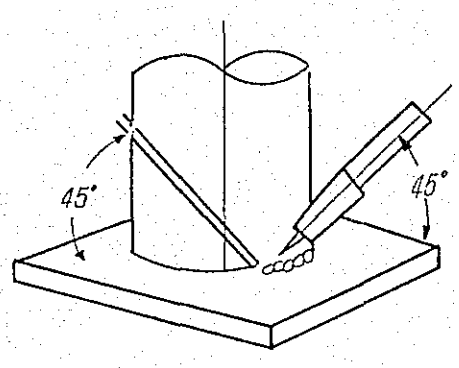


Work No.	No. 59
Type of work	Horizontal fillet welding
Main points	T section joint
Materials	Two mild steel plates, 4 x 50 x 150 mm Welding rod 2 mm in diameter
Tools	

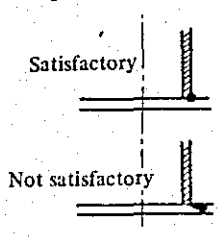
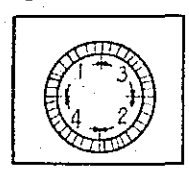
No.	Sequence of work	Description	Related information
1.	Make preparation	Refer to No. 43-1. Place the base material horizontally and set the vertical base material on the center of the horizontal plate.	
2.	Make tack weld	At the both ends (At the position A and B).	
3.	Start welding	1. Maintain the angle of blowpipe and rod at 45°to the horizontal plane and at 30°to the vertical plane, respectively. 2. Move blowpipe in the elliptical pattern. 3. Swing rod left and right slightly from the weld line. 4. Push up molten metal which is falling down with the flame. 5. Pay attention not to cause erosion on vertical plane and overlapping on the horizontal plane. 6. Since the vertical surface easily melt much faster than the other, attention should be paid to the angle of blowpipe.	The leg length should be about the same as the thickness of the plate, and the leg length should be the same for both vertical and horizontal surfaces. Throat depth should be about 70% of the leg length. As the vertical base material is more likely to be melted, horizontal base material must be preheated when the horizontal material and vertical material are to be melted at the same time. Distribution of heat in the process of welding should be in the ratio of 4 to 6, giving more heat to the horizontal base material.
4.	Inspect welds	Refer to No. 43-2. Put horizontal base material on the vice and hit the vertical base material with a hammer to see the weld strength.	

Remarks

Fillet welding requires a highly skilled technique for heat distribution. Since the vertical base material is very likely to have holes and the molten metal often hangs down (droops) and it is often difficult to have uniform bead, it is necessary to keep practicing this process repeatedly to acquire necessary techniques.

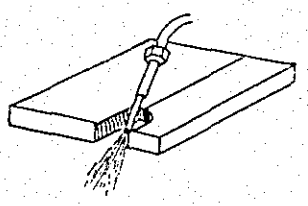


Work No.	No. 60
Type of work	Horizontal fillet welding
Main points	Changing the direction of bead
Materials	Gas pipe: 1" x 100 mm Mild steel plate (1.6-2) x 80 x 80 mm Welding rod 1.2-2 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 43-1. 2. Place flange horizontally and place a pipe over it.	
2.	Make tack weld	1. Make tack weld at four equally divided points. 2. Make four welds symmetrically.	
3.	Start welding 	1. Maintain the angle of blowpipe and rod at 45°to the horizontal plane and at 30°to the vertical place, respectively. 2. More blowpipe in the elliptical pattern. 3. Move rod up and down lightly in the upper half of the molten pool. 4. As the pipe is more likely to melt at first, direct flame to the flange so that uniform melting may be obtained. 5. As the falling molten metal frequently causes undercut, rod should be moved up and down lightly over (in) the upper half of molten pool and moved forward so as to push up molten metal. 6. Proceed while maintaining proper angle for blowpipe and rod and make bead of uniform width. 7. Finishing point of bead should overlap the starting point for approximately 10 mm.	Leg length for both vertical plane and horizontal plane should have similar bead. Change in the angle of blowpipe will result in unbalanced leg length or erosion in the pipe.
4.	Inspect welds 	1. Refer to No. 43-2. 2. Sudden quenching of the weld should be avoided. 	It is very important to avoid undercuts.

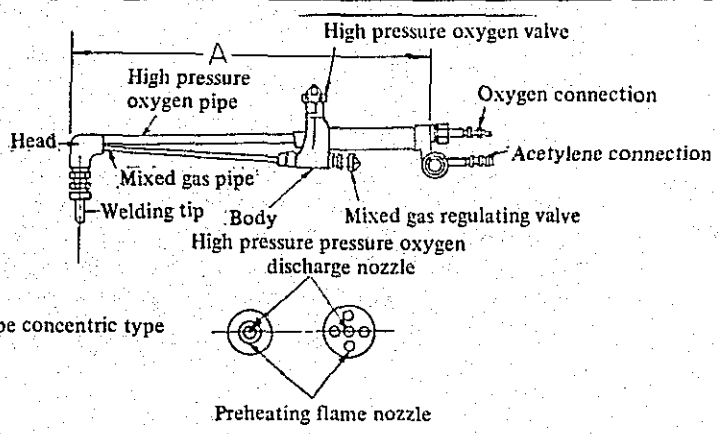
Remarks

Use of symmetrical method is recommended when the elimination of strain is required in particular.

Subject		Gas cutting	Work No.	No. 61
No.	Subject	Description		
1.	Principle of cutting and procedures for cutting operation 	This is a process to cut metal such as steel by utilizing a sudden oxidizing reaction which takes place between the heated iron and oxygen. Base on this principle, this operation, with the use of a cutting blowpipe, heat one specific point of iron or steel to 750-900°C and blast a stream of highly purified oxygen against that point, thus causing oxidization of metal within the narrow opening (cut end) and letting the opening (cut end) pierce through base material.		
2.	Gas flame used for cutting	1. Acetylene Because of its greater thermal (heat) efficiency and high flame temperature compared with other gases, the required time prior to the cutting operation can be reduced considerably. 2. Hydrogen Hydrogen is now widely used for underwater cutting operation. However, because of its less carorific value, it is not so sidely used as the acetylene. 3. Propane Cheaper than acetylene and has a higher heating value than acetylene. It also provides a clean cutting face. It is particularly noticeable that two or three layers of material can be cut at a time with this gas. Disadvantage with this gas is that it requires a long time for preheating and requires about four times more oxygen for burning propane, thus resulting in an increase in the cost of oxygen.		
3.	Efect of alloy elements	Largely classified into: 1. Increased resistance against cutting. 2. Increased hardness of cutting face.		
	1. Carbon (C)	1. Cutting is easily accomplished for carbon steel containing carbon up to 30% but difficult for that containing more than 0.2% carbon.		
	2. Manganese (Mn) and Silicon (Si)	2. Cutting is easily accomplished when preheated.		
	3. Chrome (Cr)	3. Cutting is possible if the content is less than 5%.		
	4. Nickel (Ni)	4. Depend on the amount of carbon (cutting is possible even when content is 20-30% if the amount of carbon is small. If the content is less than 7%, cutting is easily accomplished).		
	5. Molybdenum (Mo)	5. Cutting is difficult.		
	6. Tungsten (W)	6. Sufficient heating is required. Cutting is difficult when the content exceeds 20%.		
	7. Copper (Cu)	7. Cutting is possible if the content is around 2%.		
	8. Phosphorus (P)	8. No effect is seen if the content is within the allowable limit for steel.		
	9. Sulfur (S)	9. No effect is seen if the content is within the allowable limit for steel.		
	10. Vanadium (Va)	10. Small quantity accelerates cutting rather than hapering it.		

Remarks

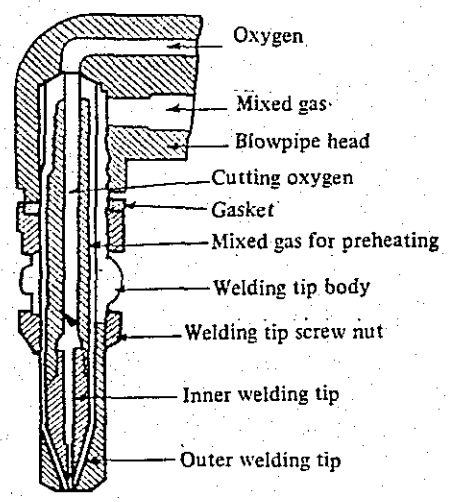
Metal which may not be cut with torch can be cut with powder cutting machine.



Work No.	No. 62
Type of work	*Handling of manual gas cutting machine*
Main points	Handling of blowpipe
Materials	
Tools	

No.	Sequence of work	Description
1.	Attach welding tip	1. *Tighten it down rigidly.* 2. Insert oxygen hose to the root of *connection and clamp it down with* a band.
2.	Check suction	1. Open gas valve and then open regulating valve. 2. Check suction with a thin paper. 3. Open high pressure oxygen valve and check suction with a thin paper. 4. Attach gas hose.
3.	Light blowpipe	Open acetylene cock and then open regulating valve slightly.
4.	Regulate flame	1. Regulate the valve to make the flame closer to oxidizing flame rather than standard flame. 2. Then regulate valve so that even *the supply of oxygen would not* produce carbonizing flame.
5.	Extinguish flame	1. Close regulating valve. 2. Close acetylene valve (cock).

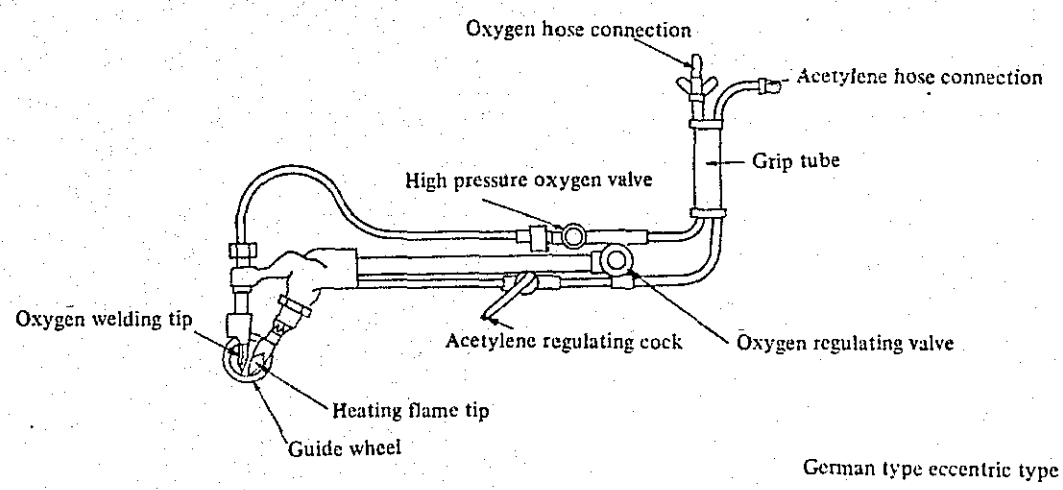
Related information



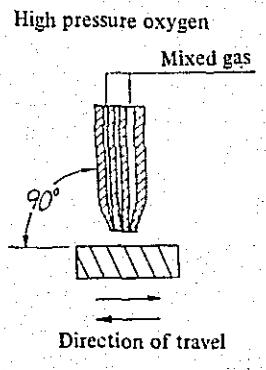
French type flame tip cross-section details

Remarks

For instructions on handling of blowpipe, refer to No. 50, preparations for welding.



German type eccentric type



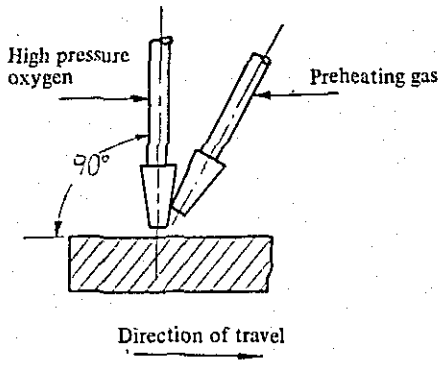
Work No.	No. 63
Type of work	*Manual cutting*
Main points	Cutting of mild steel
Materials	One mild steel plate, (4.5-8) x 150 x 200 mm
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Clean the portion to be cut. 2. Draw a cutting line and punch the plate. 3. Place the work as low as possible to prevent slag from flying over. 4. Maintain open space under the plate and place a pad steel on the floor.	Requirements for oxy-arc cutting: 1. The temperature at which the material to be cut begin combustion, or the firing temperature, must be lower than the melting point of the material. 2. Melting temperature of oxide produced as a result of combustion must be lower than that of the material. 3. Molten oxide must have high fluidity and easily separate from base material. Purity of oxygen: Generally, the oxygen contains some impurities. Oxygen less than 99% in purity results in slow cutting speed and greater consumption of oxygen. When the metal still hangs on the base material after cutting, do not strike it down with blowpipe.
2.	Regulate flame	Regulate valve so that there will be no carbonizing flame even when cutting oxygen is discharged.	
3.	Start cutting	1. Maintain the angle of blowpipe at 80-90° 2. Clearance between the white heart and base material should be about 3 mm. 3. Heat the edge of base material to 700-900° C and discharge high pressure oxygen. 4. Cutting should be done as fast as possible (350 mm/min). 5. Shut off cutting oxygen as soon as cutting of base material is completed.	
4.	Extinguish flame	1. Shut off the supply of oxygen for heating. 2. Close gas valve.	
5.	Inspect cut portion	1. Dropping of angle (Reduction of angle) is caused by excessive temperature of heating flame. 2. Undulating cutting line is caused by improper handling of blowpipe. 3. Wide cutting path is caused by improper flame (welding) tip. 4. Accumulation of slag is caused by insufficient pressure of cutting oxygen. 5. Excessively long drags are the result of improperly maintained angle of blowpipe.	

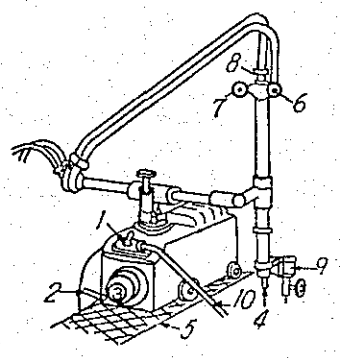
Remarks

Because of the high pressure gas involved in the cutting operation, special attention should be given to the prevention of gas leakage t... and to the combustible materials in the operating area, which might be ignited by flying slag.

Thickness of steel plate mm	Cutting speed mm/min	Pressure of oxygen kg/cm²
4	450–500	2.0–2.2
5	400–480	2.1–2.5
16	340–450	2.2–2.9
15	300–375	2.7–3.3
20	260–350	2.8–3.8
25	240–270	3.7–4.2
30	210–250	4.0–4.7
40	180–230	4.3–5.5
60	160–200	5.0–6.2
80	150–180	5.5–6.7
100	130–165	6.0–7.7



German type eccentric type-Direction of travel is constant.



Component parts of automatic cutting machine

1. Switch
2. Moving lever
3. Speed gage
4. Flame tip
5. Rail
6. Gas valve
7. High pressure oxygen valve
8. Preheating oxygen valve
9. Jig for circular cutting
10. Power cable

Work No.	No. 64
Type of work	Automatic cutting
Main points	Cutting of mild steel
Materials	One mild steel, (4.5-12) x 100 x 600 mm
Tools	

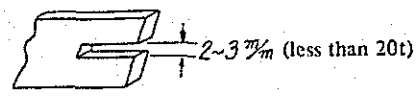
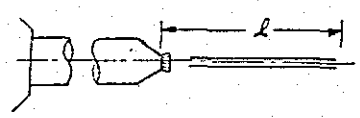
No.	Sequence of work	Description	Related information
1.	Make preparation	1. Remove stains and rust from the surface of steel plate, mark off a line of prescribed dimension and inscribe marks at necessary points with a punch. 2. Inspect the cutter (cutting machine). (1) To see that proper flame tip is used. (2) To see that no fault exist in the moving parts. (3) To see that hose connection is secure and tight. 3. Position the plate and cutter properly along the mark off line.	Keep in mind that the width of cutting groove produced by cutting operation should be 2–3 mm.  Thickness of plate (mm) / Diameter of flame tip / Width of cutting groove 6 / 0.8–1.0 / 2.0 10 / 0.8–1.5 / >2.5 15 / 1.0–1.7 / 2.5 20 / 1.2–1.8 / > 3
2.	Light flame tip	1. Make preheating flame at the end of the starting point. 2. Open valve for high pressure cutting oxygen and see if the discharge of xoygen is satisfactory.	Satisfactory discharge of high pressure oxygen is shown below. Discharge of high pressure oxygen should have a straight line which is twice as long as the length of flame tip. 
3.	Start cutting	1. Set speed gage properly to the desired cutting speed. 2. Turn on the switch (for racing). 3. Red heat the starting point of cutting line (750-900 C). 4. Open valve for high pressure oxygen. 5. Start moving in the direction of cutting. 6. Maintain 2-3 mm clearance between white heart and the face of base material.	A. It should be kept in mind that excessive pressure of of oxygen, which is higher than that required for cutting, will only result in the waste of oxygen and would not help to speed up the cutting operation and it will also result in inferior cutting face instead. B. Relationship between pressure of oxygen and cutting speed (mean value) Thickness of plate / Diameter of flame tip / Pressure of oxygen kg/cm² / Cutting speed cm/min 3.2 / 0.6–1.0 / 1–1.5 / 55–80 6 / 0.8–1.5 / 1–2.5 / 48–68 10 / 0.8–1.5 / 1.2–3.0 / 48–64 15 / 1.0–1.5 / 1.5–3.0 / 38–56 20 / 1.2–1.7 / 1.7–3.0 / 36–53 25 / 2 / 2.0–4.0 / 30–48
4.	Discontinue cutting	1. Shut off the supply of high pressure oxygen. 2. Turn off the switch and shut off the supply of oxygen acetylene.	
5.	Inspect cut portion	Refer to No. 63-5.	

FIG. 1

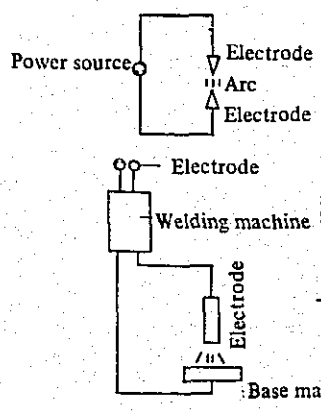


FIG. 2 (Weldment)

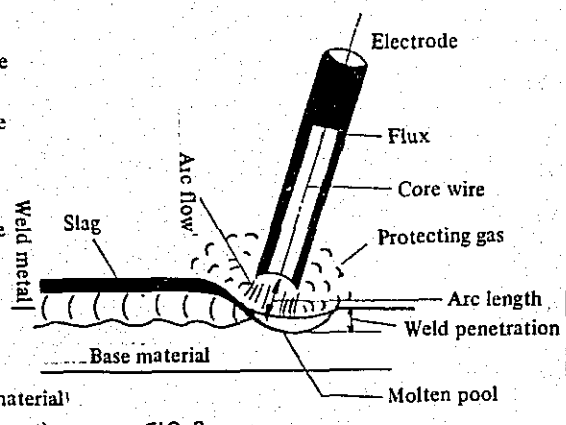


FIG. 3

FIG. 4

No.	Subject	Description
1.	What is arc?	As shown in Fig. 1, arc is produced when two electrodes, connected to appropriate power sources, come into contact with each other and then arc pulled apart slightly and kept at an appropriate distance. The arc produces strong light and heat at this moment.
2.	What is arc welding?	Electric welding are the methods in which insculation is made by fusing the metal locally after the electric energy, is changed to heat energy. Arc welding is one of these processes and used widely as a means to inosculate metals. In arc welding, electrode is brought to come into contact with the base material as shown in Fig. 2 instead of using two electrodes as shown in Fig. A and causes the arc to be produced between the two contact points, using resultant high temperature for welding. Presently, metal arc welding is most commonly used.
3.	What is metal arc welding?	The arc produced between the tip of electrode and base material melts part of the base material and at the same time, the electrode itself melts and deposits on the base material. The metal arc welding is the method which employs a repetition of the foregoing process. For electrodes, coated electrode, which is a core wire coated with flux, is usually used. The state of arc can not be observed with the naked eyes because of its intense glare but it may be illustrated as shown in Fig. 3 when observed through a shield glass.
4.	Welding operation	In actual welding operation, welding equipment such as welding machine, holder, and captire cable are required. Welders are required to wear protective equipment against harmful beam of arc, flying spatter and electric shock. Fig. 4 shows the arc welding operation.

Part 1	Basic Knowledge		
Subject	Arc welding equipment	Work No.	No. 66-1

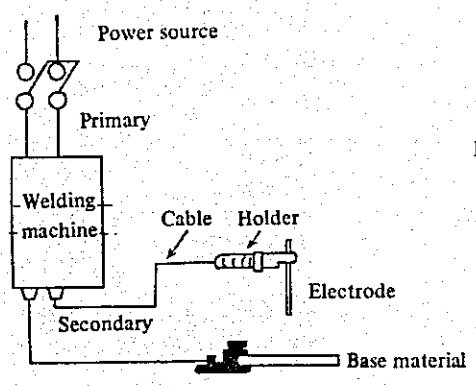


FIG. 1

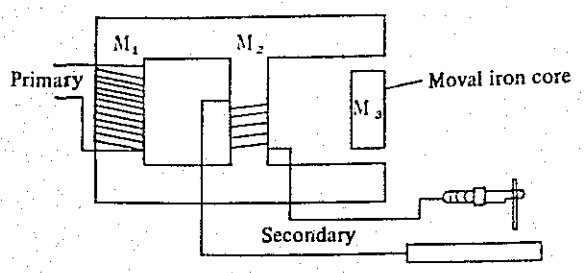


FIG. 2

No.	Subject	Description
1.	Arc welding equipment	Arc welding equipment consists of a welding machine, holder, cable, etc. Completeness of welding equipment has an important bearing on the success of welding operation. As the improper handling of the equipment often causes accidents, utmost care should be exercised in handling these equipment.
2.	Welding circuit	As shown in Fig. 1, electric current is supplied by connecting primary terminal of welding machine to the power source with wires. This is called the primary circuit. One of the secondary terminals of the welding machine is connected to the holder by a cable and another to the earth plate also by a cable, which is further connected to the weld materials (base material) by the earth plate. This is the secondary circuit and is usually refered to as the welding circuit.
3.	Arc welding machine	Arc welding machine is an electric device having characteristics suitable for continued arc generation and is also designed to provide control of welding current. The unit is classified into the direct current arc welding machine and the alternating current arc welding machine according to the type of current the unit is used on. The direct current arc welding machine obtains the direct current either from DC generator which is driven by DC motor or by other prime movers, or from the rectifier. Rectifier most in use are selenium rectifier and silicon rectifier. The alternating current arc welding machine is a sort of transformers, having characteristics suitable for the generation and continued existance of arc.
4.	AC arc welding machine (1) Moval iron core type welding machine	AC arc welding machines are manufactured in two major types, moval iron core type welding machine and moval coil type welding machine. However, the older type, separate leg coil winding type (Tap type) is also in use. This is the type most widely used among the AC arc welding machines. As shown in Fig. 2, an auxiliary iron core is provided in addition to the main iron core, which is movable against the main iron core. Movement of this moval iron core controls electric current.

Subject	Arc welding equipment	Work No.	No. 66-2

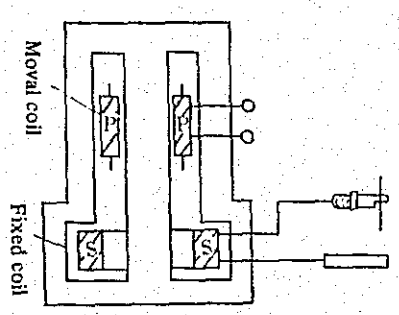


FIG. 3

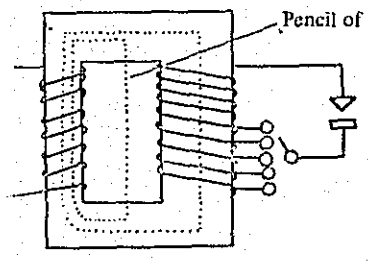


FIG. 4

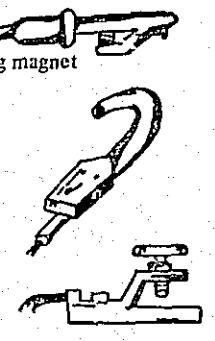


FIG. 5

No.	Subject	Description
	(2) Moval coil type welding machine	The welding machine of this type has a fixed secondary coil as shown in Fig. 3. Movement of the primary coil changes the distance between the primary coil winding and the secondary coil winding to control electric current.
	(3) Separate lag coil winding type welding machine	As shown in Fig. 4, this type has the primary coil and the secondary coil wund separately around each of the iron core legs. Control of electric current is provided by the change in the winding ratio of the primary coil to the secondary coil by shifting the tap. However, precise control of current is not provided with this type.
5.	Holder	Holder is used to support the electrode and therefore should be as light as possible in its weight. It must be of the design which provide a rigid holding of the electrode. Holder and captire cable must be joined perfectly in terms of electricity so as to prevent the generation of resistance heat in the joint. The joint is generally soldered.
6.	Earth palte	The device which connects a grounding wire to the base material or to the work bench. Types available are magnet type, clamp type and screw type. The type to be used should provide a secure holding and easy removal.
7.	Welding cables	Cables used to connect the welding machine to the holder or to the earth plate. Rubber insulated captires are used for this purpose. Cables for the holder should be of a high flexibility to provide easy handling during the operation. Cables for the grounding do not require such high flexibility as the one for the holder but should be of the type which provide easy handling. Standard allowable current for single core captire is shown in the table below. When the distance between the welding machine and the work site is great, cables of rather larger size are desirable for the prevention of the loss of electricity and smooth flow of current. For the distance of 2 meters from the holder, cables should be of high flexibility and their size should be smaller than the standard one in view of the fatigue of operator in his hand and the convenience's sake in the work.

Standard allowable current for welding cable (Single core captire cable)

Nominal section area (mm^2)	Allowable current (A)	Voltage drop (V/100 mm)
67	375	12.1
53	300	12.3
42	250	12.6
33.5	200	12.8

Part 1	Basic Knowledge		
Subject	Arc welding rod	Work No.	No. 67

Table JIS Z 3211 - 1961

Type of welding rod	Type of coatings	Position of weld	Electric current to be used
D4300	No provision	F, V, OH, H	AC or DC
D4301	Illuminite type	F, V, OH, H	AC or DC
D4303	Limetitanum type	F, V, OH, H	AC or DC
D4311	High cellulose type	F, V, OH, H	AC or DC (R)
D4313	High titanium oxide type	F, V, OH, H	AC or DC (S)
D4314	Iron powder titanium oxide type	F, V, OH, H	AC or DC (S)
D4316	Low hydrogen type	F, V, OH, H	AC or DC (R)
D4318	Iron powder low hydrogen type	F, V, OH, H	AC or DC (R)
D4320	High iron oxide type	F, H-Fil	AC or DC (S) for horizontal fillet welding and AC or DC for flat welding.
D4324	Iron powder titanium oxide type	F, H-Fil	AC or DC
D4326	Low hydrogen type	F, H-Fil	AC or DC (R)
D4327	Iron powder oxide type	F, H-Fil	AC or DC (S) for horizontal fillet welding and AC or DC for flat welding.
D4328	Iron powder low hydrogen type	F, H-Fil	AC or DC (R)
D4330	High iron oxide type	F	AC or DC
D4600	No provision	F, H-Fil	AC or DC

Remarks: 1. Symbols used for the position of weld are as follows:

F: Flat, V: Vertical, OH: Overhead, H: Horizontal, H-Fil: Horizontal fillet.

Positions of weld shown in Table 1 above apply to the welding rod less than 5 mm in diameter.

2. Abbreviations used for the type of current to be used are as follows:

AC: Alternating current, DC: Direct current double polarity
DC (S): Direct current straight polarity, DC (R): Direct current reversed polarity

No.	Subject	Description
1.	Outline	1. Arc welding rod (electrode) has a combined (dual) function of electrode and weld metal for the weld. Since it has a close relation with the convenience in the welding operation and the quality of weld, a careful attention should be paid to its selection and handling. 2. Arc welding rod commonly in use is a coated electrode. Coatings help, promote the generation, stability and durability of arc, provide protection for molten metal (prevention of oxidization and nitriding), supply useful elements and promote the improvement of mechanical properties of weld metal.
2.	Type of coated arc electrode for mild steel	1. Coated arc electrode for mild steel is classified as shown in Table 1, depending on the mechanical property of molten metal, position of weld, type of coatings and type of current. 2. Characteristics comparison of these electrodes is shown in Table 2.
3.	Optimum current for electrode	1. Each electrode has its own optimum current. Use of optimum current in welding result in the maximum performance of the electrode. 2. Optimum current has a certain range and the use of current higher than its upper (maximum) limit will result: (1) Excessive heating of electrode, thus causing a change in the quality of flux and degrading its function. (2) Deterioration of the condition of protector (guard) tube at the tip of electrode, thus causing weld bead to become larger and rendering inefficiency of the work. (3) Increase of spatter and unsatisfactory covering of slag. As a result, appearance of bead is not satisfactory either. 3. When the welding is done with the current lower than the optimum current, it will result in slow weld speed and roll-in of slag, thus making the work more difficult. Appearance of bead is not satisfactory either.
4.	Handling of electrode	(1) Care should be exercised so that coatings do not get moisted. Moisted coatings cause an increase of hydrogen in the weld metal, thus creating defects such as fish eye, linear composition and cracks. It also degrades the efficiency of electrode. (2) Electrode should be dry prior to its use. Do not apply intense fire in an attempt to dry it quickly. Drying for about two hours at about 150°C is most desirable. (About one hour at 355°–400°C for low hydrogen type). (3) Electrode should be free of oil and grease or dirt and other impurities. (4) Electrode should never be left indicriminately but should be placed in a container.

Subject	Manual arc welding (Thin steel plate)	Work No.	No. 68

Shape and welding requirements of weld joint is governed by (1) – (6) (JIS Z 3601 – 1961) in princple.

(1) Butt joint (Square groove welding)

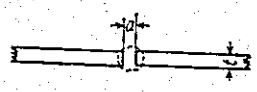


Table 1 Standard requirements for butt joint welding

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings	Root opening	Remarks
0.8	Flat, vertical, horizontal	2.0	25–35	Illuminite type, lime titamium type, high titan oxide type, high cellulose type	0-1/2 t	Single weld
1.2	"	2.6	40–55	"	0–1/2 t	
1.6	"	2.6	55–70 (50–65)	"	0–1/2 t	Single or double welding
2.3	"	2.3	65–90 (65–85)	"	0–1/2 t	

Remarks: Figures in parenthesis show the current for internal welding.

(2) T joining (Fillet weld)

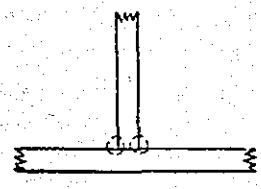


Table 2 *Standard welding requirements for T jointing*

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings
1.6	Flat, vertical	2.6	60–80	Illuminite type, lime titanium type, high titan oxide type, high cellulose type
2.3	Flat, vertical	3.2	85–100	"

(3) Lap joint

(A) Fillet weld

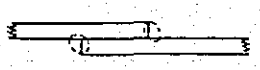


Table 3 Standard welding requirements for lap joint

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings
0.8	Flat, vertical, horizontal	2.0	30–40	Illuminite type, lime titanium type, high titan oxide type, high cellulose type
1.2	"	2.6	55–65	"
1.6	"	2.6	65–80	"
2.3	"	3.2	90–100	"

(B) Plug weld

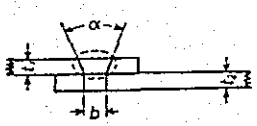


Table 4 Standard welding requirements for lap joint (for plug weld)

Thickness of drilled plate (mm) t'	Thickness of undrilled plate (mm)	Position of weld	Diameter of electrode (mm)	Welding current	Type of electrode coatings	Bore size	Included angle
0.8	More than 1.2	Flat	2.0	45–60	Illuminite type, lime titanium type, high cellulose type	0–4	0
1.2	More than 1.2	"	2.6	80–100	"	6	0
1.6	More than 1.2	"	3.2	105–125	"	8	0
2.3	More than 1.2	"	3.2	105–125	"	10	0
3.2	1.2–2.3	"	3.2	110–130	"	10	0
4.5	1.2–2.3	"	3.2	110–130	"	10	0
6.0	1.2–2.3	"	3.2	115–135	"	12 10	0 60

(4) Joggled lap joint (Fillet weld)

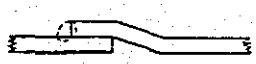


Table 5 Standard welding requirements for joggled lap joint

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings
0.8	Flat, vertical, horizontal	2.0	30–40	Illuminite type, lime titamium type, high titan oxide type, high cellulose type
1.2	"	2.6	55–65	"
1.6	"	2.6	65–80	"
2.3	"	3.2	90–100	"

(5) Corner joint

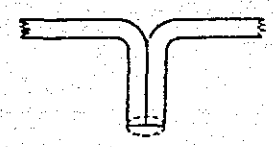


Table 6 Standard welding requirements for corner joint

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings
0.8	Flat, vertical, horizontal	2.0	20–35	Illuminite type, lime titanium type, high titan oxide type, high cellulose type
1.2	"	2.6	40–50	"
1.6	"	2.6	50–70	"
2.3	"	3.2	70–90	"

(6) Edge joint

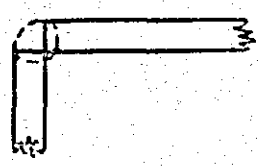
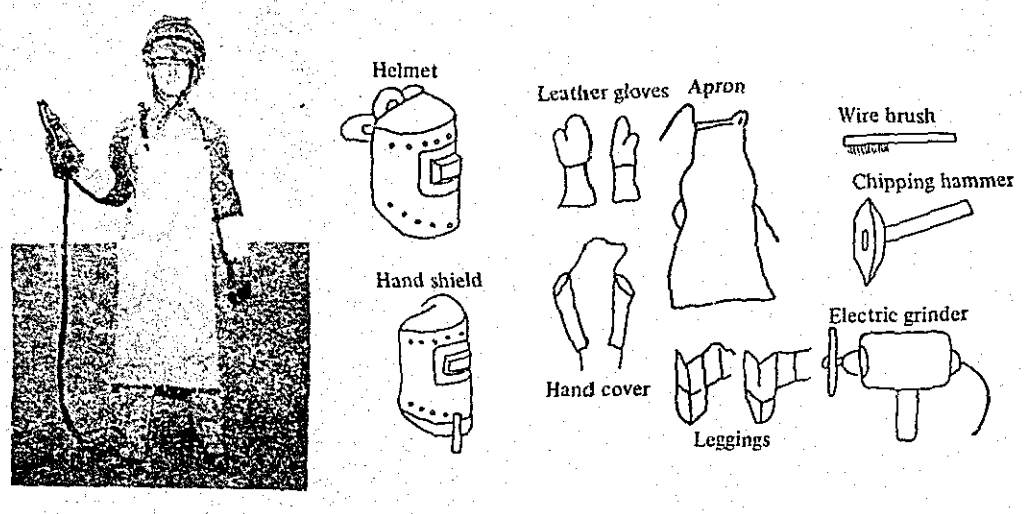


Table 7 Standard welding requirements for edge joint

Plate thickness (mm)	Position of weld	Diameter of electrode (mm)	Welding current (A)	Type of electrode coatings
0.8	Flat, vertical, horizontal	2.0	20–35	Illuminite type, lime titanium type, high titan oxide type, high cellulose type
1.2	"	2.6	35–50	"
1.6	"	2.6	45–60	"
2.3	"	3.2	55–80	"

Subject	Protective equipment and other equipment	Work No.	No. 69

Operator wearing protective equipment



No.	Subject	Description
1.	Requirement for protective equipment	Hazards of arc welding are electric shock, harmful rays (ultraviolet rays, infra-red rays), poisonous gases and spatterings. In order to protect the body from these hazards, welders must wear protective equipment shown in the picture above during the work.
2.	Helmet and hand shield	1. This provide protection for head and face and at the same time it can be used for observing the weld by installing a light shield glass in the lense box. Material to be used should be non-conductor of electricity and light in weight. 2. Helmet is suitable for the work being performed on unstable footings such as scaffolding or for vertical and overhead welding. Hand shield is sutable for the work on the ground level where wide range of vision is required.
3.	Light shield glass	1. It must be able to absorb and shield harmful rays completely and moreover it must have the transparency which provides distinct observation of the weld. It is used along transparent glasses in its front and back to protect from the spattering. 2. Transparent glass should be replaced before they become extremely dirty.
4.	Other protective equipment	1. Other protective equipment are leather gloves, apron, hand covers, and leggings. All of these equipment should have heat resistancy and should contain less moisture. They should also be of soft materials so that the operation may not be hampered. 2. Gas masks should be worn for the work which may involve poisonous gases. 3. Screen and light shield curtains are also needed as a protection against harmful rays.
5.	Cleaning tools and others	1. Rust or other foreign matters in the weld degrade mechanical strength of the deposite metal and cause blowhole or cracks. Therefore, weld joint should be thoroughly cleaned prior to the welding operation. 2. For cleaning of weld joint and removal of slag, chipping hammer, wire brush, chisel and single hand hammer are required. Portable electric grinder is also helpful for edge preparation, grinding of excess metal or surface finishing. 3. Other tools required include pliers, electrode containers and holder hanger.

Table 1 Plate thickness and diameter of electrode

Thickness of base material (mm)	Diameter of electrode (mm)
Less than 2	1.5–2
2	2–2.6
3	2.6–3.2
4	3.2–4
5–6	4
7–10	4–5
More than 11	5–8

Table 2 Diameter of electrode and welding current

Diameter of electrode (mm)	Welding current (A)
Less than 2	20–50
2	40–80
2.6	50–100
3.2	80–120
4	120–180
5	150–230
6	200–300

Work No.	No. 70
Type of work	Preparation of welding equipment
Main points	Installation of welding machine, establishment of welding circuit and other preparations
Materials	Insulating tape
Tools	Cleaning tools Protective equipment

No.	Sequence of work	Description	Related information
1.	Connect welding machine to power source	1. Welding machine having the primary voltage of 100 V should be connected to 100 V power source and that having the primary voltage of 200 V should be connected to 200 V power source. 2. Welding machine having three taps, 220 V, 200 V and 180 V on primary side should be connected to its 220 V tap when the voltage at power source is 220 V and should be shifted to 180 V tap when the voltage at power source dropped to 180 V. However, when the voltage at power source returned to normalcy, it must be shifted to corresponding tap. 3. Check primary line (Poorly insulated portion should be repaired with insulating tape). 4. Outer container (outside box) of welding machine should be grounded.	
2.	Establish welding circuit (secondary circuit)	1. Connect holder line and grounding wire to the secondary terminal of the welding machine. 2. Check cable and repair frayed portion. 3. Make sure that the earth plate is attached to the weldment or to the work bench securely. 4. All connections should be clamped securely. 5. Check and ascertain that the connection of the cable and holder is complete (generally connection is soldered).	
3.	Prepare cleaning tools	Prepare wire brush, chipping hammer, single hand hammer, chisel and pliers.	
4.	Prepare protective equipment	1. Put on gloves, apron, hand covers, leggings and head gear and ascertain their dependability against the hazard of welding. 2. Check to see that the light shield glass of hand shield or helmet is not soiled and dirty.	
5.	Select electrode and determine welding current	1. Selection of electrode and welding current should be made by taking into account the type of material, plate thickness and welding requirements. 2. For relationship between plate thickness and the diameter of electrode, see Table 1. 3. For relationship between the diameter of electrode and welding current, see Table 2.	

Part 2	Demonstration

(Sheet metal work)

(1) Tap shifting handle
(2) Moval iron core operating handle
(3) Secondary terminal
(4) Switch

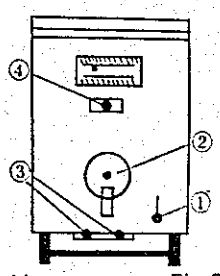


Fig. 1 Moval iron core type welding machine

(1) Control handle
(2) Current indicator
(3) Secondary terminal

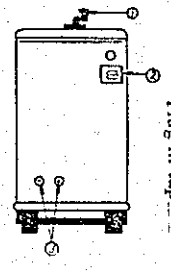


Fig. 2 Moval coil type welding machine

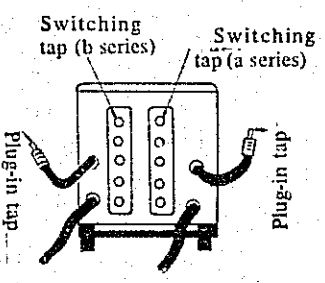


Fig. 3 Separate leg coil winding type (tap type) welding machine

Work No.	No. 71
Type of work	Handling of welding machine
Main points	Handling of welding machine and control of current
Materials	
Tools	One ammeter (400 A) One voltmeter (50 V)

No.	Sequence of work	Description	Related information
1.	Prepare welding equipment	1. Connect welding machine to power source 2. Establish (make) welding circuit. Refer to No. 70	
2.	Connect ammeter and voltmeter	1. Measurement of welding current: Measurement is taken by connecting ammeter in series to the welding circuit. 2. Measurement of arc voltage: Measurement is taken by connecting the voltmeter to the point betweeen the both terminals of circuit to produce arc and pressing the switch on the voltmeter.	
3.	Control current	1. Control of current for moval iron core type welding machine. See Fig. 1. (1) Throw in switch on power source (side after checking the internals of welding machine and ascertain that there is no possibility of short circuit or burning of the line. (2) Throw in switch on the welding machine, turn handle (2) and shift moval iron core to control current. (3) Then, throw in switch on the welding machine, turn handle (2) to shift moval iron core for a precise control of current. (4) Shifting of tap should be made only after disconnecting the switch. 2. Control of current for moval coil type welding machine. See Fig. 2. (1) Throw in switch after checking the internals of the welding machine. (2) Turn handle (1) in Fig. 2 and shift moval coil to control current. 3. Control of current for separate leg coil winding type (tap type) welding machine. (1) Throw in switch after checking the internals of welding machine. (2) Plug the plug tap into the shifting tap to control current. For the type having the change (shifting) taps in two rows as shown in Fig. 3, control of current is made by plugging the tap (a) into the line (a) and the tap (b) into the line (b) and also by the combination of plug-in position of (a) and (b). (3) Tap should be plugged in completely.	Make certain that shifting of switch has been made. This welding machine provides only fragmental control of current.
Remarks	Other precautions	1. Switches on power source and welding machine should always be disconnected after work or at time of breaks. 2. Welding machine should not be installed at the location where leakage of rain water or sumersion in the water may be encountered or at the location of high humidity. 3. Internals of the welding machine should be inspected periodically and all connections should be tightened securely. Moving parts should be lubricated. 4. Welding machine should never be used without its cover placed in right location. 5. When the machine is to be used for a prolonged duration, attention should be paid to the rise of temperature in the coil or other parts. When there is a sign of burning out, disconnect switch immediately and let the internals cool down.	

FIG. 1

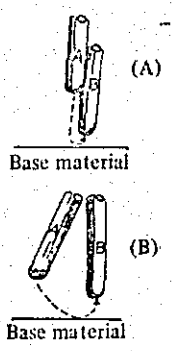


FIG. 2

Work No.	No. 72
Type of work	Generation of arc
Main points	Generation of arc
Materials	One mild steel plate (6-8) x 100 x 150 mm Electrode 4 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Prepare welding equipment. Refer to No. 70. 2. Place steel plate horizontally and brush off the surface with wire brush to remove rust and foreign matters. 3. Welding current should be 140-160 A.	Work under No. 1 is common to all processes. Therefore, this procedure will not be repeated for the subsequent demonstrations.
2.	Posture	1. Bend the upper half of the body forward slightly, stand with both feet spread a half step apart, weaken the strength in the shoulder and spread elbows but horizontally. 2. Grip holder lightly. 3. Handle holder cable in such a manner that will not hamper operation. (1) Care should be taken so that the cable will not twist. (2) When the weight of the cable hampers operation, wind the cable around the wrist or lay it over the lap or put it on the shoulder.	Position of weld should be natural and stable. Fig. 1 shows an example of positions of weld (welding posture) for flat welding.
3.	Generate (produce) arc	1. Insert electrode in the holder at a right angle. 2. Hold electrode vertically to the surface of steel plate and bring the tip close to the point of arc generation. 3. Put on handshield or helmet to protect face. 4. (1) Hit the steel plate lightly with the tip of electrode, reaction of which will provide a clearance of 2-3 mm between the tip of electrode and base material and produce arc. (Refer to Fig 2. (B)) (2) Rub the tip of electrode against the base material in the manner similar to striking a match by maintaining a clearance of 2-3 mm between the tip of electrode and base material and produce arc. (Refer to Fig. (B)). 5. When the electrode stuck to the base material and would not move, disconnect switch immediately.	(1) When using a handshield, put on the shield first and then produce arc. (2) When using a helmet, pull down the shield first and then produce arc.

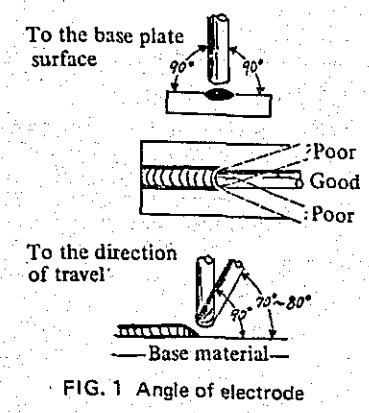


FIG. 1 Angle of electrode

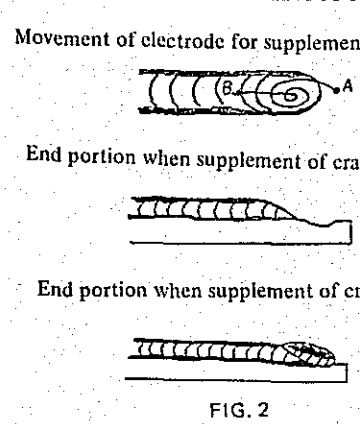
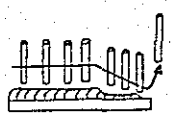


FIG. 2

Work No.	No. 73-1
Type of work	Placement of bead
Main points	Placement of string bead
Materials	One mild steel plate (8-10) x 100 x 250 mm
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Refer to No. 72-1. 2. Welding current should be 140-160 A.	
2.	Posture	Refer to No. 72-2, position of weld for flat welding.	
3.	Produce arc	Arc should be produced at the starting point of welding. Refer to No. 72-3.	
4.	Place bead	1. Maintain the angle of electrode vertically to the surface of base material but the electrode may be held at an inclination of 70-80° in the direction of movement depending on the type of electrode. Refer to Fig. 1. 2. Electrode should be moved from left to right in a straight line. 3. Lower electrode slowly and move it in the designated direction while maintaining the arc length at 2-3 mm. 4. Maintain uniform bead width (6-8 mm).	Base material—weldment (1) If the speed of movement is too slow, it will result in wider bead and cause roll-in of slag. (2) If the movement is too fast, it will result in a discontinued bead and involve (rolls in) slag. If the speed is not constant, width of the bead will not be uniform.
5.	Cut off arc	Shorten the arc a little before discontinuing the bead and promptly pull it apart immediately before a short-circuit occurs. 	
6.	Join bead	1. Remove slag from the suspended portion and clean it up. 2. Produce arc at point A shown in the figure at right, and join the bead by turning back in the order of A-B-C. 	
7.	Supplement the bead	1. Crater at the end of bead should always be supplemented by deposited metal. 2. Remove slag from crater, produce arc at the point A shown in Fig. 2 and supplement crater by moving electrode as shown in the figure. Repeat this movement until the concaved portion of crater is supplemented to the height of the bead.	When supplementing the crater, care should be exercised so that the portion will not be overheated, which may result in a flow out of deposite metal or enlargement of crater. Arc should be maintained as short as possible.

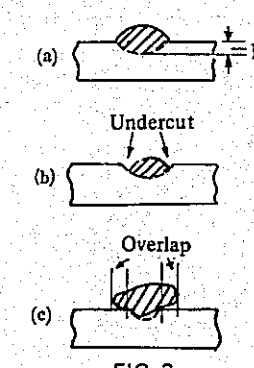
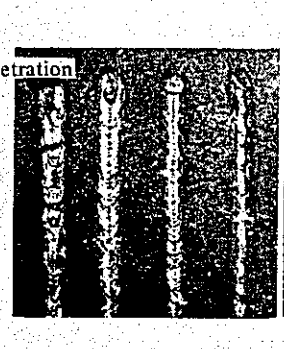


FIG. 3


200A 150A 90A 50A
FIG. 4


(a) (b) (c)
200A 150A 50A
FIG. 5

Work No.	No. 73-2
Type of work	Placement of bead
Main points	Placement of string bead
Materials	One mild steel plate (8-10) x 100 x 250 mm
Tools	

No.	Sequence of work	Description	Related information
8.	Inspect (check) bead	1. Satisfactory bead should have a proper penetration as shown in Fig. 3 (a) without undercut or overlap and should have uniform wave pattern with less irregularities. 2. Bead should be straight and in uniform width. 3. Bead having undercut or overlap as shown in Fig. 3 (b) and (c),disproportioned wave pattern and extreme irregularities and uneven penetration is not desirable. 4. Welding current and penetration: Fig. 4 shows the relationship between the welding current and penetration. An electrode 4 mm in diameter was used on the mild steel plate 9 mm in thcikness and the bead was placed by changing the welding current from 50 A to 90 A, 150 A and 200 A. With 50 A and 90 A, penetration was insufficient and the bead had many irregularities. With 150 A, penetration was sufficient and the wave pattern of bead was fine and uniform. With 200 A, penetration was sufficient but the wave pattern of bead showed rough and discontinued string. 5. Welding current and appearance of bead: Fig. 5 shows the appearance of each of the above mentioned beads. (a) Bead made with excessive current. (b) Bead made with appropriate current. (c) Bead made with weakened current. Description in 4 and 5 above may be summarized that the optimum current for flat string bead on the mild steel plate 9 mm in thickness with an electrode 4 mm in diameter would be 140-160 A. It should be kept in mind, however, that the welding current varies with the type of electrode and the thickness of the plate.	Undercut Fine groove created along the weld line on the boundary between bead and base material. Overlap Boundary of bead and base material has not been fused and only overlapping each other. Cause of undercut (1) Excessive electric current. (2) Improper handling of electrode. (3) Excessively long arc as a result of excessive current. Cause of overlap (1) Current is too weak. (2) Improper movement of electrode. (3) Arc is too long as a result of weak current.

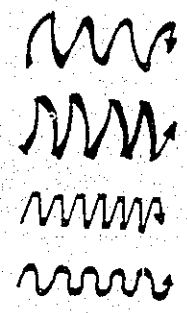


Fig. 1 Movement of electrode for weaving bead. Move electrode slowly where it is shown by thick line and move it fast where it is shown by thin line.

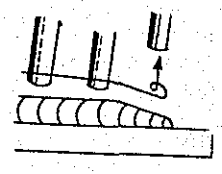


Fig. 2 Separation of arc

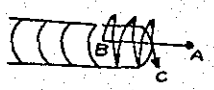


Fig. 3 Bead joint

(a) 200A (b) 150A (c) 50A

Fig. 4

Work No.	No. 74
Type of work	Placement of bead
Main points	Placement of weaving bead
Materials	One mild steel plate (8-10) x 100 x 250 mm Electrode 4 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	1. Make preparation	1. Refer to No. 72-1. 2. Welding current should be 150-170 A.	
2.	Posture	Refer to No. 72-2.	
3.	Produce arc	Refer to No. 72-3.	
4.	Place bead	Refer to No. 73-1-4, angle of electrode. For the movement of electrode, See Fig. 1. 1. Maintain constant arc length and proceed by moving the electrode as shown in Fig. 1. 2. Move electrode fast when it passes the center of bead and stop it a little at both ends in the movement of electrode from side to side. 3. Weaving pitch should not be of rough or irregular intervals. 4. Movement of electrode should be made in such a manner that it would not cause irregularities in the condition of molten pool.	Molten pool (1) Movement of electrode for weaving bead should not be done by the wrist alone (angle of electrode to the base material changes). Try to use the whole arm for its operation. (2) Care should be exercised so that the width of bead will not become greater than three times the diameter of electrode being used.
5.	Cut off arc	Shorten arc while making the weaving and quickly cut off it by turning the tip in a small circle as shown in Fig. 2.	
6.	Join the bead	1. Remove slag and clean the supended portion. 2. Produce arc at point A shown in Fig. 3, proceed to point B, and return to join the bead by maintaining weaving movement of electrode.	(1) A-B is for preheating. (2) The turn at point B should be made promptly, otherwise satisfactory joint of bead can not be expected. (3) B-C is for deposition of metal.
7.	Supplement crater	Refer to 73-1-7.	
8.	Check welds	1. Wave pattern of bead should be uniform and without irregularities. 2. Bead should not have undercut or overlap. 3. Relations of welding current to the penetration and appearance are similar to those for straight bead. Refer to 73-2-4 and 5. 4. Fig. 4 shows the appearance of weaving bead. (a) Bead made with excessively high current. (b) Bead made with appropriate current. (c) Bead made with too low current.	

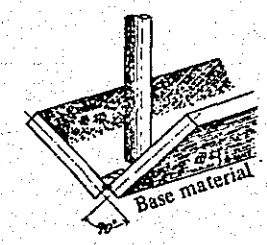


FIG. 1

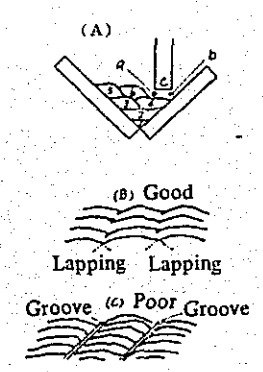


FIG. 2

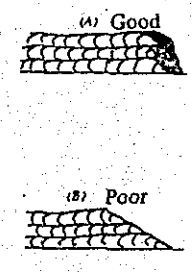
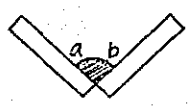
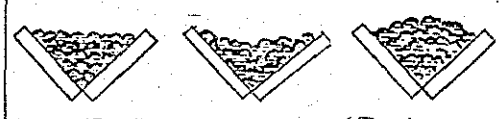


FIG. 3

Work No.	No. 75
Type of work	Placement of bead
Main points	*Lapping of bead*
Materials	Two mild steel plates (8-10) x 80 x 200 mm Electrode 4 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Clean weld surface. 2. Welding current (For string bead- 140–160 A) (For weaving bead- 150–170 A)	Current for tack weld should be slightly stronger than that required for final welding to provide easy production of arc and sufficient penetration and also to prevent *piling of* bead.
2.	Make tack weld	1. Join both steel plates at an angle of 90° as shown in Fig. 1 and make tack weld *at both ends.* 2. Produce arc on other steel plate and bring *the tip close to the weldment while* the tip is still red in color to make tack weld. 3. After tack weld has been made, place the plate horizontally with the top of angle facing down.	*If arc is produced directly over the weldment in making* tack weld, the shock of arc may upset the joint of base material.
3.	Place bead	1. Practice string bead and weaving bead movement alternately. 2. For the angle and movement of electrode, refer to No. 73-1 and No. 74. 3. For bead lapping, refer to Fig. 2 (A). 4. First and second layers should be welded by single bead. The third layer and thereafter should be made by several passes after determining appropriate bead width. 5. Remove slag and clean at each pass. 6. When making a final pass for each layer, try to make the opening (clearance) between the previous bead (a) and base material (b) a little wider than electrode as shown in Fig. 2 (A). 7. *Lap of each pass should be welded by* providing complete joint as shown in Fig. 2 (B) and care should be taken not to make deep groove in the surface as shown in Fig. 2 (C).	*Single bead:* Bead in single line. Path (pass): Bead made with a single movement of electrode. Shape of single bead layer. When the single bead layer has a pile like the one shown in the figure below, point (a) and (b) often accumulate slag. Try to make a flat bead. 
4.	Supplement crater	Supplement of crater should be made accurately and care should be taken not to make the final portion of bead layer inclined. Refer to Fig. 3.	
5.	Check the bead	1. Check to see that the deposite metal has any cavities because of blowhole or slag. 2. Check to see that finished surface is flat. 	

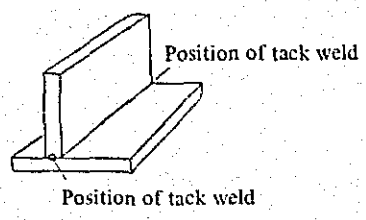


FIG. 1

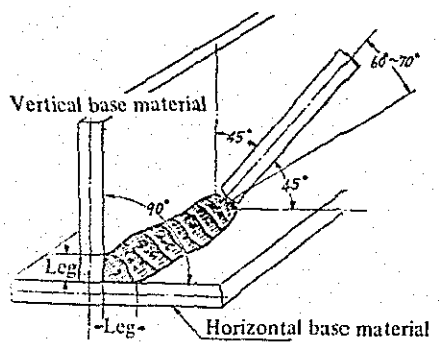
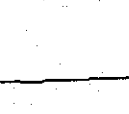
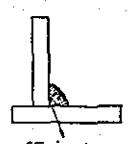
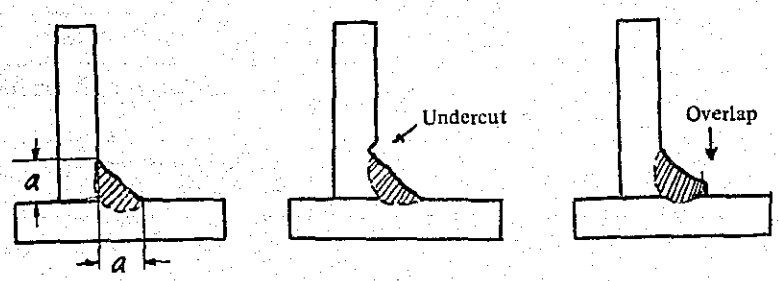


Fig. 2.

Work No.	No. 76-1
Type of work	Horizontal fillet welding
Main points	Placement of string beam for T Joint
Materials	Two mild steel plates (8-10) x 70 x 200 mm
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Finish cross-section and surface plane so that butt portion (joint) will not have a gap and then clean weld joint. 2. Welding current should be 150—170 A.	
2.	Make tack weld	1. Set up base materials in T shape and make tack weld at both ends avoiding weld line. See Fig. 1. 2. For tack weld procedure, refer to No. 75-2. 3. After completing tack weld, place weld line horizontally.	
3.	Produce arc 	1. Maintain the angle of electrode at 45° to both base materials and produce arc in the manner described in No. 72. 2. Produce arc at the point 10 mm inside from the end of weld line. While preheating the weld joint with arc, move toward the end and turn back to start welding. See figure at left.	
4.	Place bead	1. Maintain electrode at 45° to both base materials. Incline (tilt) is at 60°-70° to the direction of movement. However, inclination as close to 90° as possible will result in better penetration. Refer to Fig. 2. 2. Movement of electrode. Straight line (from left to right). 3. Movement from the point where arc is produced to the starting point of welding is aimed at providing preheating. Use long arc and shift to weld point before molten metal starts dripping. 4. While giving both base materials uniform penetration, move over the weld line so as to make the length of both legs equal. 5. Care should be taken so that it will not result in an insufficient penetration in the root of bead. 6. Electrode should always travel before slag. If slag travels before the electrode, it results in roll-up of slag.	Angle to the direction of movement should not be less than 60°:  Insufficient penetration
5.	Cut off arc	Maintain electrode at 45° to both base material and cut off arc in the manner described in No. 73-1.	



(A) (B) (C)

FIG. 3

Work No.	No. 76-2
Type of work	Horizontal fillet welding
Main points	Placement of string beam for T Joint
Materials	Two mild steel plates (8-10) x 70 x 200 mm
Tools	

No.	Sequence of work	Description	Related information
6.	Join bead	Maintain electrode at 45° to both base materials and follow procedures described in No. 73-1-6.	
7.	Supplement crater	Maintain electrode at 45° to both base materials and follow procedures described in No. 73-1-7.	
8.	Welds Inspect welds	1. There should be complete penetration at the starting point of welding. 2. Surface of bead should be smooth and should have uniform wave pattern. The width of bead should be uniform and the length of vertical leg and horizontal leg should be even. 3. Cross section of desirable bead should have equal leg length as shown in Fig. 3 (A) and should have no faults such as overlap and undercut. It should also have sufficient penetration to its root. 4. Weld having undercuts or overlaps at the toe of bead weld or that having sufficient penetration at the bead root, as shown in Fig. 3 (B), (C), are not desirable.	Toe of weld: The boundary line of bead and base material. Undercut tends to occur in vertical base material and overlap is frequent with horizontal base material. When current is too weak or when the weld rate is too fast, it often results in an insufficient penetration.

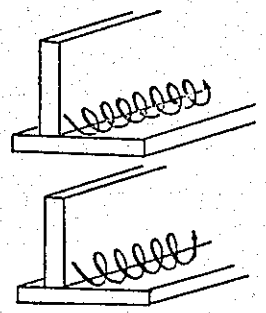


FIG. 1

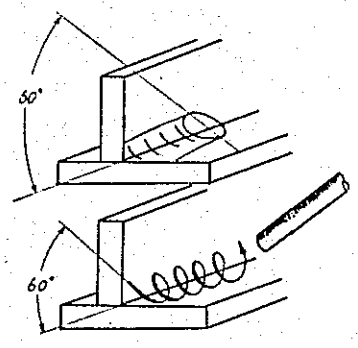


FIG. 2

Work No.	No. 77
Type of work	Horizontal fillet welding
Main points	Placement of weaving bead for T Joint
Materials	Two mild steel plates (8-10) x 70 x 200 mm
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	Refer to No. 76-1-1. Welding current should be 150-170 A.	
2.	Make tack weld	Refer to No. 76-1-2.	
3.	Produce arc	Refer to No. 76-1-3.	
4.	Place bead	1. Angle of electrode-Same as for string bead. 2. Movement of electrode-Refer to Fig. 1. 3. Weaving operation should be made at an incline of about 60° against the weld line (as a result, surface of molten pool has a similar inclination). Refer to Fig. 2. 4. In weaving operation, movement of electrode from bottom to top should be made as if to only maintain arc and the movement from top to bottom should be made as if to supply molten metal. 5. Care should be exercised since this process involves more deposite metal than string bead and tends to make overlapped bead. 6. For other information, refer to No. 76-1-4.	
5.	Cut off arc	Maintain electrode at 45° to both base materials and follow procedures described in No. 74-5.	
6.	Join bead	Maintain electrode at 45° to both base materials and follow procedures described in No. 74-6.	
7.	Supplement crater	Maintain electrode at 45° to both base material and follow procedures described in No. 73-1-7.	
8.	Check welds	Refer to No. 76-2-8.	

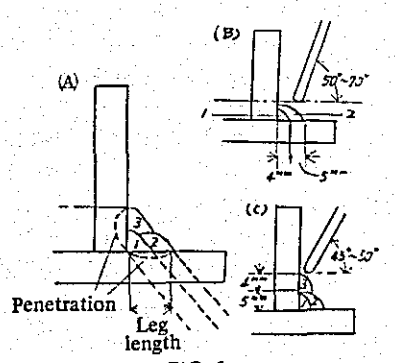


FIG. 1

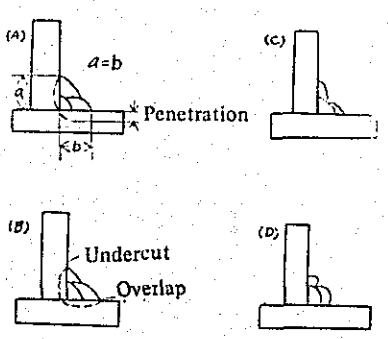


FIG. 2

Work No.	No. 78
Type of work	Horizontal fillet welding
Main points	Placement of multi-layer bead for T Joint
Materials	Two mild steel plates (8-10) x 70 x 200 mm
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	Refer to No. 76-1-1.	
2.	Make tack weld	Refer to No. 76-1-2.	
3.	Welding sequence and size of fillet	1. When finishing in two layers, place bead in the sequence shown in Fig. 1 (A). 2. Finish bead of the second layer with the pass 2 and 3. 3. Leg length should be 9-12 mm.	
4.	Produce arc	Refer to No. 76-1-3.	
5.	Place bead of the first layer	1. Place string bead or narrow weaving bead. Refer to No. 76-1-4 and No. 77-4. 2. Since the leg length should be finished to 9-12 mm in the second layer, make the leg length of bead 4-6 mm.	Welding current slightly stronger (higher) than that described in the Demonstration No. 7 and 8 will provide sufficient penetration and make the work easier.
6.	Place bead of the second layer	1. Remove slag and clean the weld joint for each layer. 2. For making the pass shown in Fig. B-2, refer to Fig. 1 (B). (1) Maintain electrode at 50°—70° to the horizontal base material. (2) Welding should be made by using the toe of weld of the first bead on the side of horizontal base material as a basis with a particular attention paid to overlap. 3. For making the pass No. 3, refer to Fig. 1 (C). (1) Maintain electrode at 45°—50° to the horizontal base material. (2) Welding should be made by maintaining the arc short and using the toe of weld at the side of the vertical base material as a basis, paying a particular attention to undercut. 4. For other information, refer to No. 77.	Undercut often occurs in the vertical base material and the overlap is frequent with the horizontal base material. Refer to Fig. 2 (B).
7.	Check (inspect) welds	1. Cross-section of desirable bead is shown in Fig. 2 (A). 2. Lap of bead should not be like the ones shown in Fig. 2 (C) and (D). 3. For other information, refer to No. 76-2-8.	

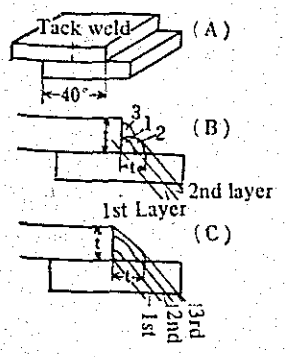


FIG. 1

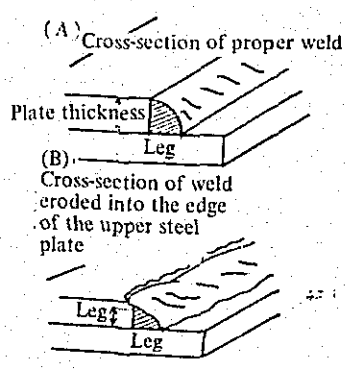


FIG. 2

Work No.	No. 79
Type of work	Horizontal fillet welding
Main points	Placement of multi-layer for lap joint
Materials	Two mild steel plates (8-10) x 80 x 200 mm Electrode 4 mm in diameter
Tools	

No.	Sequence of work	Description	Related information
1.	Make preparation	1. Finish surface in such a manner that no gap is made at the lap portion of base material. 2. Welding current should be 150—160 A.	
2.	Make tack weld	1. Maintain the lap length of base material at 40 mm and make tack weld at the both ends of the plate avoiding weld line. Refer to Fig. 1 (A). 2. For tack weld procedure, refer to No. 75-2. 3. Clean weld joint and lay weld line horizontally.	
3.	Produce arc	Refer to No. 76-1-3.	
4.	Place the first bead layer	Make straight bead or narrow weaving bead. Refer to No. 76 and No. 77.	
5.	Place the second and third layers	1. When finishing is made by the second layer: (1) Welding sequence is shown in Fig. 1 (B). (2) Make each pass to place weaving. Refer to Demonstration No. 77 and No. 78. (3) Since the edge of upper base material tends to melt easily, move electrode promptly on that portion to avoid undercut. 2. When finishing is made with the second and third layer: (1) Welding sequence is shown in Fig. 1 (C). (2) Place weaving bead. Refer to No. 77. (3) Try not to leave undercut on the edge of upper base material.	Size of fillet: Since the vertical leg length is equal to the plate thickness, make the horizontal leg length also equal to the plate thickness.
6.	Check welds	1. Weld joint should be in proper shape as shown in Fig. 2 (A). 2. The one shown in Fig. 2 (B), which has eroded the edge of upper base material, appears to have proper bead. Its cross-section, however, shows uneven leg length and penetration. 3. For further information, refer to No. 78-7.	

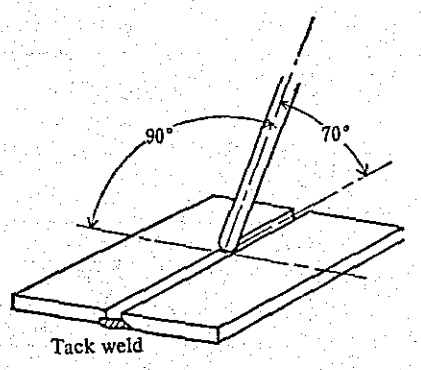


FIG. 1

Example of strain relieving

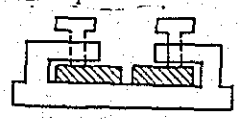
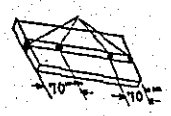


FIG. 2

Work No.	No. 80
Type of work	Flat butt welding
Main points	Square groove welding
Materials	Two mild steel plates (3-6) x 80 x 250 mm
Tools	

No.	Sequence of work	Description
1.	Make preparation	1. Cut base material to the desired dimension, relieve strain and finish butt portion (surface of joint) with a grinder. 2. Welding current should be 80–120 A.
2.	Make tack weld 	1. Butt (join) steel palte and make tack weld by maintaining a proper root opening. 2. For position of tack weld, see figure at left. 3. After finishing tack weld, finish the surface of bead with a grinder to make the surface equal to the thickness of the plate. Place the plate horizontally with the surface facing down.
3.	Produce arc	Refer to No. 72-3.
4.	Place the first bead layer	1. Maintain electrode at 90° to the plane of base material and incline it to 70–80° against the direction of movement. Refer to Fig. 1. 2. Movement of electrode–string bead. 3. Proceed by maintaining the arc short and giving both base materials even penetration.
5.	Place the second bead layer	1. Welding current should be 120–150 A. 2. Angle of electrode–Same as for the first layer. 3. Movement of electrode–String bead or narrow weaving bead. 4. Give sufficient melting to the point where holes of the first bead layer was filled up. 5. Move electrode in such a manner as to correct irregularities in the surface of the first bead layer and maintain the width of bead a little greater than that of the first bead layer. 6. For other information, refer to No. 73 and No. 74.
6.	Check welds	1. Weld should have sufficient penetration to the bottom. 2. Bead surface should be smooth and wave pattern should be uniform. 3. Weld should not have such defects as undercut or overlap. 4. Excess metal of bead should not lean toward one side or crooked. 5. Brooping bead in the back in not desirable.

Related information

(1) In butt welding, thin plate less than 6 mm in thickness are normally welded without beveling. For the plate 6 mm in thickness, however, make a root running after making backchipping.

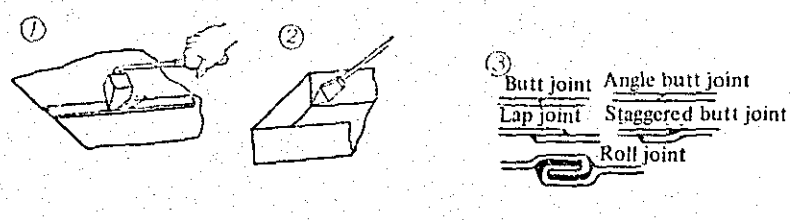
(2) Plate thickness and root opening.

Plate thickness mm	Root opening mm
2.3	0–1
3.2	2
4.5	3

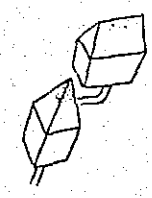
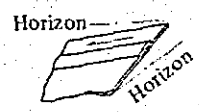
(3) Welding of thin plate often causes strain. Provide appropriate clamp to prevent strain. Refer to Fig. 2.

(4) When welding current is too strong (hight) or when movement of electrode is too slow, weld point get overheated causing the flow out of molten metal and making blow holes in the base material.

(5) When blowholes have been made, clean the portion thoroughly and fill up the hole by supplementing with deposit metal by using intermittent arc. (This process is similar to that for supplementing craters).



Work No.	No. 81
Type of work	Soldering
Main points	Soldering of steel plate of various types
Materials	Galvanized iron sheet, thin mild steel sheet, apply procedures in Subject No. 1, 2 and 3 as necessary. Dilute hydrochloric acid, solution of zinc chloride, rugs, emery cloth, charcoal
Tools	Soldering iron, files, wire brush, fire pot

No.	Sequence of work	Description	Related information
1.	Preparation of soldering iron 	1. Work with a file or brush on the soldering iron in the portion up to 1/3 from the tip until the base metal appears. Bevel the iron while giving it a shape. 2. Place it in the red hot charcoal and heat it until it gives off blue smoke. 3. Immerse the iron in the solution of zinc chloride and put the solder on it (solder plating).	1. For soldering the outside of the object, soldering iron in the shape of an axe shown in Fig. (1) above provides a wider contact surface and is efficient because it provide prompt transmission of heat from the iron. For soldering the inside of the object, however, the iron in the shape of a lancer as shown in Fig. (2) is more convenient in the work. 2. Since the oxide film remains on the tip of used soldering iron, it is necessary to remove this film completely. Solder plating after this process insures satisfactory soler deposit on the iron.
2.	Wipe off the plate joint	1. Remove dust and grease completely with rugs.	1. In the case of mild steel, remove black skin completely with a file. Use file also on clip.
3.	Heat iron	1. Take it out of fire sometimes and check the condition of color by placing solder on it. Care should be taken not to over-heat it.	
4.	Coat the joint with dilute hydrochloric acid.	1. Coat it evenly with a hydrochloric acid rod. 2. Take caution so that the acid will not penetrate into the portion other than required.	1. For the plate other than galvanized iron sheet, use solution of zinc chlorid .
5.	Take iron out of fire and immerse it in the solution of zinc chloride	1. Immerse the tip up to 1/3 of the length. 2. Do this quickly.	1. This should be done promptly before the solvent (dilute hydrochloric acid or solution of zinc chloride) coated on the sheet dry up.
6.	Put solder on the iron	1. Place solder on the tip of iron.	1. When placing the solder on the iron, formation of gray film over the surface of solder indicates overheating of the iron and the formation of granules in the solder indicates insufficient heating. Glittering of solder in silver color shows appropriate temperature (300° C). When the temperature of the iron lowers, spread of solder is not satisfactory and reheating of iron is necessary. When a thick iron is to be used, heat it up to rather high temperature (500° C).
7.	Coat the joint of sheet 	1. Hold the sheet so as to make the gap in the joint facing up diagonally. (see figure at left). 2. Shift the solder from the tip of iron to the joint of sheet and spread it and let it penetrate well (bonding and capillarity). 3. When the iron cooled down, add solder and dilute hydrochloric acid.	
8.	Wipe off the joint	1. Wash thoroughly with water and wip off.	1. Wash the joint well, otherwise the remaining solvent will cause rust. 2. A particular care should be taken when working on electrical equipment because the rust increases electric resistance and causes a failure of equipment. For this reason, solvent normally used on electrical equipment is the paste, in the form of slurry, made from resin, olive oil, animal fat, and use of zinc chloride is avoided.

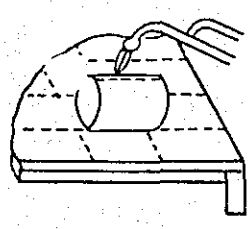
Remarks

(Inspection)

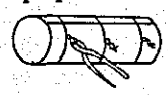
Check and see that the solder is well melted and penetrated into the joint and finishing is made evenly.

(Note)

1. Joint of sheet metal by means of soldering is made in 5 different methods as shown in Fig. (3) above. "Butt joint" is desirable from the standpoint of finishing because of its flush surface but it lacks strength. "Angle butt joint" makes up the above disadvantage to some extent but is not practical for a thin plate. When the strength is taken into account, "Lap joint" is required but the surface is not even. To avoid this, "Staggered butt joint" may be used but it can not avoid protrusion on the back. When extra strength is required, "Roll joint" may be used.
2. When soldering thick plates, heat the bottom plate until the solder start melting, put solvent and melt in the solder. Then place the other plate over it and push the upper plate down.
3. How to make a solution of zinc chloride: Fill the porcelain or glass jar with hydrochloric acid of appropriate amount. Place a zinc foil or a piece of galvanized iron in the jar. Chemical combination of hydrochloric acid and zinc forms the solution of zinc chloride. Foam generated during this process is the hydrogen generated as a result of chemical combination. Keep adding zinc until the formation of foam ceases, or it reaches saturated point. It takes approximately 24 hours before it reaches the state of complete saturation. However, active formation of foam almost ceases in about an hour and the solution at this point may be used if it is needed urgently, in its original density or in dilution with water of 1/2 or equivalent quantity.



Work No.	No. 82
Type of work	Hard brazing
Main points	Brass brazing
Materials	Brass plate (0.7-0.8 mm thick), apply Subject No. 5-(1)--(3). brass wax (braze) borax, emery cloth, rugs, wire
Tools	Brazing stand, gas welding equipment, blowpipe, pliers, files

No.	Sequence of work	Description	Related information
1.	Make preparation 	1. Polish the joint thoroughly with emery cloth to the base metal. 2. Bind it with a wire (See figure at left).	1. In the case of copper, wash with nitric acid, and then rinse with water.
2.	Put wax on the joint	1. Put wax evenly and dry it well.	1. The wax to be used should be of the same metal as the work in principle because it provides the joint the same luster as the base metal. 2. Solvent to be used may be either borox or boric acid but a mixture of both will provide better results. Borox should be used in the form of boiled borox or baked borax and not in the original form of crystal. Borox in the powder form would not stay on the joint. Use it in the form of slurry by adding water.
3.	Heat the joint with blowpipe	1. Maintain a constant clearance between the flame and base material. 2. Heat it sufficiently until the wax spread over evenly.	1. It may be accomplished with city gas by using a blow-pipe, or blow torch may be sufficient for small works. For a large work, use fire bed (pot) with wood or cock as a fuel for heating and soldering.
4.	Finish the weld	1. Remove wire, immerse the plate in dilute solution of acid or alkali to remove oxide films. 2. When the excess wax on the joint presents ugly appearance, remove it with a file or scraper.	2. Since the melting temperature of brass wax is similar to that of brass plate, care should be taken not to heat the wax for excessively long duration, for the metal may start melting. Use of brass silver wax, which is made by adding a small quantity of silver to the brass, (It has to be made in the shop because it is not available in the market) will eliminate this possibility because it has slow melting point. 3. Brazing stand: A frame of iron angles with fire bricks on the top is generally in use.

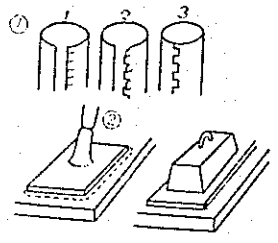
Remarks

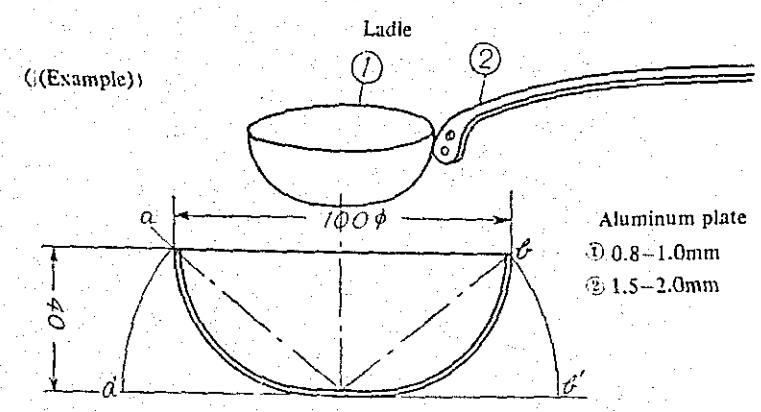
(Inspection)

Check and see that the joint is not staggered, that braze is well penetrated and evenly distributed and that there is no erosion in the plate surface.

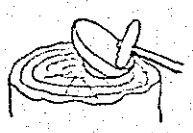
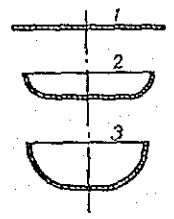
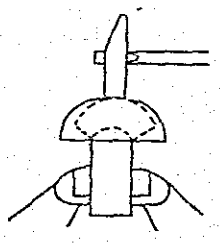
(Note)

1. The point to be brazed may be either "lap joint" or "butt joint". Selection of the type of joint should be made depending on the work. When working on tube-like material, use a binding wire for "butt joint". For "lap joint", just lay one end on another or clasp both ends together in the manner as shown in Fig. (L) and then bind it over with a wire.
2. When brazing on a wide area, application of wax from the edge alone will not provide sufficient penetration to the joint. Spray wax in powder form mixed with solvent over the entire surface of the joint, join the plate together and heat them up. When the wax has been melted sufficiently and starts flowing out to the edge, stop heating and hold them down by weight until they cool down, as shown in Fig. (2) below.





Work No.	No. 83
Type of work	Chocking (Reduction of area)
Main points	Hammer out (press out) work
Materials	1. Mold steel sheet (0.8mm) Subject No. 4-(3) 2. Brass sheet (0.7–0.8 mm) No. 5-(2) 3. Aluminum plate (0.8–1.0 mm) No. 6-(1), used as necessary
Tools	Wood mill, level stand, mallet, scale, compass, file, gage

No.	Sequence of work	Description	Related information
1.	Pick up base material	1. Mark off a circle of required diameter. 2. Clip out the plate with a tin snipper and bevel the corner. 3. Braw a concentric circle.	1. As the striking action proceeds, irregularities form on the surface of the plate and present an urgly look with rumples. Accumulation of the rumple makes it impossible to remove it later and causes cracks. Removal of rumples should be started as early as possible.
2.	Strike plate 	1. Place the work on the wood mill. 2. Strike the work with a mallet at a regular intervals and with uniform strength, not too hard. 3. Start from the edge toward the center aiming at the concentric circle. (Refer to figure at left).	
3.	Stretch rumples	1. Place the work on the strike surface plate and hit the work from the inside.	
4.	Repeat above action	1. The work must be shaped up to the desired shape in proper sequence while being measured with a gage. (Refer to figure at right)	1. Annealing: In the process of "Press-out" and "Choking" work on the sheet metal, change in its shape and striking force (action) make the material harder and finally causes cracks. For this reason, the sheet metal must be annealed sometimes to recover its original material composition. Annealing can be accomplished by placing it in the heating furnace 40–50 for minutes to maintain an appropriate temperature and quenching it gradually. Copper or brass plate is annealed by putting it in the water after heating. Annealing temperature may be determined by experience by looking at the color of the plate. Appropriate annealing temperature is shown in red (840-380 C) for steel, pink (600–700 C) for copper and brass (works of 6.4–600 C, that of 7.3–600–650 C). Determination of temperature for aluminum (300–500 C) and duralumin (350 C) is difficult because these materials start melting before becoming red in color when overheated. For these materials, rub red pencil over the material surface and heat them up. As the temperature rises, the red color changes to crimson, purple and then to blackish purple. This point is the appropriate temperature. 2. Mold steel plate, copper plate, brass plate and aluminum plate may be treated with cold working but had plate like duralumin should be worked while being heated with a blow torch.
5.	Smooth out 	1. Place the work on the smooth-out anvil and hit the entire surface evenly with a hammer. (Refer to the figure at left). This will remove small rumples and smooth out irregularities. It will also prevent cracks to some extent.	
6.	Finish	1. Mark off an edge line accurately and finish the work with a snipper and file.	

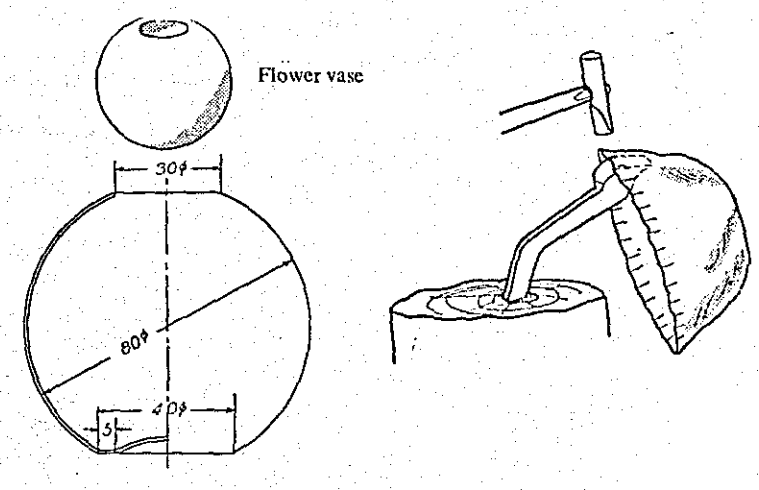
Remarks

(Inspection)

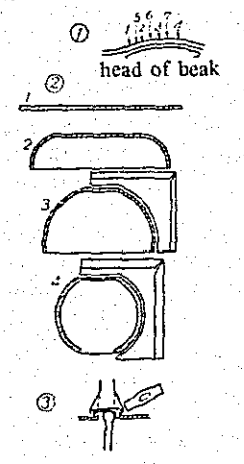
Check and see that the shape of the work is as accurate as the gage, that the finishing is smooth without irregularities or rumples and that no cracks or scratches are made in the plate.

(Note)

Since the shape of the work with a deep bottom like a flower base and jar can not be obtained sufficiently by press-out work, a combination of press-out, smooth out and choking may be applied. One of disadvantages of press-out work is that it will make the center portion thinner than others.



Work No.	No. 84
Type of work	Choking (Making a flower base)
Main points	Chocking work
Materials	Copper plate or aluminum plate, 10 x 160 x 160 (Subject No. 7)
Tools	Scale, compass, iron sheet, file, mallet, bealk, wood stand, gage

No.	Sequence of work	Description	Related information
1.	Pick up base material	1. Mark off a circle of desired diameter. 2. Clip out the plate with a tin snipper and bevel the corner. 3. Draw a concentric circle.	1. Radius of blank must be determined so as to make the surface area of the work equal to the area of blank. In this case, the work is a sphere (radius Y) and the radius R of the blank would be as follows: (Surface area of sphere) (Area of blank) $4\pi r^2 = \pi R^2$ $R = 2r$
2.	Put it against the smooth out stand	1. Hold the plate securely with three fingers of left hand and match the center with the smooth out stand.	
3.	Strike 	1. Start from the center toward this side. Strike the work while turning it around slowly by aiming at the concentric circle. 2. Avoid striking at one particular point but strike evenly with proper sequence as shown in Fig. (1) at left. 3. Keep striking until the desired shape is obtained by paying attention so that no rumples may be formed and measuring with a gage as shown in Fig. (2) at left. 4. If a rumple is formed, remove it promptly in the manner shown in Fig. (3) at left.	1. Since the shape of the head of beak bow spacer must match the curvature of the work, several beak bow of various shapes should be provided. 2. Anneal the work at appropriate time. 3. The gage may be produced by clipping out tin plate or thin steel plate.

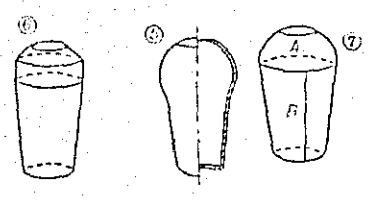
Remarks

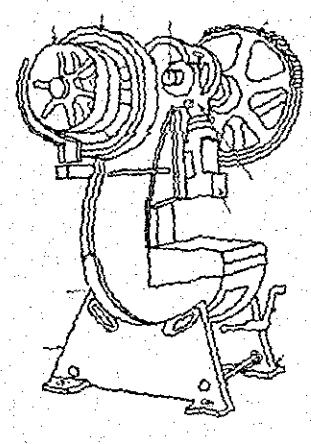
(Inspection)

Check and see that the surface is smooth (Without scratches, irregularities or rumples) and that the dimension is as accurate as the gage.

(Note)

To make the shape (flower vase) shown in Fig. (5) below, for which the bottom plate should be made and joined separately, divide the entire portion into several parts and calculate the surface area and then make a blank.
This method, however, requires a skilled technique and consumes a lot of time and is not practical. More simple way is to make a shape by pressing out part A, shape part C with a curved plate and then to join these plates together later.





Work No.	No. 85
Type of work	Handling of power press
Main points	Operation of power press
Materials	
Tools	

(Basic knowledge)

1. *Crank press*

Generally called as a power press. Its principal construction is shown in the figure above and main components are a regulating wheel (f), flywheel (g), and crankshaft which goes through (b) of the gear (a). High speed revolution of regulating wheel reduces the revolution of gear (a) to a moderate speed and transmits it to (b).
This is possible because the pinion at the end of base axle which goes through regulating wheel engages with the gear wheel (a). When the foot lever (e) is pushed down, the clutch makes the gear wheel (a) and crank (d) turn at the same time. Coupler (c) moves up and down and the slide (d) which is connected to (c) also moves vertically.

The machine shown in the figure leans backward while maintaining the contact with the upper half (d). Degree of inclination may be controlled when necessary. Inclined press is very convenient because the work falls down to the back of the machine.

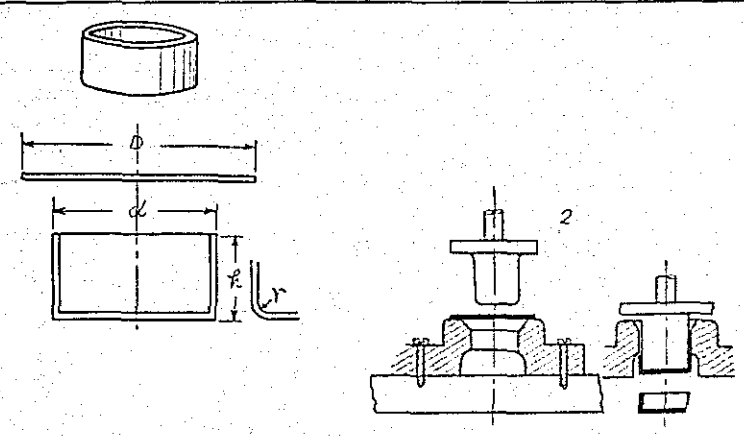
2. *Press type*

This type is further divided into the following types depending the work.

1. Press out type (piercing type)
2. Choke type: Push down choke type
   Push out choke type
   Piercing choke type
3. Bending type
4. Roll type
5. Cautions to be taken during the work.

All phases of press operation including press-out and choking work involve extreme hazards and utmost care should be exercised during the operation. It is important therefore to check all parts of machine and template thoroughly prior to the start of work in order to prevent accidents. Safety device is desirable but it is not generally installed because it increases the weight of clutch and decrease efficiency of the work. Most important is that the clutch should be disengaged for each stroke of the slide. The machine is sometimes operated with the clutch engaged by negligence on the part of operator and it is causing a major accident.

No.	Sequence of work	Description	Related information
1.	Remove belt from pully	1. Do it while turning flywheel slowly by hand.	
2.	Attach punch to the slide	1. Insert the round handle of punch deep and tighten down.	
3.	Attach die to the punch	1. Lower slide slowly by turning it by hand.	
4.	Attach die to the bolster	1. Tighten it down while adjusting the clearance between the punch and die.	
5.	Adjust connection screw	1. Keep the slide at the bottom, tightten screw.	
6.	Check result	1. Check the clearance between the punch and die carefully while turning them slowly by hand.	



Work No.	No. 86
Type of work	Choking work by power press
Main points	Fundamental work of choking by power press
Materials	Thin mild steel plate
Tools	

(Basic knowledge)

1. Size of blank

Area of blank must be equal to the area of its full length as in the case of hand chocking and it is expressed by $D = d^2+4dh$ in Fig. A. When the circumference at the bottom of the cylinder is round, it is depressed by $D = d^2+4dh-r$. Where there is a difference in the thickness between the side and bottom plate, the formula would be more complicated.

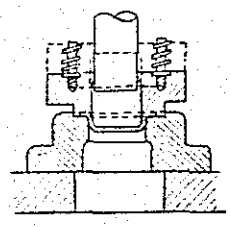
2. Choking rate

Items having a shallow bottom such as the lid of a can is easy to work but the one having a deep bottom requires two or more chocking processes. Maximum chocking rate per stroke, (d/D) in Fig. A, is said to be approximately 50%. Chocking rate for aluminum plate and brass plate of the same thickness as the mild steel plate may be 40% because of their greater flexibility. This rate applies only to the case where an edge holder is provided as shown in Fig. C, however. Without this holder, rumples are often formed when the plate slides in between the punch and the wall on the side of the die, thus enabling only a shallow choking. When the blank is thin and the diameter of the work is great, rumples are often formed and breakage of the plate occurs. To prevent this possibility, a rather greater coefficient must be established.

Besides the above coefficient, the diameter of the cylinder made by the first choking, or the bore size, which is applicable to the general use, may be obtained from the following equation.

$$d = \frac{D}{1.8}$$

Then, the diameter of the cylinder contracted by the second choking is fixed at 0.85–0.75 (85%–75%) of the diameter made by the first choking. Following equations apply to the choking of mild steel and tin plate.



First choking $d = \frac{x \times D}{100-0.025 \times D}$

Where D= the diameter of blank
d is the bore size of die by the first choking

Second choking $d_1 = \frac{x_1 \times d}{100-0.025 \times d}$

Where d_1 is the bore size of die by the second choking
d_3 is the bore size of die by the third choking

Third choking $d_2 = \frac{d_1 \times d_1}{100-2.025 \times d_1}$

x, x_1 = safety factor for the thickness of the plate

Where

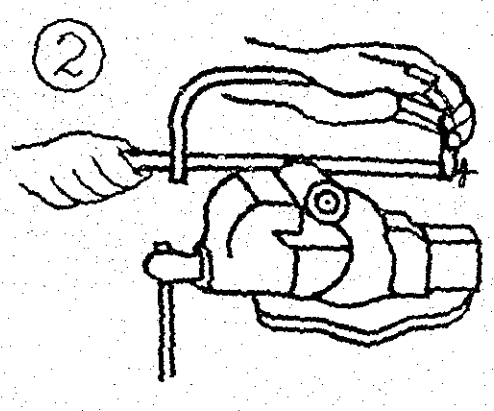
Plate thickness (m/m)	x		x	
	Minimum	Maximum	Minimum	Maximum
6.4–0.45	61	68	74	81
0.5	58	65	73	80
0.55–0.6	56	63	72	80
0.7	54	60	71	79
0.8	50	56	70.5	77
1.5	47	53	70	75
3.0	51		65	

No.	Sequence of work	Description	Related information
1.	Obtain a signal blank	1. Adaw (Mark off) a circle of desired radius. 2. Clip out the circle with a snipper.	
2.	Wipe off punch and die		
3.	Attach blank to die	1. Adjust the center precisely.	
4.	Step on clutch pedal		

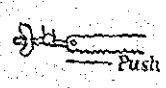
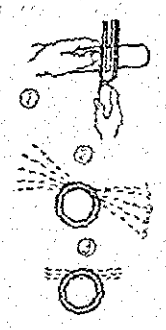
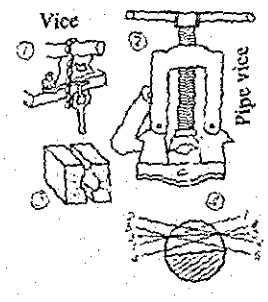
(Question)

What would be the diameter (D) of blank when making cylinder having d.....60 mm and h.....90 mm with a mild steel plate?

How many choking processes would be required?



Work No.	No. 87
Type of work	Cutting of tubs by hand saw
Main points	1. Use of hand saw 2. Cutting of tubes
Materials	Steel pipe
Tools	Hand saw, cross vice, scale, marking-off pin, file, chalk

No.	Sequence of work	Description	Related information
1.	Attach blade  	1. Adjust the length of bow to fit the hole in the blade. 2. Tighten it down while examining the tension of blade with the blade edge facing front.	1. Select blade of appropriate number of teeth depending on the type of material and shape of the work.
2.	Mark off cutting line	1. Mark off over the chalk coating.	
3.	Secure the work	1. Place a pad wood, keep the work horizontally with the portion to be cut off at right and the cutting line close to the mouth (opening) of the vice and tighten it down.	2. To secure tube materials, chain vice (Fig. 1 below) or pipe vice (Fig. 2 below) may be used. When a pipe vice is used, the saw must be used far from the point where the pipe is secured and operation becomes very inconvenient.. Care should be exercised not to tighten the work excessively because both types often deform the pipe. When many pipes of the same diameter have to be cut, make pad woods which fit the pipe size, as shown in Fig. (4) and attach them to the vice to protect pipe and to obtain efficient operation.
4.	Start cutting 	1. Hold the saw and take a posture same a s for the filing work (refer to No. 8). 2. Use left thumb as a guide as shown in the figure at left and make a slight cut with the root of the saw. 3. Place left hand over the bow as shown in the figure above and use entire length of the blade. When pulling the saw, weaken the strength with a feeling of floating the saw slightly. Cut the work without swining the saw sideway. 4. Cutting should be made as if the going round the pipe gradually to leave a small portion of the wall of the pipe uncut, as shown in figure (2) at left. Cutting shown in Fig. (3) at left will often result in a breakage of blade because of strong resistance of the inner corner (edge) against the blade. 5. Finishing cut should be made lightly wi th weakened strength. 6. When a new blade is used, do not exert excessive strength at first but increase strength as the blade becomes dull. This is necessary because the new blade cut in sharp and often breaks out easily. Coating with chalk is useful for prevent ing breakage of a new blade. 7. Lubricate sometimes.	 3. When cutting a pipe, work horizontally and in inclined motion as shown in Fig. (4). 4. Since a new blade has thin set wrest,change of saw blade to a new one during operation and use of it on the previously cut groove sometimes cause a cut-in, thus resulting in the breakage of blade. In the case like this, start cutting from other portion.
5.	Finish work	1. Give a finishing touch and bevel corners with a file.	

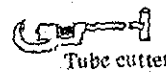
Remarks

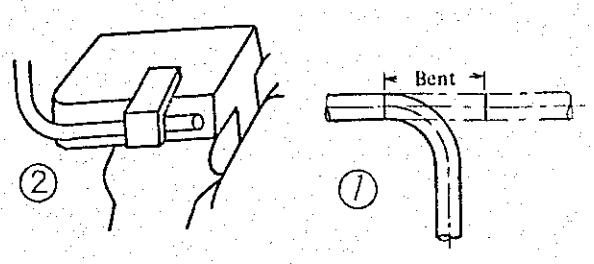
(Inspection)

Check and see that the cutting is made accurately matching the mark-off line and that the pipe is not deformed.

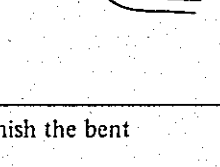
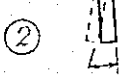
(Note)

The tube cutter shown at right is isometimes used for cutting tubes but the face cut with a hand saw has a better appearance.


Tube cutter



Work No.	No. 88
Type of work	Bending of steel pipe
Main points	Fundamental work for bending of pipes
Materials	Steel pipe, sand, chalk, rugs
Tools	Pipe bender, vice, scale, hacksaw, wooden plug, blowpipe, mallet

No.	Sequence of work	Description	Related information
1.	Mark the portion to be bent	1. Mark the portion clearly with chalk.	1. The length of the bend should be determined by the neutral line as shown in Fig. (1) above. 2. Since the fusion zone of welded pipe (steel) and brazed pipe (brass and copper) is fragile and easily broken out, bring the fusion zone to the neutral line. 3. There is a maximum bending radius (radius of circular arc for the center line of pipe) for each pipe depending on the type of material and dimension, which is shown in the table below.
2.	Put sand in pipe and plug with a wooden plug	1. Add sand and pack it tight by hitting the pipe with a mallet. A stick may be used to pack the sand. 2. Put the plug secure and tight.	
3.	Put pipe on the pipe bender	1. Match the portion to be bent closely with bender	1. Care should be taken when putting sand in the pipe so that the pipe is completely free of moisture and that the sand is sufficiently dry, otherwise heating of pipe may generate steam which blows out the plug, thus creating a hazardous condition. 2. Resin, lead or solder may be used beside sand to stuff the pipe but these materials are generally used when bending brass pipe or copper tube with a small radius. 3. In some cases, the pipe is welded at its end. In such cases, the pipe should not be sealed completely but should always be a gap or a venthole.
4.	Heat pipe with a blowpipe	1. Heat the portion to be bent sufficiently.	
5.	Bend the pipe	1. Do it slowly by allowing the pipe to adapt itself to the bender.	
6.	Keep bending 	1. Keep bending as shown in Fig. (1) at left while heating the pipe gradually and paying attention so that no rumples are formed. 2. Cool down bend line with water sometimes. 3. Make the final bend slightly beyond the desired point and bend it back as shown in Fig. (2) at right. 	1. Bending of a large pipe may be accomplished with a furnace and small pipe may be worked on with the use of blowtorch. When bending a thin copper tube with a small radius, cold working (treatment) would be sufficient.
7.	Finish the bent	1. After the pipe is sufficiently cooled down, remove sand and clean inside of the pipe. 2. Cut to the desired length and finish it with a file.	1. When bending a pipe of thin wall thickness, straight portion may also bend at the same time. So cool down straight portion with water.  2. Prolonged heating at one particular portion results in the bent floating out from the pattern as shown below.

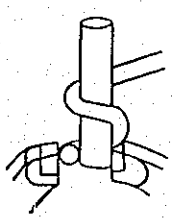
Remarks

(Inspection)

Check and see that the bent is made with correct bending radius, that the curvature is made uniform and that the pipe is not deformed.

(Note)

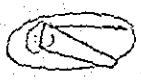
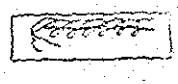
1. Use of the bender as described above provides correct beinding radius and is convenient in the work but a round bar of pipe of appropriate radius may also be used as a bending tool by inserting it in the pipe.
2. Relatively small pipe may be bent in a loop shape by placing the end of the pipe on the vice along with a core bar having a radius slightly smaller than the desired curvature and winding the pipe closely around the core bar, as shown below.



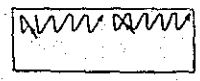
Maximum (lower) radius for pipe bending Unit: m/m

Dimension	Out side diameter	3	5	6	8	10	12	14	15	16	18	20	22	25	28	30	35	40
	Wall thickness	0.75–2.0																
Aluminum		10	15	20	25	30	35	40	45	55	65	75	90	120				
Aluminum alloy		15			35	60	80	120				150	180					
Steel		5	10	15	20	25	30											
Copper		5	10	15	20	25	30											
Brass		10	15	25	35	40	45											

Work No.	No. 89-I (Painting)	Materials	*Emery cloth*, wire brush, surface *plate*, *pallet*, *staggered*, brush, *paint* containers
Type of work	1. Conditioning of base metal for steel plate 2. Puttying of steel plate 3. Primary coat for steel plate 4. *Intermediate coat for steel plate* 5. Finishing coat for steel plate	Tools	Emery cloth or emery paper, gasoline lacqure putty or size putty, rugs, lacqure primer, oil primer, lacqure surfacer, oil surfacer, water-proof *paper* lacqure, enamels
Main points	Fundamental work for painting of metals Conditioning of base metal Puttying work Primary, intermediate and finishing coatings		

Work Classification	No.	Sequence of work	Description	Related information
Conditioning of base metal (1)	1.	Rust removing 	1. Cut emery cloth or emery paper into four pieces. Fold a piece in two, hold it with five fingers as shown in figure at left and rub the rusted portion of the metal with it. 2. To remove oil from the surface, use gasoline along with emery cloth or emery paper. Use wire brush when excesively thick rust has to be removed.	1. Emery cloth or emery paper is folded in two to obtain required thickness of sanding material for the convenience of the work. 2. When the paint is loose on the surface at places, heat it with a blowtorch first and apply emery paper. 3. Cast iron often has rust in its porosity. A wire brush must be used to remove rust in such portion.
Putty work (2)	1.	Putty making	1. As shown below, spread putty of appropriate quantity over the surface plate with a pallet and scoop it up as if to cut it apart. 	1. Putty work is required prior to the primary coat after the conditioning of base metal to fill up irregularities caused by the remaining coat on the metal in such cases as the repair of damaged portion. 2. When only a minor repair work is required, the foregoing process may be substituted increased coatings of surface. 3. Use size putty in the form of hard paste which is made by a mixture of lacqure putty (available in the market) or gold size and polishing powder at the ratio of 2 to 8. 4. Besides , , which is used by shaving it off each time it is used, may be used but it involves difficult process for making.
	2.	Putty work 	1. Stick the putty to the inside of the damaged portion. 2. Spread it over as shown at left but do not force it out of the damaged portion. 3. Overlap of putty spread may not be avoidable in this case but the pallet boundary should not be visible. 4. Lacqure putty drys quickly. Do it promptly and make a thin layer.	
Primary coating (3)	1.	How to hold a brush 	1. Press lightly from underneath the corner marked with a circle shown in the figure at left with the ring finger. The tip of the middle finger is placed securely at the point marked with a circle on the other side.	1. An inch brush (flat brush) may be used but the brush in any event should always have elasticity and its tip should have uniform length. 2. Placement of fingers is the same as for the flat brush.
	2.	How to soak the paint	1. Soak the paint sufficiently but not to the extent as to cause dripping.	1. Lacqure primer is cheap and drys quickly but it must be used promptly and requires skilled technique. Its is also poor and does not provide complete adhesion to the base metal. Therefore, a complete rust removal is required when using this primer. Recommended type available in the market are metal primer (red), dark black metal primer (black) and oxide black metal primer (light black) for the use on natural drying metal.
	3.	How to use a brush 	(Lacqure primer) 1. As shown in the figure at left, move the brush quickly at a breath by going over the previous streak, with a light movement of brush as if to stretch the coating to the side, and paying attention so that no mark of brush may be left at the starting point.	

No. 89-2 (Painting)

		(Oil primer) 1. Movement of brush is the same as for the lacqure primer but it does not require such a prompt movement as required for lacqure primer 2. It also requires reciprocating movement of brush but the brush should be used as if to cut the patches crosswise as shown at left.	2. Oil primer lacqure has higher quality than lacqure primer. It drys in 24 hours and provides a complete coating. Coating is easily done and provide better adhesion to the base metal. It is most ideal for primary coating. It must be kept in mind, however, that the coating will not result in excessively thick or thin layer. Oil metal primer (reddish rust color) available in the market is recommended.
Intermediate coat (4)	1. How to hold a brush 2. How to soak the coating 3. How to use a brush 4. Water grinding (polishing)	1. Holding of brush for lacqure surfacer and oil surfacer is the same as for the primary coating. 2. Give another coat in the same manner as before after letting the previous coat dry completely. 1. Use fire-proof paper (No. 320–400) soaked with hot water and soap and rub surface with it evenly to remove irregularities in the same manner as for the conditioning of base metal. Try to smooth out the edge of damaged portion in a light movement. 2. Wipe the portion sometimes and check to see if the base metal is showing. 3. After the work, wipe off completely.	1. When coating locally as in the case of repair of damaged portion, this process may be omitted.
Finishing coat (5)	1. How to hold a brush 2. How to soak the coating (paint) 3. How to use a brush	1. Same as for the intermediate coating but since it is the last coating, work must be done carefully. 2. Care should be taken so that dust and foreign matters will not get to the surface. Large dust particles may be removed with brush tip. 3. It is important that the work area is thoroughly cleaned prior to the start of the work.	1. In the case of lacqure, desired color is not easily obtained and three or more coatings may be required. When the white coating is used, increase the frequency of coating. 2. In the case of oil coatings, desired color is obtained in the second coating. Therefore, two coatings are generally adequate.

Remarks

(Note)

Paint spray is a method in which paint is applied in the form of spray instead of using a brush. This method provides uniform and prompt painting work and makes it possible to save paint depending on the operation of machine and the skill of spraying operation. Component parts of spray machine are the air compressor, air tank which stores compressed air, transformer which filters oil which was not removed in the air tank and which acts as a regulator for spray pressure and a spray gun of pistol type, which by pulling the trigger discharges compressed air and paint at the same time.