

## Report about the practical work at ESAB Laxa : March - April 1985

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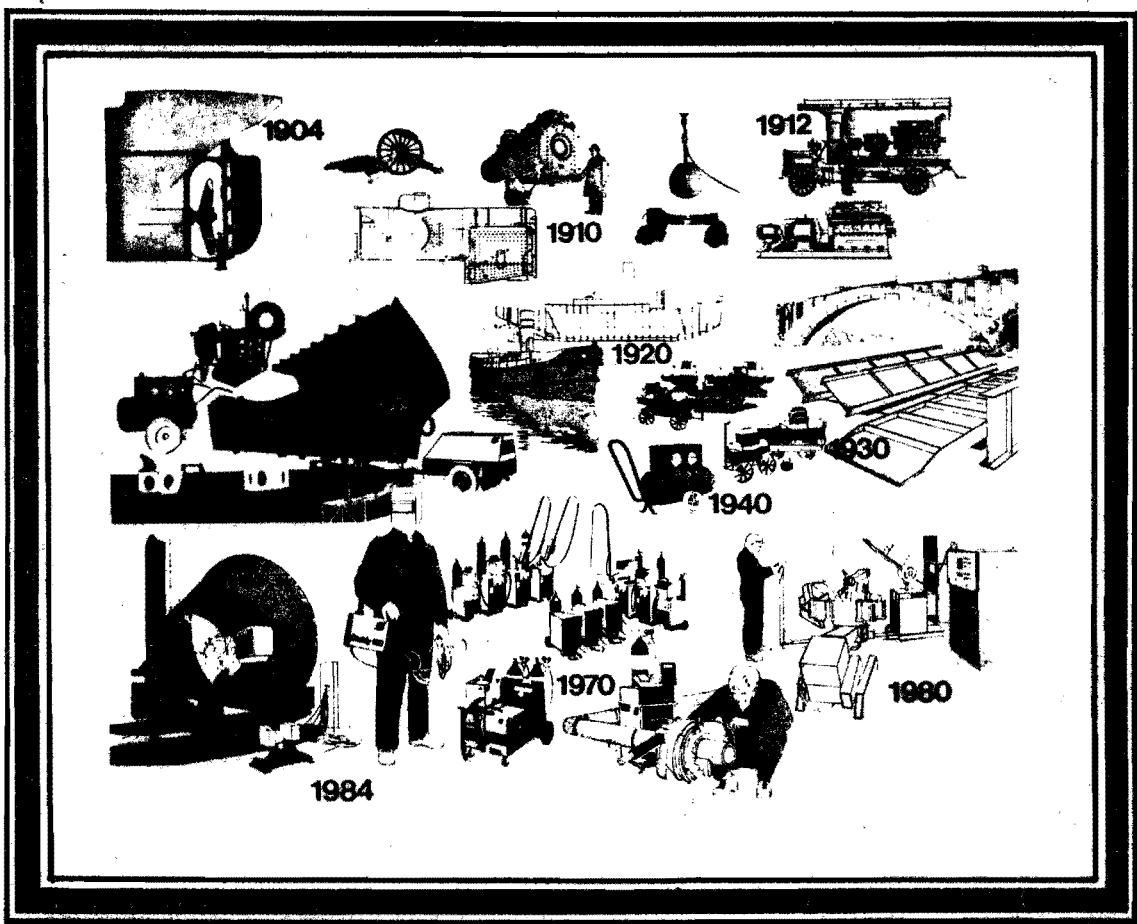
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REPORT ABOUT THE PRACTICAL WORK

MAP Frank  
v Akkeren  
WPB0287-2  
BB 435866

AT **ESAB** LAXA



MARCH-APRIL 1985

BY FRANK VAN AKKEREN  
EINDHOVEN UNIVERSITY OF TECHNOLOGY  
THE NETHERLANDS

## Sammanfattning.

Den här rapporten innehåller förutom bakgrundsinformationen om ESAB Laxå, en beskrivning av ESAB Weldguide. Weldguide är ett nyligen utvecklat startpunkt och följnings system.

Rapporten innehåller också resultaten av några små tester, exempelvis "store location" i ett svetsprogram.

Beskrivningen av ESAB Weldguide innefattar tre delar.

Den första delen ger en system beskrivning och visar hur man programmerar Weldguide.

Del två beskriver installation och nödvändiga anslutningar till robot systemet.

Slutligen beskriver del tre hur Weldguide kan testas sedan den blivit installerad.

## Summary.

This report consists besides some background information about ESAB Laxå a description of the ESAB Weldguide, a recently developed combined joint location and joint tracking system, and the results of some other small tests e.g. "store location" in a welding program.

The description of the ESAB Weldguide consists of three parts. The first part gives a system description and describes also the way to program the Weldguide.

The second part describes how the Weldguide has to be installed and which connections to the robot system have to be made.

The third part describes how the Weldguide can be tested, when installed.

## Samenvatting.

Dit verslag bevat behalve enige achtergrond informatie omtrent ESAB Laxå, een beschrijving van de ESAB Weldguide, een recent ontwikkeld gekombineerd lasnaad zoek- en volgsysteem, en de resultaten van enige kleinere experimenten zoals bijvoorbeeld het gebruik van de "store location" instructie in een lasprogramma. De beschrijving van de ESAB Weldguide bestaat in feite uit drie gedeeltes.

Ten eerste wordt een systeem beschrijving gegeven en wordt uitgelegd hoe de Weldguide geprogrammeerd moet worden.

Een tweede gedeelte maakt duidelijk hoe de Weldguide geïnstalleerd moet worden en welke verbindingen met het robot systeem nodig zijn.

Ten slotte enige tests om de Weldguide, wanneer deze eenmaal geïnstalleerd is, te beproeven.

## Preface.

This is a report about the practical work at ESAB Laxå by Frank van Akkeren, student at the Eindhoven University of Technology (the Netherlands).

The period offered was from 3-3-'85 till 26-4-'85, but after this period ESAB offered to stay longer so the practical work has been continued till 10-5-'85.

This practical work included following main occupations:

- Executing testwelds using the ESAB Weldguide, a recently developed combined joint location and joint tracking system, to create a weld-data and parameter value library.
- Making a translation a translation from English to Dutch of the Weldguide's users manual.
- Composing an installation-service manual, assuming earlier separate manuals.

This resulted in a report which contains apart from some background information about ESAB a technical description of the ESAB Weldguide system and some other short reports of tests done during this period.

In this part of this report I would like to thank all people that made my practical work at ESAB Laxå possible, especially Mr. Palm and Mrs. Kock from ESAB Laxå and Mr. Corzilius from Eindhoven University of Technology.

Further I would like to thank all people I cooperated with during this period, especially my tutor Mr. Staffan Wiberg. Due to his efforts I had a very interesting practical work at ESAB and a very pleasant period in Sweden.

Tack så mycket,

Laxå 8-5-'85



Frank van Akkeren  
Bergerothweg 35  
6039A1 Stramproy  
The Netherlands.

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## 1. HISTORICAL BACKGROUND.

At the end of the 19th century and at the beginning of the 20th century, a Swedish Engineer, Oscar Kjellberg was involved in the repair of leaking boilers on board ships. He started to experiment with arc welding and quickly realised that the resulting porous and brittle weld was caused by the ingress of air. In order to protect the molten metal during its transfer from the electrode to the weld pool, he developed a chemical coating which, during welding, turned into molten slag and covered the molten metal. From this start came the covered electrode for manual metal arc welding which has done so much for the industry over the last 80 year which even today still holds a major share of the consumable market. Kjellberg's patent, which was valid from 14 June 1905 was actually granted in 1906. This patented technology was then sold to many companies in countries throughout the world.

The ESAB Group, however, had already been established in 1904 and gradually began to develop not only electrodes but also suitable welding power sources. For the first year electrodes were not sold externally but served only for internal use for shop repair work. Gradually though the process was sold to specialist companies based at Swedish harbours and set up to carry out welding work. The welding method was sold also to companies abroad, normally with controlling rights for each particular company but, because of a lack of money, it was not possible to ESAB to establish affiliated companies abroad. This had to wait until 1912, when ESAB established the Anglo-Swedish Electric Welding Co. Ltd. in London. The initial work was welding on ships but there was also some repair work carried out on boilers at power stations.

Further development of arc welding with coated electrodes was dependent upon receiving official acceptance by organisations such as Lloyd's Register of Shipping, Bureau Veritas and Det Norske Veritas. In 1907 Lloyd's had contacted their Gothenburg representative for further information but it was really the onset of war in 1914 that pushed the Classification Society to seriously consider this new process. Regulations were quickly established as regards the application of welding and tests carried out in London in 1920 on electrodes: About this time three all-welded ships, SAF No. 4 by La Soudure Autogene Francaise, ESAB IV in Sweden and Suwa Maru in Japan by Mitsubishi, were launched. These are believed the three of the first all-welded ships to be constructed.

Twelve months later, ESAB established a plant in Germany, Kjellberg Elektroden GmbH in Berlin, later to be Kjellberg Elektroden & Maschinen GmbH at Finsterwalde, the main activity of which was to manufacture of electric welding machines. This decision was based upon the already developing strength of the German market and the fact that Germany also constituted a well organised distribution point for the European market. This factory at Finsterwalde remained the manufacturing plant until the return of the war in 1939 when part of the production was transferred for strategic reasons to a plant in Sweden.

Initially production was at Gothenburg but then in 1941/1942 a plant was constructed at Laxå, an industrial area formerly based around the iron industry but suffering from general decline in industrial output. This factory has over the next 40 years become the major manufacturing plant for the ESAB Group. Table 1 shows the main developments which have taken place during the last 81 years as the Group has grown and spread its interests around the world.

1904	Foundation of Parent Company
1906	Patent granted
1907	Move to Hisingen site in Gothenburg
1912	Foundation of Anglo-Swedish Electric Welding Co. Ltd. UK
1914	Patent rights sold to Mitsubishi Zosen Kaisha, Japan
	Foundation of Belgium-Swedish Electric Co. Ltd.
1920	Kjellberg's method approved by Lloyd's Register of Shipping
1921	Kjellberg Elektroden & Maschinen GmbH, Finsterwalde, Germany
1927	Oscar Kjellberg awarded Gold Medal of the Royal Swedish Academy of Engineering Sciences
1931	Kjellberg dies, Walter Edstrom appointed MD
1932	ESAB Spain
	ESAB Belgium
	Kjellberg Elektroden & Maschinen GmbH, Prague
	ESAB Welding School established
1933	ESAB England
	ESAB Denmark
1934	ESAB Holland
1936	ESAB Italy
1938	ESAB Norway
	Introduction of extruded electrodes
	Introduction of automatic welding machines for stick electrodes
1940	ESAB Welding Cpn. USA
1942	Laxå factory started
1943	ESAB Finland
1948	Kjellberg-Eberle GmbH, Germany
1960	ESAB France
1961	Manufacture of electrodes at Perstorp plant, Sweden
1963	ESAB Brazil
1966	ESAB Austria
1968	ESAB Arc Rods Ltd. Montreal
	Maquinas ESAB Ltda Brazil
	Licence from Paton Institute, Kiev for electro-slag welding
1969	ESAB-Sclieren AB
1968	ESAB takes over Asasvets
1967	ESAB takes over Hagghunds welding section
1970	Ake Ahlstrom MD
	Licence agreement with Iniquid Carbonic Cpn. Toronto for manufacture of welding electrodes
	ESAB takes over Hebe AB
1972	Agreement with BSC for cladding of mill rolls
	ETARC SA France
	ESAB Inc. USA
	Protea-ESAB Holdings, South Africa
	Licences with Hilal Industrial Co. of Baghdad and SARL of Angola for manufacture of electrodes
1973	ESAB SA, Algeria
	ESAB-KEBE, Sweden
	Licences with Kaymak Teknigi Sanayi re Ticaret of Istanbul and Protea-ESAB, Johannesburg, for manufacture of electrodes
1974	ESAB-Ekman Welding, Singapore
	ESAB-Iran, Iran
	ESAB-Romar, Portugal
	ESAB Manufacturing Inc. USA
	Chematron-ESAB Europa, Belgium
	FEMSA Italy
	ESAB Maquinas & Equipamentos para Solda, Brazil
	ESAB Australia
	TEHAC GmbH acquired
1976	Intergas AS, Norway
1977	Sodextron et Cie "Sarazin Soudure" acquired
1980	50% of ESAB Iberia acquired
	Ake Ahlstrom leaves and Bengt Eriksson appointed MD
	40% of SIKMA SA, Mexico acquired
	Varlos Fabriken acquired
1981	Hancock GmbH bought from BOC
1982	ESAB Middle East, Dubai
	Hancock Cutting Machines acquired from BOC
	Arcoo, Lincoln and Brinal acquired from GEN
	Murex Operations acquired from BOC
1983	Arcoo SpA
	Eicholzer Switzerland
1984	Arcoo Brazil

Fig.1. Growth of ESAB's activities worldwide.

The figures on the next page show ESAB's position in the world and the product shares of its sales.

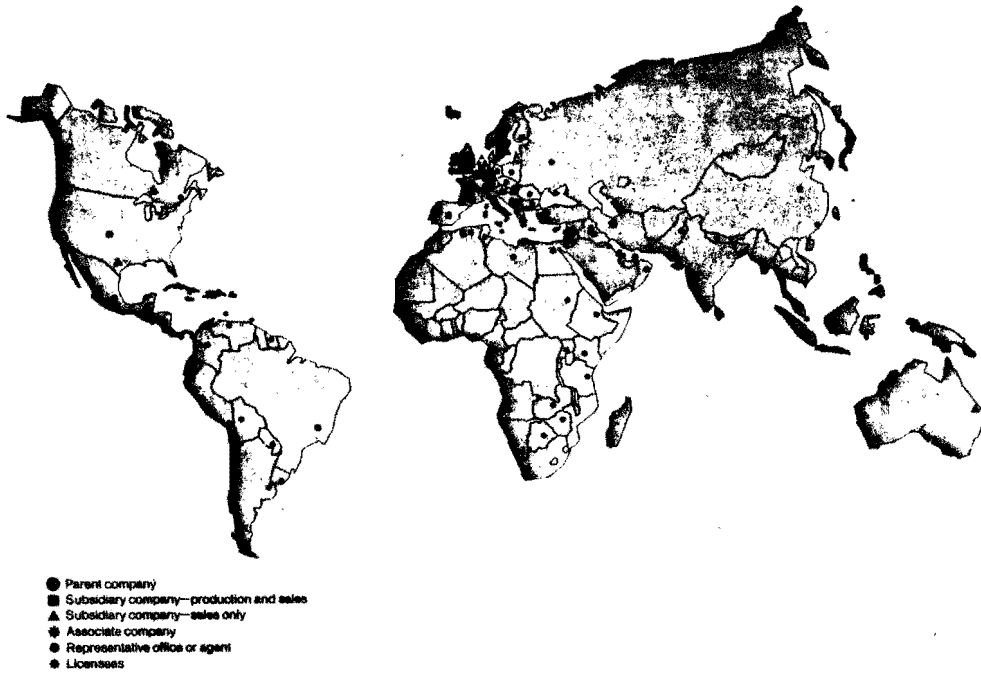


Fig.2.ESAB's position in the world.

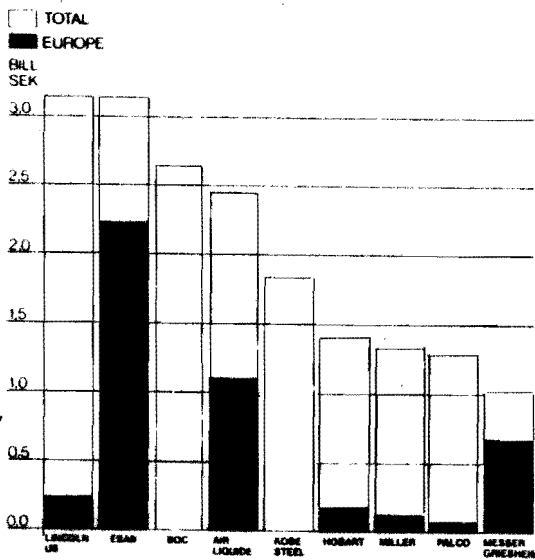


Fig.3.The world's largest welding companies.

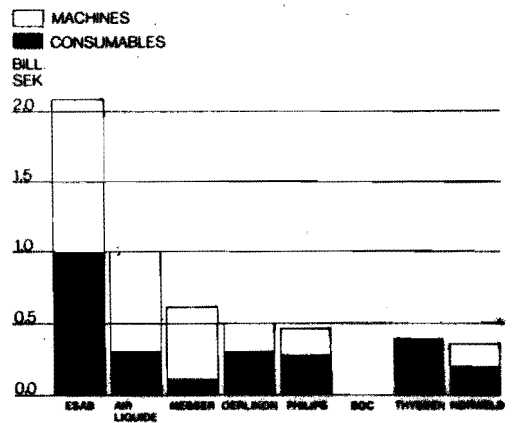
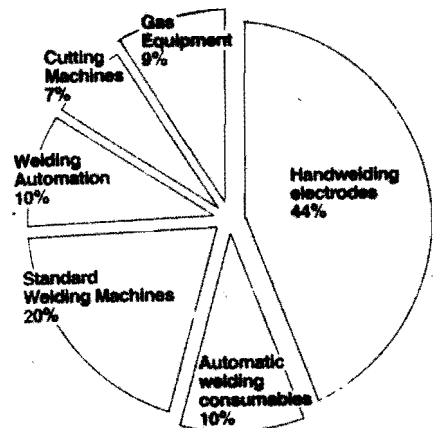


Fig.4.West European machine/consumable sales(June 1983)

Fig.5.Product shares of ESAB Sales.





2:ESAB LAXA.

As mentioned in the historical background to ESAB's development the company started out near the Lindholmen shipyard in Gothenburg but in 1915 moved to a new workshop situated in Marieholm near the Göta River on the outskirts of Gothenburg. In 1932 the company opened a Welding School and with the continuing growth, ESAB had once again outgrown its premises and so in 1936 a building at Hisingen was bought from Volvo. The onset of war caused further problems, for ESAB had concentrated welding machine manufacture at Finsterwalde in Germany in order to be near to the biggest market place. By 1941, the company was considering starting machine production at its Gothenburg factory but at the same time, investigations were in hand to find a suitable industrial site.

A suitable site was found at Laxå with good transport connections for both internal distribution and export. An industrial site of 36000 m<sup>2</sup> was purchased in 1942 from Laxå Iron Works together with some buildings and during the next 43 years the site has been constantly expanded. At the same time ESAB has contributed to the growth of the local community, building a tightly knit relationship between the two factions and involving some 1100 people.

Today the Laxå plant comprises three main production lines. Hand welding concentrating on transformers, rectifiers and semi-automatic welding machines.

Automation which combined with a heavy engineering section, concentrates on standard modular and sophisticated automatic equipment.

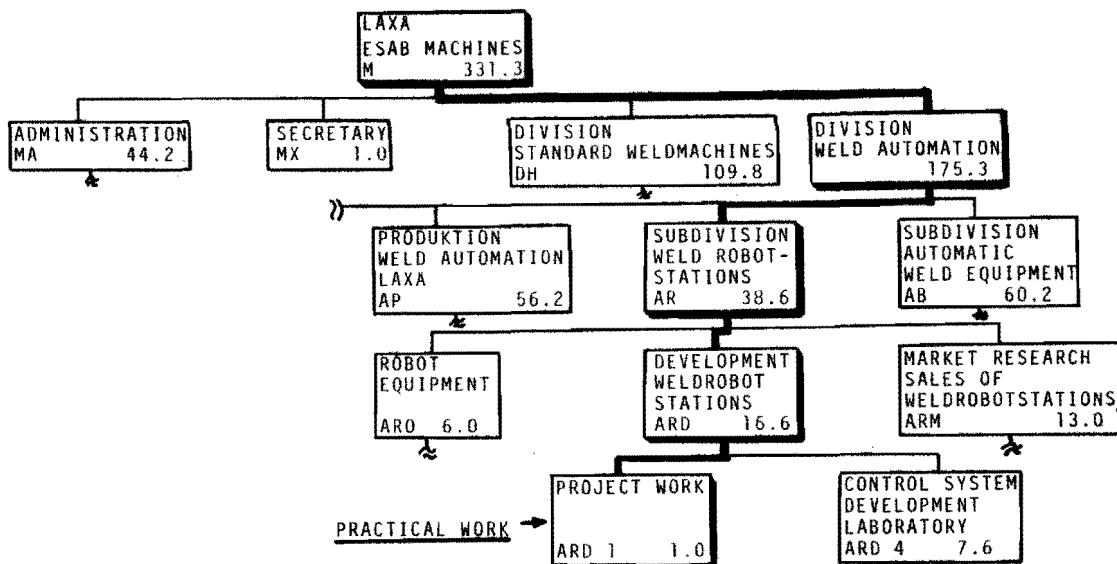
Engineering which manufactures columns and booms, resistance chain welding and other resistance welding equipment, narrow gap welding and high technology. plant.

Finally there is a plant producing welding wires.

Laxå today is also the home of ESAB's International Welding institute and training school.

The practical work is done in the second mentioned department and its organisation diagram is shown in the following picture:

Fig.6. Organisation diagram.



### 3. SYSTEM DESCRIPTION.

#### 3.1 INTRODUCTION.

ESAB Weldguide is a combined joint location and joint tracking system which is completely integrated with the ESAB/ASEA welding robot system.

It can be used to find the starting position of a welded joint and to maintain the arc in the correct position throughout the subsequent weld.

#### 3.2 SYSTEM COMPONENTS.

The ESAB weldguide consists of two distinct units and several interconnection cables and leads. See figure 7.

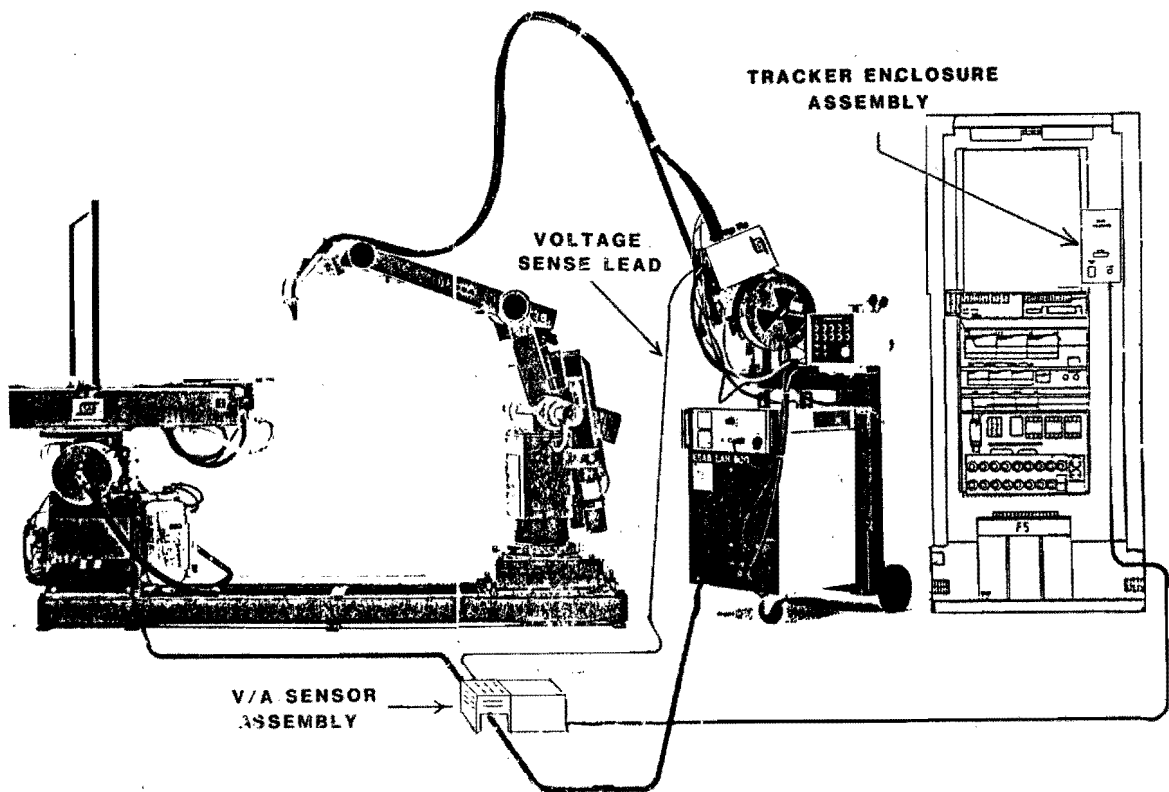


Fig.7.ESAB Weldguide jointtracking system.

#### A.Tracker enclosure assembly.

The tracker enclosure assembly which is normally mounted inside the IRB 6/2 control cabinet, houses the dual channel processor. The dual channel processor processes welding arc signals supplied to it by the V/A sensor assembly. The dual channel processor outputs correction vectors to the IRB 6/2 control electronics based upon the results of the processed signals.

The tracker enclosure assembly has several cables connected to it. See figure

One cable provides 230 volts A.C. power. A ribbon cable provides for 16 digital inputs and digital outputs from an IRB 6/2 DSDX110 module. A third cable provides a digital output to a second DSDX110 module for program interrupts.

A forth cable provides for a digital input from the teach pendant safety pad. This signal is used to inhibit the tracker during parameter overrides.

A fifth cable is used to connect the dual channel processor to the V/A sensor assembly.

Eventually a printer or visual display unit (VDU) can be connected to the RS-232 output port.

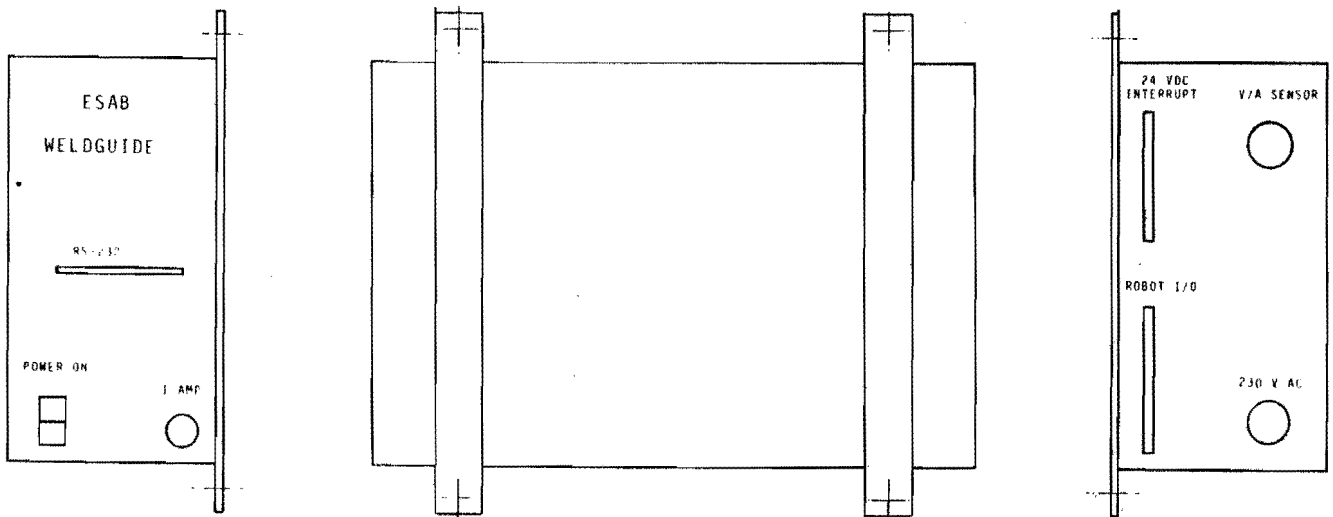


Fig. 8. Tracker enclosure assembly.

B. The V/A sensor assembly.

The V/A sensor assembly is used to isolate the welding voltage and amperage signals from the electronics inside the IRB 6/2 control cabinet. The V/A sensor assembly is connected to the tracker enclosure assembly by means of the V/A sensor cable and the V/A sensor bulkhead cord.

Two welding leads are used to splice the V/A sensor's 500 Amp shunt into the work leg of the welding current circuit.

A third voltage sensing lead is used to measure the welding arc voltage at a point close to welding torch contact tip.

A fourth optional lead is used to measure the welding arc voltage at a point close to the point at which the welding arc impinges upon the workpiece. If this lead is not used, the welding arc voltage is referenced to the shunt potential via a jumper on the V/A sensor assembly strip. The shunt must be spliced into the work side of the welding current circuit to operate in this manner.

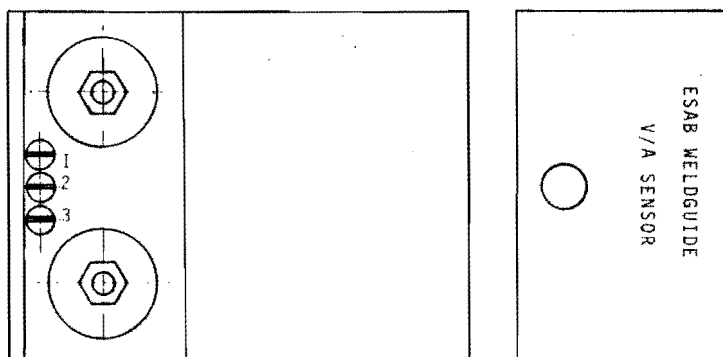


Fig. 9. V/A sensor assembly.

### 3.3 JOINT TRACKING AND JOINT LOCATION.

The joint location facility employs a search voltage which is applied to the gas nozzle of the welding gun in order to locate starting, stopping and intermediate positions along the weld run. Contact between the gas nozzle and the workpiece short-circuits the voltage interrupting the robot's search motion and storing details of the position in the robot's memory.

The joint tracking facility works by sensing the arc voltage and current. A superimposed oscillatory or weaving motion, perpendicular to the main direction of the weld motion travel, results in a sine-wave path between the sides of the joint, establishing a picture of the joint profile.

Current and voltage values, read off as the welding head moves from one side of the joint to the other, are passed from the V/A sensor/converter to the process board, which converts them into correction signals. These signals are then converted by the robot's adaptive system into the necessary motion to correct the preprogrammed route, so that the welding gun follows the joint. Corrections are applied both vertically and horizontally.

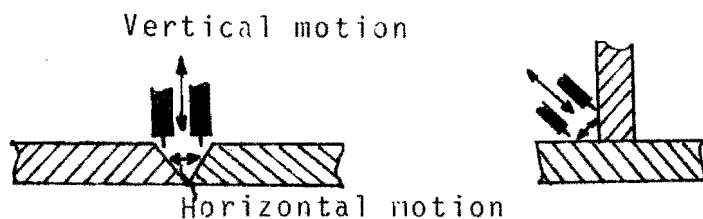


Fig.10.Torch motions.

### 3.4 APPLICATION MODES:

The ESAB Weldguide can be used in four different modes:

#### -Joint location(touch work)

As soon as the switch of the Weldguide is turned on, the system is automatically set to the joint location mode and is always in this mode except when the joint tracking function, output 18 is on.

#### -Height maintenance

In the height maintenance mode, the system maintains constant distance between the welding gun and the workpiece while welding is in progress. Welding current is compared with the preset reference value, and any difference results in a correction of the height of the welding gun above the weld. The reference value is obtained either automatically by the system, by measuring the current at the start of the weld or by an entry programmed by the operator via the robot control unit before welding starts. The height maintenance mode does not require any weaving action.

#### -Transvers position maintenance.

In this mode, the system corrects the robot motion so that the centre line of weaving action remains in the joint. When tracking symmetrical joints, the increase in welding current which occurs as the welding gun approaches the left-hand side of the joint, is compared with the corresponding increase in welding current for the right-hand side of the joint. Any difference between these two values results in a correction signal, which is converted by the adaptive control facility to an appropriate transvers correction motion. When welding asymmetrical joints, the operator can apply a bias value, calibrated directly in amps and either positive or negative in order to offset the asymmetry.

#### -Height and transvers position maintenance.

In this mode, the system maintains a constant welding height and keeps the centre line of the weaving motion in the centre of the joint. It operates as a combination of the height maintenance mode and the transvers position mode, described above.

### 3.5 THE JOINT TRACKING PROCESS.

The main difference between the action of the ESAB Weldguide and ordinary robot welding is to be found in the superimposition of a weaving motion on the linear welding motion, together with the definition of sensors for vertical and transvers position maintenance, with associated correction vectors. Besides the direct sensor definition input data, the Weldguide must also be loaded with data on the required parameters (scale factors, reference values etc.), so that the sensor signals can be applied to, and used with, the particular weld in progress. This is done by programming robot registers with the required values, which are then transferred to the Weldguide before welding.

Weaving must be in operation when the Weldguide starts. The first passes are used to measure the current across the weld traverse, together with the traverse time between the extreme positions of the weave motions.

#### Reference current.

The mean value of the measured current is used as the setpoint value signal for height maintenance, although the operator can also load a preset value from the robot register, which is then used instead of the measured value.

This means that an unstable arc during the initial stages of welding will have no adverse effect on height maintenance performance later on.

#### Weaving time.

The purpose of measuring the weaving time, both from right to left and from left to right, is to provide the system with information on when height measurements and transverse measurements are to be made.

Output 16 goes high when the robot reaches the right-hand weave limit, and is maintained high for about 50 ms, after which the robot starts to move back to the left-hand weave limit, when output 17 will go high. The weave time is therefore the time between one output going low until the output for the opposite side goes high (see diagram). When the system starts to act, the height control current is measured between 30% and 70% of the weave traverse time, and the transverse control current is measured between 80% and 100%.

### Definition of directions.

The following conventions define correct polarity of correction vectors:

- The left-hand weave limit=that side at which output 17 goes high. This output is reset when the robot leaves the side of the joint on its passage towards the opposite side.
- The right-hand weave side=that side where output 16 goes high.

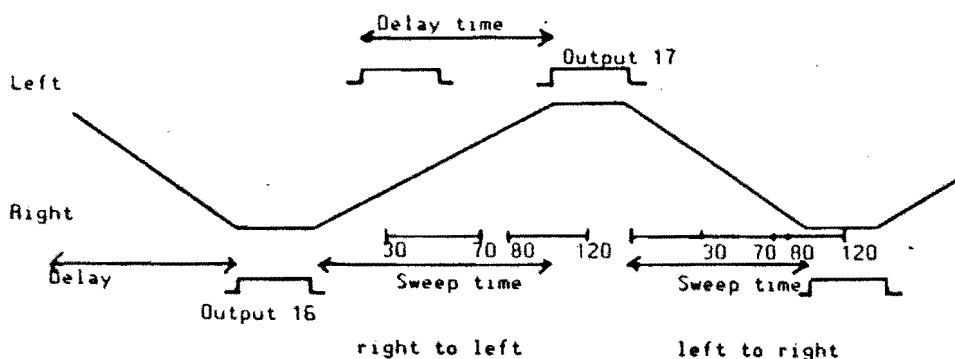


Fig.11. Weaving motion.

Due to the way in which the servo system in the robot operates, there is a slight delay between positioning the robot and execution of the next instruction. This results in the side output channels, 16 and 17, not going high exactly when the robot reaches the sides of the joint, but about 170-210 ms earlier. This time can be varied by downloading data from the robot to the Weldguide.

### Measurement methods.

Current values are processed in different ways, depending on the welding process being used. When pulsed arc welding is in use, current measurements must always start at the beginning of a pulse and always be concluded on completion of a pulse. The base current, which depends on the wire size in use, must also be entered.

When using short-arc welding, the current peaks must be clipped when the arc short-circuits, and this is done when the voltage is less than the "clipping voltage". When the arc again rises above the clipping voltage level, the arc will restrike shortly after, and welding current will flow.

This is known as the "clip hold-off time" and depends on the inductance of the welding power source.  
 All these values are defined in the Weldguide's parameters

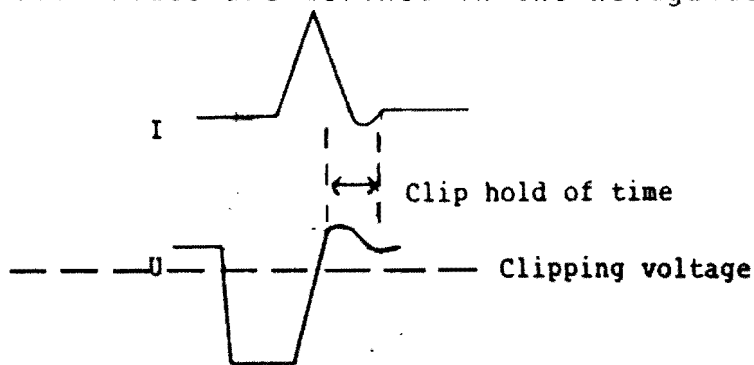


Fig.12. Definition  
 Clip hold of time  
 and clipping  
 voltage.

Measured values are sampled at a frequency of about 8kHz.

### Gain.

When the sweep times are known, the necessary gain factors for both vertical and transvers correction can be calculated, as they are linear functions of the sweep time.  
 If the sweep time is short, current values will be measured more frequently and the robot corrected more often, so that the gain of each correction application should be less.

### Transvers correction.

$$SCORR = (I_l - I_r + 2 \times BIAS - 256) \times SFACTOR$$

where:

- SCORR = transverse correction, expressed in numbers of bits
- $I_l$  = most recently measured current value for the left-hand side.
- $I_r$  = most recently measured current value for the right-hand side
- SFACTOR = transvers correction gain factor = constant x sweep time.  
 Before starting to weld or track the joint, the operator can write over this factor by downloading a suitable value from the robot to the Weldguide.

BIAS, (2 x BIAS - 256):

When tracking joints with symmetrical edges, this factor is 0, i.e. the correction depends on the current difference between the left-hand and right-hand sides. The BIAS value is therefore 128, which is the normal value.

If the joint is being tracked with reference to only one side, e.g. the left-hand side, where there is no edge to sense, the estimated difference is then entered by the operator or robot program in the BIAS-value: e.g. if the difference is 12 A, the BIAS value will be 122. If, on the other hand, the reference edge is on the right, with no reference edge on the left, the corresponding BIAS value for a difference of 12 A will be 134.

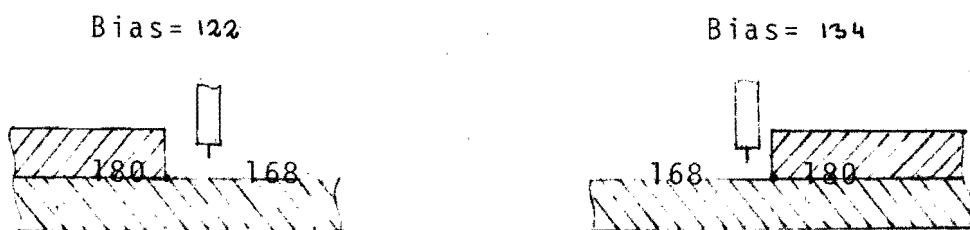


Fig.13.Bias value.

The required BIAS value is entered by downloading a value from the robot into the Weldguide. The easiest way to establish the required BIAS value is to allow the Weldguide to measure it. If the joint is being welded correctly, with joint tracking engaged, but without correction, the BIAS value can be read off in a robot file and/or printed out on a printer.

This value is then used subsequently for joint tracking and correction.

#### Height correction.

$$HCORR = \frac{I_m - I_{ref}}{I_{ref}} \times HFACTOR$$

where:

HCORR = height correction, expressed in number of bits.

$I_m$  = most recently measured current value.

$I_{ref}$  = reference current, either as measured by the system or as entered by the operator.

HFACTOR = height correction gain factor = constant x sweep time, either as measured by the system or as entered by the operator.

When the robot reaches the edge of the joint, the previously measured side current value is compared with the measured value before that, and the most recently measured centre current value is compared with the reference value. The system calculates the necessary SCORR and HCORR correction values, and passes them to the robot's adaptive control system for any necessary correction of robot motion. This process is repeated all the time the weld is being made, and correction is updated after each half cycle.

#### Correction operating time.

The correction operating time is 98 ms, unless the operator changes it via the robot registers. During this time correction is updated twice, on average. Note that the correction operating time can be regarded as a gain factor.

#### Override.

If the operator changes the welding data while a joint is being tracked, it will be necessary temporarily to interrupt tracking, as otherwise the Weldguide will attempt to control the weld on basis of an incorrect reference value.



When the override has been completed and the safety pad on the programming unit is released, a new reference value is measured and joint tracking is resumed.

Printout.

Upon completion of tracking, when the "Tracker On" output has gone low, the Weldguide outputs data from the completed weld. Values of reference current for height maintenance, gain factors for transverse and vertical height maintenance and bias values are printed out, followed by values of all current samples and resulting correction factors. If the operator has entered the reference and bias values, these will be printed out in place of the measured values. Printout is started by touching the space key on the printer or VDU. Subsequent operations of the space key will alternately stop and restart the printer. If the printer does not have a keyboard, printout can be started by a routine from the robot control system. The printer or VDU can be connected via the RS 232 output.

```

AAA  ESAB WELDGUIDE AT YOUR SERVICE  AAA
TORCH TO WORK REFERENCE VALUE WAS  125.0
CROSS SEAM BIAS VALUE WAS  137.0
TORCH TO WORK SENSITIVITY VALUE WAS  035.0
CROSS SEAM SENSITIVITY VALUE WAS  030.0
I TO-W  LE-CS  RT-CS  TW  CS
113.5  109.5  000.0  -06  -09
115.0  000.0  121.5  00  -06
110.0  114.5  000.0  -08  -03
122.0  000.0  109.5  -01  02
112.0  097.5  000.0  -07  -06
115.0  000.0  115.5  00  -09
114.0  109.5  000.0  -06  -03
126.0  000.0  111.5  00  -01
107.0  112.0  000.0  -10  00
123.5  000.0  108.5  -00  01
103.5  108.5  000.0  -12  00
124.0  000.0  112.0  -00  -01
100.0  103.5  000.0  -14  -04
109.5  000.0  113.5  02  -05
111.0  103.0  000.0  -08  -05
114.0  000.0  113.5  05  -05
111.5  106.0  000.0  -07  -03
108.5  000.0  129.0  02  -11
106.5  104.0  000.0  -10  -12
103.5  000.0  124.0  05  -10
101.5  110.0  000.0  -13  -07
124.5  000.0  121.0  -00  -06
112.5  109.5  000.0  -07  -06
132.5  000.0  119.0  04  -04
109.0  106.0  000.0  -09  -06
130.5  000.0  119.5  03  -06
101.0  110.0  000.0  -14  -04
133.5  000.0  129.0  05  -09
109.0  107.0  000.0  -09  -11
127.5  090.0  116.5  01  -04
109.0  116.5  000.0  -09  00
131.5  000.0  117.0  03  -00
115.5  107.5  000.0  -05  -04
114.0  000.0  122.0  05  -07
112.5  115.0  000.0  -07  -03
129.0  000.0  121.0  02  -03
110.5  106.5  000.0  -08  -07
137.5  000.0  122.0  07  -12
108.0  115.0  000.0  -10  -08
125.0  000.0  118.0  00  -01
121.0  116.5  000.0  -02  -00
127.0  090.0  115.0  01  00
108.0  113.5  000.0  -10  -00
139.5  000.0  122.0  08  -04
119.0  105.0  000.0  -03  -08
129.0  000.0  131.0  02  -13
103.0  117.5  000.0  -13  -06
125.5  060.0  116.0  00  00
126.5  118.5  000.0  00  01
132.0  000.0  121.0  04  -01
112.0  120.0  000.0  -07  -00
130.5  000.0  122.5  03  -01
111.5  118.0  000.0  -07  -02
134.0  000.0  132.0  05  -07
114.0  111.0  000.0  -06  -10
133.0  000.0  132.0  04  -10
111.0  119.5  000.0  -08  -06
126.5  000.0  114.5  00  02

```

ANOTHER GOOD WELD BY ESAB WELDGUIDE

Fig. 14. Printout.

### 3.6 JOINT TRACKING PARAMETERS.

Weldguide is controlled by a number of parameters, which must have clearly defined values before the joint tracking starts. These values are downloaded from the robot into the Weldguide system. Values for sweeptime and reference current can be based on measurements. If any parameter values are missing, they will be assigned default values on power-up.

The parameters are stored in an eight-bit register (0-255), which means that two registers, for high and low bytes, are required for some of them.

Parameter number	Default value	Description
1	0	<p>Welding process: Raw data from the welding process is processed differently, depending on the type of welding process:</p> <p>For pulsed arc welding: measurements must be synchronised with the pulses. For short-arc welding: measured values must be clipped when the arc short-circuits.</p> <p>Values are: 0=MIG/MAG DC, non-pulsed spray arc. 1=MIG/MAG AC and DC, pulsed spray arc. 2=TIG DC, non pulsed arc. 3=TIG AC/DC, pulsed arc 4=CO<sub>2</sub></p>
2	0	<p>Dead band for height maintenance correction. If the difference between the measured value and the reference value is less than the specified dead band value, no correction will be applied. Scale range is 0-255 Amps.</p>
3	--	<p>Height correction gain factor. If the operator does not enter a value, the Weldguide will calculate a value based on, and linearly related to, the sweep time (See HFACTOR page 14). Range is 0-255.</p>
4	128	<p>BIAS-value for transverse tracking. 0-127 applied to the right-hand side of weaving. 128 no bias: symmetrical weld. 129-255 applied to the left-hand side of weaving. Units 0.5 A. See definition of direction.</p>
5	0	<p>Deadband for transvers correction. If the difference between measured values of current for the two sides is less than the specified deadband value, no correction will be applied. Scale range 0-255 Amps.</p>

Parameter number	Default value	Description
6	--	Transvers correction gain factor. If the operator does not enter a value, the Weldguide will calculate a value based on, and linear factor of the sweep time. See SFACTOR page 13 . Range 0-255
7	30	Sampling start, height measurement. Expressed in % of the sweeptime.
8	70	Sampling stop, height measurement. Expressed in % of the sweeptime.
9	80	Sampling start, transverse measurement. Expressed in % of the sweep-time.
10	120	Sampling stop, transverse measurement. Expressed in % of the sweeptime.
11	3	Joint tracking mode: 0=undefined 1=height maintenance only 2=transverse maintenance only 3=height and transverse position maintenance.
12	100	Clipping voltage for arc short-circuiting in 0.1 V steps.
13,14	400	Clip hold off time. See definition. Units are $\mu$ s. Parameter 13=high byte, parameter 14=low byte, where clip hold of time=param.13 x 256 + parameter 14.
15,16	--	Reference current for height maintenance. Units are ampères. Parameter 15=high byte, param.16=low byte. Ref.current=Par.15 x 256+Par.16.
17,18	170	Delay time between joint side output going high and robot reaching the side of the joint. Units are ms.
19	98	Operating time for robot correction in height and transverse directions. Correction is updated every 50 ms.
20	--	When using pulsed arc welding, the base current must be defined. The appropriate base depends on the size of filler wire being used as follows: 0.80 mm- 80 A base current=0 1.00 mm- 110 A base current=1 1.20 mm- 210 A base current=2 1.40 mm- 235 A base current=3 1.60 mm- 255 A base current=4

Parameter number	Default value	Description
21,22	--	Sweep time for weaving from right to left. These parameters should naturally not be assigned any values. Sweep time=(Par.21 x 256 + Par.22)/12.288 ms.
23,24	--	Sweep time from left to right. See 21,22.
25	0	Baud rate for data transfer to printer. 0 300 bit/s 1 1200 bit/s 2 9600 bit/s
26	-	On conclusion of a weld, data from the weld can be printed out on the terminal or printer: -by touching the spacer key, or -by setting parameter 26=1
27	250	When the Weldguide is operating only in height regulation mode, and weaving is not required, the sampling time can be varied using parameter 27 over a range of 0-255 ms.

### Loading of parameters.

The weldguide parameters must have properly defined values before tracking starts. It is only printer start-up which is carried out after conclusion of welding. Parameter definition in the joint tracking program is affected by assigning two of the robot registers to the parameter values. The first register is loaded with the Weldguide parameter number and the second with the parameter value. A subprogram then transfers this data from the robot to the Weldguide. Some parameters require two sets of values to be transferred: these are loaded and transferred separately.

Example:

Clipping voltage for short-arc welding is to be set at 9.5 V. The robot welding program for this is as follows:

```

10 ROBREG R1=12           Clipping voltage=parameter 12
20 ROBREG R2=95          Clipping voltage in 0.1 volt steps
30 CALL PROG 10          Transfer to the Weldguide

```

The reference value for height maintenance is to be 300 A

$$300 = 256 \times \text{parameter 13} + \text{parameter 14}$$

So parameter 13=1 and parameter 14=44

The robot welding program is then as follows:

```

10 ROBREG R1=13
20 ROBREG R2=1
30 CALL PROG 10
40 ROBREG R1=14
50 ROBREG R2=44
60 CALL PROG 10

```

If no value is assigned to a parameter, then it will be given the default value. All parameters retain the values that they have been assigned until the power is turned off, or until they are reset by pulsing output 20. Parameters then, and also after the power has been turned off and then again turned on, revert to their default values. The loading program, program 10, is described on page 21 under "PROGRAMMING".

### Reading of parameter values.

When joint tracking is concluded, a printout shows the parameter data. However, the operator can also obtain information on parameter values by manually loading the parameter number into a robot register, executing a sub-program and then addressing another register, in which the value of the parameter is now loaded. For example the following sequence should be carried out in order to check the sweep time between the left-hand and right-hand sides of the joint:

```
Manual :SET ROBREG R1=21
Execute:PROG 11
Manual :READ ROBREG R2           (=parameter 21)
Manual :SET ROBREG R1=22
Execute:PROG 11
Manual :READ ROBREG R2           (=parameter 22)
```

The sweep time is given by  $(\text{Param. 21} \times 256 + \text{Param. 22}) / 12.288$  ms. The factor 12.288 is a function of the clock frequency in the Weldguide computer. Program 11 is described on page 21 under "PROGRAMMING".

### Communication between the robot and the Weldguide.

Inputs 15-30 and outputs 16-31 are reserved for communication the robot and Weldguide on an ASEA DSDX 110 board. The ribbon cable from the board is connected directly to the Weldguide.

Data inputs/outputs and port numbers on the I/O board are as follows:  
Inputs 15-22 can be accessed in parallel via port 13.  
Inputs 23-30 can be accessed in parallel via port 14.  
Outputs 16-23 can be read in parallel via port 3.  
Outputs 24-31 can be read in parallel via port 4.

A description of the inputs and outputs is shown on the next page.

Input	Description
15-20	Correction signal for height maintenance. This signal can have any value between -31 and +31, with input 15 being the least significant bit and input 20 being the sign bit.
21	Data valid. This signal goes high when the Weldguide issues correction signals to the robot.
22	Tracking sensor input. This input must be defined in the robot's sensor memory when the Weldguide is being used for joint searching. It goes high when the tip of the welding gun contacts the workpiece, stopping the robot's search motion.
23-28	Correction signal for transverse tracking. This signal can have any value between -31 and +31, with input 23 being the least significant bit and input 28 being the sign bit.
29	Tracker ready. This signal goes high when the system is ready to start tracking.
30	Not used.
Output	Description
16	Output "Right-hand joint side". This output goes high to indicate that the Weldguide is to receive information on current measurement at the right-hand side of the joint. It is associated with the definition of the correction vector. The signal goes high when the robot reaches the side of the joint and, with allowance for delay time, is reset when the robot starts to move towards the left-hand side of the joint.
17	Output "Left-hand joint side". This is defined in a similar manner to output 16.
18	Tracker starts. This output goes high when the arc has struck, and is reset immediately before termination of welding.
19	Toggle bit. Downloading of information from a robot register to the Weldguide is effected by parallel data transfer from outputs 24-31, port 4. When output 19 is high, it indicates to the Weldguide computer that the data to be transferred relates to the parameter number. When output 19 is low, the robot register data to be transmitted contains the parameter value.
20	Automatic reset. If this output is pulsed, with a pulse time of about 0.5 s, the Weldguide system will be reset, so that all Weldguide parameters revert to their default values.

Output	Description
21	Reserved for override interrupt. This output is not present when the signal from the program control safety pad is used instead.
22,23	Not used.
24-31	Robot data bus. Output 24 represents the least significant bit, and output 31 represents the most significant bit. This bus transfers data, with values in the range 0-255, from the robot register. Depending on the value of output 19, the data indicates either the Weldguide parameter number or its value. Data is transferred in parallel mode via port 4.

### Other signals.

If the Weldguide loses the signals while a joint is being tracked, it will generate an interrupt signal to the robot interrupt input. Examples of situations which can generate an interrupt are failure to include data for the outputs indicating the side of the joint in the weaving program or faults in the Weldguide computer timer/clock.

### **3.7 PROGRAMMING**

The joint tracking program using the ESAB Weldguide is essentially similar to any other robot welding program, but with the following additions:

- Programming and transfer of register values to the Weldguide.
- Definition of sensors.
- Definition of correction vectors.

## Transfer of joint tracking parameters.

Robot register R1 contains the parameter numbers and register R2 contains the associated parameter values. This information is transferred over the data bus using the following program, assuming that output 19 has been reset before execution.

Program 10:

```
10 TRANSFER R1 TO PORT 4
20 WAIT 0.1 SEC
30 SET OUTPUT 19
40 WAIT 0.1 SEC
50 TRANSFER R2 TO PORT 4
60 WAIT 0.1 SEC
70 RESET OUTPUT 19
```

Register 1 is transferred via the data bus.

The contents of the data bus are interpreted as a parameter number.

Register 2 is transferred via the data bus.

The contents of the data bus are interpreted as a parameter value by the Weldguide.

This program results in loading Weldguide parameter number, as specified in R1, with a value as specified in R2.

## Sensor definition.

The sensors are defined using the MANUAL button and can be arbitrarily assigned any nomenclatures between S1 and S16, although the robot inputs are fixed.

Height maintenance:

```
MAN-TOOL-SENSOR=S1-INPUT=15-NO OF BITS=6-INSTALLED ON ROBOT=YES
SCALE=0.1-MAX=+31-MIN=-31
```

Transverse location:

```
MAN-TOOL-SENSOR=S1-INPUT=23-NO OF BITS=6-INSTALLED ON ROBOT=YES
SCALE=0.1-MAX=+31-MIN=-31
```

## Correction vectors.

When the sensors have been defined, their correction vectors must be determined. This can be done by using the robot to store a start position and a stop position for each sensor, so that its direction of action is defined.



The correction vector is stored in the form of a POS(itioning) instruction with a % speed.

A given speed V% acts as a gain factor on the correction action. The correction is updated at 50 ms intervals in accordance with the formula:

Correction(mm)=scale x V% x correction difference where,

Scale=scale factor from the sensor definition  
Correction=difference in numbers of bits between the measured value and the reference value.  
(=SCORR and HCORR see pages 13 and 14 ).

As each sensor is assigned a capacity of 5 bits + polarity bit, the maximum value is 011111=+31 and the minimum value is 111111=-31 (see sensor definition).

Notwithstanding the effect of the gain factor, correction as above cannot proceed more rapidly than V%. It is only the basic speed which is of account.

The magnitude of the correction action is not only influenced by V% and the scale factor, but also by the correction time, Weldguide parameter 19, and the gainfactors for height and transverse position, Weldguide parameters 3 and 6 respectively, which are either calculated from the sweeptime or entered by the operator.

Although all the above parameters can be influenced by the operator it is recommended that three of them should have a constant value and only one should be modified.

Scale =0.1

V% =40

Correction action time=98 ms default

This will result in all adjustments being effected solely by the gain factors for transverse correction and height.

#### Correction vector for height.

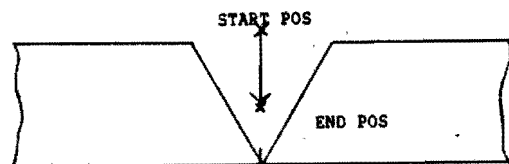


Fig.15.Height correction vector.

- Position the tip of the electrode at START POS.
- Press POS button.
- SCAN-CORRECTION VECTOR SENSOR=1.
- Position the tip of the electrode at END POS.
- Press ENDPOS
- Set V=40%

This results in the instruction: POS V=40% VECTOR S1

This instruction can be tested using the instruction  
INSTR ST-SCAN-CORR.VEC ST.

The robot should then move 50 mm in the defined direction, irrespective of where it is at the time. The defined direction is the negative correction direction.

## Correction vector for transverse positioning.

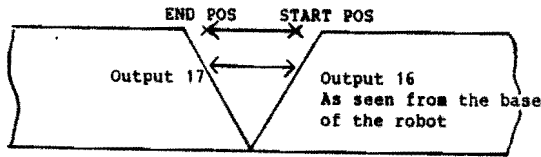


Fig.16. Transverse correction vector.

- Position the tip of the welding electrode to that side of the joint which sets output16 in the weaving program=START POS.
- Press POS button.
- SCAN-CORR:VEC SENSOR =2
- Position the tip of the electrode at ENDPOS.
- Press ENDPOS.
- Set V=40%
- Instruction: POS V=40% VECTOR S2

Note that weaving and this correction vector must be parallel.

This instruction can be tested as described before.

## Weaving program.

In order to make the arc move between the sides of the joint while the welding head moves forward, the weaving program must be superimposed perpendiculary to the linear motion. The resulting motion will be sinusoidal in real terms.

Weaving program:

```
10 POS V1%                               Right-hand position.
20 SET OUTPUT 16
30 WAIT X1 ms
40 RESET OUTPUT 16
50 POS V2%                               Left-hand position.
60 SET OUTPUT 17
70 WAIT X2 ms
80 RESET OUTPUT 17
90 RETURN
```

Weaving can be programmed irrespective of the position of the welding motion. Right and left positions can be reversed as the outputs are also changed. In order to ensure that the Weldguide starts correctly, the starting point of the linear motion should be at one side of the joint, as this position coincides with instruction 10 in the weaving program. Speeds V1 and V2, defined in % of the basic speed, and the waiting times X1 and X2 can be varied as required.

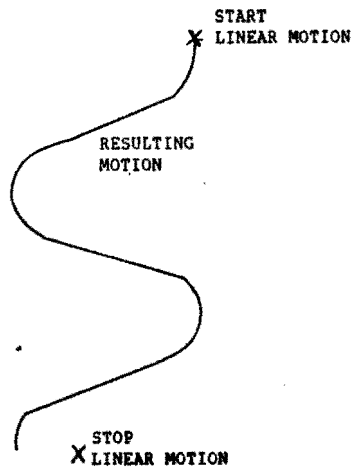


Fig.16. Resulting torch motion.

Increasing the weaving speed decreases the amplitude.

Main program.

The main program links together transfer of the Weldguide parameters, definition of the correction vectors, the welding data program with ordinary positioning instructions and the joint tracking function, on which the weaving motion is superimposed. The following program structure is used:

1. Selection of TCP, basic speed and coordinate system.
2. Automatic reset of Weldguide, followed by parameter loading.
3. Positioning to the starting position, possibly with joint location.
4. Selection of the basic speed for weaving and correction vectors, possibly with change of the coordinate system. Rectangular coordinates must be used.
5. Definition of correction vectors.
6. Welding speed data.
7. Start of Weldguide.
8. Joint tracking with superimposed weaving.
9. Stop of Weldguide.
10. Welding stop data.
11. Positioning, possibly with new basic speed and coordinate system.
12. Printer routine, if used.

The joint tracking instruction is programmed in the form of:  
 POS V% CONTOUR S1:50,S2:50 WEAVE PROG V=100%, where weave and contour are arguments subordinate to the POS pushbutton.

POS V% indicates the preprogrammed finishing point.  
CONTOUR indicates joint tracking using sensors S1 and S2, the zero point of which(=no correction) is in the centre(=50%) of the working range(-31 to +31).  
WEAVE indicates use of weaving program operating at a speed of 100% of the programmed speed.

Note that both linear speed and weaving speed in the joint tracking instruction follow the basic speed.  
The welding stop position, with its finishing data, must be programmed at the same point as the joint tracking instruction and preceded by a reference point. This ensures that the welding stop position will be adjusted even if the joint tracking procedure has corrected the finishing point.

Program example:

10 V=2500 mm/s, Vmax=2500 mm/s	
20 TCP 1	
30 ROBOT COORDINAT	
40 PULSE OUTPUT 20	Automatic reset
50 R1=3	
60 R2=40	Height gain factor=40 is transferred to the Weldguide
70 CALL PROG 10	
80 R1=6	
90 R2=25	Transverse gain factor=25 is transferred to the Weldguide.
100 CALL PROG 10	
110 R1=15	
120 R2=1	
130 CALL PROG 10	
140 R1=16	Height reference current=340 A is transferred to the Weldguide.
150 R2=84	
160 CALL PROG 10	
170 R1=18	
180 R2=194	Delay time=194 is transferred to the Weldguide.
190 CALL PROG 10	
200 POS V=100%	
210 POS V=100% F	Setting to start position.
220 V=34 mm/s, Vmax=100 mm/s	New basic speed.
230 RECT COORDINAT	
240 POS V=40% VECTOR S1	
250 POS V=40% VECTOR S2	
270 POS V=25% WDATA 1/1	Welding start data. Same pos. as 210
280 SET OUTPUT 18	Start Weldguide
290 POS V=25% CONTOUR S1/50 S2/50 WEAVEPROG 20, V=100%	
300 RESET OUTPUT 18	Stop Weldguide.
310 POS V=100% REFP ON	
320 POS V=25% WEND 1	Welding stop. Same pos. as 290.
330 POS V=100% REFP OFF	
340 POS V=100%	Positioning away from the workpiece
350 R1=26	
360 R2=1	Start of printer routine.
370 CALL PROG 10	
380 WAIT UNTIL INP 99=1	
390 RETURN	

## Reading of parameter values.

On concluding of joint-tracking ,output 18=0,the parameter values that have been used can be read.If register R1 is loaded with the parameter number in the manual mode and program 11 is run,the parameter value can be read off from register 2.Output 19 must be low before execution.

### Program 11:

```
10 TRANSFER R1 TO PORT 4
20 WAIT 0.1 SEC
30 SET OUTPUT 19=1
40 WAIT 0.1 SEC
50 FETCH R2 FROM PORT 13
60 WAIT 0.1 SEC
70 TRANSFER R2 TO PORT 4
80 WAIT 0.1 SEC
90 RESET OUTPUT 19
100 WAIT UNTIL INP 99=1
110 RETURN
```

Reg 1 is transferred via the data bus.  
The bus contents are interpreted as the parameter number by the Weldguide.  
The contents of the parameter are transferred to R2 via port 13.  
Rewrite the contents so that the param. is set to its correct value before the toggle bit,output 19,goes high.

#### 4. INSTALLATION.

##### 4.1 MOUNTING THE TRACKER ENCLOSURE ASSEMBLY IN THE ASEA IRB 6/2 CONTROL CABINET.

Caution: Before attempting to install the Weldguide, disconnect the mainpower from the robot control cabinet. Use care to prevent metal drilling chips from falling into the control components. Vacuum all loose chips out of the cabinet base before reactivating the unit.

The tracker enclosure assembly should be mounted in the IRB 6/2 control cabinet as shown in figure 18

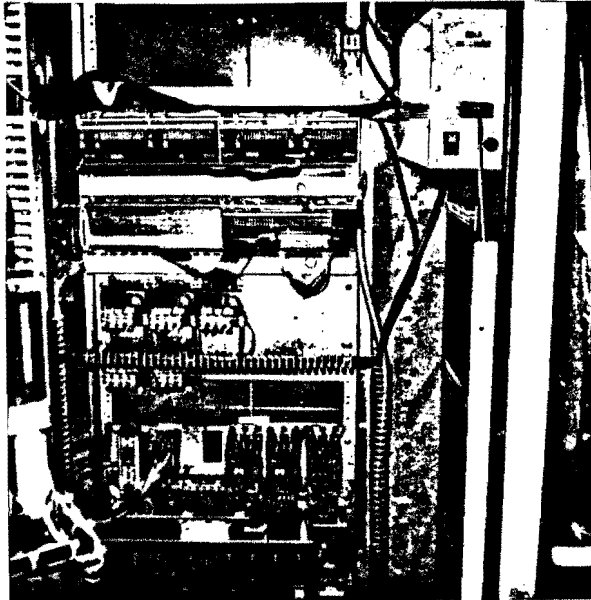


Fig.18. Tracker enclosure shown mounted in IRB 6/2 control cabinet.

Holes for self-tapping sheet metal screws should be drilled in the steel inner liner per the pattern shown in figure 19 below. Approximately 6 mm (1/4") dia sheet metal screws should be used.

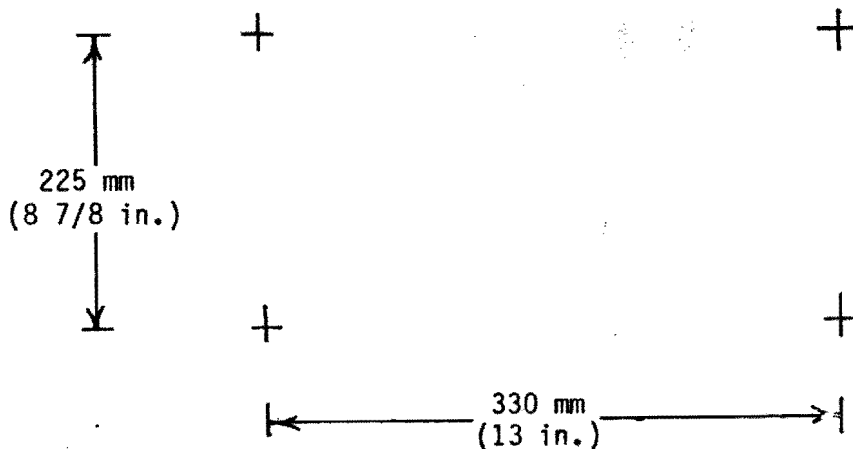


Fig.19. Hole pattern for mounting the tracker enclosure assembly.

#### 4.2 MOUNTING THE DSDX110 I/O MODULES IN THE IRB 6/2 CONTROL CABINET.

Caution: Before attempting to add the first and the second optional DSDX 110 digital I/O modules, disconnect the main power from the robot control cabinet.

Normally the IRB 6/2 control unit will be shipped with the first and second optional DSDX110 digital I/O units installed. If the units are not installed follow these installation instructions and refer to the ASEA IRB 6/2 installation manual.

The first optional DSDX110 module should be installed in rack D14 in the slot for I/O 165. See figure  
The second optional DSDX 110 module should be installed in rack D14 in the slot for I/O 169.

The dstd 160 terminal units should be mounted on the rear wall of the control cabinet above terminal unit D14.153x90.  
24 Volt D.C. power should be connected to the terminal units as illustrated in figure 6.6a of the ASEA installation manual.

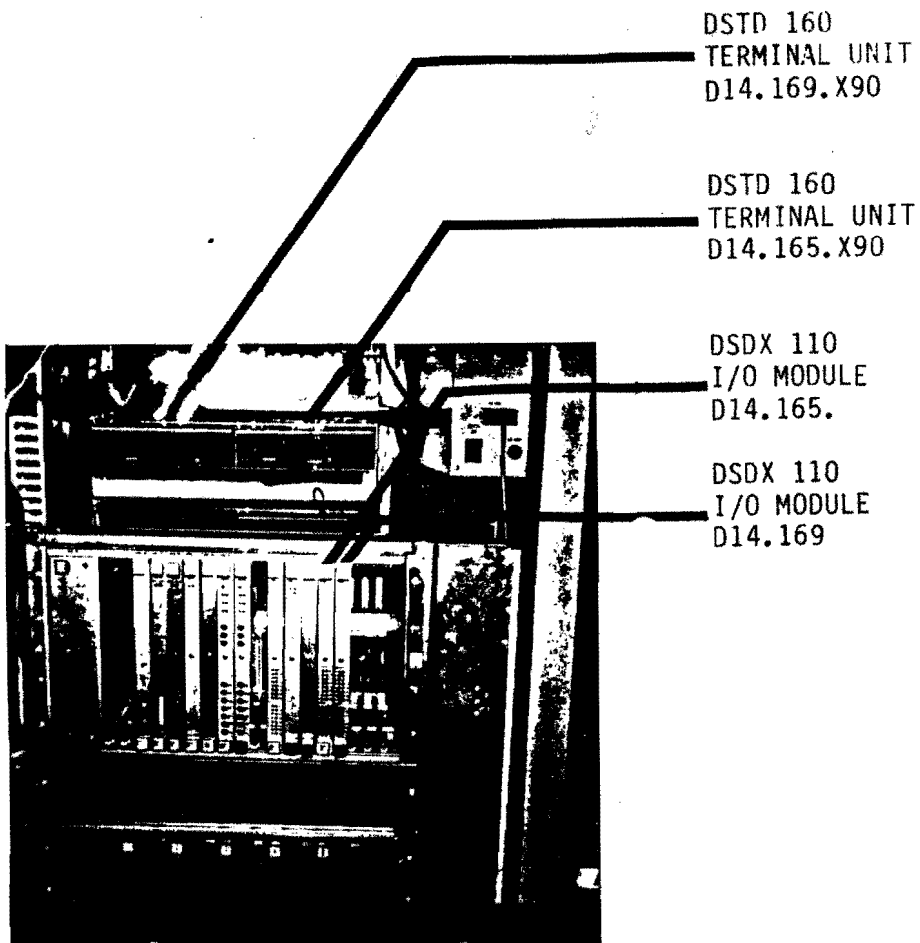


Fig.20. Location of the DSDX 110 I/O modules and DSTD 160 Terminal units.

### 4.3 TRACKER ENCLOSURE ASSEMBLY CONNECTIONS.

Caution: Before attempting to make any of the following connections, disconnect the main power from the control cabinet.

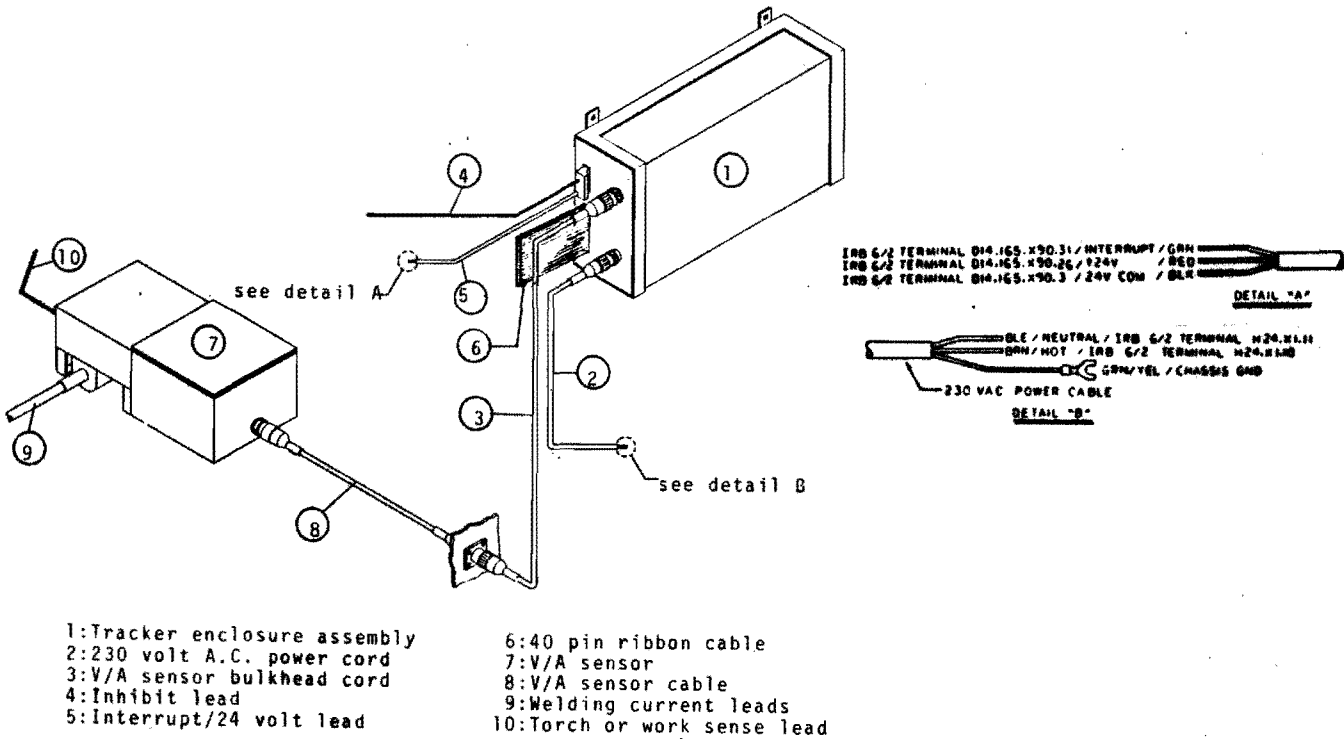


Fig.21.ESAB Weldguide.

#### A.230 Volt A.C. power cord.

The ESAB Weldguide has been furnished with a 230 volt A.C. power cord. One end of the cord is equipped with a connector which plugs into the back of the dual channel processor enclosure.

The other end should be connected to terminal strip H24.X1 as follows:

- brown insulated lead (230 volt "hot" ):H24.X1.10
- blue insulated lead (230 volt neutral ):H24.X1.11
- green insulated lead(protective earth ground):  
screw on back plane of H24.

#### B.V/A sensor bulkhead cord.

The ESAB weldguide has been furnished with a 1.6 meter length of 3 twisted shielded pair 22 gauge stranded cable with a free hanging socket connector on one end and a square flange bulkhead mounted pin connector on the other.

The acces panel for the welding power supply control cable should be removed and the Amphenol connector core removed from the shell.This is easily done by removing the snap ring from the inside of the shell.



The shell can then be removed and the hole pattern shown in figure can be machined in the plate.

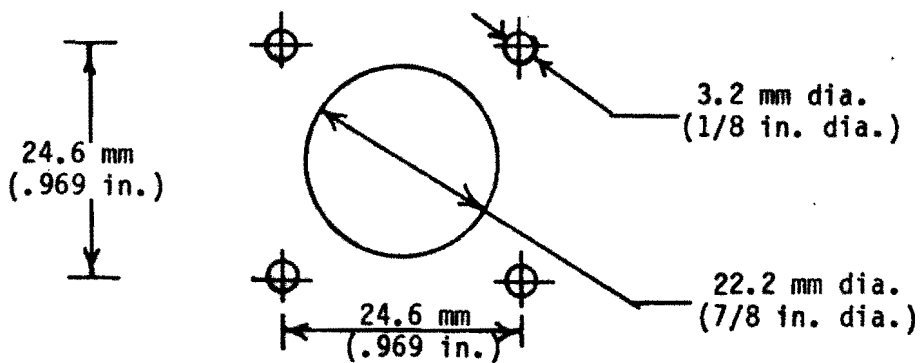


Fig.22.Hole pattern for V/A sensor bulkhead connector.

The bulkhead connector should then be mounted to the inside of the plate and the welding power supply control cable connector replaced. The free hanging end of the V/A sensor bulkhead cable should be plugged into the back of the tracker enclosure assembly.

#### C. Interrupt/24 volt/inhibit connector.

The IRB 6/2 should be equipped with two additional DSDX110 modules and terminal units.

The DSDX110 digital I/O units are located in rack D14 and the DSTD160 terminal units are located in the back of the control cabinet. The first optional DSDX110 module and DSTD160 terminal unit provide for interrupt instruction and jump program inputs.

The wires from terminals 1, 2 and 3 of P5 on the tracker enclosure assembly should be connected to terminals X90.26, X90.3 and X90.31 of the first optional DSTD160 terminal unit. A jumper should be added from terminal X90.31 to terminal X90.33.

Terminal 6 of plug P5 on the back of the tracker enclosure assembly should be connected to socket D of connector F18.X1 on the programming unit rack.

#### D. 40 pin ribbon cable.

The 40 pin ribbon cable connected to the second optional DSTD160 terminal unit (D14.169X90) connector X80 should be disconnected from connector X80 and plugged into the back of the dual channel processor enclosure.

This completes the installation and interconnections of the dual channel processor unit in the IRB 6/2 control enclosure.

#### 4.4 V/A SENSOR CONNECTIONS.

##### A. V/A sensor cable.

The 9 meter cable with free hanging socket connectors should be used to connect the V/A sensor to the bulkhead connector previously installed on the robot control cabinet access plate.

Plug one end of the cable into the bulkhead connector on the IRB 6/2 control enclosure and the other end into the bulkhead connector on the V/A sensor enclosure.

##### B. Welding current leads.

The welding current lead from the welding power supply to the workpiece should be broken at some convenient location.

Lugs should be attached to the new cable ends. The lugs must be capable of fitting over a 13 mm (1/2") diameter stud.

The protective rubber boots furnished with the Weldguide should be slipped over the cable ends before attaching the cables to the studs. The studs are labeled "To work" and "To power source".

##### C. Torch sense lead.

A single 22 gauge stranded insulated conductor should be attached to terminal 1 of the V/A sensor terminal strip, located between the welding current lead studs.

The other end of the conductor should be connected to the welding current supply cable as close as feasible to the welding torch contact tip. In most cases, this will be the point at which the torch umbilical leaves the wirefeed unit.

##### D. Work sense lead.

This lead is only necessary if long welding cables are used or high resistances are introduced in the weld current path, for example a rotating connection. The jumper supplied with the V/A sensor connects the work sense terminal to the shunt. If one of the exceptional conditions mentioned above exists, the jumper should be removed and a single 22 gauge stranded insulated conductor should be connected to terminal 3.

The other end of the lead should be connected to the workpiece fixture as close as possible to the point of welding arc impingement on the workpiece.

The polarity switch on the V/A sensor assembly should be set to the appropriate position for the welding process in use.

DCRP is for electrode positive, DSCP is for electrode negative and AC is for AC welding processes, such as TIG.

Open circuit welding voltage should be applied to the work and torch. If the circuit breaker trips, either the switch has been set to the opposite polarity from the one in use, or a connection error has been made.

Push in the white button to reset the circuit breaker after remedying the problem.

#### 4.5 TESTING INTERCONNECTIONS.

To test the interconnections, turn off the welding power supply and turn on the robot and Weldguide. Observe the I/O lights on the second optional DSDX110 unit while making and breaking contact between the electrode and workpiece. Input light number 8 should light whenever the electrode touches the plate. This indicates the touch work feature is operating. This feature is disabled when the polarity switch is in the A.C. mode.

#### 4.6 RECONFIGURING THE IRB 6/2 PARAMETER TABLES TO INCLUDE THE

Refer to section 10 of the IRB 6/2 Installation manual to supplement the following instructions:

After completing the Weldguide installation and electrical interconnections between the Weldguide and ASEA IRB 6/2 robot control, switch on the robot control power and select standby mode. Load in the parameters from Eprom or Disc per section 10.2 of the ASEA installation manual. Use the instruction: MANUAL-SCAN-PARAM-CHANGE to call up the parameters table for amending. Call up the successive parameters listed in table 10-1 of the IRB 6/2 installation manual until "I/O TYPE" is displayed. In response to "I/O 165" enter "1". In response to "I/O 169" enter also 1. Enter a "CLEAR" for "I/O 173" and "I/O 177". Finish scanning through the remaining functions until the IRB 6/2 returns to STANDBY.

This completes the reconfiguration of the IRB 6/2 control system to incorporate the first and second optional DSDX110 digital I/O modules.

#### 4.7 DEFINING SENSORS 1, 2 AND 3.

Refer to section 10-3 of the IRB 6/2 installation manual to supplement the instructions provided in this section. Sensor 1 is the touch work sensor, sensor 2 is the torch-to-work sensor and sensor 3 is the cross-seam sensor. To access the sensor table use the MANUAL-SCAN-TOOL-SENSOR instruction. Enter the following information in response to the robot prompts:

SENSOR:	1
NUMBER OF BITS:	1
INPUT:	22
MOUNTED ON ROBOT:	YES
SCALE:	1
MORE SENSORS:	YES
SENSOR NUMBER:	2
NUMBER OF BITS:	6
INPUT:	15 (LSB of TW Sensor)
MOUNTED ON ROBOT:	YES
SCALE:	0.1
MINIMUM VALUE:	-31
MAXIMUM VALUE:	31
MORE SENSORS:	YES
SENSOR NUMBER:	3
NUMBER OF BITS:	6
INPUT:	23 (LSB of I.S Sensor)
MOUNTED ON ROBOT:	YES
SCALE:	0.1
MINIMUM VALUE:	-31
MAXIMUM VALUE:	31
MORE SENSORS:	NO

This completes the definition of sensors 1,2 and 3.

#### 4.8 SAVING MODIFIED PARAMETER TABLES AND SENSOR DEFINITIONS.

After completing the reconfiguration of the robot parameters and definition of the sensors, it is recommended that the robot parameters be saved on disc.

Refer to section 10.2 of the IRB 6/2 installation manual to supplement the following instructions:

Place a formatted disc in the disc drive. With the robot in STANDBY, push the "MANUAL" button, "SCAN" key, "PARAM" key, and "TO DISC" key.

The reconfigured tables and sensor definitions are now saved.

This completes the installation of the ESAB Weldguide in the ASEA IRB 6/2 Robot.

## 5. TEST PROCEDURES:

The following procedure is recommended for diagnosing problems with the ESAB Weldguide system.

### 5.1 TRACKER ENCLOSURE ASSAMBLY

#### 5.1.1. Power convertor test.

Check that the +5,+15 and -15 voltages are present on the proper pins of power connector plug J7, before attaching J7 to P.C. board connector P7. See figure 9 below.

If the voltages are present on the proper pins, attach J7 to P7. If the voltage varies by more than 1.5% from the desired value, adjust the power supply output by removing the enclosure front plate and adjusting the power supply trim spots. If the power convertor is defective replace the unit.

The +5 VOLTS OK LED on the P.C. board should be illuminated when the power is on. See figure 10.

Typical milliamperage requirements are as follows:

+5 volts	380 ma	in touch-work mode.
	700 ma	in test mode all lamps on.
+15 volts	40 ma	W/O V/A sensor unit.
	140 ma	W V/A sensor unit.
	240 ma	W V/A sensor and touch work.
-15 Volts	60 ma	

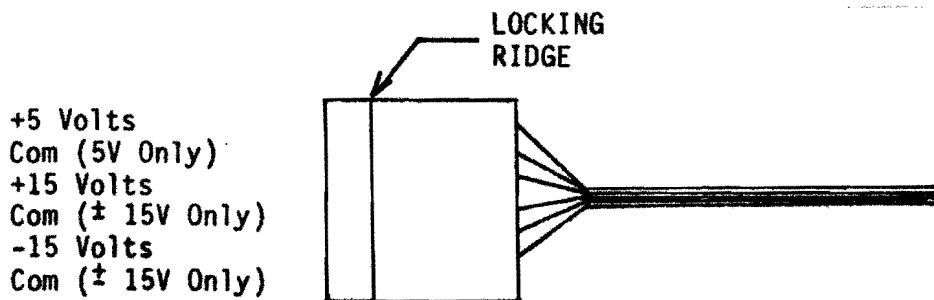


Fig.23. Power connector plug J7.

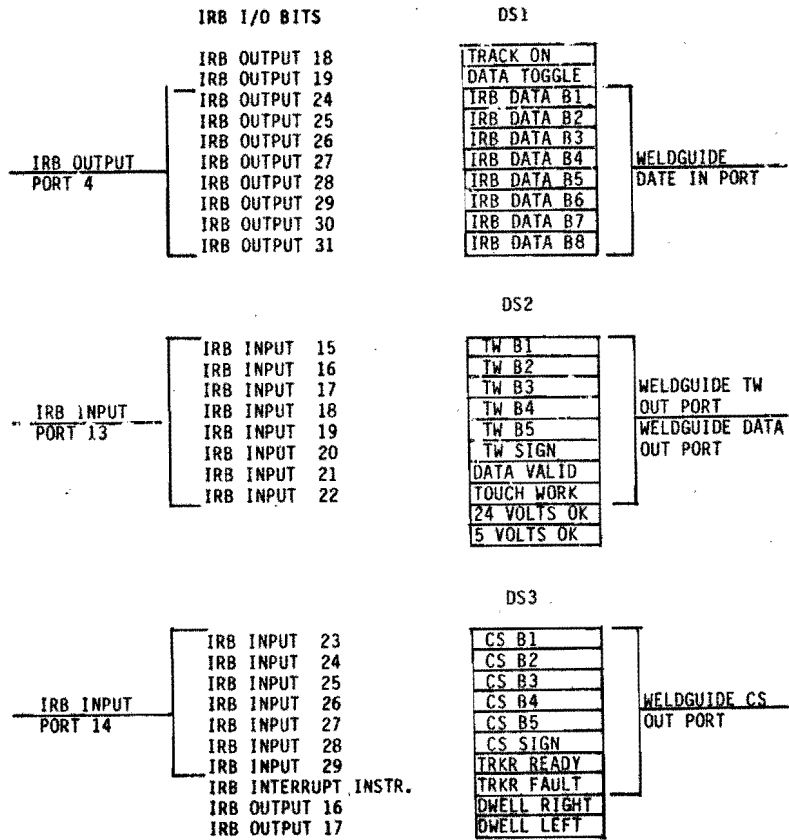


Fig.24.Tracker enclosure assembly P.C.board LED assignments.

### 5.1.2 24 Volt supply test.

Connect a source of 24 volts D.C.(250 ma minimum) to the pins on terminal connector P5.The 24 VOLTS OK LED on the P.C. board should be illuminated when power is on.See figure 10. The 1 amp fuse F1 is designed to prevent damage to the IRB control and dual channel processor board in the case of accidental polarity reversal.

### 5.2 SELF DIAGNOSTIC TESTS.

The self diagnostic tests can be carried out with the ESAB Weldguide mounted in the IRB control enclosure,or on a bench. If the unit is to be bench tested,a source of 24 volt D.C. power must be provided for the LEDs. To perform the tests,use a DIP switch or jumper wires in P.C. board switch socket S2 to jump from pin 1 to pin 16 or pin 2 to pin 15 or pin 3 to pin 14 etc.See figure 11. After setting the appropriate switch or installing the appropriate jumper,each test is initiated by resetting the Weldguide.

The Weldguide can be reset by turning it off and on again, or by pushing the reset button on the P.C. board. Before proceeding with the following tests make sure jumpers E1 and E4 have been installed and jumpers E2, E3 and E5 omitted.

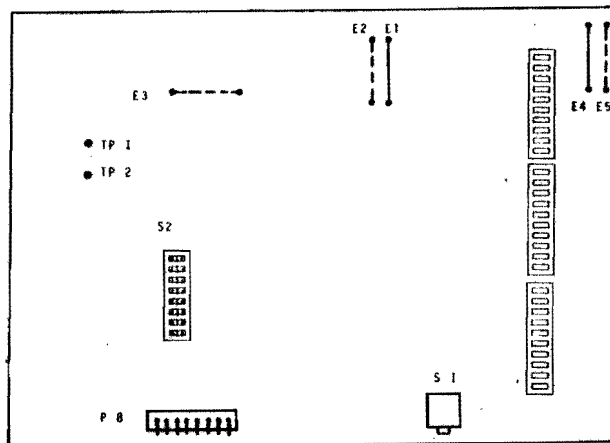


Fig.25.P.C.board.

### 5.2.1 Output test.

The output test sequences through the 16 Weldguide outputs. The test is useful for checking the output latches on the P.C. board, and for checking the digital inputs on the DSDX110 board in the IRB control rack.

To initiate the test, close switch 1 of S2 or jumper S2 pin 1 to S2 pin 16 and reset the weldguide. The touch-work output will be asserted for slightly less than 1 second, followed by the data-valid output, T/W sign bit, etc.

These output bits correspond to IRB input bits 22, 21, 20 etc. See figure 10.

The test routine will continue asserting each output sequentially. Upon reaching IRB input bit 15, the tracker fault output will be asserted, then the tracker ready output, C/S sign bit, etc. These output bits correspond to IRB input bits 29, 28, 27 etc. The test routine will continue asserting each output sequentially. Upon reaching IRB input 23, the test will repeat. Approximately 14.4 seconds are required to sequence through the 16 bits.

### 5.2.2. Input test.

The input test reflects each input bit to a Weldguide output bit and generates a sawtooth wave form at TP2.

Since there are 14 input bits to the Weldguide and 16 output bits, two output bits are always asserted: TOUCH-WORK and DATA VALID. The inputs and corresponding outputs are given in table 1.

The test is useful for testing the Weldguide input latches and for testing the IRB DSDX110 module output bits.

To initiate the test, close only switch 2 of S2 or jumper only S2 pin 2 to S2 pin 15 and reset the Weldguide.

For each IRB output listed in table 1 the corresponding Weldguide input should be asserted and the appropriate Weldguide LED should illuminate.

To test the linearity of the DAC output, connect an oscilloscope to TP1(common) and TP2(signal).

The waveform ramps from 0 to 2.55 volts in approximately 8.4 milliseconds. The waveform should be a straight ramp. Curvature in the ramp indicates non-linear DAC output.

<u>IRB OUTPUT BIT</u>	<u>WELDGUIDE INPUT</u>	<u>IRB INPUT BIT</u>	<u>WELDGUIDE OUTPUT</u>
16	RIGHT DWELL	15	TW BIT 1
17	LEFT DWELL	16	TW BIT 2
18	TRACK ON	17	TW BIT 3
19	DATA TOGGLE	18	TW BIT 4
20	RESET	19	TW BIT 5
21	INHIBIT (FROM PAD)	20	TW SIGN
22	NO CONNECTION	21	DATA VALID
23	NO CONNECTION	22	TOUCH WORK
24	IRB DATA OUT	23	CS BIT 1
25	IRB DATA OUT	24	CS BIT 2
26	IRB DATA OUT	25	CS BIT 3
27	IRB DATA OUT	26	CS BIT 4
28	IRB DATA OUT	27	CS BIT 5
29	IRB DATA OUT	28	CS SIGN
30	IRB DATA OUT	29	TRKR READY
31	IRB DATA OUT	INTERRUPT	TRKR FAULT

Fig.26.ESAB Weldguide inputs and outputs.

### 5.2.3. Voltage A to D test.

The voltage A to D test is used to test the voltage analog to digital converter and associated analog circuitry(active filter, sample and hold).

A source of 0 to 10 volts D.C. is needed to simulate the voltage output of the V/A sensor unit. A digital voltmeter can be used to monitor the DAC output test point, TP1 and TP2, which echoes the input voltage.

To initiate the test, set only switch 3 of S2 or short only S2 pin 3 to S2 pin 14. Then reset the Weldguide.



Disconnect the V/A sensor cable from the Weldguide. Apply 0 volts D.C. to P8 pin 3 (high) and P8 pin 4 (low). Slowly increase the voltage from 0 to 10.24 volts. The LED's should display the binary value of the input voltage. Table 2 lists the Weldguide output bits and their binary weight. Note the sign bit is never set regardless of the sign of the input voltage. This is because the Weldguide software converts the input to its absolute value.

The DAC output, TP2 high and TP1 low, should rise from 0 to 2.55 volts 8 times. This is because the DAC outputs 8 bits while the analog to digital converter inputs 11 bits plus a sign. It is important to ground P8 pin 3 to +15 volt common, P8 pin 2. If this is not done, the output will be very noisy.

If it is desired to output only the most significant 8 bits of the conversion, set both switch 8 and 3 of S2 or jumper S2 pin 3 to S2 pin 14, and S2 pin 8 to S2 pin 9. Then reset the Weldguide.

<u>A TO D INPUT BIT</u>	<u>WELDGUIDE OUTPUT BIT</u>
1 LSB	CS BIT 5
2	CS SIGN
3	TRKR READY
4	TRKR FAULT
5	TW BIT 1
6	TW BIT 2
7	TW BIT 3
8	TW BIT 4
9	TW BIT 5
10	TW SIGN
11 MSB	DATA VALID
12 SIGN	TOUCH WORK

Fig.27.ESAB Weldguide output bits and their binary weight when used for self diagnostic tests test 3 and 4.

#### 5.2.4 Amperage A to D test.

The amperage A to D test is used to test the amperage analog to digital converter and associated analog circuitry, (active filter, sample and hold).

A source of 0 to 10.24 volts D.C. is needed to simulate the voltage output of the V/A sensor unit. A digital voltmeter can be used to monitor the DAC output test points, TP1 and TP2, which echoes the input voltage.

To initiate the test, set only switch 4 of S2 or short only S2 pin 4 to S2 pin 13. Then reset the Weldguide.

Be sure to disconnect the V/A sensor unit from the Weldguide before performing the test. Apply 0 volts D.C. to P8 pin 6 (high) and pin 7 (low). Ground pin 7 to 15 volt common, pin 2. Slowly increase the voltage to 10.24 volts and observe the LED's and DAC output. The LED's should display the binary value of the input voltage. The DAC output should rise from 0 to 2.55 volts 8 times.

If only the most significant 8 bits are desired, set switch 8 and switch 4 of S2 and reset the Weldguide.

#### 5.2.5 Timer test.

The timer test is used to test the Motorola 6840 timer. The test loads a value into one of the three counters and allows the counter to run. When the counter times out, a second counter is loaded, when the second counter times out, the first counter is again loaded. The operation of the counters are indicated by alternately turning each bank of 8 output LED's on and off.

To initiate the timer test, turn switch 5 of S2 on or jumper S2 pin 5 to S2 pin 12 and reset the Weldguide.

The lights for the torch-to-work port and cross-seam port should light up alternately at about a 2 Hz rate.

#### 5.2.6 Set Torch-to-work output bits.

This test is used to insure the IRB robot is correctly responding to a simulated torch-to-work correction vector. Each of the 8 bits of the torch-to-work output port can be set using the 8 switches or jumpers of S2.

To initiate the test, set only switch 6 of S2 or jumper only S2 pin 6 to S2 pin 11 and reset the Weldguide.

Once this test has been initiated, any of the 8 switches or jumpers of S2 can be used to set or clear any of the output bits of the torch-to-work output port, including switch 6.

Any switch that is closed sets the corresponding output bit, and any switch that is open clears the corresponding output bit. The TRACKER READY bit in the cross-seam port is always set, so a normal welding program can be run.

All cross-seam output bits will be 0, and the preset torch-to-work output bits will be constantly present.

The following list gives the switch-output assignments for test 6:

Switch S2	Output
1	TW BIT 1
2	TW BIT 2
3	TW BIT 3
4	TW BIT 4
5	TW BIT 5
6	TW SIGN
7	DATA VALID
8	TOUCH WORK

To test proper operation of the IRB contouring instruction, set a positive correction vector pattern on the torch-to-work port. Execute a welding program without welding. The preset torch-to-work correction vector should drive the torch away from the joint as the torch moves.

### 6.2.7 Set Cross-seam output bits.

This test, like the previous test, is used to insure the IRB robot is correctly responding to a simulated cross-seam correction vector. Each of the 8 bits of the cross-seam output port can be set using the 8 switches or jumpers of S2.

To initiate the test, set only switch 7 of S2 or jumper only S2 pin 7 to S2 pin 10 and reset the Weldguide.

Once this test mode has been initiated, any of the 8 switches or jumpers of S2 can be used to set or clear any of the output bits of the cross-seam output port, including switch 7.

Any switch that is closed sets the corresponding output bits, and any switch that is open clears the corresponding output bit.

The data valid bit of the torch-to-work port is always set, so a normal welding program can be run.

All torch-to-work output bits will be 0, and the preset cross-seam output bits will be constantly present. The list below gives the switch-output assignments for test 7:

Switch S2	Output
1	CS BIT 1
2	CS BIT 2
3	CS BIT 3
4	CS BIT 4
5	CS BIT 5
6	CS SIGN
7	TRKR READY
8	TRKR LOST

To test proper operation of the IRB contouring instruction, set a positive correction vector pattern on the cross-seam port. Execute a welding program without welding. The preset cross-seam correction vector should drive the torch to the right as viewed from the robot base as the torch moves.

## 6. WELDGUIDE TESTWELDS.

To obtain good values for the reference current and the gainfactors for height and traverse correction a lot of test-welds have to be made.

These values can then be implemented in the Weldguide's software so suitable parameter values are chosen automatically, depending on the measured values at the weld-start.

A form is designed to collect all weld-data so a Weldguide-Library can be created.







WELDGUIDE					
TEST NUMBER:		DATE:		MATERIAL:	
WIRE SIZE: mm		PLATE THICKNESS: mm		SHIELDING GAS:	
TYPE OF JOINT:		  			
WELDING PROCESS:			POWER SOURCE:		
WELDING POSITION:					
WORKPIECE:			TORCH:		
					
Deviation		Deviation		Deviation	
WELDDATA:					
STARTDATA:		ENDDATA:		MAIN DATA:	
IGNITION VOLTAGE 1		END VOLTAGE 1		VOLTAGE V	
IGNITION CURRENT 1		END CURRENT 1		CURRENT A	
GAS PREFLOW TIME 5		GAS POST FLOW TIME 5		SPEL5 mm/s	
HOT START VOLTAGE 1		BURN BACK TIME 5		-----	
HOT START CURRENT 1		COOLING TIME 5		WIRE SPEED m/min	
HOT START TIME 5		FILL TIME 5		T GROUND ms	
				PULSE TIME ms	
				PULSE VOLTAGE V	
				BASE CURRENT A	
WELDING SPEED MEASURED: mm/s			REFERENCE CURRENT: A		
			o measured o operator		
NUMBER OF OSCILLATIONS/10 mm WELD:			WEAVING AMPLITUDE: mm		
WAIT TIME LEFT SIDE: s			WAIT TIME RIGHT SIDE: s		
TORCH TO WORK SENSITIVITY:			CROSS SEAM SENSITIVITY:		
CROSS SEAM TIME RIGHT TO LEFT: PARAMETER 21+ SWEEP TIME*( x 256 + )/12.288+			PARAMETER 22+ ms		
CROSS SEAM TIME LEFT TO RIGHT: PARAMETER 23+ SWEEP TIME*( x 256 + )/12.288+			PARAMETER 24+ ms		
QUALITY OF TRACKING: 1 2 3 4 5					DELAY TIME ms
REMARKS:					

Fig.28. Form for the Weldguide Library.

The delay time mentioned in this form can be measured as described on page 43

## 7. MEASUREMENT OF THE DELAY TIME

Before using the Weldguide it is recommended to measure the delay time between joint output going high and robot reaching the side of the joint.

This value must be downloaded from the robot to the Weldguide system as parameter number 17 and 18.

A two channel recorder is needed to make a picture of the joint side output signal and the joint side reaching signal.

This should be done for the torch movement from left to right and right to left.

Delay time left to right:

Connect the P.C. board's U5 pin 1 (Dwell right) to one plug of recorder channel 1. Connect U26 pin 4 (Touch work) to one plug of recorder channel 2, and ground the two other plugs.

Execute a welding program without weaving but notice that the electrode touches the workpiece at the right side of the joint when weaving.

The delay time can now be measured in the recorders picture as shown in figure

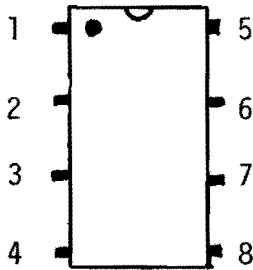


Fig.29 Pin numbers of e.g.U5

Delay time right to left:

Connect U5 pin 4 (Dwell left) to one plug of recorder channel 1. Connect U26 pin 4 (Touch work) to one plug of recorder channel 2, and ground the other two plugs.

Execute a welding program without welding but notice that the electrode touches the left side of the joint when weaving.

The value of the delay time can be measured in the recorders picture again.

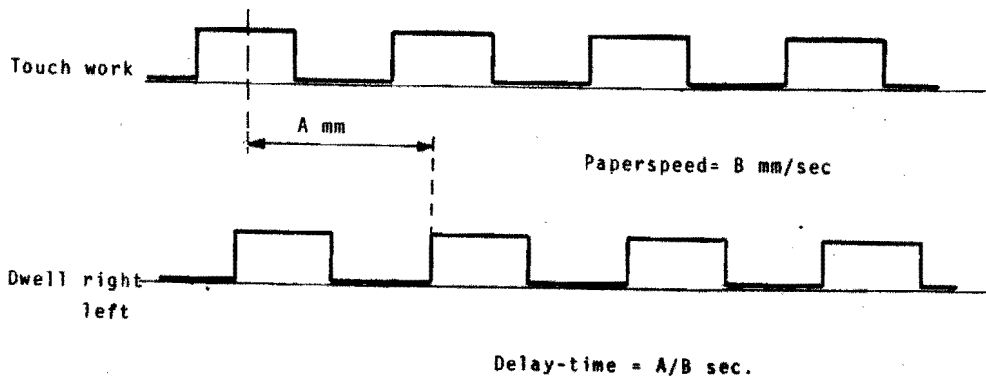


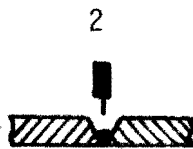
Fig.30 .Measurement of the delay time.

## 8. COMPARISON OF TWO WELDGUIDE SYSTEMS.

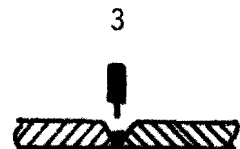
Under the same circumstances two different Weldguide systems are used to track a V-Joint.  
This is done for three cases:



Weldguide 1



Weldguide 1  
Same situation  
as situation 1.



Weldguide 2

Fig.31 .Test situation.

The printed output of the tracks can be compared to see if there is some difference in the values obtained from the Weldguide systems.

Results:

CASE	T-T0-W Amp.	LF-CS Amp.	RT-CS Amp.	TW	CS	
1	94.8 6.2	81.1 4.6	76.0 5.7	-1.5 4.4	1.6 2.0	$\bar{X}$ $\sigma_x$
2	94.6 6.3	81.0 3.8	77.9 5.4	-1.5 4.5	0.9 1.8	$\bar{X}$ $\sigma_x$
3	94.8 6.0	82.2 3.3	77.2 5.2	-1.5 4.2	1.7 1.9	$\bar{X}$ $\sigma_x$

Fig.32 .Results.

### CONCLUSION:

The difference between the values of Weldguide 1 and 2 is not bigger than the difference between the values of case 1 and 2 (two tracks with the same system).  
So there is no hardware difference measured between both Weldguide systems.

## 9. STORE LOCATION IN A WELDING PROGRAM.

It is a problem to store a location during welding. This location can be the start or end position of the weld or an intermediate position. Following tests are made to store an intermediate position P.

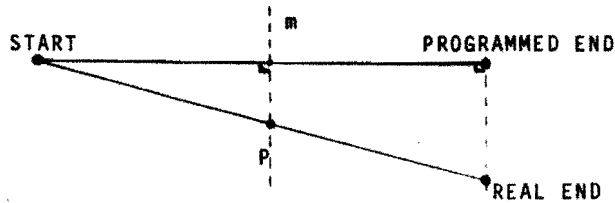


Fig. 33. Test situation.

The point P has to be stored without stopping welding.

9.1 POS-FINE-CONTOUR-WEAVE instruction is used.

The essential part of the program:

```
POS V=25% WDATA 1/1
SET OUTPUT 18=1
POS V=25% FINE CONTOUR S1/50 S2/50 WEAVEROG 20 V=100%
STO LOC 1
POS V=25% FINE CONTOUR S1/50 S2/50 WEAVEROG 20 V=100%
SET OUTPUT 18=0
POS V=100% REFP ON
POS V=100% WEND 1
POS V=100% REFP OFF
```

Following picture describes what happens:

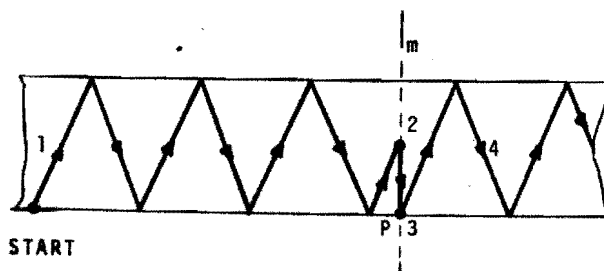


Fig. 34. Store Location with FINE POINT

1. Normal weaving
2. Moving to the start-side of the joint
3. Store location P
4. Normal weaving again, startpoint = stored point P

Remarks: The movement from 2. to 3. takes, depending on the position of point 2. too much time. This results in a bad looking weld at this position. The slow movement is caused by the FINE instruction so in the next test this argument is deleted.

9.2 POS-CONTOUR-WEAVE instruction is used.

The essential part of the program:

```
POS V=25% WDATA 1/1
SET OUTPUT 18=1
POS V=25% CONTOUR S1/50 S2/50 WEAVEPROG 20 V=100%
STO LOC 1
POS V=25% CONTOUR S1/50 S2/50 WEAVEPROG 20 V=100%
SET OUTPUT 18=0
POS V=100% REFP ON
POS V=25% WEND 1
POS V=100% REFP OFF
```

The next picture shows what happens:

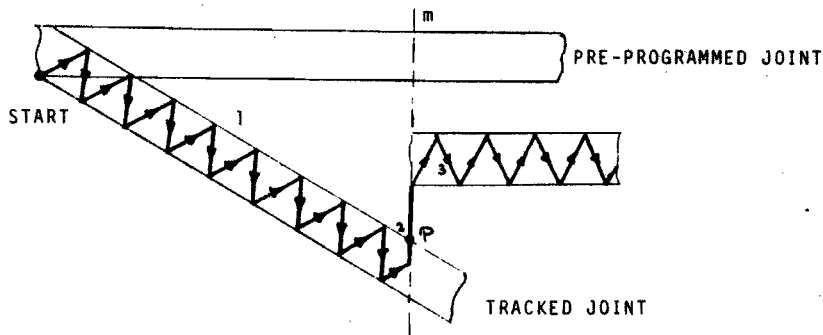


Fig.35.Store Location with a COARSE POINT.

- 1.Normal weaving.
- 2.Store location at the nearest side of the joint.
- 3.Start weaving again at a position between the tracked and the preprogrammed joint.The weaving start position is not the stored location.

Remarks:The torch jumps to a position between the tracked and the preprogrammed joint,which causes,depending on the deviation a very bad looking weld,so this instruction cannot be used in a real welding program.  
In the next two tests this instruction is used with some additional instructions so the torch will not jump to a middle position.



### 9.3.POS LOC instruction after STO LOC instruction.

The essential part of the program:

```
POS V=25% WDATA 1/1
SET OUTPUT 18=1
POS V=25% CONTOUR S1/50 S2/50 WEAVERPROG 20 V=100%
STO LOC 1
POS LOC 1
POS V=25% CONTOUR S1/50 S2/50 WEAVERPROG 20 V=100%
SET OUTPUT 18=0
POS V=100% REFP ON
POS V=25% WEND 1
POS V=100% REFP OFF
```

The following picture shows what happens:

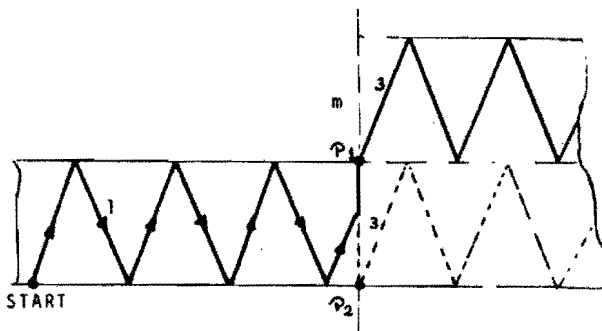


Fig 36 .POS LOC after STORE LOC instruction.

- 1.Normal weaving
- 2.Store location at the nearest side of the joint
- 3.Start weaving again.  
Startpoint=stored location.

Remarks: Depending on which side is the nearest side a point P1 or P2 is stored.  
When P1 is stored the torch will jump and cause a very bad looking weld.  
Otherwise the same result as in test 1 is reached.

9.4 REFPOINT instruction.

The essential part of the program:

```
POS V=25% WDATA 1/1
SET OUTPUT 18=1
POS V=25% CONTOUR S1/50 S2/50 WEAVERPROG 20 V=100%
STO LOC 1
REFP ON --Program this instruction and execute it.
          After that the rest of the program has to
          be programmed.
```

```
POS V=25% CONTOUR S1/50 S2/50 WEAVERPROG 20 V=100%
SET OUTPUT 18=0
POS V=25% WEND
POS V=100% REFP OFF
```

This program achieves the same result as test 3.

#### CONCLUSION:

None of the four described tests gives a good solution for storing a location during welding.  
Test 1 gives the best result of the described tests.

## 10. WAITTIMES.

This test is made to get an impression which factors influence the waittime programmed in a weaving program. Further the waittimes are measured and compared with the programmed waittimes. This is done by use of a recorder: Graphtec Linearcorder using a paperspeed of 250 mm/s.

1. Change the waittime at the left side of the joint and see if the measured waittime at the right side of the joint changes. Result: The programmed waittime at one side doesn't influence the measured waittime at the other side of the joint.

2. Relation between programmed waittime and measured waittime. Following measurements are made for a linear welding speed=6.12 mm/s and a speed in the weaving program=18.36 mm/s. Results:

Programmed waittime	Measured waittime	Oscilations per 10 mm	Linear speed measured
0.01-0.09	0.084	8.8	3.1
0.10-0.19	0.124	4.8	4.2
0.20-0.29	0.160	3.2	6.3
0.30-0.39	0.268	2.2	6.3
0.40-0.49	0.380	1.8	6.3
0.50-0.59	0.488	1.4	6.3
0.60-0.69	0.596	1.2	5.9
0.70-0.79	0.652	1.1	5.9
0.80-0.89	0.760	1.0	5.9
0.90-0.99	0.868	0.9	5.9
1.00	0.972	0.8	5.9
1.50	1.488		

Accuracy: waittime  $\pm 0.004$  s linear speed  $\pm 0.2$  mm/s

3. The influence of the linear speed on the waittime. Result: The programmed linear speed doesn't influence the measured waittime.

## II. INTERRUPTS BY USE OF A 1<sup>st</sup> EXTRA I/O BOARD:

This test is made to test the interrupt functions when a second DSDX 110 I/O board is used. Following picture shows the connections of the I/O board and the terminal unit.

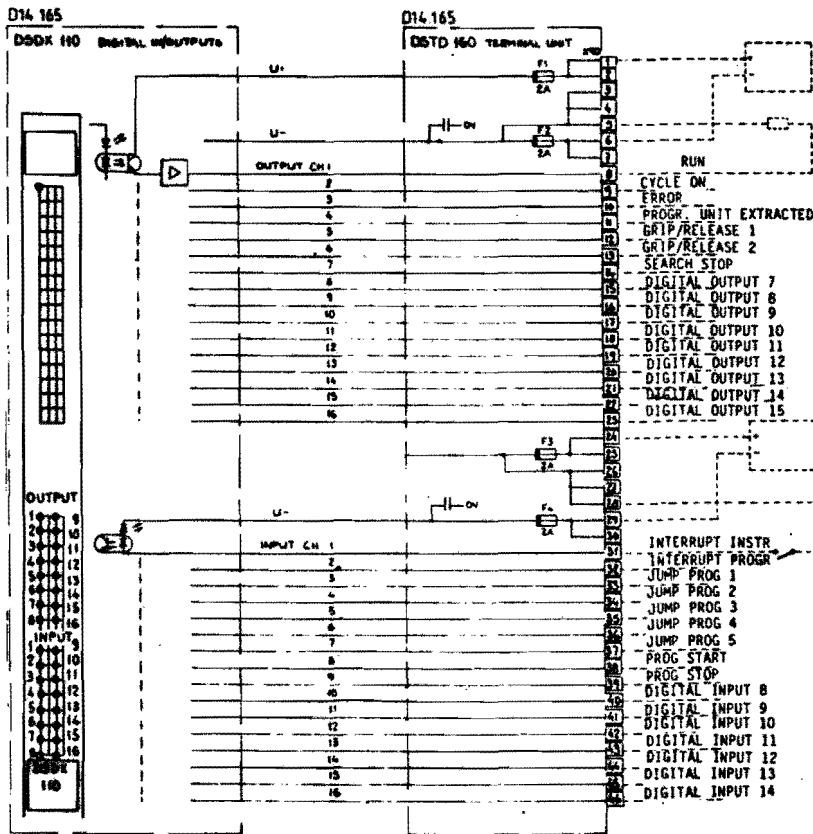
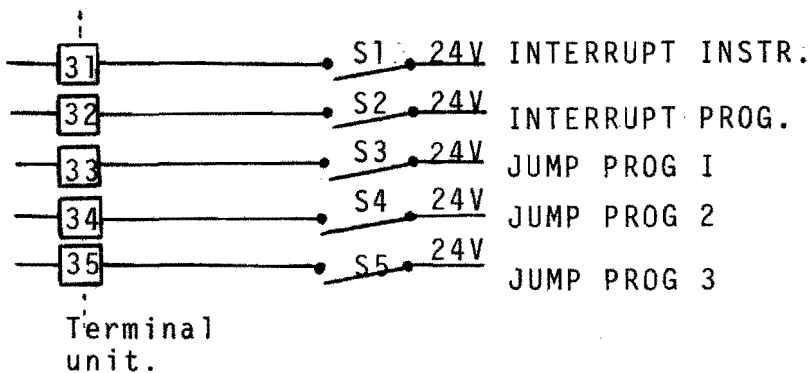


Fig.37 .1<sup>st</sup> extra I/O board connections.



By closing the switches an interrupt can be made. Depending on which switches are closed the program will start or stop at a certain instruction or program after the interrupt signal.

To enable an interrupt signal the following instruction has to be programmed:

F-button-SCAN-SCAN-INTER:ENABLE INTERRUPT?---YES.

The program can be continued in a different way after the interrupt, as described in the following table:

Switches closed	Instruction	Result
S1	Interrupt instr.	The instruction is interrupted and the program starts again at the next instruction.
S2	Interrupt prog.	The program stops after executing the current instruction.
S3	Jump PROG 1	A jump is made to program 1 after executing the current instruction.
S1+S2	Interrupt instr. Interrupt progr.	The current instruction is interrupted and the program stops.
S1+S3	Interrupt instr. Jump prog 1.	The current instruction is interrupted and a jump is made to program 1.

It is evident that when S4 is closed instead of S3 a jump will be made to program 2 and when S5 is closed to program 3 etc.

CLOSING WORD.

It will be evident that this report only gives an impression of the main occupations during this practical work but it isn't a complete description of all gained experiences.

It was very interesting to work in a department that is dealing with weldrobots during a period of ten weeks. I experienced that a robot system is not only a kind of black box that produces perfect welds after pressing some buttons. There are still a lot of problems that have to be solved.

I am very thankful that I got the possibility to get some experience in using a weldrobot and the ESAB Weldguide. Further it was a great experience to stay in Sweden for a few months.

For me this report isn't only a description of the occupations during my practical work but it will always remind me of a very beautiful period at ESAB Laxå.

Thank you very much.