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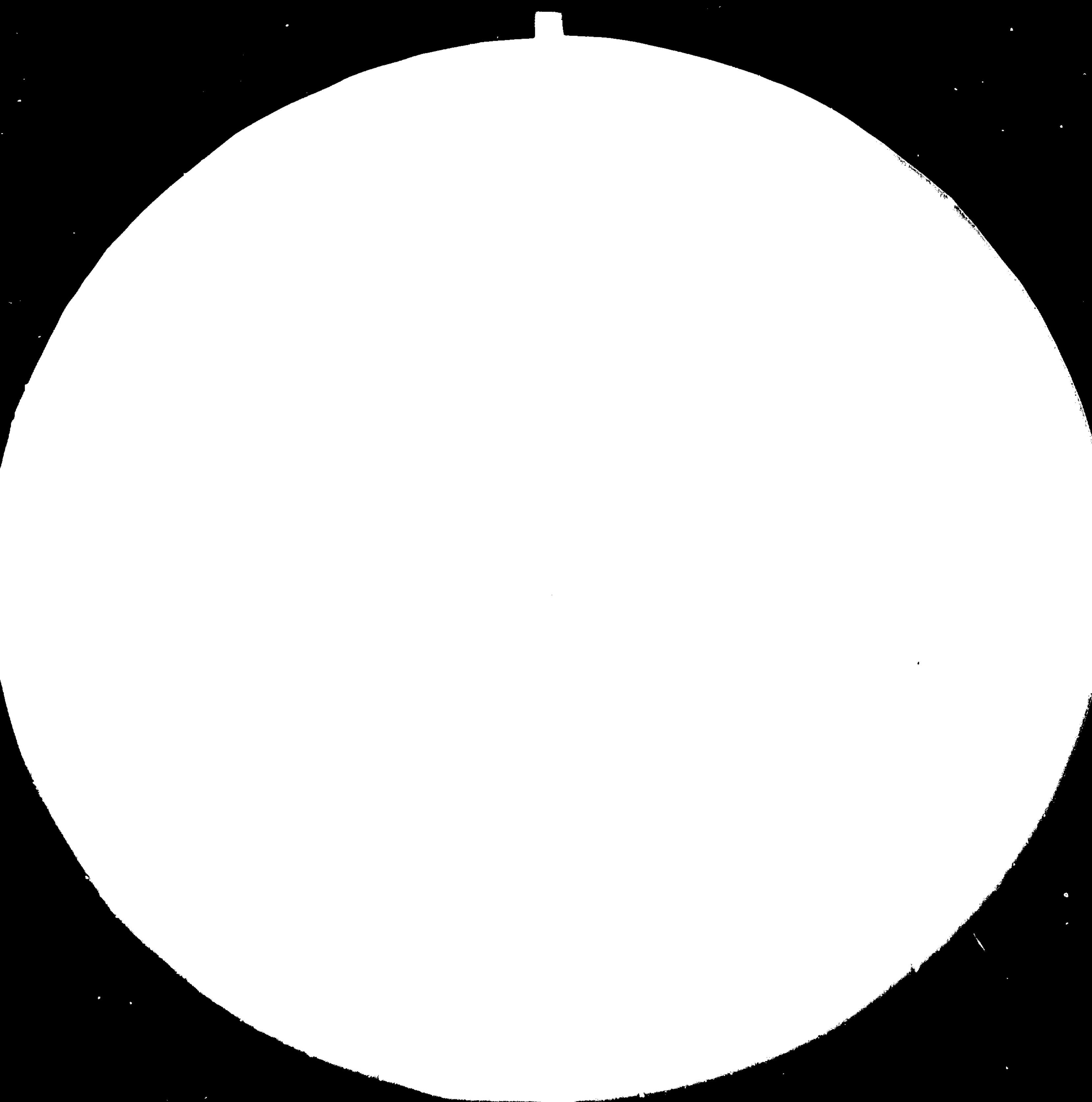

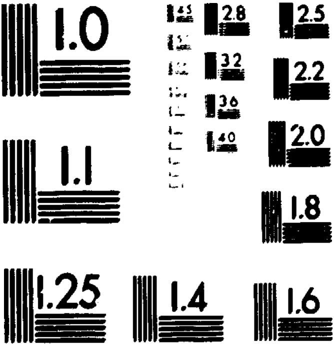

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WELDING PROCESSES AND APPLICATIONS

FUTURE TRENDS*

(SOLID PHASE WELDING PROCESSES)

by

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2027

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1.0 INTRODUCTION

Solid phase welding process can be classified as a modern welding process. This process has a distinct advantage and edge over the conventional processes being used now-a-days. The process parameters are repeatable over a period of time and good joint quality can be assured at all times. Most of the processes have a very short welding cycle and hence very high rate of production can be achieved. Dissimilar metals can be easily welded and do not pose problems as that encountered in conventional processes. Friction welding is one of the solid phase welding processes which can be fully automated and the parameters can be controlled with use of computers.

The main solid phase welding processes now in use in the world today are -

01) Friction Welding
02) Explosive Welding
03) Ultrasonic Welding
04) MIAB Welding
05) Diffusion Welding

2.0 FRICTION WELDING

Due to many inherent advantages (please refer to Table-1 and 2), this process has grown to be a major tool of fabrication in the industrialised world today. The automobile industry is a major exploiter of this process and components such as rear axles, propellor shafts, steering gears, transmission parts, Bimetal engine exhaust valves etc, are being fabricated using friction welding. With this growing awareness in mind, Welding Research Institute, Tiruchirapalli has done Research and Development in this field both in machine building and process development. The Institute has designed and developed an Inertia Friction Welding machine with a capacity to weld upto 32 mm dia rods in mild steel (Please see Photo-1). The salient features are given in Table-3. Many applications studies on friction welding have been carried out at Welding Research Institute. A few cases have been described below -

2.1 CASE - COVER ASSEMBLY FOR CHECK VALVES FOR POWER PLANTS

The component illustrated in Photo-2 is utilised in high pressure valves, where the guide pin is used for the guidance of the valve disc during operation. The guide pin is made of SA 182 F6 13% Cr martensitic steel and the cover of SA 515 Gr.70 a carbon manganese steel. At present, Manual Arc Welding is carried out using a high Cr electrode. Friction welding of this combination has been carried out and preheat and post heat-treatment operations have been eliminated. Also there is saving in the consumable since no consumable is required for friction welding.

2.2 CASE- - FOUNDATION BOLT FOR BOILER STRUCTURES

Foundation bolt for boiler structures is another area where friction welding has been successfully used in our Institute (See Photo-3). The rod and plate are made of 0.20% carbon steel. The weld joint is between Ø 25mm rod and 200 x 200 mm plate. At present Manual Arc Welding is carried out. Friction welding was suggested as an alternative to increase productivity. The saving is also obtained on the consumables, i.e., electrodes. An upset pressure of 6 Kg/mm^2, rotational speed of 1100 RPM and weld cycle time of 3 seconds was used. The joints were tensile tested and found to have an ultimate tensile strength of 24 Tons. The service requires only 7 Tons.

2.3 CASE- - TRANSITION JOINT BETWEEN LOW ALLOY STEEL AND STAINLESS STEEL

Transition joints between low alloy steel and stainless steel find application in the superheater and Reheater steam circuits of a power boiler.

One such joint is between SA 213 T11aa1Cr-½Mo low alloy steel and SA 213 TP347H 18-8 with Ti stabilised stainless steel of Ø 51 x 7 mm (Please refer Photo-3).

The continuous drive friction welding was used for welding this dissimilar combination. The following parameters were used:-

Friction pressure	: 32 N/mm_2
Friction time	: 13 secs

Forging pressure	: 8 N/mm^2
Rotational speed	: 1125 RPM
Feed Rate	: 0.8 mm/sec
Brake delay	: 0.8 mm
Upset delay	: 0.1 mm
Upsetting time	: 4.0 sec

The joints were subjected to notch tensile tests. The notch tensile strength was found to be 761N/mm^2. The joint efficiency was found to be more than 100%.

2.4 CASE- - ROD TO ROD WELDING BETWEEN HSS AND MEDIUM CARBON STEEL FOR DRILL BITS

Friction welding has been found to be advantageous over flash butt welding since the weld cycle time is only a few secs. The material lost as flash is considerably less. The power requirements are very low.

Friction welding of this combination was successfully carried out for a tool manufacturer. The shank portion was of EN9 a medium carbon steel and AISIM2 a 6-5-4-2 Cr-Mo-W-V high speed steel(Photo- 5)

Continuous drive friction welding was used and the following parameters were used:

a) Heating pressure	: 10 Kg/mm^2
b) Forging pressure	: 22 Kg/mm^2
c) Rotational speed	: 1500 rpm
d) Feed rate	: 0.58 mm/sec
e) Upset delay	: 0.1 sec

f) Break delay : 0.8 sec
g) Friction time : 25 secs
h) Upset time : 9.0 secs

After welding the joints were annealed at 850°C soaked for 4 hours. The material loss after welding was 12.1 mm on EN9 side and 3.60 mm on M_2 side which is found to be relatively lower than that of flash butt. The joints were found to have a tensile strength of 58 Kg/mm^2. The welded blanks were then machined and manufactured into drill bits at the manufacturer's end and subjected to ISO tests and found to satisfy their vigorous requirements.

2.5 CASE-

Friction welding was successfully used to weld the following configurations (Please refer Photo-6 & 7) for an automobile manufacturer. The welds were made of 0.20% carbon steel since this was only a feasibility study for finding the possibility of applying friction welding to these components. Friction welding can also be adopted for saving material and machine time (Please refer Sketch-1) shows such possible applications used in the automobile industry.

3.0 EXPLOSIVE WELDING

Explosive welding is another solid phase welding process which is being commercially used in the world today. Both explosive cladding and tube to tube sheet welding are being used. Many dissimilar materials can be cladded by this technique, to name a few -

a) Al-steel, Al-stainless steel, Al-Bronze to steel, Al-copper;

b) Cu, Cu-alloys to steel;

c) Stellite to steel, steel to stainless steel

In our Institute we have successfully cladded the following combinations on a laboratory sample scale :-

a) Al-steel
b) Steel to stainless steel
c) Brass to steel
d) Copper to steel
e) Aluminium to copper

A powder explosive with detonation velocity of 2000 m/sec was used for cladding trials. Ultrasonic examination indicated that the bonding was good. Tube to tube plate welding has been successfully carried out for the following combinations -

a) Brass tube to brass tube plate;
b) Brass tube to steel tube plate.

4.0 <u>ULTRASONIC WELDING</u>

Ultrasonic welding is another solid phase welding process which is being used by the electrical and electronic industries. In this process, the heat generated by vibration of a sonotrode is made use of and the joint obtained by application of pressure. Photo-8 illustrates some components used by electrical industry.

At Welding Research Institute, we have successfully carried out Ultrasonic welding of the following combinations :-

a) Al foil 0.1 mm thick to Al sheet 2mm thick
b) Al wire Ø 1.25mm to Al foil 0.25mm
c) Al foil 0.1mm thick to Cu sheet 0.5mm thick
d) Cu wire 12mm Ø to Al sheet 2 mm
e) Cu wire 1.2mm Ø to Cu sheet 0.5mm thick

For the combination of Al foil to copper sheet, a statistical design of experiment was carried out to arrive at the optimum parameters. The optimum parameters were found to be

Clamping pressure	:	2.6 bar
Power setting	:	160 V
Weld time	:	1.6 sec

For a battery manufacturer, ultrasonic plastic welding of battery case was carried out(Sketch-2). The welded case was subjected to hydraulic test under pressure to check for leak tightness.

For the same manufacturer, ultrasonic metal welding was carried out for welding of Ni 200 Tab to Ni200 sheet (Please refer Sketch-3). The weld was peel tested and found to satisfy their requirements.

5.0 CONCLUSION

Thus Welding Research Institute, Tiruchirapalli has entered in a most modest way to propogate the message for utilisation of such modern welding process to improve the welding productivity for the Indian industrial fatemity.

* * * * *

ADVANTAGES OF FRICTION WELDING PROCESS

1. POWER AND ENERGY REQUIREMENTS ARE VERY LOW.
2. HIGH MECHANICAL AND ELECTRICAL EFFICIENCY.
3. THE WELDING CYCLE TIME IS VERY SHORT.
4. HIGH POTENTIAL FOR AUTOMATION.
5. INSENSITIVE TO SMALL VARIATIONS IN WELDING PARAMETERS.
6. INSENSITIVE TO FLUCTUATIONS IN POWER SUPPLY.
7. HIGH RELIABILITY AND LESS WELD DEFECTS.
8. ALMOST ALL METALS ARE WELDABLE.

TABLE - 1

ADVANTAGES......

9. EASY TO WELD DISSIMILAR METALS.

10. THE HEAT AFFECTED ZONE IS VERY NARROW AND HAS A GRAIN SIZE THAT FREQUENTLY IS SMALLER THAN THAT IN THE BASE METAL.

11. FLUX, FILLER METAL OR PROTECTIVE ATMOSPHERES ARE NO NEEDED.

12. SKILLED OPERATORS ARE NOT REQUIRED.

13. NO SPATTER, FUMES AND ULTRAVOILET RADIATION DURING WELDING.

14. COMPLEX SHAPES CAN BE FABRICATED FROM SMALL COMPONENTS.

15. NO DISTORTION PROBLEMS.

TABLE - 2

TABLE-3

SALIENT FEATURES OF INSTITUTE DEVELOPED INERTIA FRICTION WELDING MACHINE

Machine Capacity:

Minimum diameter of solid bar	-	16 mm
Maximum diameter of solid bar	-	30 mm
Minimum diameter of tube	-	16 mm
Maximum diameter of tube	-	50 mm
Minimum weld cross sectional area	-	$200mm^2$ of carbon steel.
Maximum weld cross sectional area	-	$750mm^2$ of carbon steel
Maximum forging force	-	12 Tons
Maximum length of part in chuck	-	200mm upto 40 dia
Maximum length in vise	-	1300mm for rod
	-	300mm for tube
Spindle hole diameter	-	40.2mm(can accommodate) upto tube of Ø36mm OD)
Clutch	-	Electromagnetic - disc type
Operating mode	-	Manual/Semi-automatic

* * * * *

Photo-1

INSTITUTE DEVELOPED INERTIA FRICTION WELDER

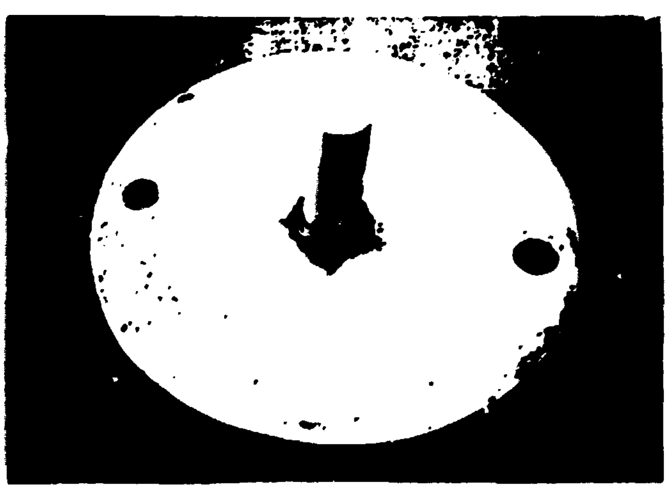


Photo-2

COVER ASSEMBLY FOR CHECK VALVES

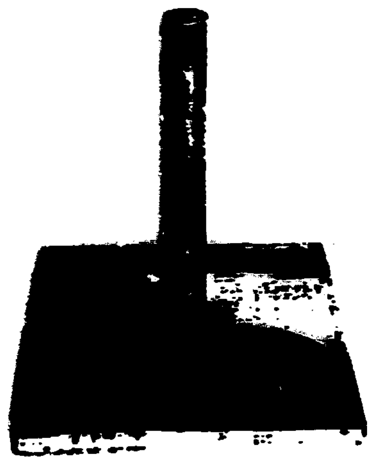


Photo-3

FOUNDATION BOLT FOR BOILER STRUCTURES

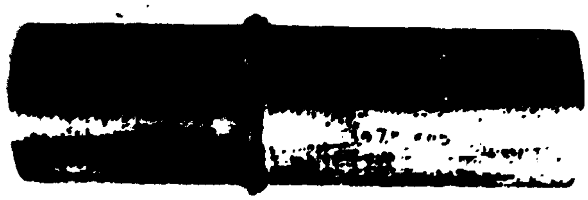


Photo-4

TRANSITION JOINT BETWEEN LOW ALLOY STEEL AND STAINLESS STEEL TUBE

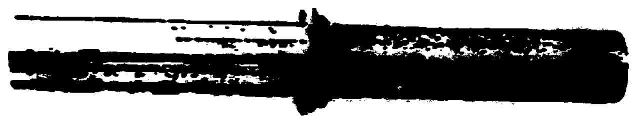


Photo-5

ROD TO ROD FRICTION WELD - END TO HIGH SPEED STEEL

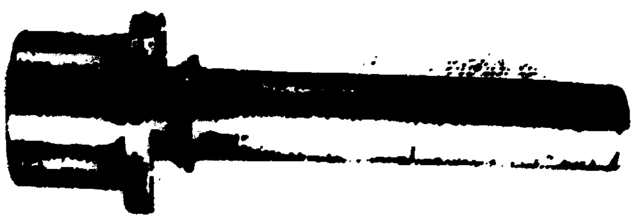


Photo-6

MAIN SHAFT FOR AUTOMOBILES

Photo-7

FRONT WHEEL AXLE FOR AUTOMOBILE

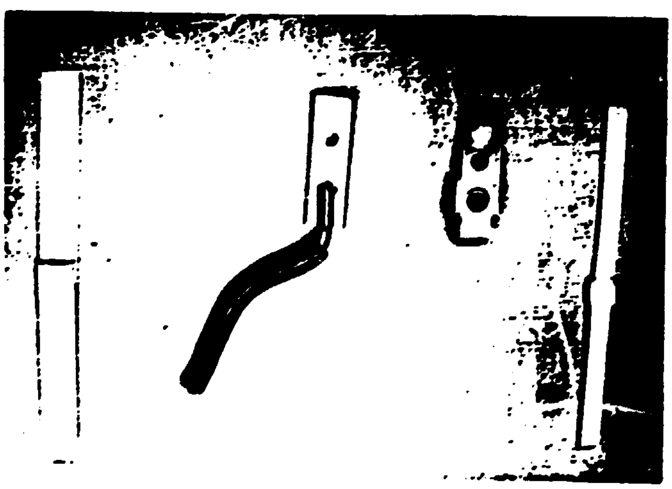
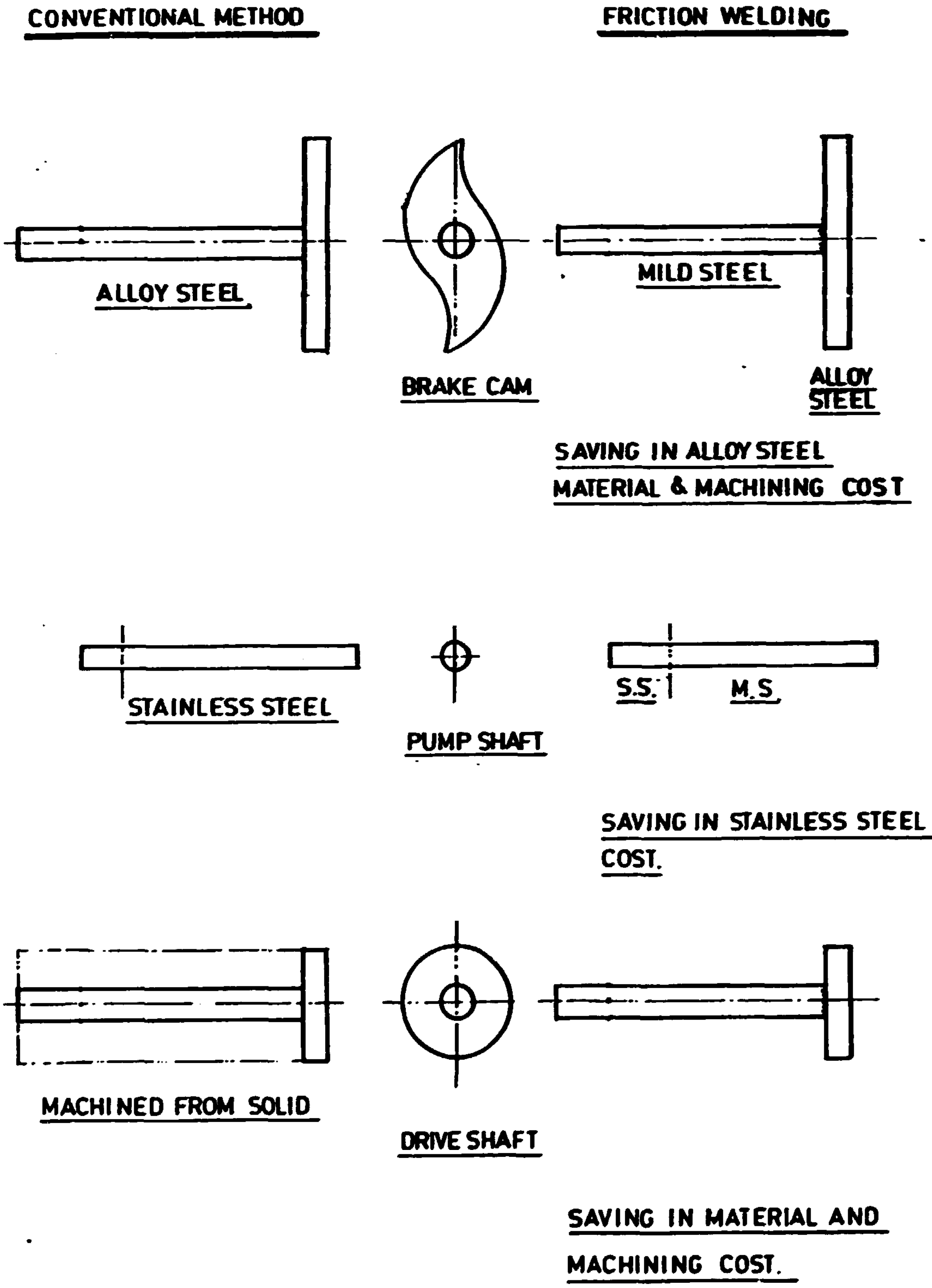
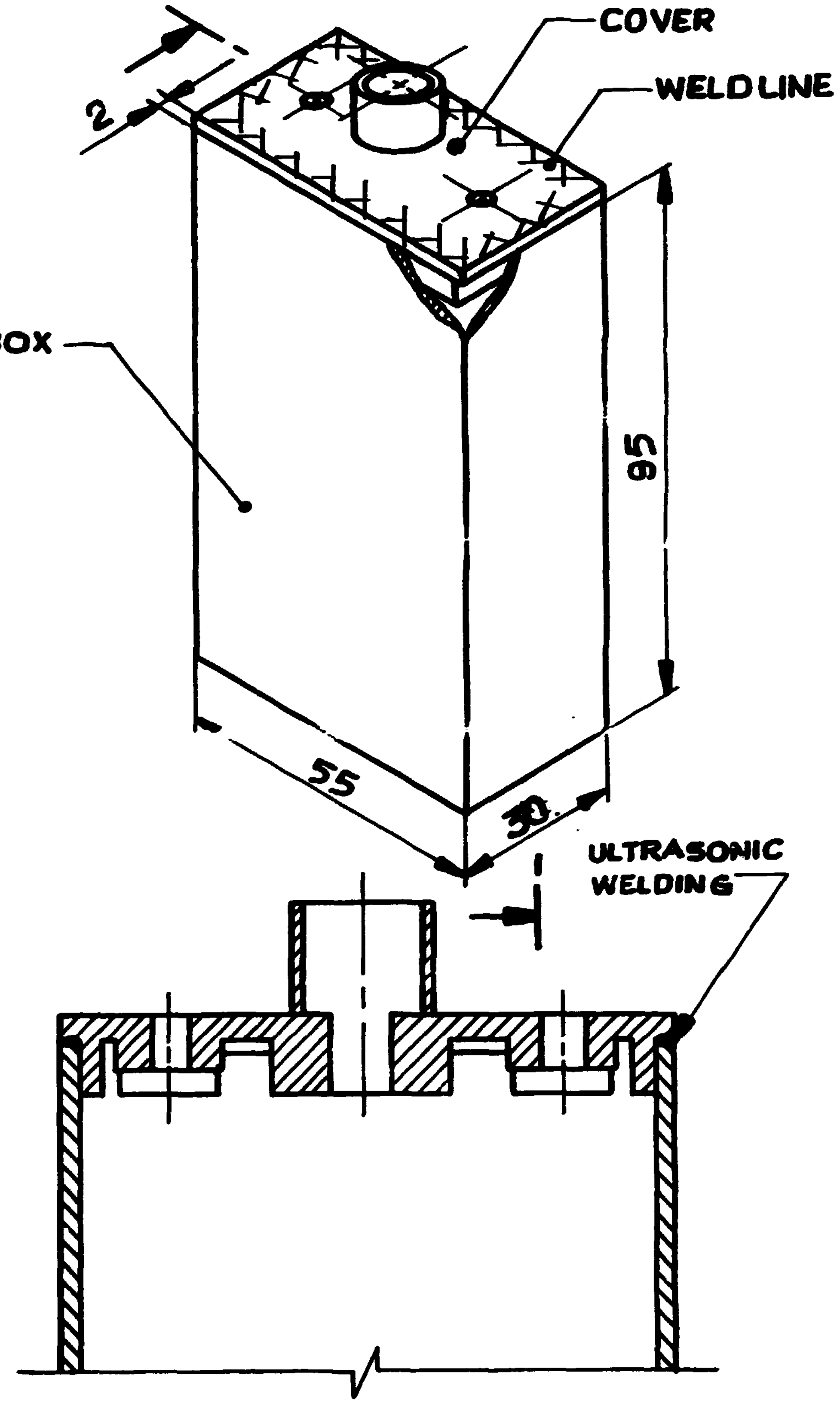


Photo-8

ULTRASONIC WELDED ELECTRICAL COMPONENTS

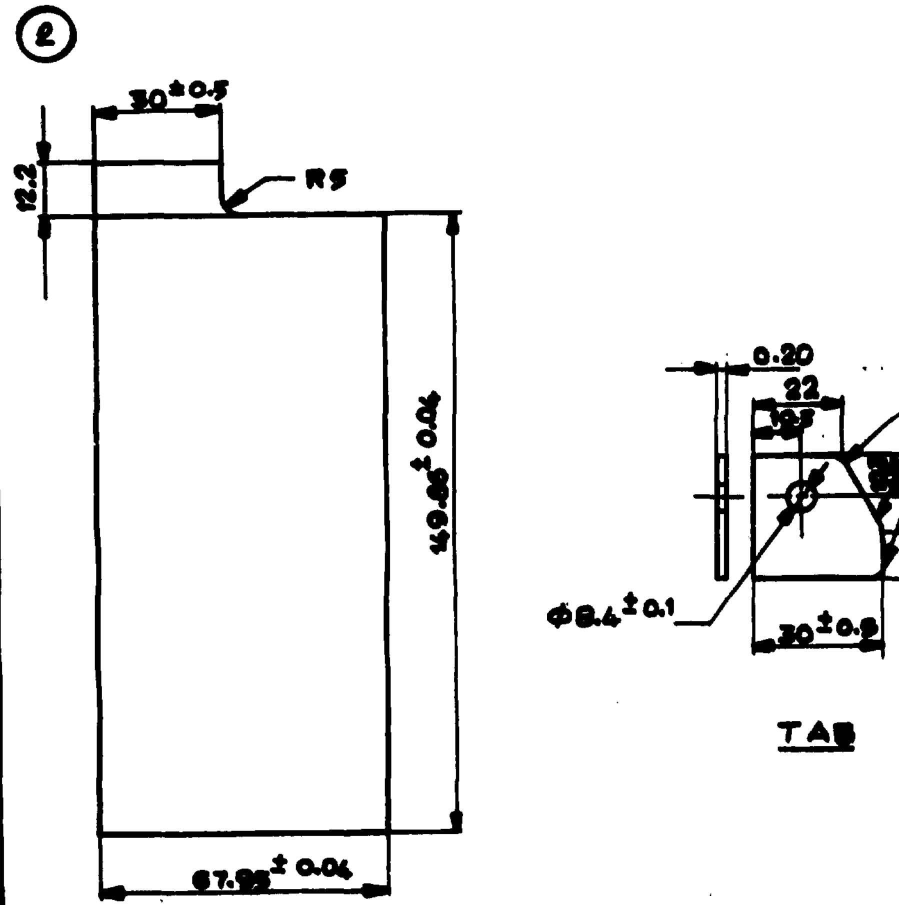

CONVENTIONAL METHOD
FRICTION WELDING
ALLOY STEEL
BRAKE CAM
MILD STEEL
ALLOY STEEL
SAVING IN ALLOY STEEL MATERIAL & MACHINING COST
STAINLESS STEEL
PUMP SHAFT
S.S.
M.S.
SAVING IN STAINLESS STEEL COST.
MACHINED FROM SOLID
DRIVE SHAFT
SAVING IN MATERIAL AND MACHINING COST.

Sketch-1



MATL :- POLYAMID BASE
ICI- MARYNIL A 100 (NYLON 66)

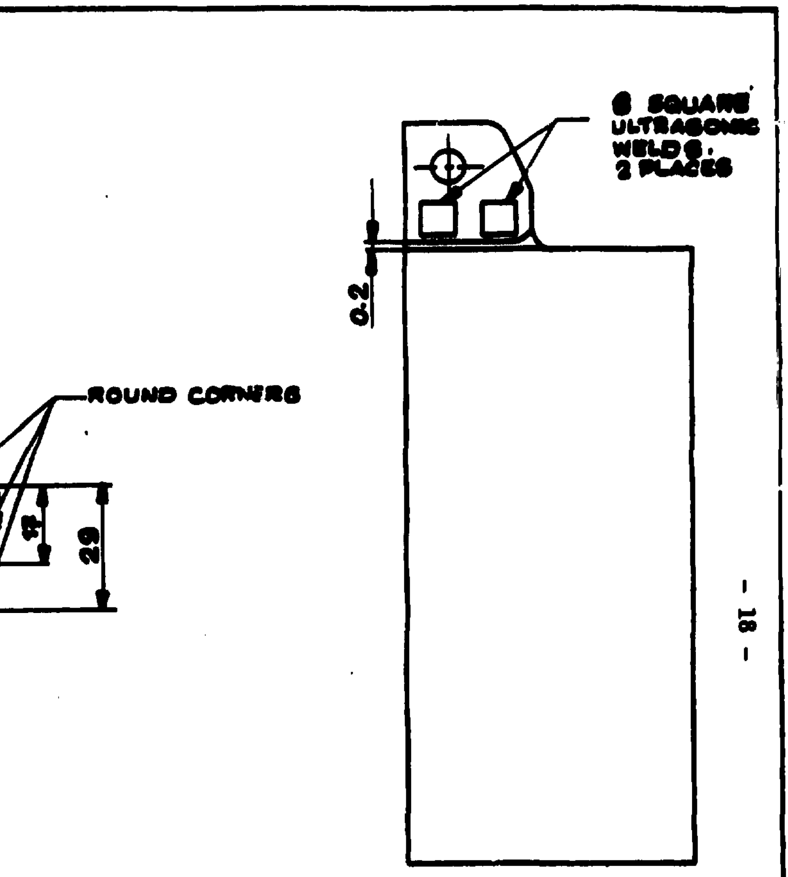
Sketch - 2



PLATE

THICKNESS OF PLATE - 0.075

Sketch-3



TAB WELDED PLATE

SCALE :- N.T.S
ALL DIMENSIONS ARE IN MM