Welding Research Laboratory - Roorkee - An Overview

- P. C. Gupta and P. K. Ghosh *

1. INTRODUCTION

Developments of new materials, requirements of sophisticated constructions and the demand for an assurance of safety in service, calls for development of technologies which shall satisfy the service requirements and produce goods of best quality and reliability at competitive cost. Welding technology is emerging as one of the key technologies of twenty first century, the application of which can not be avoided in various works ranging from the building construction and erection of onshore and offshore structures to underwater constructions, surface transportation, aerospace vehicle manufacturing and construction of nuclear vessel. Thus no country which wants to keep pace with the development around the world can afford to neglect the education, research and development activities in the field of welding technology.

In India, however, welding is still mainly considered to be a means of rapair. Wherever it is used for sophisticated constructions, only imported know how and materials are often used. But in the present world of competitive growth of technology especially considering the growth of Indian technology in diversified fields, it must be considered essential to boost up our knowledge and capability in the area of welding science and engineering. Moreover, to reduce the dependence on foreign know how such development in the technology must be achieved through indigenous effort. The primary hurdles in the direction of development of welding technology in India can be identified as :

(i) Non availability of quality welding consumables and modern equipments.

(ii) Scarcity of qualified welding personnels and expertise.

(iii) Unawareness on the part of manufactures/ fabricators regarding the developments in welding technology.

(iv) Non availability of indigenous data bank regarding the need based resources, product based technologies, economy based management and growth based forecasting.

(v) Lack of co-ordination among scattered research and development (R&D) efforts and insufficient link between the R&D institutes and industries.

To over come all these hurdles except the last one, which is essentially an organisational problem, it is essential not only to establish good facilities for training of welders but also to establish institutes/centres having suitable academic programme, R&D facilities and consultancy expertise in the field of welding science and engineering. This can produce well exposed welding personnel/experts and also provide confidence and expertise to the industry to cope up with the advancement in this area which may facilitate self reliance for intended future growth in welding technology in this country.

Keeping in view the national needs mentioned above, the Welding Research Laboratory (WRL) was established in 1981 at Department of Mechanical and Industrial Engineering, University of Roorkee, under Indo-German Technical Cooperation programme, with the financial assistance of the Federal Republic of Germany along with the ample support of the University Grants Commission (UGC) and the State of Uttar Prodesh.

2. OBJECTIVES

To fulfill the country's requirement for its versatile growth of technology in different sector and for bridging the gaps in the field of welding technology, the objectives of WRL are laid down as :

(i) To provide higher education in the field of welding technology.

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(ii) To promote basic and applied research in the area of welding science and engineering.

(iii) To provide service/consultancy to the Indian industries in the field of welding and testing of welds, especially to support their developmental activities.

2.1 Education

2.1.1 *Post Graduate Course in Welding (Master of Engineering)*

To fulfill the requirement of specialised training in welding technology to the engineers and to disseminate the vast information available in the area of welding, a three-semester Master of Engineering (M.E.) course in welding engineering was started by the Department of Mechanical and Industrial Engineering in 1984. The first two semesters are devoted to course work and the third one to research in a specific problem area. It is well recognised that nothing makes a more lasting impact on the impressionable minds of young students than the laboratory demonstration of techniques and phenomena learnt in the class room and to this end WRL offers an excellent environment. A financial assistance of Rs. 1800/- p.m. is available to all the qualified students admitted to the M.E. programme. The graduate students who come from the industry, for the M.E degree course, are permitted to select research problems of interest to their own organisation which can be undertaken at their end if adequate facilities are available there.

The M.E. programme is a practice oriented course whereby the students are exposed to theory and practice of major welding and weld testing techniques, through well designed practical exercises. Students are involved in ongoing consultancy and research projects thereby giving them some idea of the existing problem in the field of welding and the systematic approach needed to solve industrial problems, during their career. By proper selection of elective courses and M.E. dissertation topic a definite capability and attitude for research in the area of welding is initiated amongst the students desirous for a research career in this field.

A number of well qualified and experienced teachers and research scientists from the core of the group are engaged in various activities of the WRL. Faculty members of other departments of engineering and sciences in the University, possessing specialised knowledge in the allied areas, are also invited to associate themselves with the activities of Welding Research Laboratory.

There exists a team of well trained technicians in every section of WRL to handle the various requirements of practical training and experimental work of the students.

In addition, long term and short term experts of Federal Republic of Germany visit WRL from time to time and participate in its activities.

2.1.2. *Ph.D. in the area of Welding*

The Welding Research Laboratory offers excellent facilities for both, the basic and application oriented research leading to Ph.D. degree. The degree is awarded on the basis of distinct attainment in a special field of study as demonstrated by a thesis based on the independent and original research by the individual. The candidate having Master's degree in the relevant field, is eligible to register for the Ph.D. degree. The research scholars may get financial support through research fellowships, depending on its availability, besides sponsorship from institutions and industries.

2.1.3. *Continuing Education Programme*

From time to time short term intensive courses (2-4 weeks durations) on welding technology, providing education regarding lastest developments in the welding technology are offered to the engineers in service. Tailor-made courses to suit the specific requirements of an industry are also planned on demand from the industries.

Table I Participants in various academic activities

Course	Year	Number of students/ participants received degree/certificates
M.E	1985-86	6 Nos.
	1986-87	8 Nos.
	1987-88	3 Nos.
Ph.D.	Completed	4 Nos.
	In progress	4 Nos.
Short term	1981	5 Nos.
Course	1983	14 Nos.
	1984	31 Nos.
	1986	17 Nos.
	1989	17 Nos.

Table II Sponsored R & D Projects taken up in WRL

	Title of the project	Duration	Sponsoring Authority	Remarks
1.	Studies on the effect of welding parameters on the mechanical properties of pulsed arc welded Al-Zn-Mg alloy	1986-1989	Council of Scientific and Industrial Research	Completed
2.	Development of technology of shape welding using submerged arc welding process.	1987-1990	Dept. of Science & Technology	In progress
3.	Influence of flux constituents on physico-chemical and metallurgical properties of some submerged arc welding fluxes.	1989-1992	Dept. of Science & Technology	In progress
4.	Evaluation of welding process stability of stick electrodes from German and Indian manufacturers with the help of statistical analysis.	1988-1991	Volks Wagen Foundation Federal Republic of	In progress

The participants turned up in various academic activities are listed in table I.

2.2. Research

WRL offers excellent facilities for both the fundamental and application oriented research and is actively engaged in carrying out different research programmes sponsored by various Government Agencies and Industries. The research work is planned to be concentrated on problems identified in different areas such as:

(i) Innovation and modification in existing welding processes for improving their versatility or productivity in specific applications (Fig. 1).

(ii) Evaluation of mechanical (static and dynamic) and chemical properties as well as microstructures of the weld metal and HAZ of a particular material obtained by using different welding processes in order to determine proper

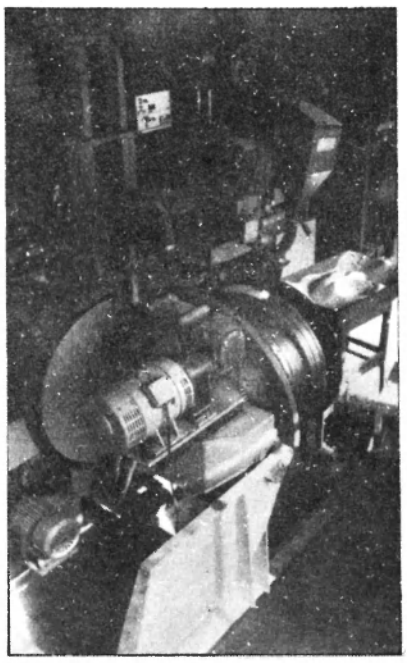


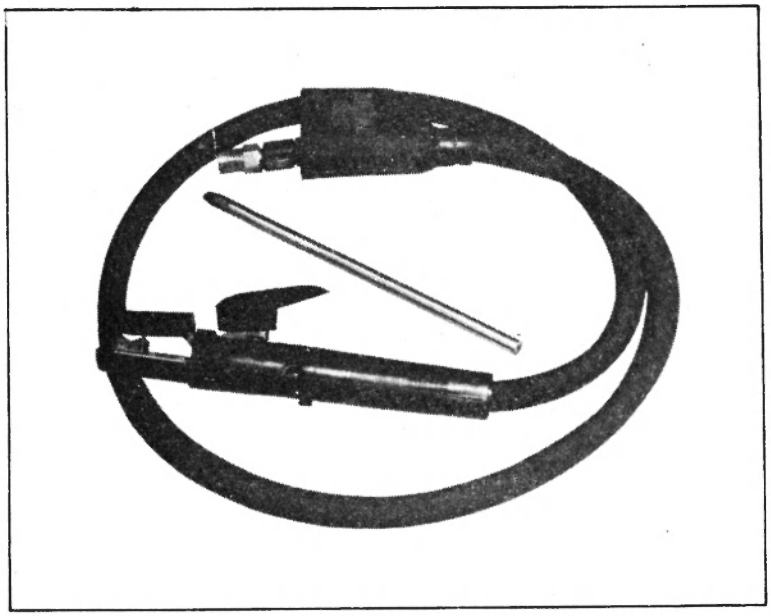
Fig. 1 *Modification in SAW set up for production of shape welded component*

metal arc

GOUGING TORCH

• WELDING HOLDER • CABLE CONNECTOR • EARTH CLAMP

metal arc GOUGING TORCH WITH 360° FREE REVOLING CABLE



Metal Arc Torches are used to Gouge, Chamfer, Groove, Cut, Bevel,Flush off all metals including Aluminium, Copper, Brass, Magnesium, Alloys, Steel, Stainless Steel, Cast Iron and is used by major foundries, shipyards, penstock/pipe and all structural fabricators, chemical & petroleum complexes.

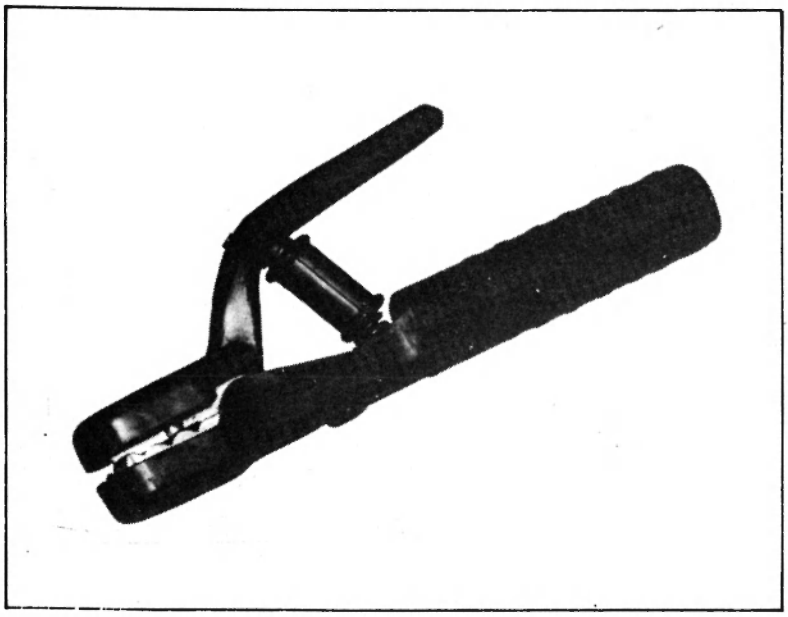
Gouging Torches are available in 3 models,M-1 for Standard Duty (for 3-8 mm Ø), M-2 for Heavy Duty (6-13 mm Ø) and Super Heavy Duty (8-19 mm Ø) Gouging Carbons.

PROCESS DESCRIPTION

The process involves (a) The striking of an ARC between the metal workpiece and the carbon electrode. (b) Melting by the ARC, and (c) Removal of the molten metal with compressed air jets, flowing parallel to the electrode from the torch.

SPECIAL FEATURES:

* For high conductivity of current, copper is used end to end.
* Heat resistant insulators (for longer life of the torch)
* Triple swivel head air nozzels (for better metal removal rate)
* High tension lever allowing firm grip of the electrode (prevents arcing)
* Insulated dual purpose monocable for compressed air and electrical current.
* 360° Free revolving movement between torch and monocable (resulting in less wrist stress for welder and better fatigue free working)

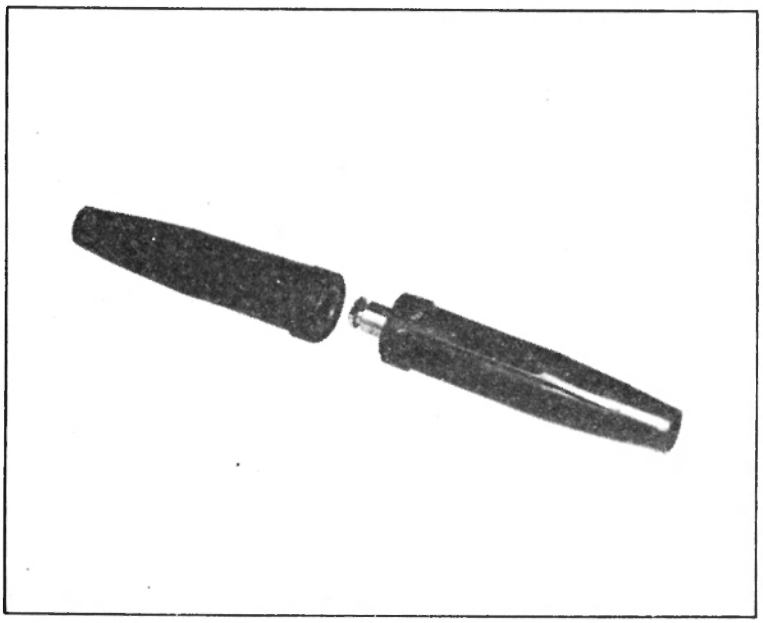


metal arc WELDING HOLDER WH-I

* For heavy duty manual arc welding.
* For current rating upto 600 Amps.
* Suitable for electrode dia up to 8mm.
* Open mouth jaw type.
* 100% fully insulated.
* Light weight and easy to handle.

SPECIAL FEATURES:

* Main body is made out of one piece brass alloy resulting in better current transmission, special design features ensure lov heat and long life.
* Hood covers and handle are made out of special heat and arc resistant compounds to protect the welding holder from arc damage.
* For quick connection/disconnection of cable/holder, handle can be removed by one recessed alien screw.
* For better cable connection 3 allen screws provided with D shape grip plate



metal arc CABLE CONNECTORS 600 AMPS

SPECIAL FEATURES:

* Heavy duty cable connector suitable for high capacity usage and efficient operation to perform at nominal voltage drop and at high duty cycles.
* Interlocking parts made of high conductivity brass machined for close tolerance and perfect fit.
* The male and female ends of the connector have quick locking arrangement for positive engage/ disengage by 180° twist.
* Tension adjustments made easily on the split male plug with a screw driver.
* Better and quick cable connection at each end by allen screws and D shape grip plate.
* Fully insulated with special heat resistant rubber covers for safe operation under normal working conditions.

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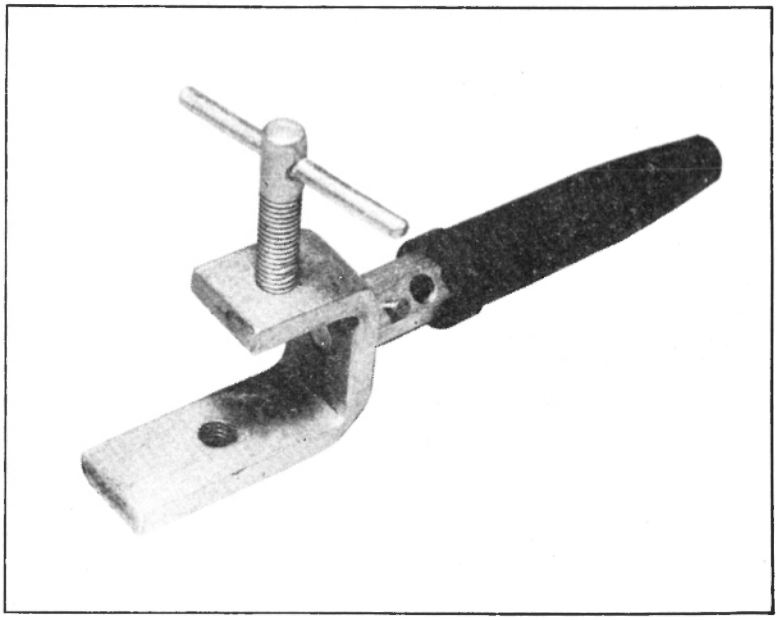
metal arc EARTH CLAMP 600 AMPS



SPECIAL FEATURES:

* For current rating upto 600 Amps.
* Robust construction from M.S. Section duly plated for longer life.
* Manual clamping effected through a screw ensuring full contact.
* Cable is fixed quickly and efficiently by two allen screws.
* Optional insulator cover available for cable connection.

ESTD. 1887

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welding technique(s) to satisfy specific service conditions.

(iii) Investigations on corrosion and stress corrosion susceptibility of welded joints of various materials under different service environments, to determine the mechanism of corrosion and reliablity of various welded joints under given exposure.

(iv) Investigation on various physical and physico-chemical properties of different SAW flux system for evaluation of suitability of particular flux for specific application and for development of new fluxes.

(v) Statistical analysis of ignition behaviour and arc stability under different conditions of welding by using instantaneous arc voltage and current signals recorded by Analyser Hannover.

(vi) Studies on fracture toughness and creep properties of welded joints and estimation of service reliability.

The sponsored research and development projects so far taken up in WRL are listed in table II.
Besides the sponsored R & D projects a number of other R & D activities in different fields of welding technology, selected in view of presant development/ need in the area of welding science and engineering, are going on in WRL. A brief out line of these fields are mentioned in table III.

The R & D efforts of WRL are high lighted so far in eighty five research papers published from time to time in various national and international journals, workshops, seminars, conferences.

2.3 Consultancy And Services

WRL extends its facilities to provide a diagnostic analysis for welding problems emerging in Indian industries and to suggest appropriate solutions or remedial measures. The industrial consultancy is basically divided in two groups such as developmental consultancy and testing services. The developmental consultancy includes :

(i) Establishment of welding procedure for ferrous and non-ferrous metals for specific applications.

(ii) Recommendation of welding procedures to improve welding productivity.

Table III Various R & D activities of WRL

o	Development of electrodes for underwater welding.
o	Ignition behaviour and spatter losses in MAG weldrng.
o	Influence of magnetic field on spatter loss in CO_2 welding.
o	High speed submerged arc welding by twin arc technique.
o	Development of simulation system for MIG/ MAG orbital welding.
o	Development of self aligning contact nozzle for narrow gap submerged arc welding.
o	Submerged arc stainless steel strip cladding.
o	Influence of electrode polarity, electrode position and angle of attack in submerged arc welding.
o	Upset butt welding of HSLA steel.
o	Development of transvarestraint test assembly for evaluation of solidification cracking susceptibility.
o	Flash butt weldability of HSLA and stainless steels.
o	Influence of ion implantation on the properties of weld joint of various materials.
o	Influence of basicity index and melting rate on the flux consumption, bead geometry and weld metal chemistry in submerged arc welding.

(iii) Design of welding fixture for specific application.

(iv) Design and development of special purpose welding systems including special torches and nozzles etc.

(v) Recommendation of welding procedures for repair and reclamation of wornout and undersized components.

(vi) Failure analysis and recommendations on remedial measures.

(vii) Stress analysis and characterization of properties of welded components.

The consultancy services so far undertaken by WRL from various industries are briefed in table IV.
The various testing services provided by WRL to the industries and organisations are listed below.

(i) Testing of coated electrodes and wire-flux combinations, according to various national and international standards.

(ii) Static and dynamic properties of base metal as well as of weldments as per national and international codes.

(iii) Creep properties of base metal and weldments.

(iv) Fracture toughness properties of base metal and weldments.

(v) Nondestructive testing of weldments.

(vi) Qualitative and quantitative analysis of microstructures as well as measurements of microhardness.

(vii) Fracture surface analysis.

(viii) Diffusible hydrogen analysis of weld deposit.

(ix) Chemical analysis of base metal and weld deposit.

(x) Analysis of ferrite content in stainless steel welds.

3. FACILITIES

Besides the manual metal arc welding WRL has a large number of sophisticated facilities in the area of welding and thermal cutting, destructive and non destructive testing, metallography, chemical analysis, heat treatment, documentation and fabrication. Moreover the research, consultancy and testing services of WRL enjoy the support of a large number of modern equipments installed at various departments and at USIC (central facility) of the University of Roorkee. The important facilities of different area can be identified as follows.

Table IV Consultancy Services undertaken by WRL

	Subject	Name of organisation
1.	Weldability of Dual Phase Steel produced by Steel Authority of India Ltd.,	Steel Authority of India Ltd., Ranchi.
2.	Designing of fixtures and development of welding for joining of following components: o Carbon steel bush to stainless steel bellow. o Bronze bush to bronze bellow.	Danfoss India Ltd., Gaziabad.
3.	Weldability of HSLA-80 steel produced by Steel Authority of India Ltd.,	State Authority of India Ltd., Ranchi.
4.	Fabrication and inspection of aluminiun rollers for photo-copying machines.	Hindustan Computers Ltd., Dehradun.
5.	Welding and testing of Lifting Lug for Chibro Power Station.	U.P. State Electricity Board.
6.	Inspection and repairing of pressure plate of heavy duty recovery vehicle.	266 Field Repair workshop, Indian Army.
7.	Evaluation of life-time of weldments in rail section.	Research Designs and Standards Organisation (RDSO), Lucknow.

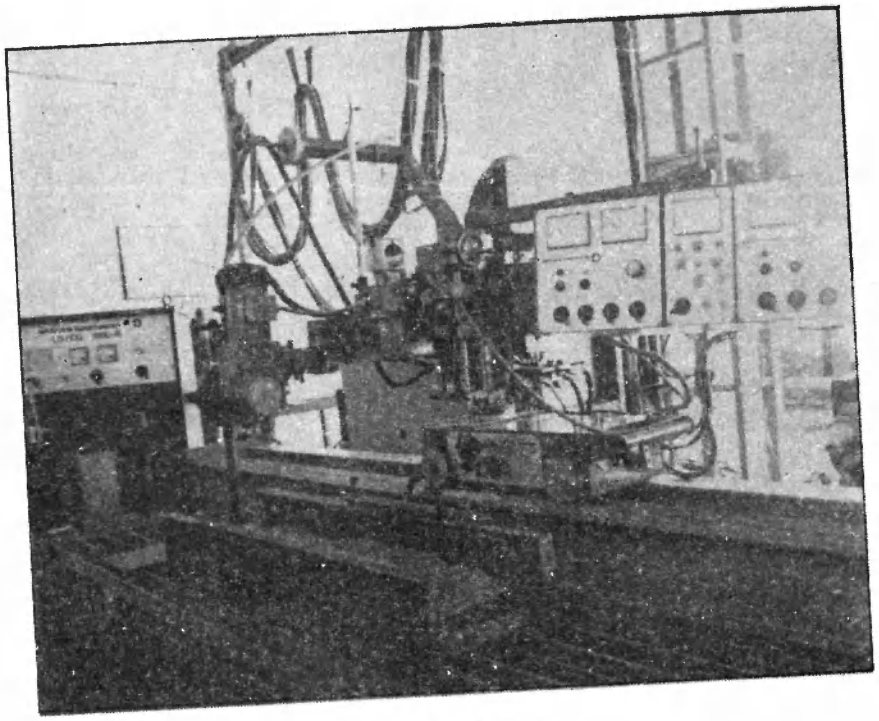

Fig. 2 *Submerged arc welding unit, Messer-Griesheim-LE-18*

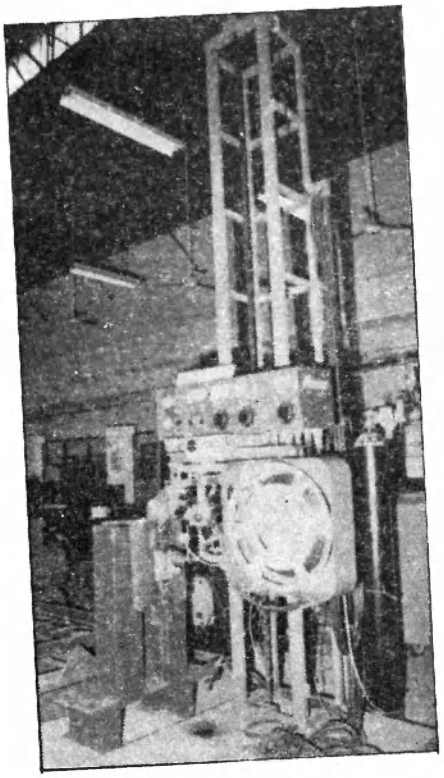

Fig. 3 *Electroslag/gas welding unit, Arcos-Vertomatic SG*

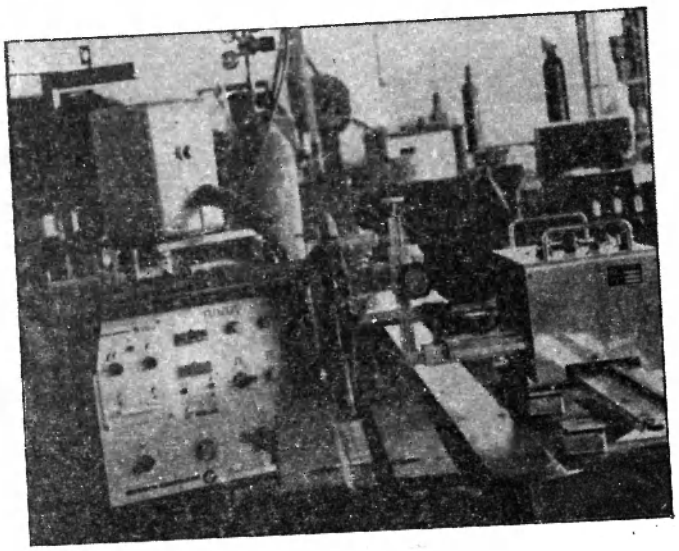

Fig. 4 *MIG/MAG welding unit and devices, Messer-Griesheim Pulsomat 450 and BUG-O-matic oscillation unit*

Fig. 5 *Facility for Computer assisted evaluation of experimental results, Analyzer Hannover with basis 108 computer*

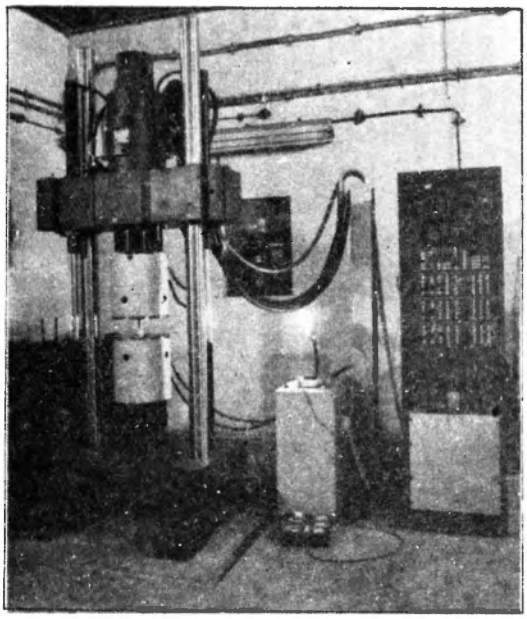

Fig. 6 *Servohydraulic universal testing machine, MFL-EZO 600*

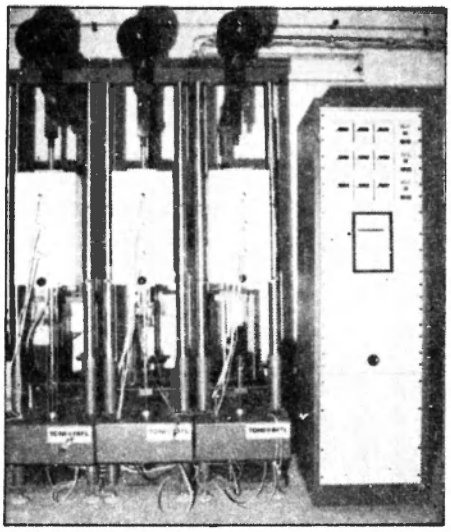

Fig. 7 *Creep testing units, Toni-MFL ST-50*

3.1 Welding And Thermal Cutting

- Submerged arc welding having single and two wire DC/AC 1000 A + 1200 A tandem system and strip cladding facility (Messer-Griesheim Le. 18), (Fig.2).
- Electroslag / electrogas welding, 700 A, suitable for the use of solid and flux cored wire and having a vertical movement of 3.5 m (Arcos-Vertomatic SG), (Fig. 3).
- MIG/MAG welding with continuous and pulsed current, 450 A (Messer-Griesheim Pulsomat 450), (Fig. 4), and Philips-MIG-440.
- Plasma-Tig DC welding and cutting equipment, 300 A (Advani Oerlikon, PCT 300/401).
- TIG welding, AC/DC 360 A continuous and pulsed current control with current time programming facility (Oerlikon ADW-360P).
- Microplasma welding, 0-50A continuous and pulsed current 100-10000 Hz (Secheron, Plasmafix 50E).
- Resistance spot welding, input 125 KVA (Nimak PMP 7).
- Micro-spot welding, input 20 KVA (Messer-Greisheim, PECO PP 2M 3510).
- Flash butt welding, 120 KVA (IDEAL AS 63-S).
- Gas/plasma cutting with mechanical and optical contour (1 : 1) control system, 60 KVA (Messer-Griesheim CORTA Plasmajet PC 250).
- Automatic Electrode feeding unit, (F.R.G.).

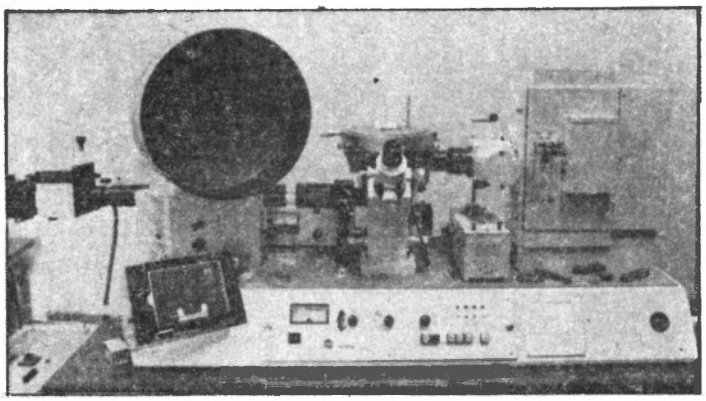

Fig. 8 *Optical microscope, Leitz-MMo*

3.1.1 *Accessories*

- Longitudinal clamping device of length 1200mm for 0.1-6 mm thick section with mechanical carriage cold wire feeder and back shielding gas facilities (Heiss, LSV-1).
- Rotating tables of 100 kg and 2.5 tonnes capacity having stepless regulating system for rotation 0.05-4 rpm (Oerlikon DTH 501 WRL RT-2.5).
- Mechanised carriage & oscillation units (BUG-O-Matic and BUG 1500 A), (Fig. 4).
- Gas mixture system for Argon and Carbondioxide with stepless regulation of mixture, and gas flow.
- Current and voltage recording and statistical processing unit with basis 108 computer (Analyzer Hannover 4), (Fig. 5).

3.2 **Testing**

3.2.1 *Destructive*

- Servohydraulic universal testing machine of capacity 600 KN (static) and 400 KN (dynamic) (MFL EZO-600), (Fig. 6).
- Hydraulic universal testing machine of capacity 60KN (static and dynamic) (Mohr and Federhoff AG:Z DPDY 6).
- Pendulum impact testing machine for charpy and IZOD specimens, 300 J, (Batliboi FIT-30).
- Creep testing machine of capacity 50 KN upto 1200 degree C (Toni-MFL ST-50), (Fig.7).
- High frequency resonance fatigue testing machine of capacity 7 KN cm bending moment, frequency upto 300 Hz (Rumul Cracktronic 8304).
- Hardness tester: Vicker's Brinell and Rockwell (Wolpert Diatestor 2-RC).

3.2.2 *Non-destructive*

- Ultrasonic flaw detectors, portable type and table type (Kari Deutsch Echograf HH 1024 and ECIA UFD-6255).
- X-ray radiography unit, 300 KV, 5mA, with fluorescent window facilities (Balteau 6H 300 D).
- Magnetic crack detectors, 500-1500 A, 220 V/ AC stable type and portable type (INDAMAG and TIEDE).
- Ferritescope (Fischer FE-8D3)
- Dye-penetrant testing equipment.

3.2.3 *Accessories*

- COD clip gauge (Crack extensometer of different sizes).
- Multichannel recorder for strain and temperature measurements (Hottinger UPM -60).
- Light beam UV recorder, recording speed 1m/ sec. (SIEMENS).
- X-Y compensograph (SIEMENS)
- Digital thermometer with different type of probes (THERMIZET-D, SIEMENS).

- Digital Storage oscilloscope with magnetic disc recording facility (NICOLET 206).
- X-Y-t recorder (SIEMENS SERVOGOR M).

3.3 Chemical Analysis

- Atomic absorption spectrophotometer with graphitic furnace and programmer, for analysis of alloying and trace elements upto ppb level (Parkin Elmer 2380 and HGA - 400).
- Infra red carbon and sulphur analyser (Strochlein CS-mat 600).
- Apparatus for the measurement of diffusible hydrogen in weld metal.
- Oxygen-nitrogen analyser.

3.4 Metallography And Photo Processing

- Modern equipments for metallographic sample preparation: Cutting, grinding, mounting, polishing, Ultrasonic cleaning and etching (normal and colour).
- Optical pancratic and illumination microscope with inverted microhardness and photographic facilities and TV projection attachments (Leitz MM-6), (Fig. 8)
- Stereo microscope with camera (Zeiss MC-63).
- Vertical microhardness tester (Leitz Miniload 2).
- Enlarger (Durst M 805 color).
- Processor (Durst RCP 405 N).

3.5 Heat treatment

- Electrical air/controlled atmosphere furnace 1150° C (Heraeus KR- 260/E).
- Muffle furnace 1000° C (Therelek).
- Electric air oven 300° C (Heraeus T- 5042 EK).
- Electrode drying oven 400° C (Vishwa Advani Oerlikon).

3.6 Documentation

- Professional video system U-matic with colourmonitor (Panasonic NV-9200E, Grundig BGC-61).
- Slide, overhead and film projector (Liesegang NEC)

3.7 Fabrication Facilities

The laboratory is having excellent workshop facility for weld groove preparation and fabrication of various set - ups and test specimens. The workshop is equipped with the following machines.

- Lathe machine.
- Universal milling machine.
- Shaper.
- Drilling machine.
- Band Saw.
- Power hacksaw.
- Grinding machines etc.

3.5 University Central Facilities

- Transmission electron microscope
- Scanning electron microscope
- Electron microprobe analyser
- X-ray diffractometer
- Atomic absorption spectrometer
- Differential scanning calorimeter (DSC/ DST).
- Liquid scintillation counter
- Mossbauer spectrometer
- Universal testing machine with elevated temperature testing facility.
- DEC 2050 Computer with 512 K memory.

4. CONCLUSION

WRL possesses unique facilities for Education, Research and Consultancy services in the field of Welding Technology.These are supplemented by competent staff motivated to interact with industries and help them not only in their R & D efforts but also in solving their practical problems in the area of welding.

The ultimate goal of WRL is (i) to bring awareness amongst the user industries regarding the capabilities of welding technology (ii) to provide latest know how upto the grass root level in the field of welding (iii) to establish a system to disseminate the knowledge of R & D efforts at various level to the ultimate users (iv) to establish organisation which can identify the gaps in the existing technology in the country and steps to fill it up and send its recommendations to the appropriate authorities of the country for necessary action.