CONTENT

SAFETY DEVICES AND NORMAL OPERATION

Precaution:

As Electrical Discharge Machine is working with spark between electrode and workpiece, there should be safety devices with correct operation to prevent machine and workplace from getting fire. The correct way of operation is also illustrated in our Operation Manual. Please follow the instruction to avoid any possible accident.

A. 3 factors to cause combustion:

There are 3 factors to cause fire which are fire flame, oxygen and combustible materials. To avoid getting fire, you have to control these 3 factors. The following safety devices are equipped in our EDM to keep away from these factors.

a. Auto inspection device for abnormal machining:

During EDM working, bad cycling of the dielectric shall easily cause deposited carbon articles on the workpiece. The continuos carbon deposit shall force the electrode to move upward. In the long run, the electrode shall move above the dielectric level. This is one of the reason why it cause fire. To prevent such accident, we have equipped in our EDM the ARC Detection System as illustrated in the control panel in our Operation Manual. Please refer carefully to them.

b. Dielectric level monitor:

Normally, when the dielectric cannot cover the end of the electrode, it shall cause fire easily during machining. To avoid such trouble, we have equipped a dielectric level monitor system as illustrated in of the control panel in our Operation Manual. Please refer to it carefully.

c. Dielectric temperature monitor:

One of the reasons to cause fire is the high dielectric temperature. We have equipped a device to monitor this. Whenever the dielectric temperature is more than the set temperature, the power supply will shut off automatically to stop machining. For this, please refer to the control panel in Operation Manual for the details.

d. Flame monitor:

Another device to avoid getting fire is the flame monitor. As it gets spark when the machine is working, there might some occasions to have a flame when the dielectric cannot cover the end of the electrode. When there is a flame in this case, the lamp for the flame monitor will light and main power supply will shut off automatically to avoid any possible accident.

e. Fire Extinguisher:

The series machines need to fit fire extinguisher. Please refer to the local qualified supplier to install.

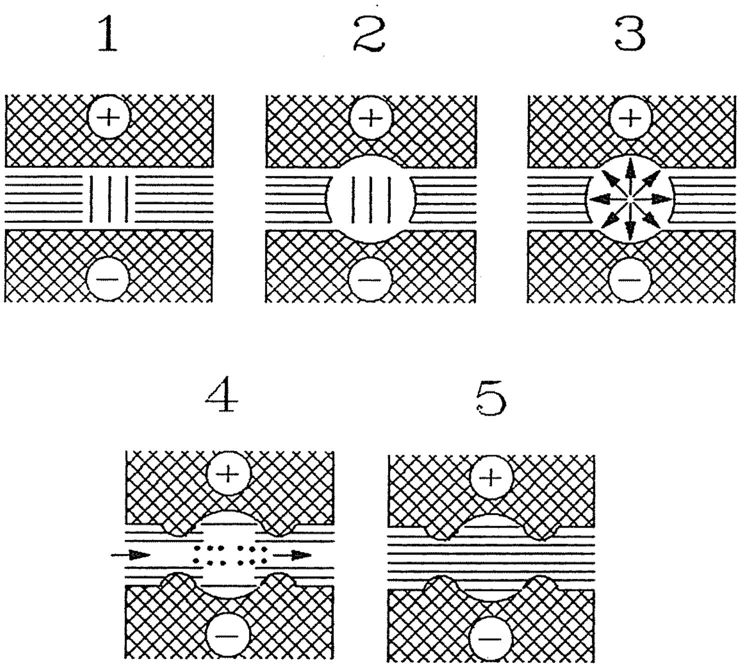
B. For the social security, the end user of the EDM machines are requested compulsory to buy the insurance especially for the fire accident in your country. The end user should take responsibility in case that he doesn't follow this regulation.

CHAPTER 1

THE BRIEF INTRODUCTION OF EDM

1.1 The outline of EDM

EDM is a machining of converting electricity energy into heat energy directly, and a little different from mechanical machining. The fundamental concepts show as below:
Single discharge process.



1. When the electrode is closest to the workpiece, on the nearest point the ARC occurs, between both electrode & workpiece spart generates, sparks become tiny ARC soon i.e. high density of electronic current strikes a point of workpiece.

2. This electronic currents produce heat of high temperature. The workpiece will be melted if touching this heat.

3. This heat vaporizes the dielectric fluid surrounding here, put pressure on melted workpiece and electrode.
The pressure is small to the all workpiece and electrode, but it is big to the unit area.

4. The melted metal was turned into particles and dispersed in the dielectric fluid. The residuals around the discharging point bulge, attached to electrode & workpiece.
The bulge will become a successive discharging point.

5. The melted metal is removed and filtered with dielectric fluid soon. After cooling the discharging gap becomes insulated again.

Continuous discharge machining

While discharging thousands even tens thousand discharge in one second. Accumulative discharges proceed machining. The more the discharge works the faster the speed becomes. The gap is bigger, then machining roughness on top surface is coarser. The comparison among machining speed, current & pulse width. The machining speed is in compliance with current. While pulse width is fixed, the stronger the current the faster the machining speed. But the value of current is over 10A/㎠2 , the speed will show down. Therefore fine finish & small surface had better employ small current to machine. When pulse width is extremely short or long, the machining speed has tendency to slow down even if the pulse on & pulse off are at the same ratio. The peak current has not reached the setting current, so the pulse width lengths, the density of current drops. The discharge current lower, it is hard to eliminate the melted metal. The residuals cease on the surface, the roughness of machining surface worsen, his machining surface with deformed layer thickens and machining efficiency worsens, so it is impractical.
Therefore the volume of current should match pulse width well. The theory of machining with low wear. There are some factors to affect the electrode wear. The theory of machining with low wear. There are some factors to affect the electrode wear.

The main two factors show as below :

1. Using the original characters of materials i.e. the outcome of melting point multiplexed by thermal conductivity to achieve the low wear. The more the outcome the lower it wears.

2. After machining the carbon attaching to the positive part will produce protection, and lower electrode wear. The deformed layer after machining. The processed material was treated by fast heating & cooling & the physical, chemical influence of high pressure, the deformed layer occurred. When pulse width is long, the existing time of heat energy will be long. The high temperature of ARC can conduct to the inner side of material the deformed layer will thicken. To thinning the deformed layer the machining condition should be under shorter pulse width. Besides, while steel is under machining in the dielectric fluid the fluid & decomposition of workpiece producing carbon will penetrate carbon under high pressure & temperature, and become highly rigid top surface containing high carbon.

1.2 The applications of EDM machining

1. EDM using heat energy to process is different from that of conventional mechanical method. Therefore, all the conductive material can be machined regardless of hardness & toughness. Especially for hardened steel & Tungsten Carbide hard alloy.

2. The force EDM machine produces is small, and machining surface shows no pile-up carbon therefore EDM is fit for thin slice and tiny workpiece machining.

3. When machining the electrode doesn't need rotate. Therefore it is favorable to machine complex and in the recent years the great progress has been made in the technological field. The EDM has been improving under the study of EDM experts. To the common steel, the electrode wear can be under 0.2%, the surface exactness reaches 0.3 μ m Ra. Consequently the EDM machine has been applied to high exactness and aero equipment.

CHAPTER 2

SYSTEM INSTRUCTIONS FOR AZ SERIES E.D.M.

2.1 COMPOSITION INSTRUCTION OF MACHINE FRAME AND POWER SUPPLY UNIT

2.1.1 MODELS OF POWER SUPPLY UNIT.

1. AZ50 ; MAX. MACHINING CURRENT 50A.
2. AZ75 ; MAX. MACHINING CURRENT 75A.
3. AZ100 ; MAX. MACHINING CURRENT 100A.
4. AZ125 ; MAX. MACHINING CURRENT 125A.
5. AZ150 ; MAX. MACHINING CURRENT 150A.

2.1.2 MODELS OF MACHINE FRAME.

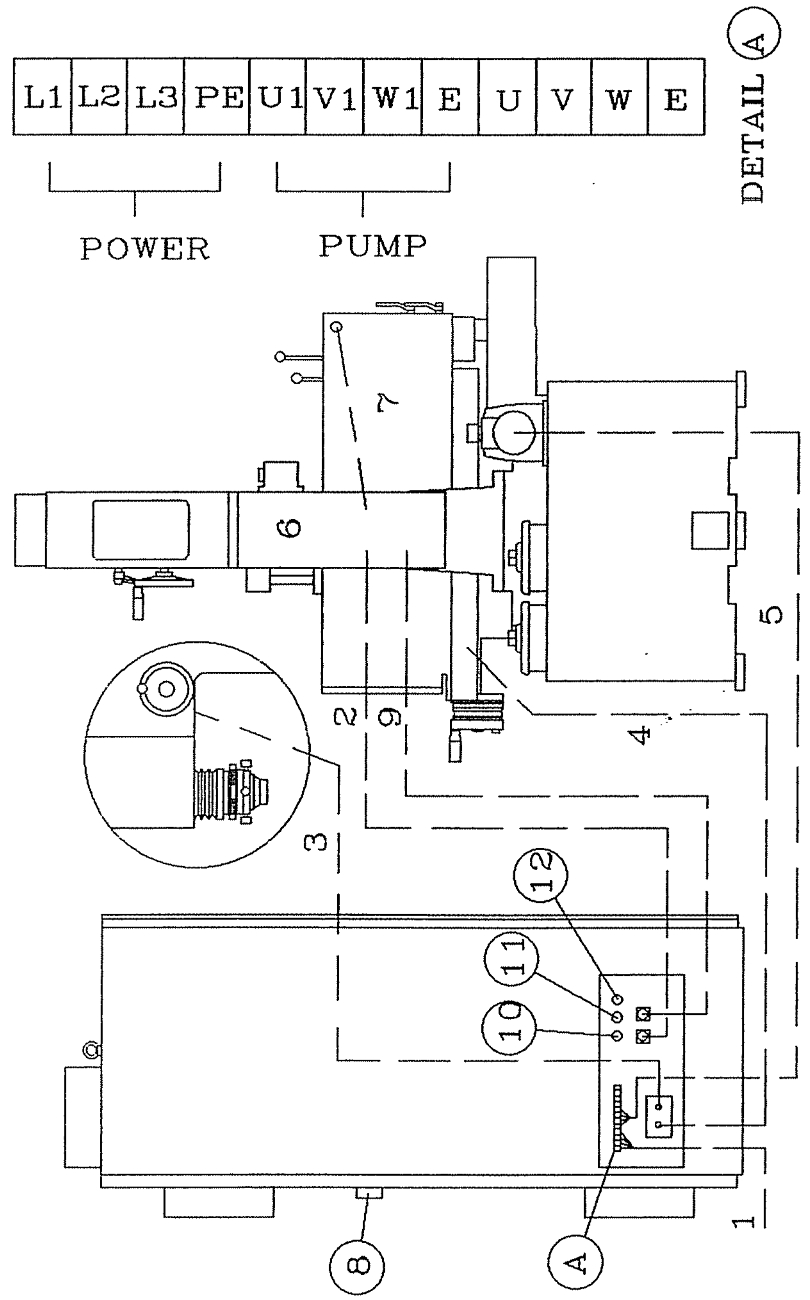
1. SED301
2. SED401
3. SED501
4. SED551
5. SED601
6. SED1051

2.1.3 COMPOSITION INSTRUCTION.

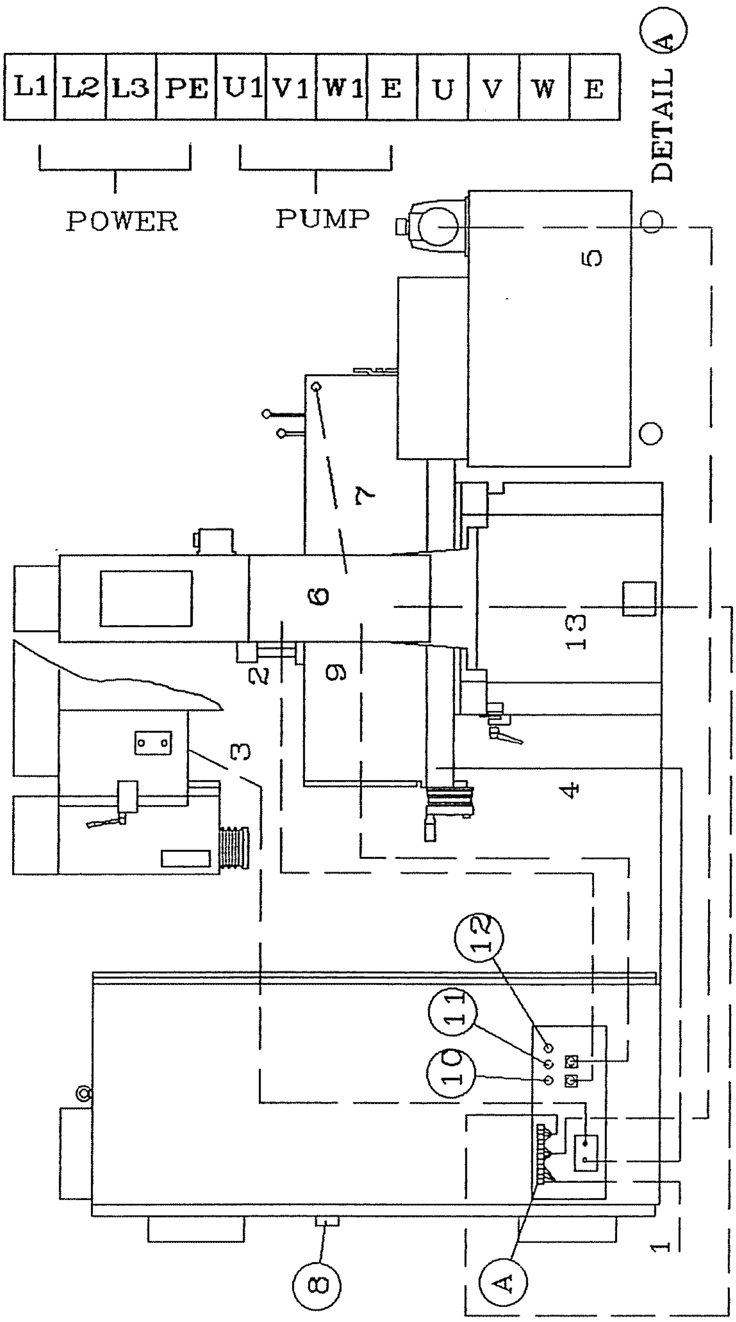
POWER SUPPLY UNIT	MACHINE UNIT
AZ50	SED301
	SED401
	SED501
AZ75	SED401
	SED501
	SED551
	SED601
AZ100/ AZ125 /AZ150	SED501
	SED551
	SED601
	SED1051

2.2 CABLE CONNECTION BETWEEN MACHINE FRAME AND POWER SUPPLY

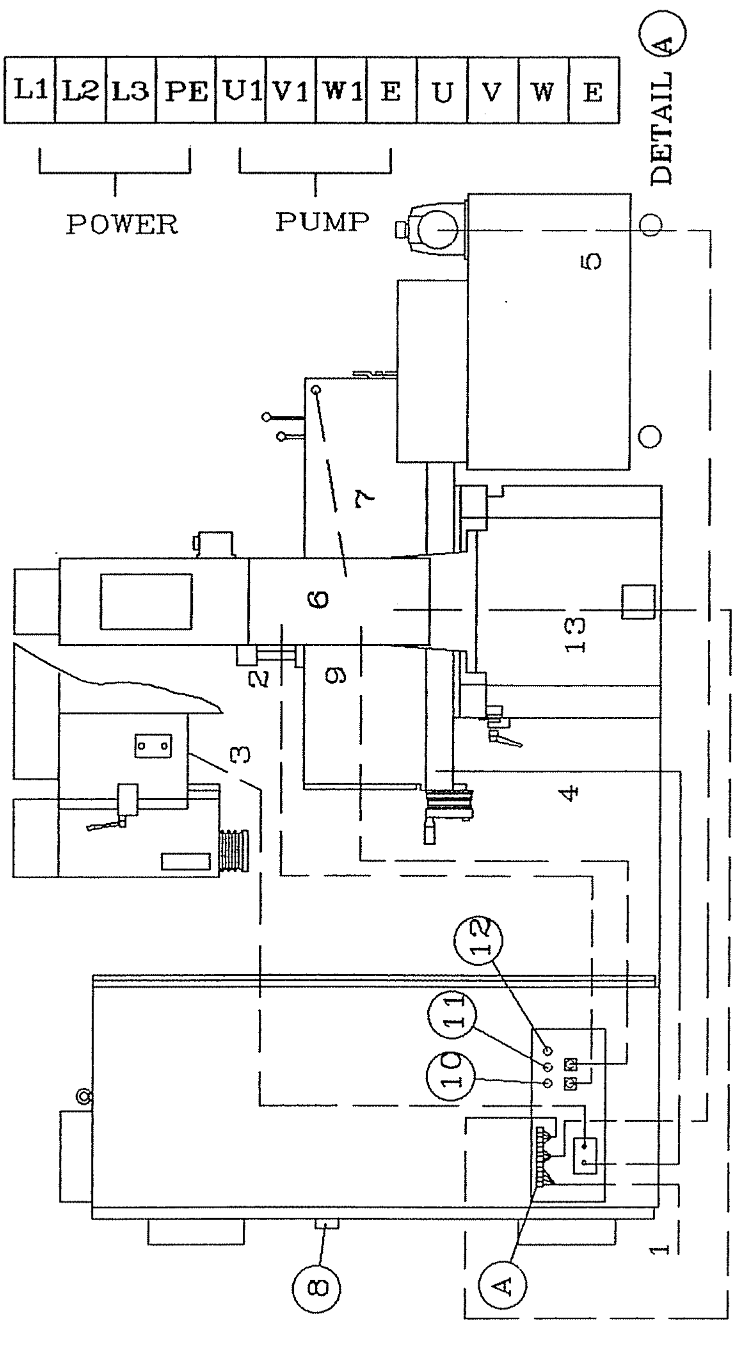
2.2.1 SED301



2.2.2 SED401,SED501,SED551,SED601

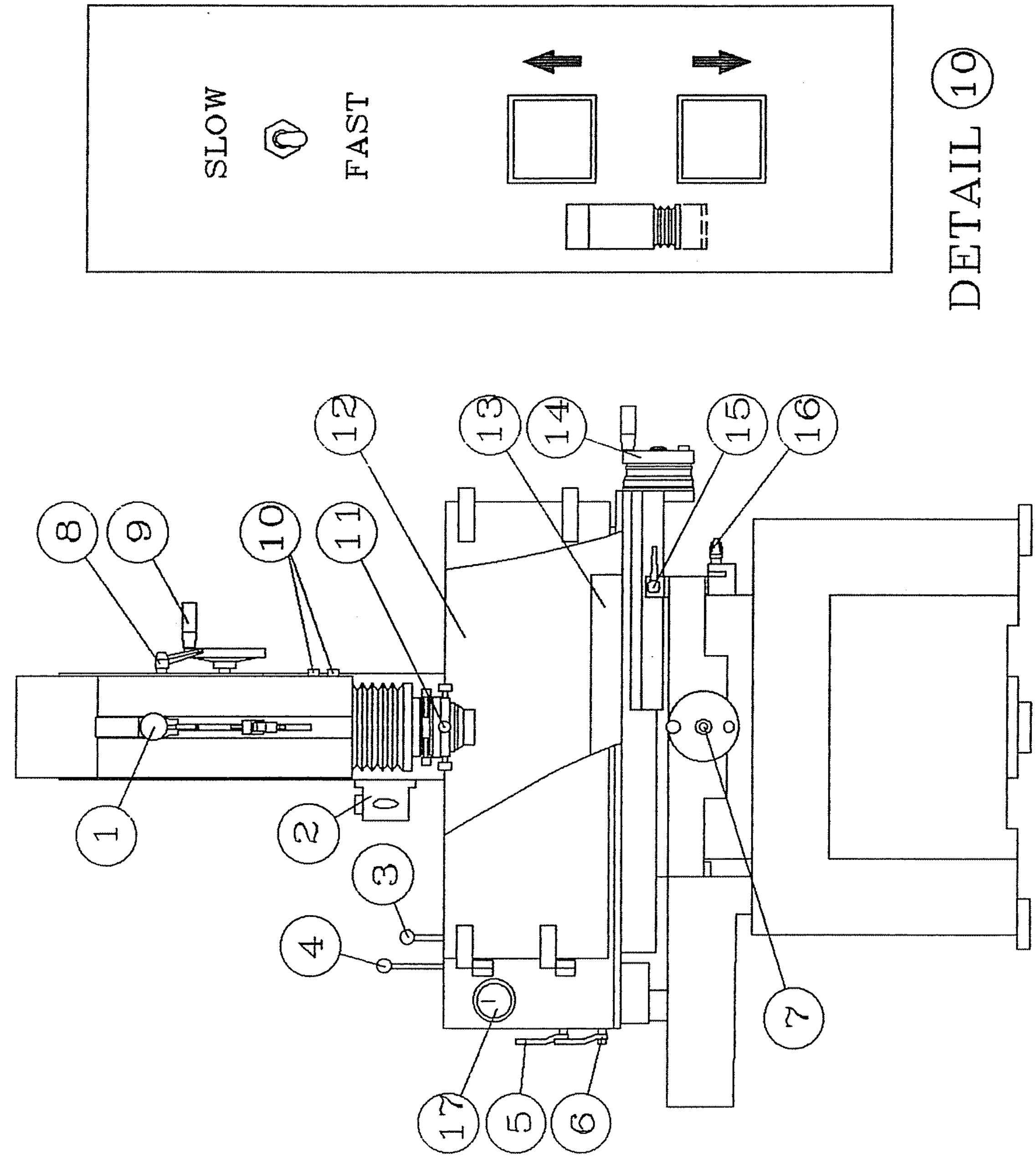


2.2.2 SED401,SED501,SED551,SED601



ITEM	DESCRIPTION
1	POWER INPUT CABLE (CONNECTION TO THE POWER IN YOUR FACTORY)
2	10P CONTROL CABLE
3	ELECTRODE CABLE RED + OUTPUT
4	ELECTRODE CABLE BLUE - OUTPUT
5	DIELECTRIC PUMP POWER CABLE
6	MACHINE FRAME CONTROL BOX
7	WORK LAMP, DIELECTRIC LEVEL, DIELECTRIC TEMPERATURE AND SYNCHRONOUS PULSE FLUSHING CONTROL CABLE.
8	POWER SUPPLY MAIN SWITCH
9	24P CONTROL CABLE
10	D.R.O. X AXIS CONNECTOR
11	D.R.O. Y AXIS CONNECTOR
12	D.R.O. Z AXIS CONNECTOR
13	W AXIS MOTOR POWER CABLE

2.3 MACHINE UNIT AND ACCESSORIES



1. DEPTH SETTING :
   USING THIS DIAL GAUGE TO SET THE MACHINING DEPTH OF WORKPIECE. THE MACHINING DEPTH ALSO CAN BE SET BY D.R.O. " END " POINT. TO BE NOTED THAT ANY ONE OF THE SETTING DEPTH (BY DIAL GAUGE OR D.R.O. " END ") IS REACHED, THAT IS THE MACHINING DEPTH IS REACHED.

2. LUBRICATOR :
   FOR GUIDE WAY AND LEAD SCREW/ BALL SCREW, INCLUDING X, Y, Z, AND W AXES.

3. DIELECTRIC LEVEL CONTROL LEVER.

4. DRAIN CONTROL LEVER.

5. DIELECTRIC FLUID CONTROL VALVE:
   TO CONTROL FLUSHING AND FLUID SUPPLY SPEED.

6. SUCTION OR FLUSHING CONTROL VALVE.

7. Y AXIS HAND WHEEL:
   FOR TABLE MOVEMENT IN Y AXIS DIRECTION.

8. WORKHEAD CLAMP LEVER.

9. W AXIS HAND WHEEL FOR SED301.
   W AXIS MOVEMENT IS FEED BY MOTOR FOR SED401,SED501,SED551,SED601.

10. WORKHEAD SIDE CONTROL PANEL: (FOR SED301.SED401)
    FOR RAM MOVEMENT UP AND DOWN.

11. ELECTRIC HOLDER:
    WITH UNIVERSAL ADJUSTMENT (ANGULAR, PERPENDICULAR).

12. WORK TANK.

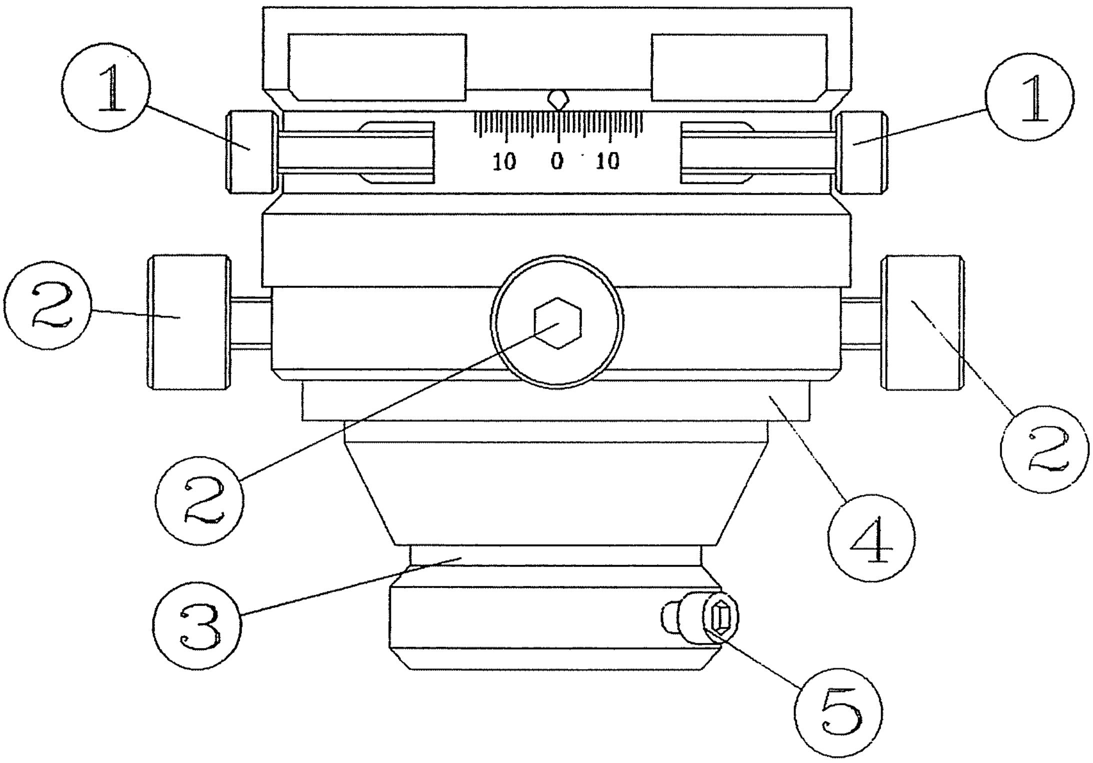
13. WORK TABLE.

14. X AXIS HAND WHEEL :
    FOR TABLE MOVEMENT IN X AXIS DIRECTION.

15. WORK TABLE BRAKE LEVER.

16. SADDLE BRAKE LEVER.

2.4 ELECTRODE HOLDER



1. ANGULAR ADJUSTMENT SCREW.

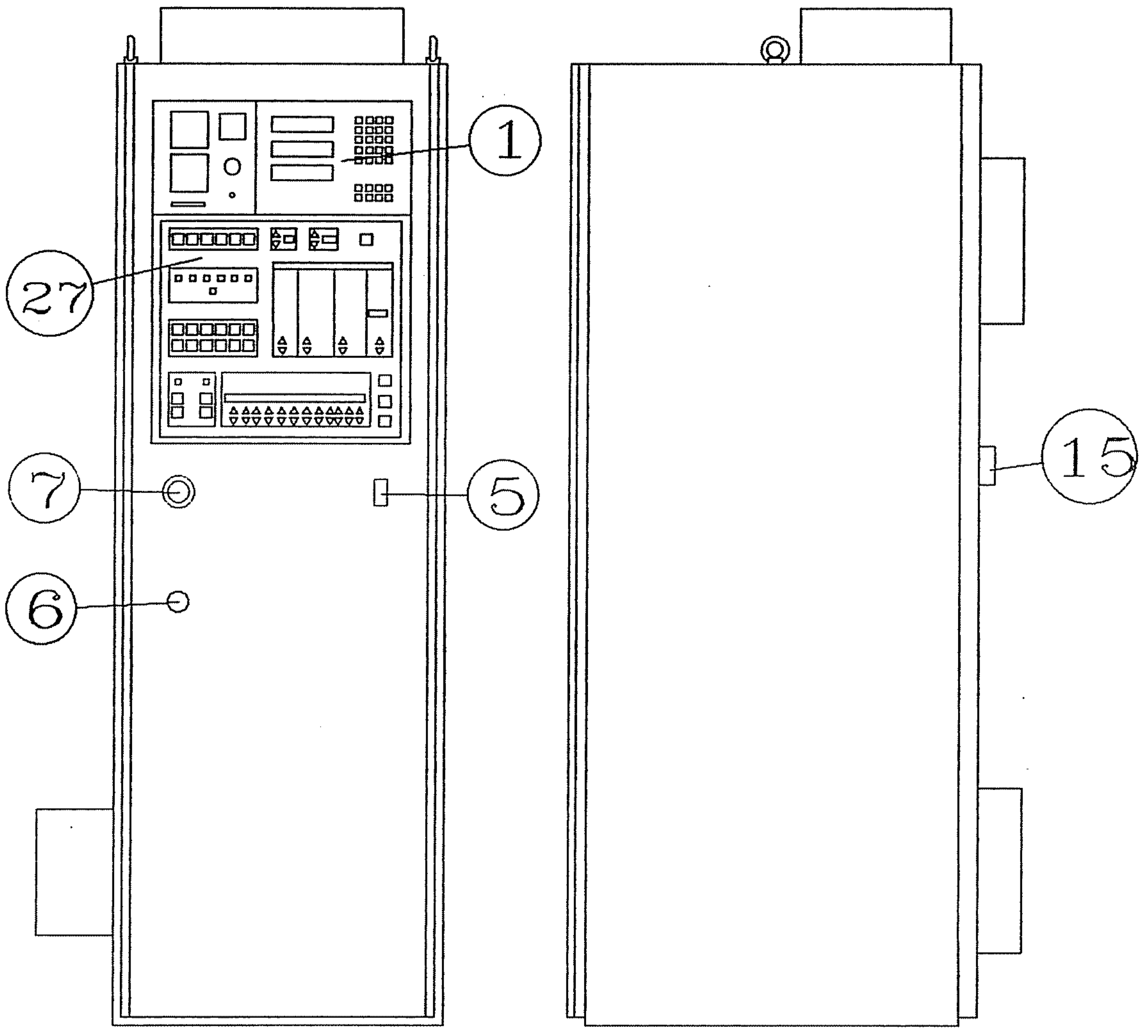
2. HORIZONTAL ADJUSTMENT SCREW.

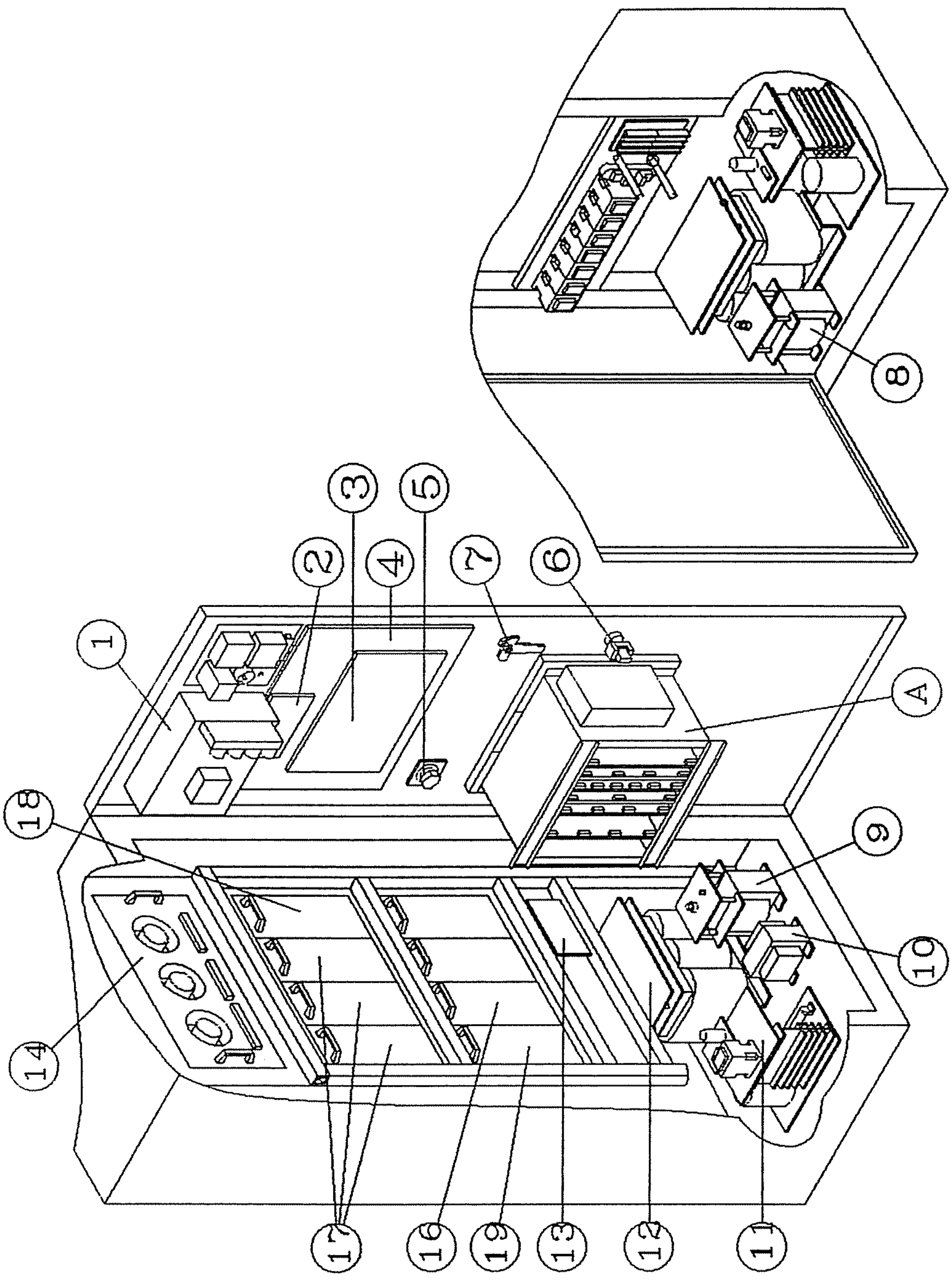
3. V- HOLDER.

4. INSULATOR.

5. SCREW FOR FIXING ELECTRODE.

2.5 GENERATOR

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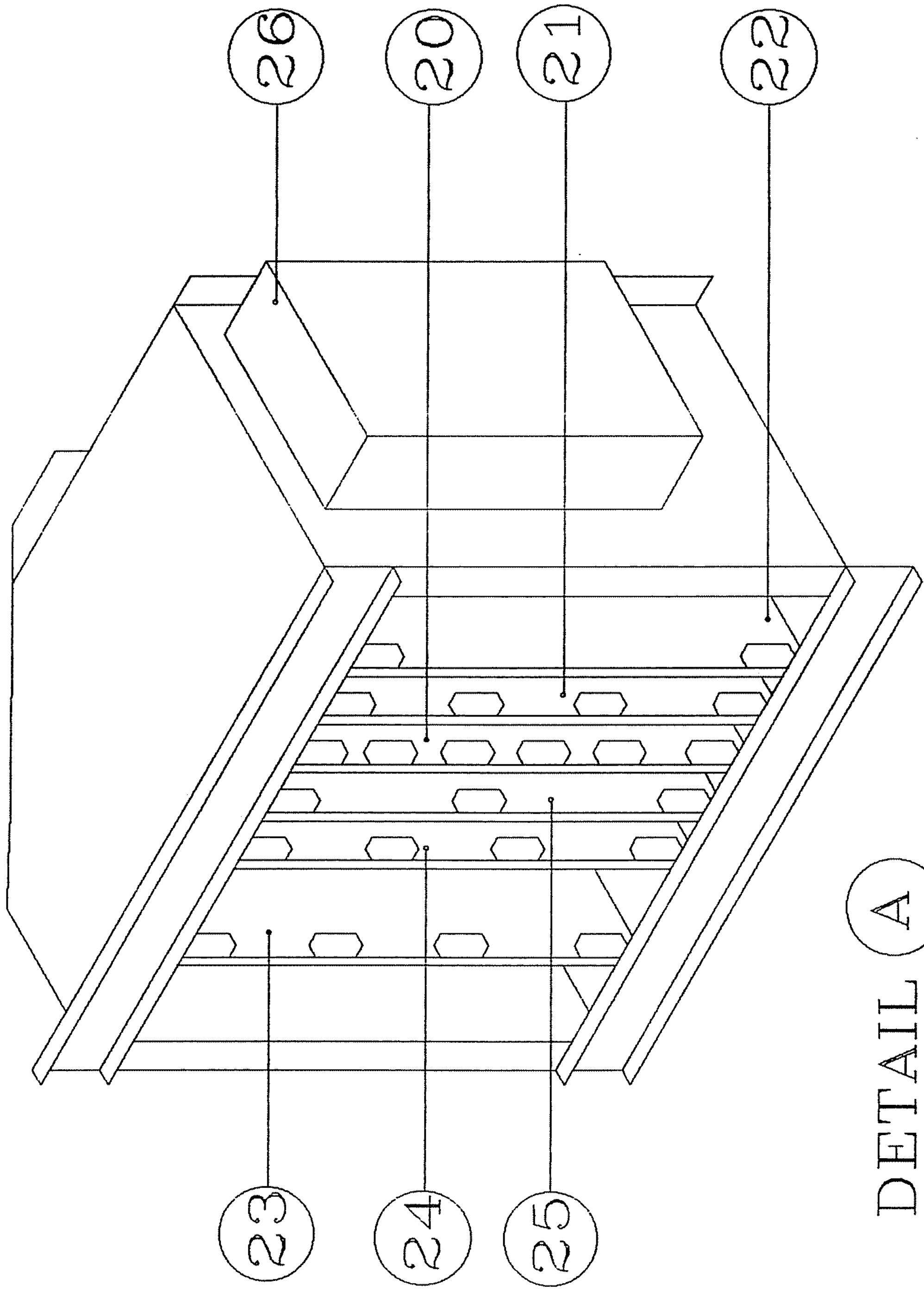


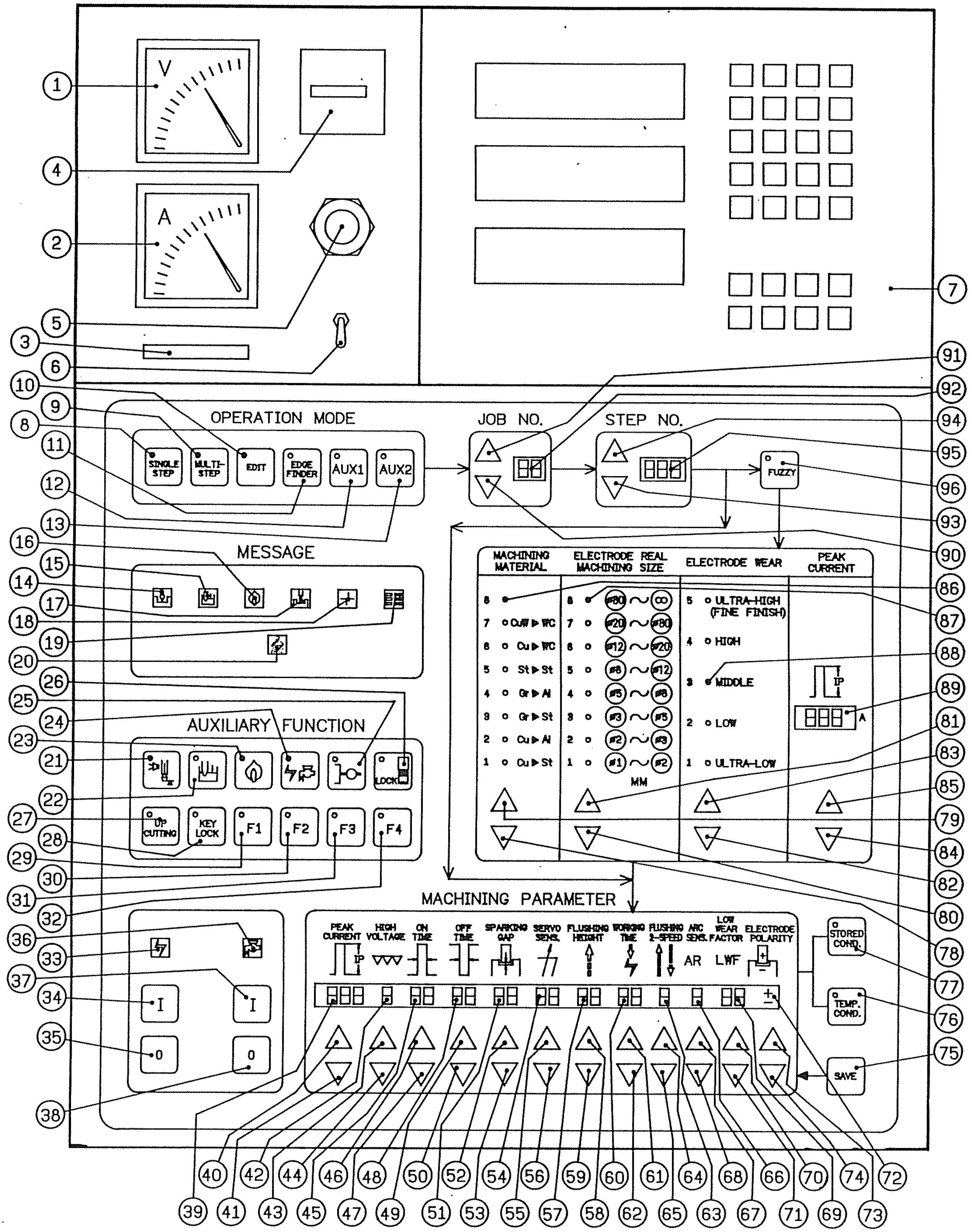
DETAIL A

ITEM	DESCRIPTION
1	COUNTER
2	DROIF P.C.B.
3	DSPIF P.C.B.
4	DSPKBD P.C.B.
5	POWER SWITCH
6	EMG. STOP SWITCH
7	CLAMP UNIT
8	TRANSFORMER JM110
9	TRANSFORMER PT180
10	TRANSFORMER MH110
11	HIGH POWER SUPPLY
12	TRANSFORMER PT-1
13	CONUERTER
14	RESISTANCE R-50A
15	POWER SWITCH
16	DRV-180 UNIT
17	LVD-25 UNIT
18	HVA-03 UNIT
19	PS-30 UNIT
20	FETBFR P.C.B.
21	DOSC P.C.B.
22	SCPU P.C.B.
23	SPKIF P.C.B.
24	SIO P.C.B.
25	SVO P.C.B.
26	PSU
27	CONTROL PANEL

CHAPTER 3

CONTROL PANEL

3.1 CONTROL PANEL OF GENERATOR



1. Voltage meter
2. Ampere meter
3. Stability display
4. Timer
5. Buzzer
6. A.O.S. key
7. D.R.O. counter
8. Single step machining key
9. Multi steps machining key
10. Edit key
11. Edge finder key
12. Aux1 key
13. Aux2 key
14. Depth arrival indicator
15. Dielectric level & temperature indicator
16. Flame indicator
17. Arcing indicator
18. Electrode-workpiece collision indicator
19. D.R.O. settings error indicator
20. Reset key
21. Auto retract key
22. Dielectric level & temperature sensor key
23. Flame sensor key
24. Pump-sparking synchronous start key
25. Alignment adjusting key
26. Z-lock key
27. Up-cutting key
28. Key lock key
29. F1 key
30. F2 key
31. F3 key
32. F4 key
33. Spark indicator
34. Spark on key
35. Spark off key
36. Pump indicator
37. Pump on key
38. Pump off key
39. Peak current indicator
40. Peak current increase key
41. Peak current decrease key
42. High voltage indicator
43. High voltage increase key
44. High voltage decrease key
45. On time indicator
46. On time increase key
47. On time decrease key
48. Off time indicator
49. Off time increase key
50. Off time decrease key
51. Sparking gap indicator
52. Sparking gap increase key
53. Sparking gap decrease key
54. Servo sensitivity indicator
55. Servo sensitivity increase key
56. Servo sensitivity decrease key
57. Flushing height indicator
58. Flushing height increase key
59. Flushing height decrease key
60. Working time indicator
61. Working time increase key
62. Working time decrease key
63. Flushing 2-speed indicator
64. Flushing 2-speed increase key
65. Flushing 2-speed decrease key
66. ARC sensitivity indicator
67. ARC sensitivity increase key
68. ARC sensitivity decrease key
69. Low wear factor indicator
70. Low wear factor increase key
71. Low wear factor decrease key
72. Electrode polarity indicator
73. Electrode polarity increase key
74. Electrode polarity decrease key
75. Save key
76. Temporary condition key
77. Stored condition key
78. Machining material decrease key
79. Machining material increase key
80. Electrode real machining size decrease key
81. Electrode real machining size increase key
82. Electrode wear decrease key
83. Electrode wear increase key
84. Peak current decrease key
85. Peak current increase key
86. Machining material indicator
87. Electrode real machining size indicator
88. Electrode wear indicator
89. Peak current indicator
90. Job No. decrease key
91. Job No. increase key
92. Job No. indicator
93. Step No. decrease key
94. Step No. increase key

95. Step No. indicator
96. Fuzzy key

THE INTRODUCTION TO JOEMARS NEW FUZZY LOGIC CONTROL SYSTEM CONTROL PANEL

1. VOLTAGE METER :
   NORMALLY INDICATES AT ABOUT 50V DURING SPARKING AND 60V - 70V AT FINE FINISHING.

2. AMPERE METER :
   INDICATES THE MACHINING AVERAGE CURRENT OUTPUT.

3. STABILITY DISPLAY :
   INDICATES THE MACHINING STABILITY. 20% - 40% MEANS POOR MACHINING AND PARAMETERS NEED TO BE ADJUSTED. 80% - 100% INDICATES STABLE MACHINING.

4. TIMER :
   TO COUNT ON THE MACHINING TIME.

5. BUZZER :

6. A.O.S KEY :
   AFTER START MACHINING, PUT TO " I " THEN WHEN THE DEPTH IS REACHED, MACHINING STOP AND SHUT OFF THE POWER. PUT TO " 0 " , THEN THE DEPTH IS REACHED, MACHINING STOP BUT POWER IS STILL ON.

7. D.R.O. CONTROL PANEL.
   TO SET THE MACHINING DEPTH AND MACHINING STEPS : SINGLE STEPS OR MULTI STEPS MACHINING. HEIDENHAIN COUNTER (5 STEPS) & FAGOR COUNTER ARE SELECTABLE.

   ** OPERATION MODES: (FROM 8. SINGLE STEP MACHINING TO 13. AUX2)*

8. SINGLE STEP MACHINING: MANUAL MACHINING.
   MACHINING STEP BY STEP AND INDIVIDUALLY SET THE PARAMETERS FOR EACH STEP OF DEPTH.

9. MULTI STEP MACHINING: AUTO MACHINING FROM ROUGH TO FINE FINISHING.
   SET THE DIFFERENT DEPTH FOR EACH STEP MACHINING FROM D.R.O. COUNTER PANEL, AND INPUT THE PARAMETERS FROM OPERATION PANEL FOR EACH STEP OF DEPTH.

10. EDIT: SET & EDIT THE PARAMETERS FOR EACH STEP OF MACHINING.

11. EDGE FINDER: TO SET & ADJUST THE WORKPIECE SURFACE, CENTER.
SET AT " ON ", EXCEPT FOR (54. SERVO SENSITIVITY) IS STILL ON AND ALL OTHER MACHINING PARAMETERS WILL OFF. ADJUST NO. 54 (SERVO SENSITIVITY) TO CONTROL THE SERVO SPEED.
SET AT " ON ", PRESS Z SERVO " DOWN " BUTTON FROM THE WORKHEAD SIDE CONTROL PANEL THEN Z MOVES DOWN SLOWLY UNTIL TOUCH THE WORKPIECE THEN BUZZER ALARMS. THAT IS THE ZERO POINT OF WORKPIECE.

12. AUX1: TO CLEAR UP ALL (76. TEMPORARY CONDITIONS) INPUT BY USERS AND CALL OUT THE (77. THE STORED CONDITIONS) BY THE MAKER.

13. AUX2: SPECIAL MODE FOR EXPANSION IN FUTURE.
NOTES: DURING SPARKING, TO AVOID WRONG SETTINGS AND DAMAGE THE WORKPIECE, THE (96. FUZZY LOGIC CONTROL SYSTEM) WILL AUTO LOCK (92. JOB NO.), (95. STEP NO.), (86. MACHINING MATERIALS) & (87. REAL ELECTRODE MACHINING SIZE).
** MESSAGES INDICATORS: (FROM 14. DEPTH ARRIVAL TO 19. D.R.O. SETTINGS ERROR)*

14. DEPTH ARRIVAL INDICATOR :
WHEN SINGLE STEP MACHINING DEPTH OR THE FINAL STEP DEPTH OF MULTI STEPS MACHINING REACHED, " ON " AND MACHINING STOP.

15. DIELECTRIC LEVEL & TEMPERATURE INDICATOR :
SET (22. DIELECTRIC LEVEL & TEMPERATURE SENSOR) FUNCTION " ON ", WHEN THE LEVEL IS LOWER THAN REQUIRED OR TEMPERATURE IS HIGHER THAN PRESET IN MANUFACTURE'S FACTORY, THE LED " ON " AND MACHINING STOP.
FOR SAFETY, SET THE DIELECTRIC LEVEL AT LEAST 5CMS HIGHER THAN WORKPIECE AND DON'T ADJUST THE TEMPERATURE CONTROL.
ENSURE THIS FUNCTION WORKS NORMALLY BEFORE OPERATION.

16. FLAME INDICATOR :
SET (23. FLAME SENSOR) FUNCTION " ON ", WHEN FLAME HAPPENING, THE LED " ON " THEN MACHINING STOP.
FOR SAFETY, DAILY CLEAN UP SENSOR & CHECK THE FLAME SENSOR FUNCTION WILL BE REQUIRED.
ENSURE THIS FUNCTION WORKS NORMALLY BEFORE OPERATION.

17. ARCING INDICATOR :
SANTEC NEW FUZZY LOGIC CONTROL SYSTEM WILL AUTO MONITOR & ADJUST THE MACHINING PARAMETERS WHILE ARCING HAPPENING OR POOR MACHINING SITUATION. IF ARCHING STILL EXIST AND CAN NOT BE CLEARED BY ADJUSTING THE PARAMETERS, THEN LED " ON " AND MACHINING STOP.
THE ARCING HAS TO BE CLEARED BY USER.
NOTE : TAKE CARE OF THE ARCING HAPPENING TO AVOID WORKPIECE DAMAGE OR CAUSE FIRE HAZARD.

18. ELECTRODE-WORKPIECE COLLISION INDICATOR :
AT (8. SINGLE STEP MACHINING MODE), (9. MULTI STEP MACHINING MODE) & (10. EDIT MODE), WHEN ELECTRODE COLLIDE THE WORKPIECE BY OPERATOR'S NEGLIGENCE, THE LED " ON " THEN BUZZER ALARM AND MACHINE STOP.

19. D.R.O. SETTINGS ERROR INDICATOR :
WRONG D.R.O. DEPTH SETTING, THE LED " ON ".

20. RESET KEY :

** AUXILIARY FUNCTIONS: (FROM 21. AUTO RETRACT TO 32. F4)*

21. AUTO RETRACT KEY :
SET AT " ON ", WHEN THE DEPTH REACHED, THE SERVO HEAD WILL AUTO RETRACT TO THE TOP.

22. DIELECTRIC LEVEL & TEMPERATURE SENSOR KEY :
SET AT " ON ", THE MACHINE WILL AUTO MONITOR THE DIELECTRIC LEVEL AND TEMPERATURE.
FOR SAFETY, PLEASE SET IT AT " ON " AND ENSURE THIS FUNCTION WORKS.

23. FLAME SENSOR KEY :
SET AT " ON ", THE MACHINE AUTO MONITOR THE FLAME.
FOR SAFETY, TO CLEAN THE SENSOR DAILY AND BE SURE THAT THE FUNCTION WORKS DURING MACHINING. THE FIRE EXTINGUISHER IS RECOMMENDED TO BE FIXED ONTO MACHINE.

24. PUMP-SPARKING SYNCHRONOUS START KEY :
SET AT " ON ", WHEN STARTING SPARKING, THE OIL PUMP WILL WORK SYNCHRONOUSLY. WHEN STOP SPARKING, THE OIL PUMP STOP.

25. ALIGNMENT ADJUSTING KEY :
NORMALLY IS " OFF " AND ONLY USED TO ADJUST THE ALIGNMENT OF ELECTRODE & WORKPIECE. THE SERVO SPEED CAN BE DECIDED BY THE TOGGLE SWITCH ON THE WORKHEAD SIDE CONTROL PANEL.
SET " ON ", WHEN ELECTRODE TOUCH THE WORKPIECE, IT STILL MOVES SLOWLY BUT NOT STOP AND ELECTRODE ALIGNMENT CAN BE ADJUSTED.

26. Z LOCK KEY :
SET AT " ON ", THE ELECTRODE WILL STOP COMING DOWN. EQUIPPED WITH SANTEC ORBIT CUTTING SYSTEM, CAN MACHINING ORBITING FUNCTIONS.

27. UP CUTTINGS KEY :
(REVERSE SPARKING.) THIS FUNCTIONS CANNOT BE CHANGED DURING MACHINING. WHEN USING UP CUTTING FUNCTION, THE MACHINING DIRECTION WILL BE CHANGED AND THE MACHINING DEPTH & D.R.O. DEPTH SETTING MUST BE CONSIDERED TO AVOID DAMAGE ELECTRODE OR WORKPIECE.

28. KEY LOCK KEY :
TO AVOID ANY ERROR ADJUSTING AFTER STARTING MACHINING, SET AT " ON " AND ALL THE KEYS WILL BE LOCKED AUTOMATICALLY EXCEPT FOR (34. 35. SPARK ON & OFF), (37. 38. PUMP ON & OFF), (28. KEY LOCK) & D.R.O.

29. F1 KEY : SYNCHRONOUS FLUSHING:
SET " ON " : DURING MACHINING, WHEN ELECTRODE MOVES UP THE IT FLUSHING SYNCHRONOUSLY AND WHEN ELECTRODE MOVE DOWN, IT STOP FLUSHING.

30. F2 KEY :
SET AT " OFF ":
DURING DOWNWARD SPARKING, PRESS THE " UP " BUTTON ON THE WORKHEAD, SPARKING & PUMP STOP.
DURING UP SPARKING, PRESS THE " DOWN " BUTTON ON THE WORKHEAD, SPARKING & PUMP STOP.
SET AT " ON ":
DURING DOWNWARD SPARKING, PRESS THE " UP " BUTTON ON THE WORKHEAD, SPARKING STOP AND PUMP STILL WORKS.
DURING UP SPARKING, PRESS THE " DOWN " BUTTON ON THE WORKHEAD, SPARKING STOP AND PUMP STILL WORKS.

31. F3 KEY :
FOR SPECIAL FUNCTIONS EXPANDED.

32. F4 KEY :
FOR SPECIAL FUNCTIONS EXPANDED.

33. SPARK INDICATOR :

34. SPARK ON KEY :

35. SPARK OFF KEY :

36. PUMP INDICATOR :

37. PUMP ON KEY :

38. PUMP OFF KEY :

MACHINING PARAMETER : (FROM 39. PEAK CURRENT INDICATOR TO 74. ELECTRODE POLARITY DECREASE KEY).

WITH SANTEC FUZZY LOGIC CONTROL SYSTEM, 12 MACHINING PARAMETERS MAY BE SET AUTOMATICALLY BY INPUT 4 BASIC DATAS : (NO. 86 - NO. 89) PRESS OFF (96. FUZZY) KEY, THE MACHINING PARAMETERS CAN EDITED BY OPERATOR. DURING MACHINING, THE PARAMETER MAY BE ADJUSTED WITHOUT AFFECTING THE MACHINING BUT (96. FUZZY) KEY MUST BE PRESS OFF SO THAT IT CAN BE ADJUSTED.

39. PEAK CURRENT:
LOW VOLTAGE CURRENT. SAME AS (89. PEAK CURRENTS).
PEAK CURRENT & REAL MACHINING, PLEASE REFER TO CHART 1.

42. HIGH VOLTAGE CURRENT: 0 - 6 CODES.
DUAL VOLTAGE CURRENTS (LOW VOLTAGE CURRENTS & HIGH VOLTAGES CURRENTS) BEING SYNCHRONOUSLY DISCHARGES ALLOWS FAST METAL REMOVAL RATE AND UNIFORM SURFACE FINISHING.
CODE 0: 0A
CODE 1: 0.5A CODE 2: 1A CODE 3: 1.5A
CODE 1, 2 & 3: THE HIGH VOLTAGE CURRENT OUTPUT APPEAR ONLY FOR A SHORT TIME (ABOUT 10UμS) AT " ON TIME " PERIOD THEN DISAPPEAR.
CODE 4: 0.5A CODE 5: 1A CODE 6: 1.5A
CODE 4, 5 & 6: THE HIGH VOLTAGE CURRENT OUTPUT APPEAR FOR THE WHOLE " ON TIME " PERIOD.
HIGH VOLTAGE CURRENT & REAL MACHINING, PLEASE REFER TO TABLE 1.
NOTE : SET CODE AT 1, 2 OR 3 : ONLY APPEAR ABOUT 10μS SO THAT THE ELECTRODE WEAR WILL BE LOWER BUT MACHINING SPEED WILL BE A LITTLE SLOW.
SET CODE AT 4, 5 OR 6 : MACHINING SPEED WILL FASTER BUT ELECTRODE WEAR BE HIGHER.

45. ON TIME : 1 - 99 CODES.

48. OFF TIME : 1 - 99 CODES.
ON TIME, OFF TIME SETTING & REAL PULSE, PLEASE REFER TO TABLE 2.
ON TIME, OFF TIME & REAL MACHINING, PLEASE REFER TO CHART 2.

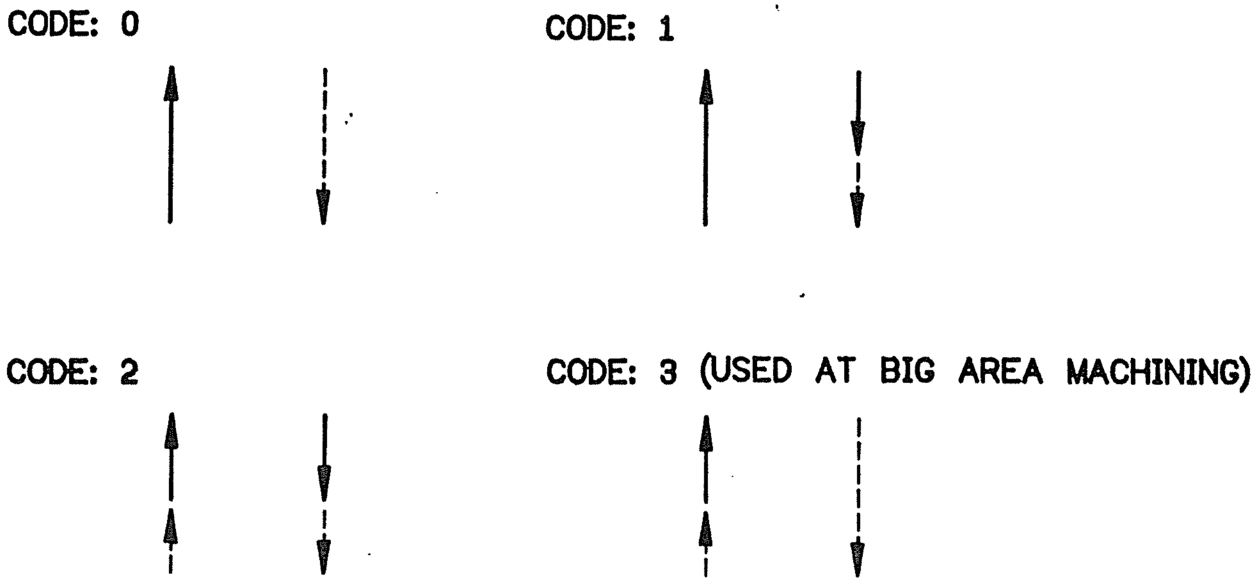
51. SPARKING GAP : 1 - 16 CODES.
NOTE : LARGER SPARK GAP CODE, LARGER GAP VOLTAGE OUTPUT AND MACHINING WILL BE MORE STABLE BUT THE GAP BETWEEN ELECTRODE & WORKPIECE WILL INCREASE.

54. SERVO SENSIVITY: 0 - 15 CODES.

57. FLUSHING HEIGHT: 0 - 99 CODES.
NOTE : LARGER FLUSHING HEIGHT CODE, HIGHER FLUSHING HEIGHT AND MACHINING WILL BE MORE STABLE BUT THE MACHINING SPEED WILL BE SLOW.

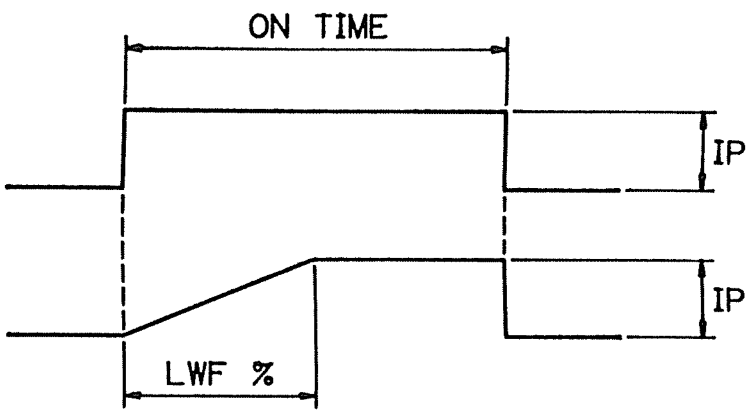
60. WORKING TIME: 1 - 99 CODES.
DURING WORKING TIME, WHENEVER THERE IS ARCING HAPPENING, THE WORKING WILL AUTOMATICALLY PAUSE AND FLUSHING IMMEDIATELY THEN GO ON WORKING.
NOTE : THE REAL WORKING TIME IS THE CODE X 0.1 SEC. FOR EXAMPLE, SET CODE AT 25 AND THE REAL WORKING TIME IS 25 X 0.1 SEC. = 2.5 SEC.

64. FLUSHING TWO SPEED: 0 - 3 CODES.



66. ARC SENSITIVITY: 0 - 9 CODES.
NOTE : LARGER ARC SENSITIVITY CODE, MORE SENSITIVE.

69. LOW WEAR FACTOR:
NOTE : LARGER LOW WEAR FACTOR CODE, LONGER SLANTWISE LINE AND LOWER ELECTRODE WEAR BUT SLOW MACHINING SPEED. SET THIS CODE BIGGER WHEN MACHINING A SHARP CORNER WORKPIECE OR REQUIRE A LOWER ELECTRODE WEAR.
OPPOSITLY, SET THIS CODE SMALLER, SHORTER SLANTWISE LINE AND FASTER MACHINING SPEED BUT WEAR WILL BE HEAVY. WHEN SET AT 0, SAME AS NORMAL SPARKING CIRCUITS.



72. ELECTRODE POLARITY: CODES: +. +1. -. -1

CODE: + : ELECTRODE " + " AND WORKPIECE " - "

CODE: +1: ELECTRODE " + " AND WORKPIECE " - "
AND, DURING SPARKING, THE FUZZY LOGIC CONTROL SYSTEM WILL AUTO SENSOR & AUTO ADJUST THE PARAMETERS.

CODE: - : ELECTRODE " - " AND WORKPIECE " + "

CODE: -1: ELECTRODE " - " AND WORKPIECE " + "
AND, DURING SPARKING, THE FUZZY LOGIC CONTROL SYSTEM WILL AUTO SENSOR & AUTO ADJUST THE PARAMETERS.

75. SAVE KEY :
TO SAVE ALL MACHINING PARAMETERS AFTER EDITING, ADJUSTING UNDER SPECIFIC (92. JOB NO.) & (95. STEP NO.)

76. TEMPORARY CONDITION:
THE MACHINING PARAMETERS CAN BE ADJUSTED BY THE USERS DURING SPARKING.
IF IN THE FUZZY LOGIC CONTROL SYSTEM, THE (96. FUZZY KEY) MUST BE
NOTE : IF THE OPERATOR WANT TO ADJUST THE MACHINING PARAMETERS AND THE (96. FUZZY) KEY MUST BE PRESS OFF.
WHEN (96. FUZZY) KEY IS OFF THEN (76. TEMPORARY CONDITION) WILL ON AND OPERATOR MAY MODIFY THE PARAMETERS. AFTER ADJUSTING THE PARAMETERS, IF PRESS (75. SAVE) KEY THEN THE AFTER ADJUSTING PARAMETERS WILL REPLACE THE STORED PARAMETERS.
IF DON'T PRESS (75. SAVE) KEY AND PRESS (96. FUZZY) KEY OF (77. STORED CONDITION) KEY, IT WILL RETURN TO THE PREVIOUS (96. FUZZY) PARAMETERS AND THE TEMPORARY PARAMETERS DISAPPEAR.

NOTE : TO CLEAR UP ALL THE TEMPORARY PARAMETERS SET BY OPERATOR AND CALL OUT THE STORED FUZZY PARAMETERS, REFER TO THE BELOW STEPS :
(1) PRESS IN ORDER (12. AUX 1), THEN (40. PEAK CURRENT INCREASE KEY), THEN (77. STORED COND.) THEN (75. SAVE). (NO.5 BUZZER) SOUNDS FOR ABOUT 10 SECONDS.
(2) TURN OFF THE POWER.
(3) TURN ON THE POWER AND THEN PRESS (75. SAVE).

77. STORED CONDITION:
THE SPECIFIC CONDITION / MEMORY UNDER (92. JOB NO.) & (95. STEP NO.) SAVED BY USERS.

86. MACHINING MATERIALS:
TOTAL 8 DIFFERENT MATERIALS MACHINING MODES: Cu-St, Cu-Al, Gr-St, Gr-Al, St-St, Cu-Wc, CuW-WC & OTHERS. THE OPERATOR CAN SELECT THE SUITABLE MODE.

87. ELECTRODE REAL MACHINING SIZE:
FROM DIA. 1.00 - DIA. 80MM TOTAL 8 SELECTABLE SIZE FOR MACHINING.

88. ELECTRODE WEAR:
5 SELECTABLE ELECTRODE WEAR RATIO. NORMALLY, ULTRA-LOW WEAR ONLY USED FOR ROUGH MACHINING AND ULTRA-HIGH WEAR ONLY USED AT SUPER FINE FINISHING.

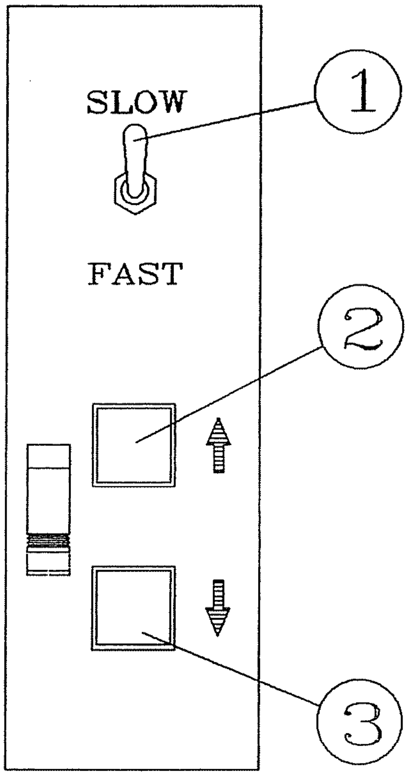
89. PEAK CURRENT:
MAX. 30 SELECTABLE CURRENT STEPS.
POWER SUPPLY AZ50: 0 - 50A: TOTAL 14 CURRENT STEPS SELECABLE.
POWER SUPPLY AZ75: 0 - 75A: TOTAL 18 CURRENT STEPS SELECABLE.
POWER SUPPLY AZ100: 0 - 100A: TOTAL 22 CURRENT STEPS SELECABLE.
POWER SUPPLY AZ150A: 0 - 150A: TOTAL 30 CURRENT STEPS SELECABLE.

92. JOB NO.:
THE MEMORY CAN SAVE TOTAL 50 SETS OF JOBS FROM ROUGH TO FINAL FINISHING AUTOMATICALLY.

95. STEP NO.:
SINGLE STEP, 5 STEPS AND CAN EXPANDED TO 10 STEPS IN FUTURE (OPTION).
FOR SINGLE STEP MACHINING, ONLY SET THE " END " POSITION FROM THE D.R.O. PANEL AND WHEN THE DEPTH REACHED, MACHINING STOP AND SET ANOTHER " END " POSITION TO CONTINUE THE MACHINING.
FOR MULTI STEP MACHINING, SET DIFFERENT DEPTHS FROM THE D.R.O. PANEL AND EDIT MACHINING PARAMETERS FOR STEP. PRESS (9. MULTI STEP) THEN START SPARKING. THE MACHINE MAY AUTO MACHINING FROM ROUGH TO FINAL SURFACE FINISHING.

96. FUZZY KEY:
USING THE FUZZY KEY AND ONLY INPUT 4 DATAS : (NO. 86 - NO. 89.), THE FUZZY SYSTEM WILL AUTOMATICALLY SET THE MOST EFFICIENT & SUITABLE PARAMETERS. PRESS THE FUZZY KEY OFF AND MAY MODIFY THE PARAMETERS.

3.2 MACHINE UNIT SIDE CONTROL PANEL (FOR SED301/SED401)

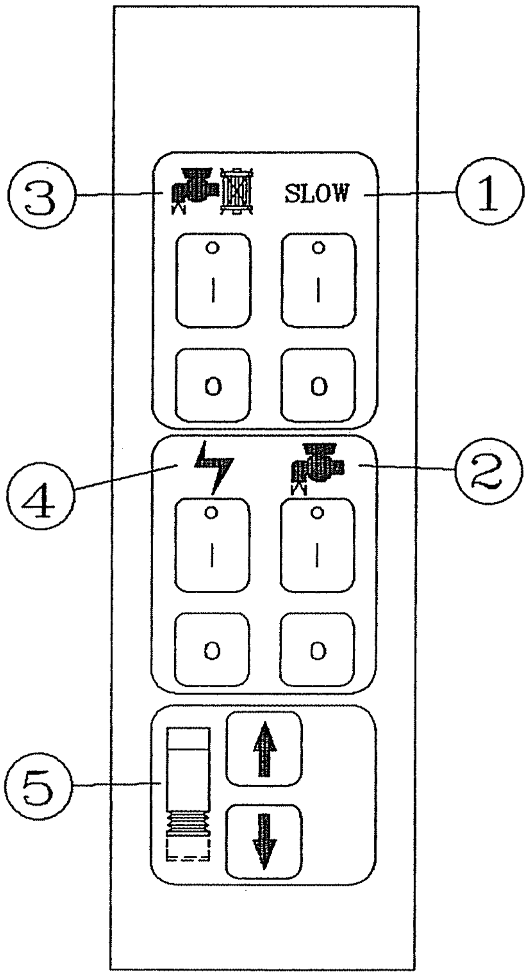


1. PUT SWITCH ON "SLOW " , THE RAM MOVEMENT WILL BE SLOW UP/ DOWN.
   PUT SWITCH ON " FAST " , THE RAM MOVEMENT WILL BE FAST UP/ DOWN.

2. BUTTON SWITCH :
   PRESS THIS BUTTON, THE RAM WILL MOVE UP UNTIL RELEASE THIS BUTTON.

3. BUTTON SWITCH :
   PRESS THIS BUTTON, THE RAM WILL MOVE DOWN UNTIL RELEASE THIS BUTTON.

3.2.1 REMOTE CONTROL OPERATION PANEL (FOR SED501/SED551/SED601)



1. Z AXIS UP/ DOWN SPEED SWITCH:" I " SLOW & " O " FAST.

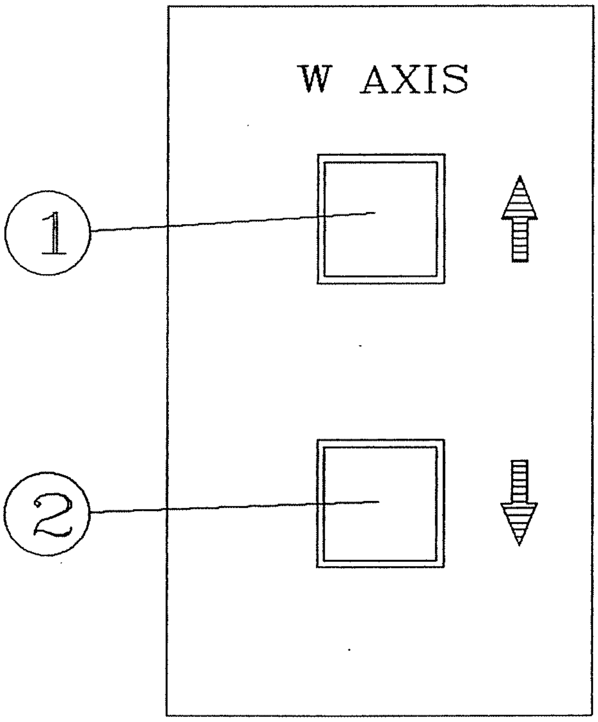
2. DIELECTRIC PUMP (THRU. FILTER): " I " ON & " 0 " OFF.

3. BY-PASS DIELECTRIC PUMP: " I " ON & " 0 " OFF.

4. SPARKING START: " I " ON & " 0 " OFF.

5. Z AXIS " UP/ DOWN ".

3.3 OPERATION PANEL ON COLUMN (FOR SED401/SED501/SED551/SED601)



1.W AXIS " UP " SWITCH.

2.W AXIS " DOWN " SWITCH.

3.4 OPERATION EXAMPLES

3.4.1 AZ SERIES (HEIDENHAIN VRZ670E DRO)

1. FIRST DECIDE THE MACHINING DEPTH:

A. (1) SINGLE STEP MACHINING: INPUT [END] POINT FROM D.R.O. PANEL.

FOR EXAMPLE: SINGLE STEP DEPTH IS 4.3MM - PRESS [END] , INPUT -4.3MM, (ENT) . THE MACHINING DEPTH IS 4.3MM

NOTES: a. [HOME] MUST BE SET HIGHER THAN ZERO POINT. FOR EXAMPLE : 10.00MM. - PRESS [HOME] , INPUT 10.00MM, (ENT) .

b. [⊥1] [⊥2] [↓1] [↓2] , MUST BE SET AT 0.

B. MULTI STEPS MACHINING: (FOR EXAMPLES: 5 STEPS)

(1) FIRSTLY DECIDE THE TOTAL MACHINING DEPTH AND EACH STEP DEPTH.

FOR EXAMPLES, EACH STEP DEPTH ARE: P1: 4.30 MM P2: 0.30MM

P3: 0.25MM P4: 0.10MM & P5: 0.05MM.

(2) KEY-IN: (FROM P5 TO P1)

PRESS [END] , INPUT -5.00MM, (ENT) : TOTAL DEPTH : 5.00MM

PRESS [⊥2] , INPUT 0.05MM, (ENT) : P5 : 0.05MM

PRESS [⊥1] , INPUT 0.15MM, (ENT) : P4 : 0.10MM

NOTES: 0.15MM IS THE DISTANCE FROM " END " TO P4 TOP. THAT IS INCLUDING P5: 0.05MM & P4: 0.10MM.

NEXT, INPUT [HOME] , P1 & P2 :

PRESS [HOME] , INPUT 5.00MM, (ENT) : 5.00MM HIGHER ZERO.

PRESS [↓1] , INPUT -4.30MM, (ENT) : P1: 4.30MM

PRESS [↓2] , INPUT -4.60MM, (ENT) : P2 : 0.30MM

NOTES: a. [↓1] [↓2] VALUE MUST BE " - " .

b. [↓2] IS THE DISTANCE FROM ZERO TO P2 LOWEST POINT.

THAT IS INCLUDING P1: 4.30MM & P2: 0.30MM.

c. P3 : 0.25MM IS BETWEEN [↓2] [⌶1] . THE D.R.O.

COUNTER WILL AUTO CALCUALTE AND NO NEED TO KEY IN.

(3) IF DOING 3 STEPS OR 4 STEPS MACHINING, JUST INPUT P2: 0

P3: 0 OR P4: 0.

NOTES: a. THE D.R.O. COUNTER ONLY SAVE THE LAST SET OF MACHINING DEPTH. SO, MACHINING DIFFERENT JOB MUST KEY IN EACH STEP OF DEPTH.

b. BEFORE START SPARKING, MUST MOVE THE Z SERVO HEAD HIGHER THAN THE [HOME] POINT.

2. EDIT MACHINING PARAMETERS FOR EACH STEP DEPTH :

A. SINGLE STEP MACHINING:

(1) PRESS " EDIT ", DECIDE THE " JOB NO. " & " STEP NO. "

(2) WITH FUZZY LOGIC CONTROL SYTEM TO SET MACHINING PARAMETERS:

INPUT (NO. 86 - NO. 89) DATAS THEN PRESS (75. SAVE) KEY.

THAT IS THE PARAMETERS UNDER THIS " JOB NO. " & " STEP NO. "

ON A NORMAL SUITATION, THE ELECTRODE-WORKPIECE MATERIALS & ELECTRODE SIZE DOESN'T CHANGE AND ELECTRODE WEAR IS SET SET AT 2. SO, ONLY CHANGE THE PEAK CURRENTS FOR EACH STEP OF DEPTH.

(3) UNDER FUZZY SYSTEM, THERE IS A PEAK CURRENT LIMIT AT A FIXED ELECTRODE SIZE. FOR EXAMPLES: (AZ50), SET (87. ELECTRODE REAL MACHINING SIZE) AT 1: PEAK CURRENT LIMIT: 1.5A, SET AT 2: 2A, SET AT 3: 3A, SET AT 4: 6A, SET AT 5: 9A, SET AT 6: 13A, SET AT 7: 28A & SET AT 8: 50A.

(4) OPERATOR SET MACHINING PARAMETERS:

PRESS (96. FUZZY) KEY OFF, INPUT 12 PARAMETERS THEN PRESS (75. SAVE) KEY. THAT IS THE PARAMETERS UNDER THIS " JOB NO. " " STEP NO. "

NORMALLY, WHEN PRESSING (96. FUZZY) KEY OFF, OPERATOR MAY JUST MODIFY SOME OF DATAS IN THE 12 PARAMETERS THEN PRESS (75. SAVE) KEY.

NOTES: WHATEVER THE PARAMETERS EDITED BY FUZZY SYSTEM OR BY OPERATOR, IT'LL BE SAVED AFTER PRESS (75. SAVE) KEY. BUT, (92. JOB NO.) & (95. STEP NO.) & EACH STEP DEPTH MUST BE RECORDED BY OPERATOR SO THAT WHEN MACHINING THE SAME WORKPIECE, IT CALL BE CALL OUT TO MACHINING AND ONLY INPUT AGAIN THE DEPTHS.

B. MULTI STEPS MACHINING: (FOR EXAMPLES: 5 STEPS)

(1) ENSURE P1 - P5 EACH DEPTH ARE SET CORRECTLY.

(2) PRESS " EDIT ", DECIDE " JOB NO. " & " STEP NO. "

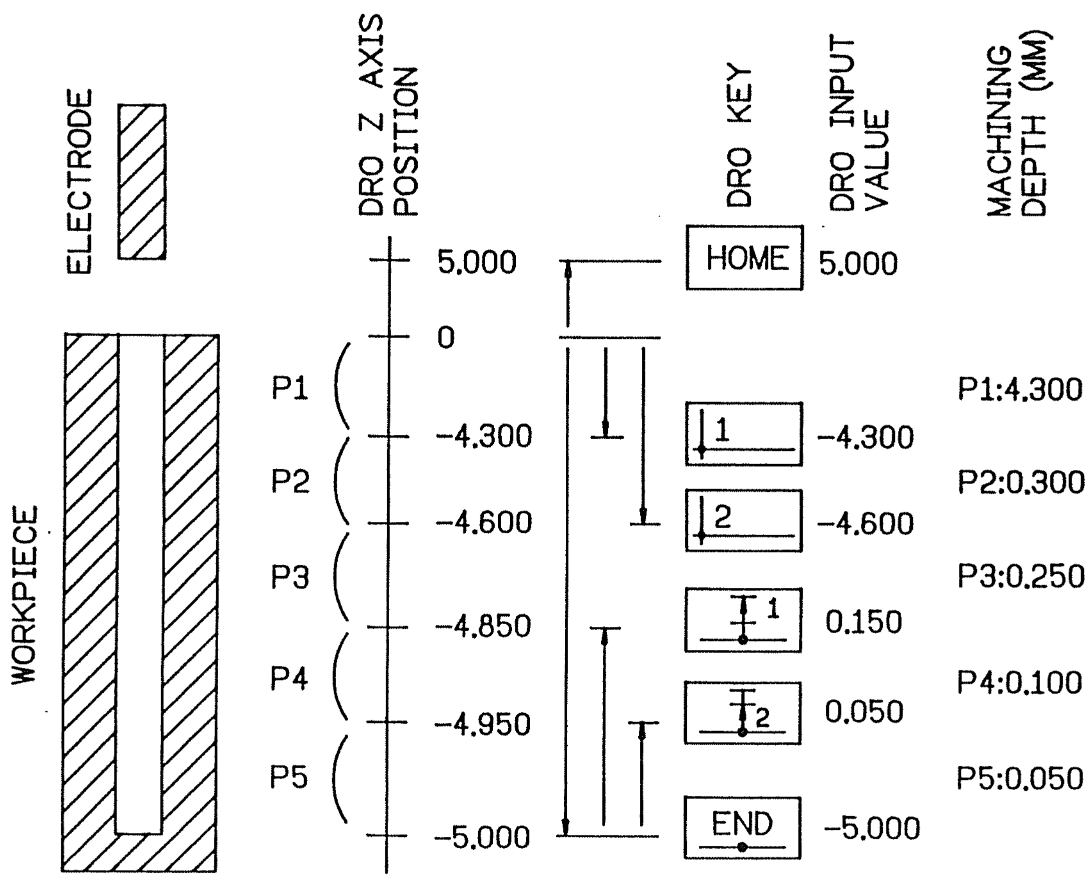
(3) INPUT MACHINING PARAMETERS FOR P1 TO P5: SAME AS THE SINGLE STEP MACHINING.

THE FOLLOWINGS SHOWS THE PROCESS FOR 5 STEPS DEPTH MACHINING SETTING :
(SET THE WORKPIECE SURFACE AT ZERO POINT BY (11. EDGE FINDER))
EXAMPLE TO SET THE DIFFERENT DEPTH FROM D.R.O. PANEL :

1. TOTAL MACHINING DEPTH : 5.00 MM : SET [END] -5.00 MM (END POINT)
2. P5 : FINAL FINISHING DEPTH : 0.05 MM : SET [2] 0.050MM
3. P4 : MEDIUM FINISHING DEPTH : 0.10 MM : SET [1] 0.15 MM
4. P3 : MEDIUM FINISHING DEPTH : 0.25 MM : AUTO CALCULATE BY COUNTER.
5. P2. : ROUGH MACHINING DEPTH : 0.30 MM : SET [2] -4.60 MM
6. P1 : ROUGH MACHINING DEPTH : 4.30 MM : SET [1] -4.30 MM

NOTICE :

1. P5 [2] , P4 [1] VALUES, MUST BE POSITIVE (+)
2. P1 [1] , P2 [2] VALUES, MUST BE NEGATIVE (-)
3. SET [HOME] HIGHER THAN ZERO POINT, FOR EXAMPLES, +5.000



3.4.2 AZR SERIES (FAGOR NV300CB DRO)

1. FIRSTLY DECIDE THE MACHINING DEPTH:

a. SINGLE STEP MACHINING: ONLY INPUT [END] VALUE FROM THE DRO PANEL.

FOR EXAMPLE:
SINGLE STEP DEPTH IS 4.3 MM : PRESS [END] , INPUT -4.3 MM, [ENTER] THEN
THIS MEANS THE MACHINING DEPTH 4.3 MM.

NOTES: (1) [HOME] MUST BE SET HIGHER THAN ZERO. FOR EXAMPLE,
SET 10.00 MM : PRESS [HOME] INPUT 10.0, [ENTER]

(2) P1, P2, P3, P4 VALUE MUST SET AT 0.000 MM. FOR EXAMPLES:

(a) P1 VALUE: PRESS [Pn] [1] INPUT 0.000 [ENTER]

(b) P2 VALYE: PRESS [Pn] [2] INPUT 0.000 [ENTER]

(c) P3 VALUE: PRESS [Pn] [3] INPUT 0.000 [ENTER]

(d) P4 VALUE: PRESS [Pn] [4] INPUT 0.000 [ENTER]

(3) SET THE WORKPIECE SURFACE VALUE AT Z= 0.000 MM.

b. MULTI STEPS MACHINING (REFER TO PAGE 3 - 24 DESCRIPTIONS)
(1) FIRSTLY DECIDE THE TOTAL MACHINING DEPTH & EACH STEP DEPTH.
FOR EXAMPLE : TOTAL DEPTH IS 5.0 MM,
P1 DEPTH : 4.3 MM,
P2 DEPTH : 0.3 MM,
P3 DEPTH : 0.25 MM,
P4 DEPTH : 0.10 MM,
P5 DEPTH : 0.05 MM

(2) KEY IN :
(a) SET HOME VALUE : PRESS [HOME] INPUT 10.000 [ENTER]

(b) SET TOTAL DEPTH : PRESS [END] INPUT -5.000 [ENTER]

(c) SET P1 VALUE : PRESS [Pn] [1] INPUT -4.300 [ENTER]

(d) SET P2 VALUE : PRESS [Pn] [2] INPUT -4.600 [ENTER]

(e) SET P3 VALUE : PRESS [Pn] [3] INPUT -4.850 [ENTER]

(f) SET P4 VALUE : PRESS [Pn] [4] INPUT -4.950 [ENTER]

NOTE :

(1) THE DRO COUNTER ONLY SAVE THE LAST SET OF MACHINING DEPTH. SO, MACHINING DIFFERENT JOB, MUST KEY IN EACH STEP OF DEPTH.

(2) BEFORE START SPARKING, MUST MOVE THE Z SERVO HEAD HIGHER THAN THE VALUE.

(3) SET THE WORKPIECE SURFACE VALUE AT Z = 0.000 MM

2. EDIT MACHINING PARAMETERS FOR EACH STEP DEPTH :

A. SINGLE STEP MACHINING:

(1) PRESS " EDIT ", DECIDE THE " JOB NO. " & " STEP NO. "

(2) WITH FUZZY LOGIC CONTROL SYSTEM TO SET MACHINING PARAMETERS:

INPUT (NO. 86 - NO. 89) DATAS THEN PRESS (75. SAVE) KEY.

THAT IS THE PARAMETERS UNDER THIS " JOB NO. " & " STEP NO. "

ON A NORMAL SUITATION, THE ELECTRODE-WORKPIECE MATERIALS & ELECTRODE SIZE DOESN'T CHANGE AND ELECTRODE WEAR IS SET SET AT 2. SO, ONLY CHANGE THE PEAK CURRENTS FOR EACH STEP OF DEPTH.

(3) UNDER FUZZY SYSTEM, THERE IS A PEAK CURRENT LIMIT AT A FIXED ELECTRODE SIZE. FOR EXAMPLES: (AZ50R), SET (87. ELECTRODE REAL MACHINING SIZE) AT 1: PEAK CURRENT LIMIT: 1.5A, SET AT 2: 2A, SET AT 3: 3A, SET AT 4: 6A, SET AT 5: 9A, SET AT 6: 13A, SET AT 7: 28A & SET AT 8: 50A.

(4) OPERATOR SET MACHINING PARAMETERS:

PRESS (96. FUZZY) KEY OFF, INPUT 12 PARAMETERS THEN PRESS (75. SAVE) KEY. THAT IS THE PARAMETERS UNDER THIS " JOB NO. " " STEP NO. "

NORMALLY, WHEN PRESSING (96. FUZZY) KEY OFF, OPERATOR MAY JUST MODIFY SOME OF DATAS IN THE 12 PARAMETERS THEN PRESS (75. SAVE) KEY.

NOTES: WHATEVER THE PARAMETERS EDITED BY FUZZY SYSTEM OR BY OPERATOR, IT'LL BE SAVED AFTER PRESS (75. SAVE) KEY. BUT, (92. JOB NO.) & (95. STEP NO.) & EACH STEP DEPTH MUST BE RECORDED BY OPERATOR SO THAT WHEN MACHINING THE SAME WORKPIECE, IT CALL BE CALL OUT TO MACHINING AND ONLY INPUT AGAIN THE DEPTHS.

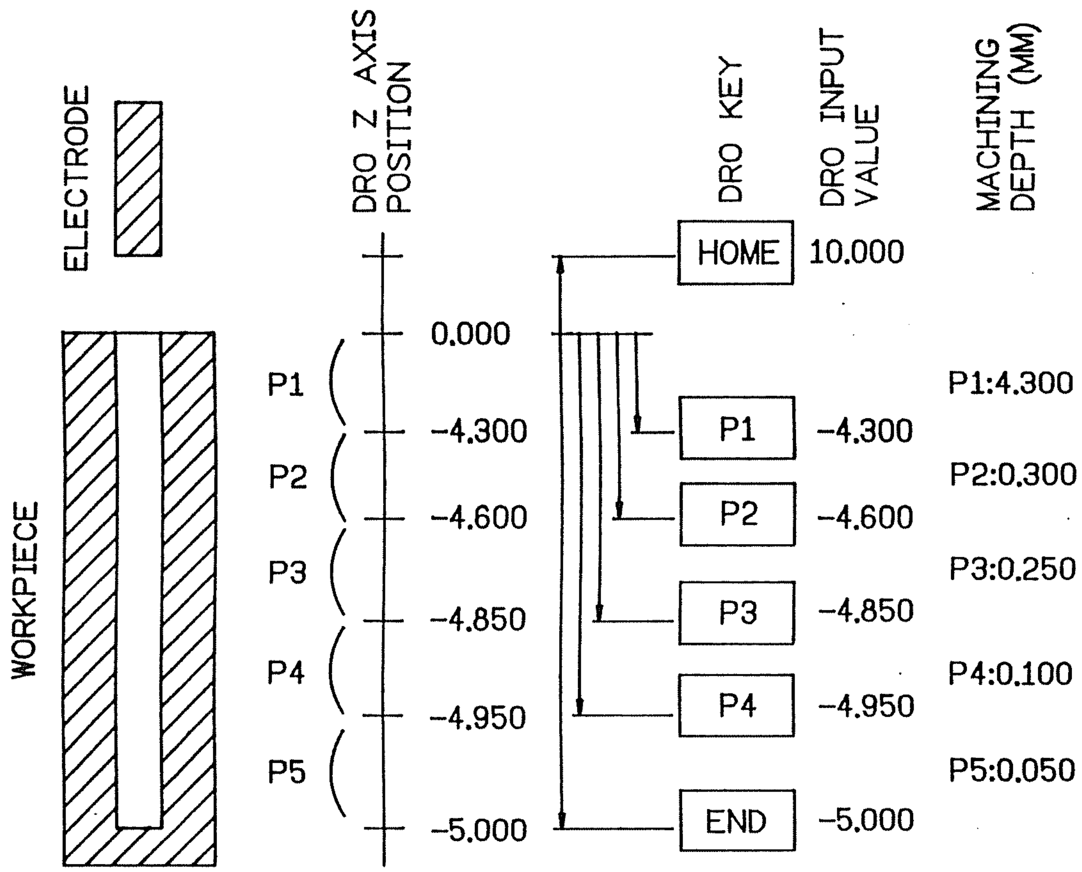
B. MULTI STEPS MACHINING: (FOR EXAMPLES: 5 STEPS)

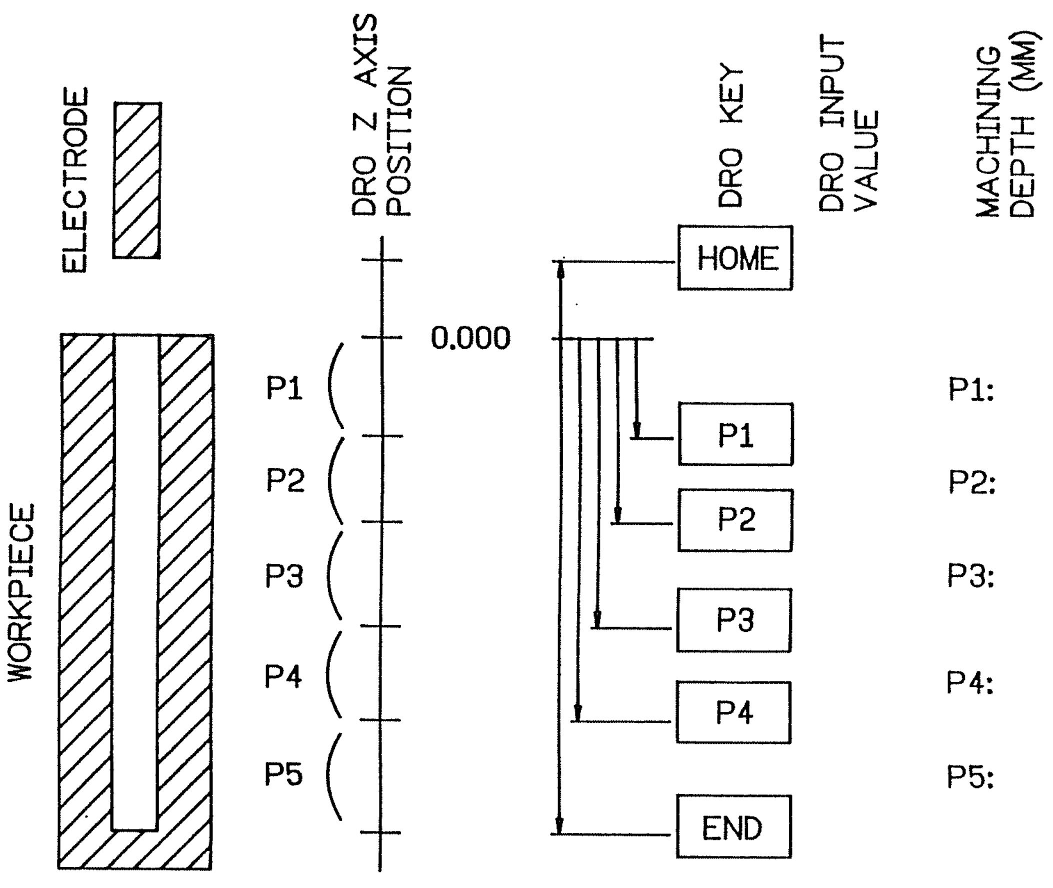
(1) ENSURE P1 - P5 EACH DEPTH ARE SET CORRECTLY.

(2) PRESS " EDIT ", DECIDE " JOB NO. " & " STEP NO. "

(3) INPUT MACHINING PARAMETERS FOR P1 TO P5: SAME AS THE SINGLE STEP MACHINING.

THE FOLLOWINGS SHOWS THE PROCESS FOR 5 STEPS DEPTH MACHINING SETTING :
(SET THE WORKPIECE SURFACE AT ZERO POINT BY (11. EDGE FINDER))
EXAMPLE TO SET THE DIFFERENT DEPTH FROM D.R.O. PANEL :




ELECTRODE
WORKPIECE
DRO Z AXIS POSITION
DRO KEY
DRO INPUT VALUE
MACHINING DEPTH (MM)
HOME
0.000
P1
P2
P3
P4
P5
END
P1:
P2:
P3:
P4:
P5:

3. START MACHINING:

AFTER SETTING ALL THE MACHINING PARAMETERS, MOVE Z AXIS HIGHER THAN " HOME " POINT, ENSURE ALL SAFETY EQUIPMENTS (22. DIELECTRIC LEVEL & TEMPERATURE SENSOR), (23. FALME SENSOR), OR FIRE EXTINGUISHER WORKS NORMALLY. LOCK WORKTANK DOOR, DECIDE (8. SINGLE STEP) OR (9. MULTI STEP) MODES, TURN ON DIELECTRIC PUMP AND THEN START SPARKING.

CHART 1: PEAK CURRENT & REAL MACHINING:

A. LOW SPARKING CURRENT, SLOW MACHINING SPEED. HIGH SPARKING CURRENT, FASTER MACHINING SPEED.

B. USING COPPER AS ELECTRODE, THE WEAR WILL INCREASE ACCORDING TO MACHINING SPEED. BUT IF USING GRAPHITE AS ELECTRODE, THE WEAR IS NOT EXACTLY SAME AS COPPER. AT A CURRENT OUTPUT FIELD, THE WEAR IS NEARLY SAME.

C. THE SURFACE FINISHING & SPARKING GAP DEPENDS ON THE SPARKING CAPACITY.

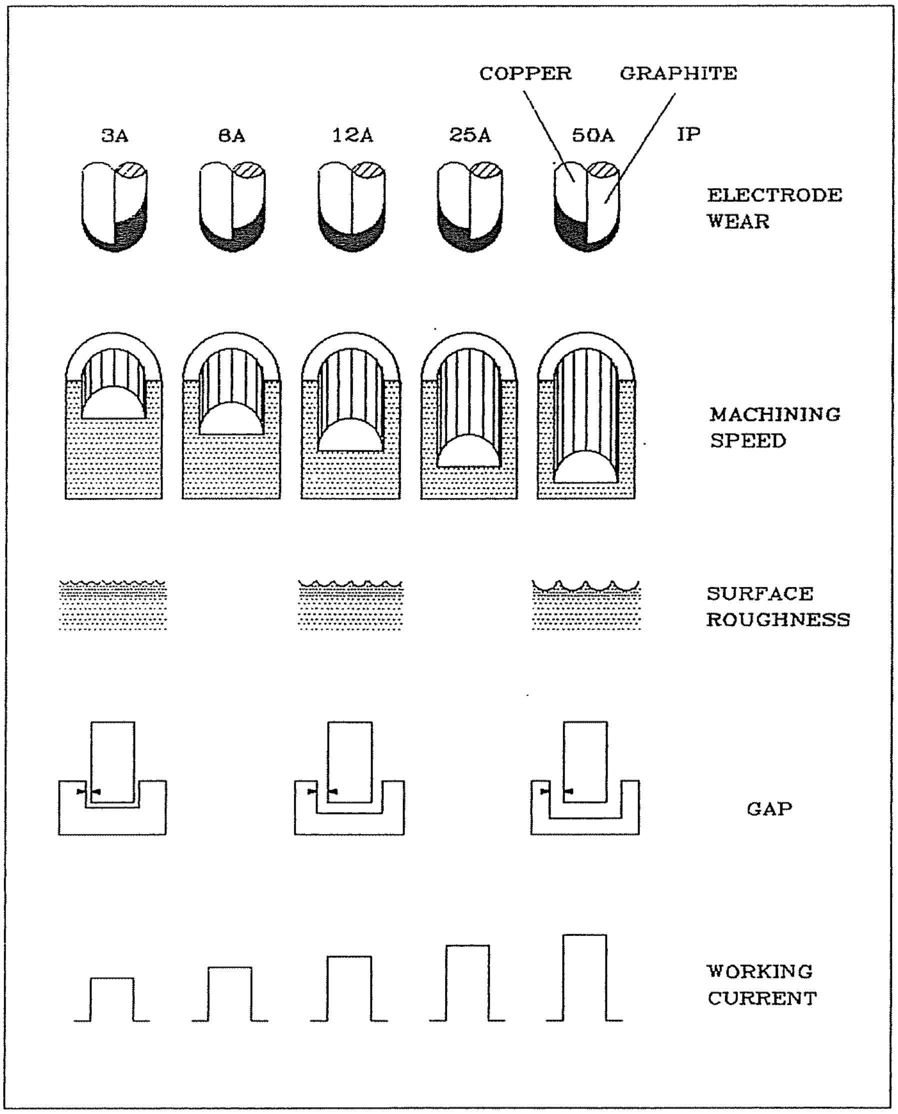


CHART 2: ON TIME & REAL MACHINING:

A. ON TIME & SPARKING CURRENT DECIDE THE SURFACE FINISHING.

B. AT A FIXED SPARKING CURRENT, SHORTER ON TIME, FINER SURFACE FINISHING BUT BIGGER ELECTRODE WEAR. LONGER ON TIME, MORE ROUGH SURFACE FINISHING BUT LOWER WEAR.

C. REQUIRE LOW WEAR MACHINING, THE ON TIME MUST BE AT LEAST 100μS AND MEET WITH SUITABLE MACHINING CURRENTS. LONGER ON TIME THEN CAUSE SLOW MACHINING SPEED AND DAMAGE ELECTRODE EASILY.

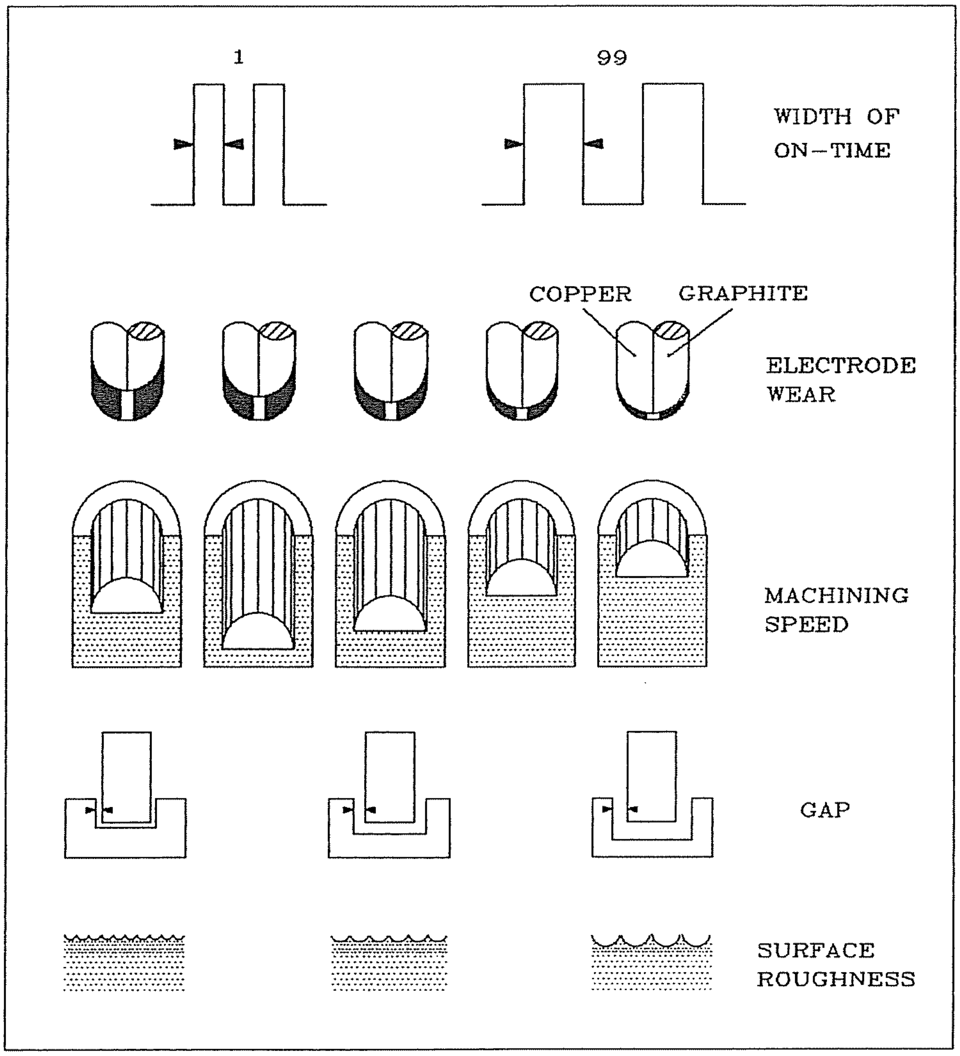


CHART 3: OFF TIME & REAL MACHINING:

A. BETWEEN ON TIME & ON TIME, THERE IS A ISOLATING TIME WHICH WAS CALL " OFF TIME ".

B. SHORTER OFF TIME, THE BIGGER AVERAGE CURRENT OUTPUT, FASTER MACHINING SPEED BUT POOR FLUSHING.
LONGER OFF TIME, THE SMALLER AVERAGE CURRENT OUTPUT, SLOW MACHINING SPEED BUT GOOD FLUSHING.

C. THE EACH SPARKING CURRENT OUTPUT IS SAME SO THAT IT DOESN'T AFFECT THE SURFACE FINISHING BUT IT'S IMPORTANT TO THE MACHINING SPEED.

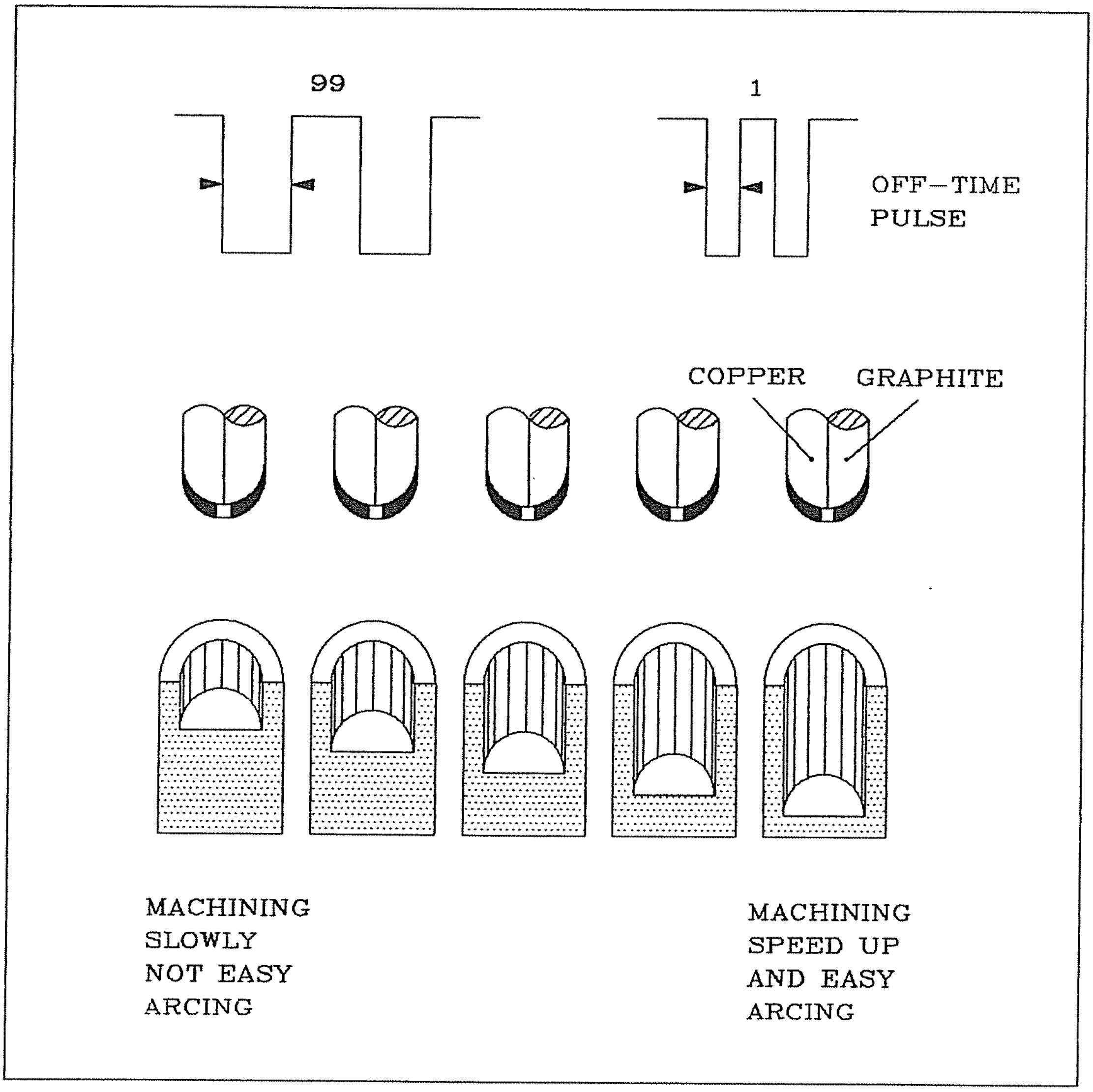


TABLE 1: HIGH VOLTAGE CURRENT SETTINGS & VOLTAGE OUTPUT, CURRENT OUTPUT :

HIGH VOLTAGE CURRENT SETTING VALUE	VOLTAGE OUTPUT	CURRENT OUTPUT
0	0	0
1	170V	0.5A
2	190V	1A
3	205V	1.5A
4	170V	0.5A
5	190V	1A
6	205V	1.5A

TABLE 2 : ON TIME, OFF TIME SETTING AND REAL PULSE TIME

SETTING VALUE	T-ON (u S)	T- OFF (u S)	SETTING VALUE	T-ON (u S)	T-OFF (u S)	SETTING VALUE	T-ON (u S)	T-OFF (u S)
1	1.5	4.5	35	65	68	69	690	690
2	2	5	36	69	72	70	740	740
3	2.5	5.5	37	74	77	71	790	790
4	3	6	38	79	82	72	840	840
5	3.5	6.5	39	86	89	73	900	900
6	4	7	40	93	96	74	960	960
7	4.5	7.5	41	100	103	75	1030	1030
8	5	8	42	107	110	76	1100	1100
9	5.5	8.5	43	114	117	77	1180	1180
10	6	9	44	121	124	78	1260	1260
11	7	10	45	129	132	79	1350	1350
12	8	11	46	135	138	80	1450	1450
13	9	12	47	145	148	81	1550	1550
14	10	13	48	155	158	82	1660	1660
15	11	14	49	165	168	83	1770	1770
16	13	16	50	180	183	84	1900	1900
17	15	18	51	195	198	85	2030	2030
18	17	20	52	210	210	86	2170	2170
19	19	22	53	225	225	87	2330	2330
20	21	24	54	240	240	88	2490	2490
21	23	26	55	256	256	89	2660	2660
22	25	28	56	275	275	90	2850	2850
23	27	30	57	295	295	91	3050	3050
24	29	32	58	315	315	92	3250	3250
25	31	34	59	335	335	93	3500	3500
26	34	37	60	360	360	94	3750	3750
27	37	40	61	385	385	95	4000	4000
28	40	43	62	410	410	96	4500	4500
29	43	46	63	440	440	97	5000	5000
30	46	49	64	475	475	98	5500	5500
31	49	52	65	512	512	99	6000	6000
32	53	55	66	550	550			
33	57	60	67	590	590			
34	61	64	68	640	640			

TABLE 3 : SPARKING GAP & REAL GAP VOLTAGE

SPARKING GAP VALUE	VOLTAGE WHEN SETTING HIGH VOLTAGE CURRENT 1-6	VOLTAGE WHEN SETTING HIGH VOLTAGE CURRENT 0
1	30V	30V
2	35V	35V
3	40V	38V
4	50V	40V
5	55V	45V
6	62V	50V
7	70V	52V
8	75V	58V
9	85V	62V
10	92V	65V
11	100V	70V
12	105V	75V
13	110V	78V
14	120V	80V
15	125V	85V
16	130V	90V

CHAPTER 4

FLUSHING

Flushing, i.e., the correct circulation of dielectric fluid between electrode and workpiece, is a very important factor in EDM. Suitable flushing conditions are essential to obtain the highest efficiency. Lately, important changes have been operated on the servomechanisms of our machines. These modifications facilitate flushing and enable to machine without big problem the most complicated shapes. Let us analyze what happens in the gap when machining without flushing: To start with, the dielectric fluid is clean, i.e., free from eroded particles and carbon residues resulting from dielectric "cracking". Since the insulation strength of a clean dielectric is higher than that of a dielectric containing particles, there is a delay before this insulation is broken down and the first discharge occurs. Particles created by the first discharges (Fig.4-1) act as "stepping-stones" in the gap, reducing the dielectric strength so that discharges can develop more easily. (Fig. 4-2)

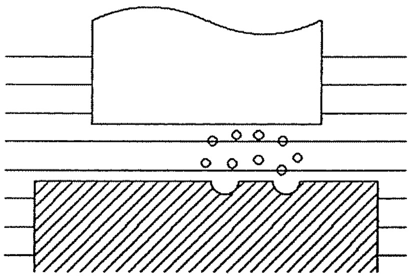


FIG. 4-1

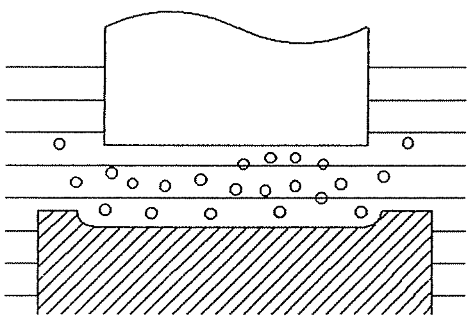


FIG. 4-2

However, if the density of particles becomes too high at certain points in the gap (Fig. 4-3), "bridges" are formed which create a conductive path, resulting in the ignition of abnormal discharges. These can then cause damage to the workpiece and electrode. This build-up of particles must be eliminated by flushing, i.e., by circulation of dielectric fluid in the gap.

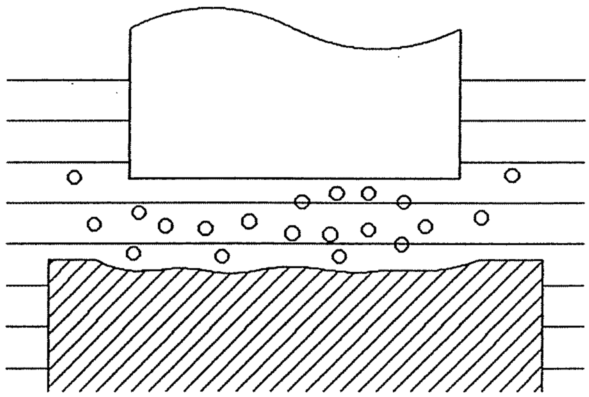


FIG. 4-3

This flushing is as important in EDM as the electrical parameters. It must be adjusted carefully to give the degree of contamination in the dielectric which produces optimum results. Different methods of flushing are employed according to the problem to be solved. All the flushing methods described below can be used with JOEMARS machines.

4.1 INJECTION FLUSHING

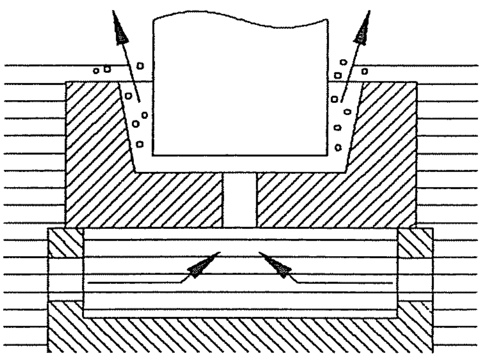


FIG. 4-4A

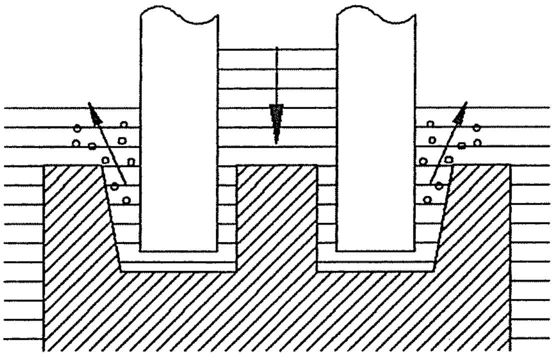


FIG. 4-4B

In this flushing method, the dielectric fluid is injected, either through the workpiece via a pot, or through the electrode. In the first case (Fig. 4-4a), the workpiece is drilled and mounted on a pot connected to the flushing supply. In the second case (Fig. 4-4b), the electrode is drilled and the dielectric fluid is fed through it, either directly or via the electrode holder cap. Components machined using injection flushing are always slightly tapered, even when using an electrode with a constant profile. This taper effect is due to particles being forced up the sides of the electrode, producing lateral discharges. As a result, this flushing method is often used when machining press tools, where a slight taper clearance is required.The press tool must, of course, be machined on the reverse side so that taper is obtained in the right sense. An excellent flushing effect can be obtained when machining deep through holes with graphite electrodes. Using a recently developed technique, high pressure dielectric is introduced into the electrode. The porosity of the graphite allows sufficient dielectric to pass through the electrode and flush the working gap (Fig.4-5). An I.B.M. patent on this flushing method is registered in the U.S.A.

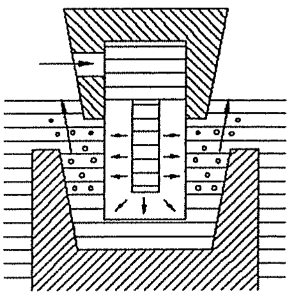


FIG. 4-5

4.2 SUCTION FLUSHING (Fig.4-6)

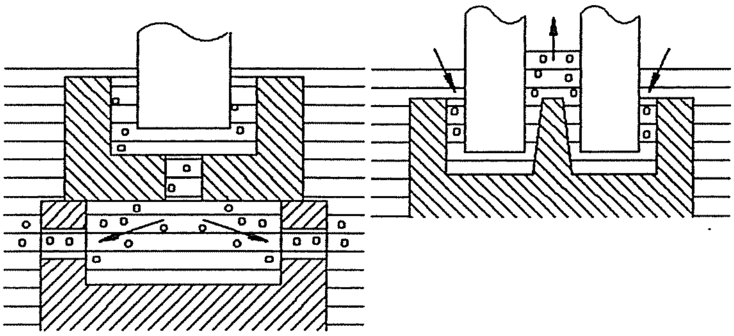


FIG. 4-6

With this flushing method the fluid is sucked, either through the workpiece via the pot, or throuth the electrode. Compared with injection flushing, suction avoids the taper effect due to sparking via particles along the sides of the electrode. The hole obtained is thus practically cylindrical but, as will be seen later, additional precautions must be taken. The suction vacuum cannot exceed 0.8 to 0.9 kg/cm2 and in certain applications suction can be replaced by injection which, of course, can exceed this pressure (Fig4-7). Suction flushing through the electrode, rather than through the workpiece, gives faster machining.

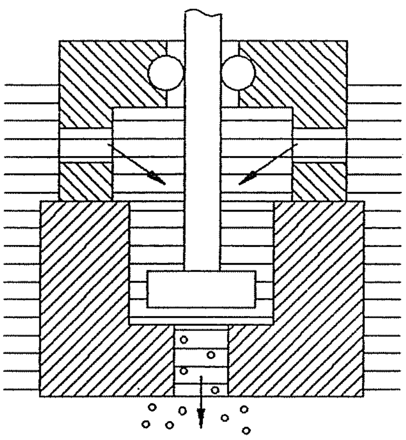


FIG. 4-7

4.3 SIDE FLUSHING

This method has to be used when it is impossible to drill one or more flushing holes either through the electrode or the workpiece. This is the case when machining coining dies or deep narrow slots, as in plastic moulds. To carry out side flushing it is necessary to use nozzles which are carefully adjusted so that the whole working surface of the electrode is flushed evenly. This technique is always combined with pulsation of the electrode to assist the flushing action. When machining a flat surface (Fig.4-8), the direction of the flushing must coincide with the form, special nozzles having the die profile must be used.

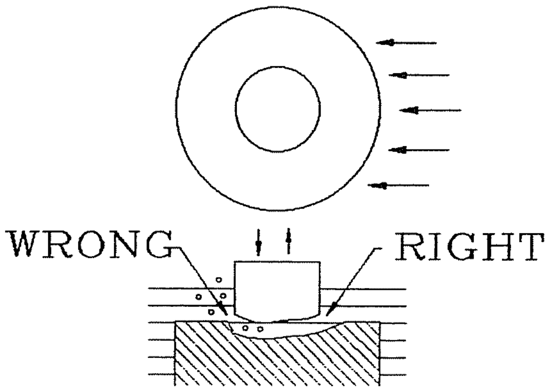


FIG. 4－8

When the direction of flushing is not parallel to the side of the electrode (Fig.4-9a), turbulence can result and only a small quantity of dielectric enters the gap, producing poor flushing.

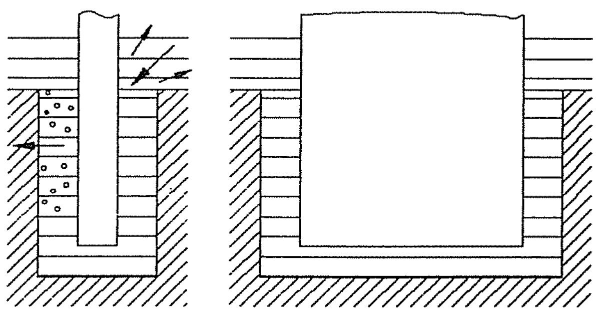


FIG. 4－9A

On the other hand, if flushing is well-directed (Fig. 4-9b), most of the dielectric enters the gap.

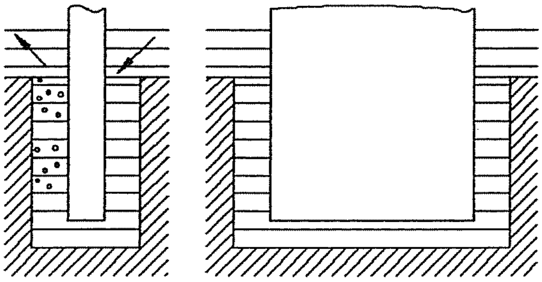


FIG. 4—9B

Side flushing must never be directed simultaneously from both sides of the electrode (Fig. 4-9c), since the two flows will tend to cancel each other out at the bottom of the cavity and particles are not flushed away.

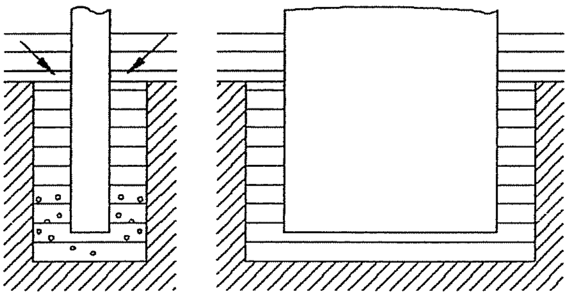


FIG. 4—9C

When machining rectangular slots, the dielectric flow must be applied to the longest side of the electrode so that it is directed into the bottom of the cavity. (Fig.4-9d)

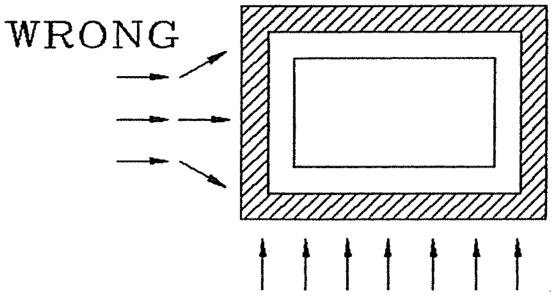


FIG. 4-9D

4.4 FLUSHING BY DIELECTRIC "PUMPING"

Flushing is obtained by using the electrode pulsation movement. When the electrode is raised, the gap increased, resulting in clean dielectric being sucked in, to mix with the contaminated fluid. A the electrode is lowered, the particles are flushed out. (Fig. 4-10).

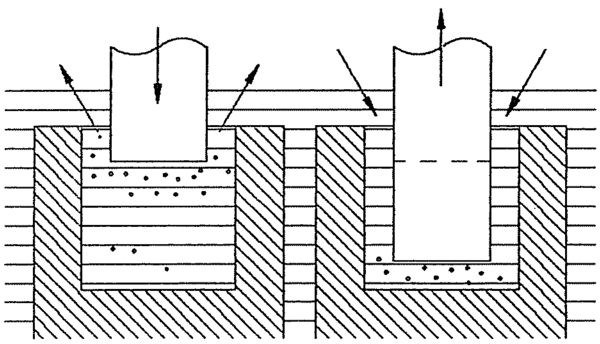


FIG. 4-10

This method is very useful for work on deep holes, since they can be machined without pressure flushing.

4.5 PULSED FLUSHING SYNCHRONIZED WITH ELECTRODE MOVEMENT

When machining with metallic electrodes it can be seen that there is abnormal wear of the electrode in the injection zone and that this wear increases with flushing pressure. (Fig.4-11)

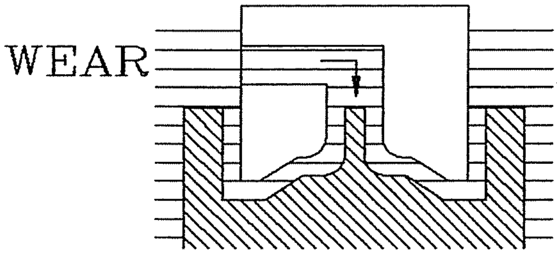


FIG. 4-11

To prevent this occurrence we have developed a method of dielectric injection which is synchronized with upward movement of the electrode. This means that dielectric fluid under pressure flushes the gap only during the time the electrode is raised. i.e., when there is no machining. (Fig.4-12)

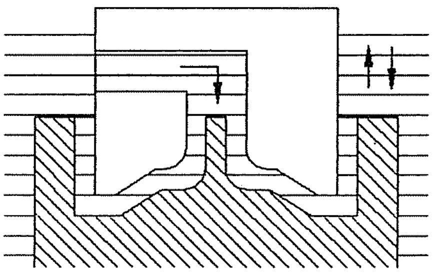


FIG. 4-12

4.6 FLUSHING TECHNIQUES

We have the various flushing methods at the users' disposal. For some applications, they can be combined. We shall now give some practical examples of the use of the various flushing systems. We cannot hope to describe every possible solution, but we hope this will help users to solve their own particular problems.

4.6.1 Flushing pressure

The flushing pressure is measured on the gauges fixed to the work tank.

- Machining with metallic electrodes: for both injection and suction flushing, the pressure must be kept as low as possible to reduce wear.

- Machining with graphite electrodes: the injection or suction pressure is not critical in determining electrode wear.

4.6.2 Gas problem

An accumulation of gas in the infection pot during machining can cause explosions which will shift the workpiece, if certain precautions are not taken. It is important to avoid the formation of an explosive mixture, i.e., gas and air. Thus, before starting to machine,
it must be ensured that the injection pot is full of dielectric and that the dielectric level in the reservoir is high enough to prevent the pump from sucking air. To reduce the gas volume which can accumulate in the post, the suction connection must be made to the pot at the highest possible point. As (Fig. 4-13) shows, suction occurs evenly around the electrode and is therefore more regular and more efficient.

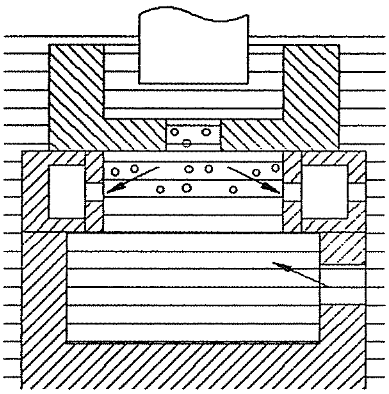


FIG. 4－13

When machining with a concave electrode gas can accumulate in the hollow part of the electrode and a hole should be drilled upwards to ensure evacuation of the gas either by free exhaust or by suction. (Fig.4-14)

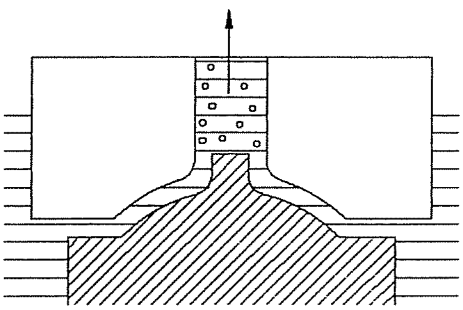


FIG. 4－14

When machining forms of large plan area using suction flushing, it is recommended that a hole is drilled with a conical seat, into which a steel ball can be fitted. The ball will act as a check valve, allowing the gas to escape without reducing the suction effect. (Fig.4-15)

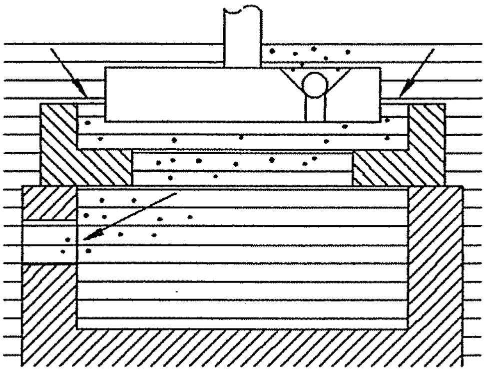


FIG. 4-15

4.6.3 Use of "washer" electrodes

As we saw in paragraph 4-2, suction flushing is preferable for cylindrical through-hole machining. However, two precautions must be taken :

(1)." Washer " electrodes must be used so that their total length goes through the workpiece.

(2). At the exit of the machined hole on the lower side of the work piece, it will be found that, over a distance of a few tenths of a millimeter, the spark gap is slightly smaller than quoted in the workpiece, either a 1 mm thick plate of same material can be inserted between the part and the pot, or the part can be made 1 mm thicker than required and this additional thickness removed later by grinding. (Fig.4-16)

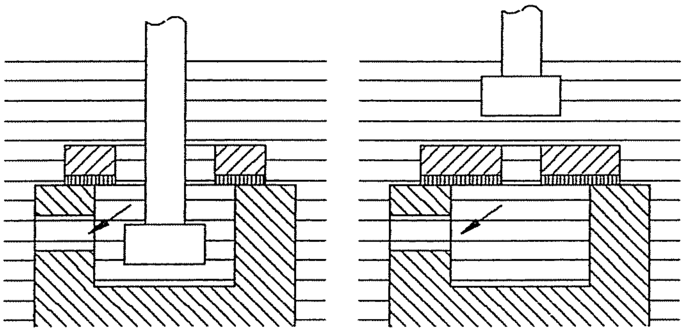


FIG. 4-16

4.6.4 Examples of side flushing

a) A narrow slot is machined between the electrode and its support. The dielectric flows readily down one side of the electrode. (Fig.4-17a)
b) A flat nozzle directs the dielectric to the side of the electrode above the lowest part of the electrode holder, thus preventing side movement of the electrode. (Fig. 4-17b)

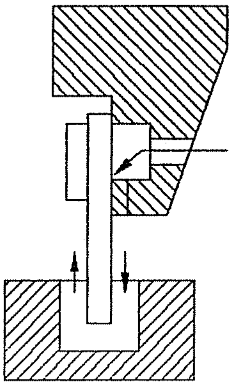


FIG. 4-17A

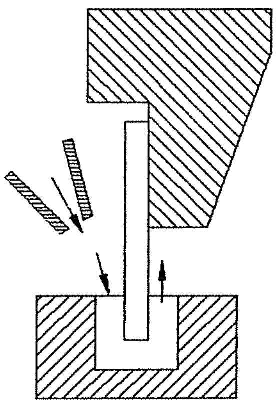


FIG. 4-17B

When machining thin complex forms as in aluminum extrusion dies, it is often difficult to drill holes in the dies, since they are al- ready in the hardened state.
An excellent flushing device can be constructed as follows (Fig. 4-18)

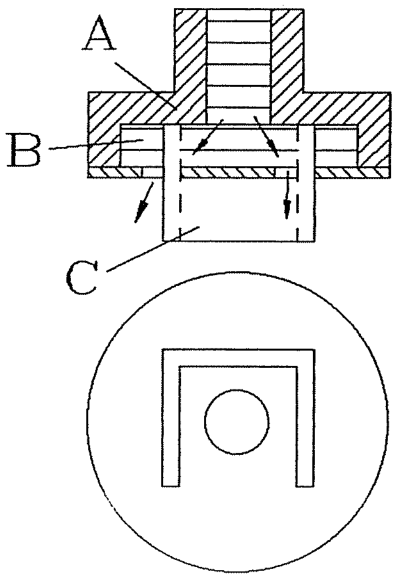


FIG. 4-18

- The electrode (C) is fixed to the bottom of chamber B.
- An aluminum plate approximately 2 mm thick is spark eroded using the electrode. After displacement of the table in two directions X Y (about 0.5 mm), this plate is again machined in order to enlarge the hole.
- The aluminum plate is than passed over the electrode and fixed to the underside of the electrode holder, taking care that the flushing slots formed by the gap between the enlarged hole and the electrode allow flushing down on one side only to avoid opposite flushing as shown of Fig. 4-9c.

The machining of the aluminum plate takes only a few minutes, but the gain in machining time for the die is considerable.

4.6.5 Cross-flow flushing

This flushing technique is very effective when it is difficult to drill flushing holes, provided the electrodes are rigid enough. It would have been impossible to undertake certain production operations by EDM without using this system. (Fig. 4-19)

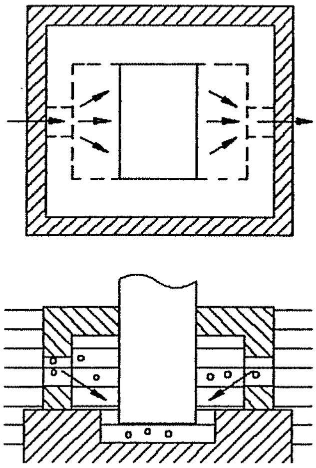


FIG. 4-19

4.6.6 Combined flushing

Here both suction and injection flushing are combined. This technique is often used when machining Molds or dies of couple forms. It allows the gas and particles, which accumulate in the convex parts of the workpiece, to be evacuated and ensures good circulation of the dielectric over the whole machining area. (Fig.4-20)

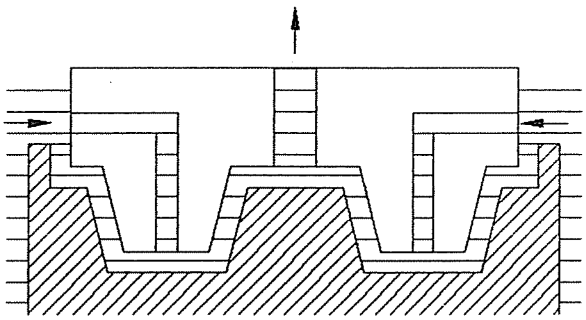


FIG. 4-20

4.6.7 Flushing when machining "open-sided" cavities or holes

To avoid dielectric escaping through the open side, a piece of aluminum for example (a) can be fixed to the side and machined at the same time as the workpiece (Fig. 4-21). As a result, the flushing pressure is improved and machining can take place under good flushing conditions.

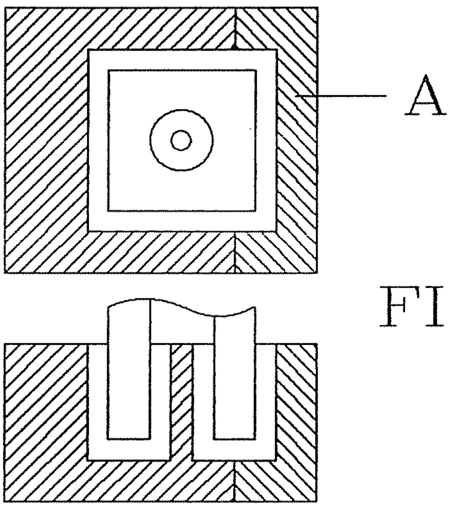


FIG. 4-21

CHAPTER 5

THE ELECTRODE MATERIAL

In the manufacture of a tool using EDM, the electrode cost can represent more than 50% of the total machining cost. Therefore, it is important to consider with great care the electrode materials to be used, the number of electrodes required and the method of their manufacture.
Theoretically, any material which is a good electrical conductor can be used with more or less advantage. Materials with the highest melting point and the lowest electrical receptivity are in theory the best. Electrode materials can be divided in three groups:

a) Metallic materials :
 electrolytic copper
 copper tungsten
 silver tungsten
 aluminum alloy
 brass
 tungsten
 steel

b) Non-metallic materials :
 graphite

c) Combination of metallic and nonmetallic materials :
 copper graphite

Information is given below on the most widely-used electrode materials.

5.1 Metallic electrodes

Immersed in rubbing alcohol. The absence of oxygen during cooling will avoid the formation of oxide and the electrode surface will remain absolutely clean.

5.2 Electrode reduction by acid etching

Copper electrode reduction by acid is an economical way of producing electrodes of different dimensions, needed for roughing, semi-finishing or even, in certain cases, finishing.
The method consists of immersing the electrode in an acid solution for a pre-determined time, the parts not to be etched have been previously or even, in certain cases, finishing.
The method consists of immersing the electrode in an acid solution for a predetermined time, the parts not to be etched have been previously protected with masking tape. The higher the concentration of the acid solution, the faster is the etching, especially at corners where it will be accentuated. (Fig. 5-1)

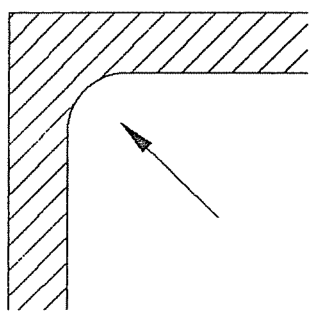


Fig. 5-1

This rapid attack on corners, which can be ignored for roughing electrodes, is serious in relation to finishing electrodes and, for this reason, use of a weak solution is recommended.
The etching rate is increased by the solution temperature being raised. Two commonly-used solutions are given below:

Solution 1

Nitric acid at 65% (density 1.4) : 400 cm^3
Phosphoric acid at 85% (density 1.7) : 70 cm^3
Distilled water : 400 cm^3

At a temperature of 40℃ (104℉), the diametrical reduction of the electrode is 0.04 mm per minute. The purpose of the phosphoric acid is to increase the life of the solution.

Solution 2

Nitric acid at 65% (density 1.4) : 400 cm^3
Distilled water : 400 cm^3
At a temperature of 40℃ (104℉), the diametrical reduction is approximately the same as for solution 1.

Important notes

(1). Carefully remove any grease from the parts to be etched.
(2). If the etching must be uniform and precise, it must not exceed 0.05 mm per side. Furthermore, the solution must be very diluted (acid 10 to 20%) to avoid corner attack.
(3). When preparing the solution, never pour water into acid, but acid into water.
(4). Etching must be carried out in a suitable room, well away from machine-tools.
(5). Before handling an electrode taken from the solution, wash it carefully with water.
(6). Avoid breathing vapors given off during the etching operation.
(7). If acid splashes on to the skin, wash it off immediately with water.
(8). Wear protective glasses.

5.3 Copper tungsten

This pseudo-alloy, having an isotropic structure, is, as its name implies, produced by combining tungsten and copper.

5.4 Electrolytic copper

Density : 8.9 g/cm^3
Melting point :1,083℃ (1,981℉)
Electrical resistivity :0.0167 Ω mm /m

5.5 Electrode stamping and coining

Electrolytic copper is very suitable for forming by stamping or coining. The two methods are:
1. Stamping
It is effected with the copper heated to 880℃ (1,616℉). Two or three operations in a hammer press are normally sufficient to manufacture an electrode.

Between each operation, annealing is Between each operation, annealing is necessary, and the last press operation must be made with the metal cold to correct for any shrinkage during cooling.

2. Coining

It is effected on cold copper in a hydraulic press. This method is more precise than stamping and is suitable for manufacture of electrodes with fine detail (medals for example). Some users employ up to twelve press operations with an annealing operation between each one.

5.6 Electrode manufacture by traditional machining methods

Electrolytic copper can be machined easily by turning or milling. To avoid tool drag, lubrication with a 50% fat oil and 50% petroleum mixture or a special lubricant is necessary. Electrolytic copper can also be ground using grinding wheels with the following specification:

Abrasive : Carborundum
Grain : 46 to 80 according to required finish
Structure : hardness H-K
porosity 13-15
Peripheral speed of the grinding wheel : 30 m/sec.
A good flushing and/or an impregnation of the wheel are necessary.

5.7 Electrode manufacture by extrusion or drawing

This method is used principally for large-scale production or constant profile electrodes. Tubular electrodes of round section or of special section or of special shape are often produced by extrusion.

5.8 Electrode manufacture by metallize

This process was used some years ago to manufacture three dimensional electrodes. Melted copper wire is sprayed into a metal mold using a special gun, thus "deposition" the electrode shape required. The electrodes produced by this process are very porous and chemical etching to adjust the electrode size cannot be used. Furthermore, the electrode wear is very high. Therefore, we do not recommend their use.

5.9 Annealing of copper electrodes

Before each forming operation with a press, the electrodes must be annealed to make them more male able. Certain precautions must be taken to prevent oxide forming on the surface of the copper. The following process can be used:
The electrode, having been heated to 500° -600℃ (932-1100°F), is quickly The proportions of the two materials can very. Usually, the tungsten content is between 50% and 80% and the copper 50% to 20%. An alloy with high percentage of tungsten will be more difficult to machine conventionally than an alloy with a lower percentage. However, it will have a lower EDM wear as an electrode. Mechanical and electrical characteristics:

Electrical resistivity : 0.045 to 0.055 Ω mm /m
Brinell hardness : 85-240 kg/mm^2
Density : 15- 18 g/cm^3

5.10 Electrode manufacture in Cuw by traditional methods

Turning

TOOL	CARBIDE	TOOL STEEL
CUTTING SPEED	60 TO 100 M/MIN.	12 TO 20 M/MIN.
NEGATIVE RAKE ANGLE	6 TO 8 DEGREE	8 TO 10 DEGREE
RELIEF	4 TO 6 DEGREE	4 TO 6 DEGREE

Grinding

Abrasive : green Carborundum
Grain : 60
Hardness : J
Structure (porosity) : 8

5.11 Advantages and disadvantages

On the whole, copper tungsten can be machined easily and are favored for their mechanical stability. Their rigidity is excellent, no deformation occurs during machining, and when ground, a good surface finish can be obtained. Consequently, they are widely-used in the manufacture of high precision electrodes. However, copper tungsten are expensive and they cannot be either cast or forged.

5.12 Applications

Copper tungsten are used mainly for the following EDM application : machining of tungsten carbide

- deep hole machining
- precision machining with fine detail
- machining of sharp corners
- large quantity machining of fine, small parts

5.13 Behavior in EDM

The table below gives indications on the EDM behavior of the common Copper tungsten compared with electrolytic copper.

	SETTINGS	STEEL MACHINING	CARBIDE MACHINING
MATERIAL REMOVAL	ROUGHING FINISHING FINISHING	20-40 % < Cu 10-20 % < Cu SAME AS Cu	SAME AS Cu SAME AS Cu SAME AS Cu
VOLUMETRIC AND LINEAR WEAR	ROUGH. AND FIN. FINISHING	3 TO 5 * < Cu 3 TO 5 * < Cu	3 TO 4 * < Cu 3 TO 4 * < Cu
MEAN AND LIMIT SPARKING DISTANCE	ROUGH. AND FIN.	SAME AS Cu	SAME AS Cu
SURFACE FINISH AT SAME SETTINGS	ROUGH. AND FIN. ROUGH. AND FIN.	SAME AS Cu	SAME AS Cu

5.14 Acid reduction of copper tungsten (UGINE-CARBONE process)

Acid composition
50% hydrofluoric acid at concentration 40%
40% nitric acid at concentration 62%
10% distilled water
Use polyethylene containers and hold the electrode with a polyethylene holder.

Working temperature
Ambient. Place the container in a water bath to avoid excessive heating, which can cause a considerable increase in the etching speed.

Process
Immerse the electrode to be etched and agitate. Interrupt the process every 30 seconds to 1 minute, wash and brush with a bronze wire brush. To remove a thickness of about 0.05 mm, the total etching time is approximately 4 to 6 minutes. If necessary after etching, polish the electrode gently with abrasive paste. The evenness of the etching is influenced by the geometrical shape and surface finish of the electrode. The geometrical shape has an effect since edges are more heavily etched than hollow parts. This disadvantage can be off-set by etching in several short operations, also by agitating and brushing the electrode. Surface finish influences attacking speed since a rough surface favors a quick attack. Tests have shown that electrodes suffered almost twice the attack on milled areas than on ground parts.
Note : The same precautions as for acid reduction of copper electrodes should be taken.

5.15 Silver tungsten

This material has very similar characteristics to those of the copper tungsten. It is commonly used in some countries, but is very costly and shows few advantages. As a result, we have not undertaken any exhaustive technological tests.

5.16 Brass

In practice, brass is not used as an electrode material on our machines, because of its high wear rate. However, good performance is obtained performance is obtained with it when machining certain Titanium alloys.

5.17 Tungsten

Is principally reserved for micro-hole machining. Tungsten wire with tolerances better than 0.01 mm is available on the market.

5.18 Steel

Steel can be used as an electrode material. However, its efficiency is lower than that of copper or graphite. The most important EDM application of steel on steel is the machining of split lines for plastic moulds and die-casting dies. In these cases, the upper part of the mold or die is used as the electrode.

5.19 NON-METALLIC ELECTRODES

5.19.1 Graphite

Since the introduction of pulse generators, graphite has become the most important material in EDM for electrode manufacture. A wide range of graphite of various qualities is offered on the market.

5.19.2 Mechanical and electrical characteristics

Electrical resistivity	: 8 - 15 Ω mm^2/m
Density	: 1.6 to 1.85 g/cm^3
Boiling point	: 3600℃ (6512℉)
Expansion coefficient	: 2-4×10 ℃ (1/6 of Cu)
Ultimate strength	: 200 - 700 kg/cm^2
Grain size	: 0.01 to 0.045 mm

The manufacturing process of graphite for EDM is very complex, and we do not intend to describe it in this guide. However, it is important to know that graphite blocks are compressed during manufacture and, according to the pressure applied, the density may vary. Generally, low-density graphite are anisotropy whereas high density graphite are isotropic.

Anisotropy graphite has variable characteristics. The electrical and thermal conductivities can differ by a factor of two according to the axis of measurement. When manufacturing electrodes from anisotropy graphite, it is an advantage to choose the electrode penetration axis to be parallel to the grain . If the electrode is made from several blocks, all parts must be cut in the same direction.

The density of graphite is a valuable indication of EDM performance. A graphite of low density (1.6 to 1.7) will generally give higher material removal rates than high-density graphite (1.8 to 1.85). On the other hand, volumetric wear ratio, particularly at corners, is better with high-density graphite. The grain size of the graphite has an influence on the surface finish of the graphite itself as well as that obtained on the eroded surface. With a fine-grain graphite, the surface finish of the electrode is the surface finish of brittle, it is easier to maintain sharp corners when machining it by conventional methods.

5.19.3 Electrode manufacture by traditional machining methods

Graphite, whatever its quality, is a material which can be machined easily by classical machining methods.

Turning

Graphite is machined with tools in steel, tungsten carbide or, when manufacturing electrodes in large quantities, with diamond tools. Manufacturers recommend:

	TOOL STEEL	CARBIDE (CAST-IRON GRADE)	DIAMOND TOOLS
CLEARANCE ANGLE	8 TO 10 DEGREE	8 TO 10 DEGREE	10 TO 20 DEGREE
RAKE ANGLE	16 TO 20 DEGREE	16 TO 20 DEGREE	8 TO 10 DEGREE
CUTTING SPEED	80 M/MIN.	150 M/MIN.	250 TO 400 M/MIN.

Graphite being abrasive, steel tools must be sharpened frequently.

Grinding

Graphite can also be ground. It is preferable to use grinding wheels with the following characteristics:

Abrasive : green Carborundum
Bonding : glazed
Grain : 60 for finishing, 36 for roughing
Hardness : J
Structure (porosity) : 5
For all additional information, users should enquire via their normal supplier.

Milling

The advantages of graphite appear when manufacturing three dimensional electrodes from a model, i.e., on copy-milling machines with manual or automatic control. The high cutting speeds (100-200 m/min.) and feed rates (100-200 mm/min.) which can be used, make it possible to manufacture an electrode five to ten time faster than in copper or tellurium copper. Furthermore, marks left by milling are very easily and quickly polished out using fine emery paper, but one must be careful not to remove too much material. Reductions in the electrode dimensions to take into account sparking distances are easily made by using a larger cutter diameter.

5.19.4 Advantages of graphite

- They are not affected by thermal shock and retain their mechanical properties.
- They display practically no distortion.
- Machining is easy by conventional methods.
- Their low density gives a light-weight electrode.
- Their low cost makes them economical.

5.19.5 Disadvantages of graphite

- The material is abrasive. Precautions must be taken to protect the slides of machine-tools from graphite dust.
- Dust produced during conventional machining of graphite necessitates good extraction system being fitted in the shop.
- Graphite are brittle, and special care must be taken, especially on corners, during manufacture. They cannot be etched by acid and are not generally suitable for casting and forming.

5.19.6 Behavior of graphite in EDM

As the technology curves show, graphite have an excellent performance in EDM. However, one will notice that:

- They cannot be used with relaxation generators.
- Machining of tungsten carbide is difficult. Risks of abnormal discharges are higher than with metallic electrodes.
- High-density graphite must be used when wear and corner strength are critical, whereas other graphite can be reserved for applications in which wear is of little importance and for cavities without fine detail. With the latter, machining speed is faster.
- Fine-grain graphite are used for fine detail machining (sharp corners).

5.19.7 Molded graphite

When machining workpieces in large numbers and wishing to use graphite electrodes, it is possible to obtain molded electrodes from specialized firms. Since the tooling cost is high, this method is reserved for large quantities of identical parts. However, for reasons inherent in the manufacturing process of such electrodes, the density tends to vary and wear rates are generally higher than with common graphite.

CHAPTER 6

DIELECTRIC

The dielectric fluid applying to many different lines has been in the market. Today there are two dielectric fluid can be used principally.

6.1 Mineral oil

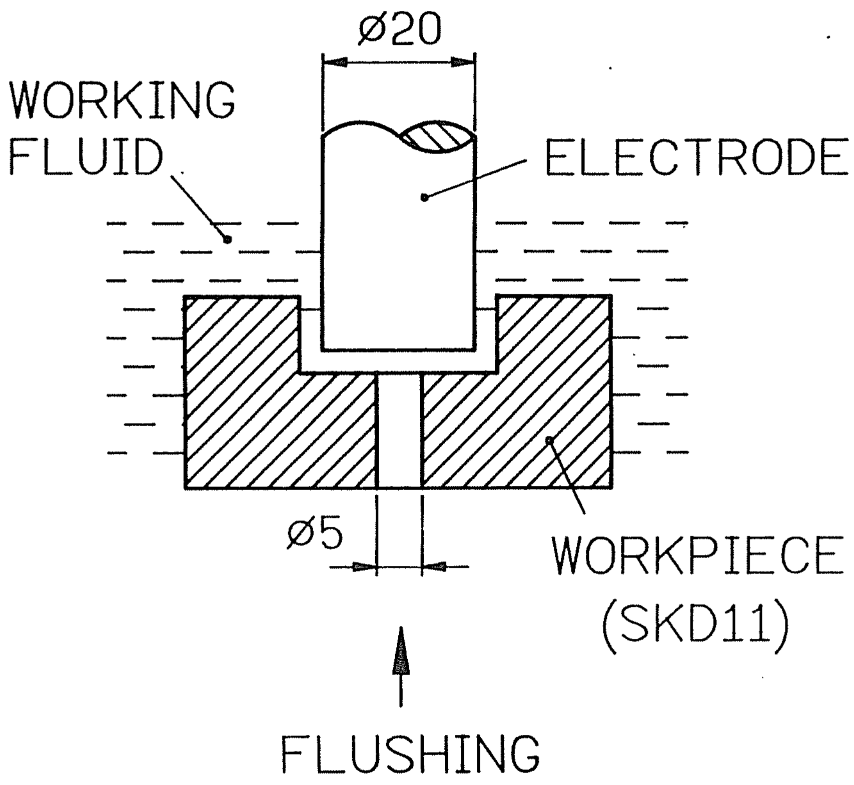
This widely applied dielectric fluid is mineral oil. To obtain better effect oil contains no aromatics or other additives. The viscosity of oil is very important. High viscosity of oil is unfit for fine finish. Because the machining gap is very narrow, and a viscous fluid has difficulty in circulation between the electrode and workpiece. On the other hand, machining efficiency is better when using a heavy oil in roughing.

6.2 Kerosene

Because of the very low viscosity, this dielectric is well suited to machining and super-finishing operations, it is often recommended for machining tungsten carbide when short duration discharges are required.

CHAPTER 7

THE MACHINING REFERENCE DATA



DIELECTRIC: KEROSENE

NOTE:
THE FOLLOWING FACTORS WILL AFFECT THE TEST RESULT FOR SURFACE ROUGHNESS, 2-SIDE GAP, WEAR RATIO AND REMOVAL RATE.

(1) THE FLUSHING PRESSURE OF DIELECTRIC.
(2) THE MATERIAL OF WORKPIECE.
(3) THE DIELECTRIC TYPE.
(4) THE CLEARANCE OF DIELECTRIC.
(5) THE TEMPERATURE OF DIELECTRIC.

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
50	6	82	52	4	7	10	15	1	1	5	+1	24	0.38	0.4	97	0.5
43	6	82	52	4	7	10	15	1	1	5	+1	23	0.37	0.2	91.8	0.5
36	6	82	52	4	7	10	15	1	1	5	+1	22	0.33	0.1	86.5	0.5
28	6	72	42	4	7	10	15	1	1	5	+1	20	0.24	0.1	81.7	0.5
21	6	72	42	4	7	10	10	1	1	5	+1	18	0.20	0.1	42	0.5
17	6	62	32	4	7	10	10	1	1	5	+1	14	0.19	–	39.3	0.5
13	6	62	32	4	7	10	10	1	1	5	+1	12.5	0.17	–	28	0.5
9	5	62	32	4	7	10	8	1	1	5	+1	9	0.14	–	12.6	0.5
6	5	52	22	4	7	10	7	1	1	5	+1	6.3	0.12	–	7	0.5
4	4	52	32	5	6	10	7	1	1	5	+1	4.5	0.09	–	0.6	0.5
3	4	42	32	6	6	10	4	1	1	5	+1	4	0.06	–	0.88	0.25
2	4	42	32	6	6	10	3	1	1	5	+1	3	0.05	–	0.26	0.25
1.5	4	32	22	6	6	10	3	1	1	5	+1	2	0.05	1.1	0.22	0.25

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
50	6	6	10	4	7	10	15	1	1	0	+1	6.3	0.15	79.7	12.6	0.5
50	6	22	22	4	7	10	15	1	1	0	+1	9	0.15	34.5	73	0.5
50	6	42	22	4	7	10	15	1	1	0	+1	18	0.22	5.2	139	0.5
50	6	62	32	4	7	10	15	1	1	0	+1	21	0.34	1.0	146	0.5
50	6	82	52	4	7	10	15	1	1	0	+1	25	0.40	0.2	147	0.5

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
43	6	6	10	4	7	10	15	1	1	0	+1	6	0.13	87.3	7.2	0.5
43	6	22	22	4	7	10	15	1	1	0	+1	8.5	0.16	31.6	61	0.5
43	6	42	32	4	7	10	15	1	1	0	+1	17	0.22	17.1	126	0.5
43	6	62	32	4	7	10	15	1	1	0	+1	20	0.30	0.1	147	0.5
43	6	82	52	4	7	10	15	1	1	0	+1	24.5	0.40	0.1	147	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. μmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
36	6	6	10	4	7	10	15	1	1	0	+1	5	0.13	80.4	7.4	0.5
36	6	22	22	4	7	10	15	1	1	0	+1	8	0.15	29	57	0.5
36	6	42	32	4	7	10	15	1	1	0	+1	16	0.20	13.7	87	0.5
36	6	62	32	4	7	10	15	1	1	0	+1	19	0.30	0.2	147	0.5
36	6	82	52	4	7	10	15	1	1	0	+1	24	0.39	–	98	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. μmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
28	6	4	6	4	7	10	15	1	1	0	+1	4.5	0.14	75.6	4.4	0.5
28	6	10	10	4	7	10	15	1	1	0	+1	7	0.15	61.1	13	0.5
28	6	32	22	4	7	10	15	1	1	0	+1	14	0.19	17.5	68.2	0.5
28	6	52	22	4	7	10	15	1	1	0	+1	18	0.23	0.6	97.5	0.5
28	6	72	42	4	7	10	15	1	1	0	+1	22	0.35	–	78	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF	+ −	S. R. µmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
21	6	4	6	4	7	10	10	1	1	0	+1	4	0.15	64	3.8	0.5
21	6	10	10	4	7	10	10	1	1	0	+1	6	0.15	42.8	10.3	0.5
21	6	32	22	4	7	10	10	1	1	0	+1	10	0.18	10.7	42	0.5
21	6	52	22	4	7	10	10	1	1	0	+1	14	0.22	0.1	73.5	0.5
21	6	72	42	4	7	10	10	1	1	0	+1	18	0.28	–	49	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF	+ −	S. R. µmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
17	6	4	6	4	7	10	10	1	1	0	+1	4	0.10	54.6	2.8	0.5
17	6	10	10	4	7	10	10	1	1	0	+1	5	0.14	40.4	8.7	0.5
17	6	22	22	4	7	10	10	1	1	0	+1	9	0.15	18	23.7	0.5
17	6	42	22	4	7	10	10	1	1	0	+1	10	0.18	0.9	48.6	0.5
17	6	62	32	4	7	10	10	1	1	0	+1	16	0.24	–	39.3	0.5

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
13	6	4	6	4	7	10	10	1	1	0	+1	4	0.07	57.7	2.1	0.5
13	6	10	10	4	7	10	10	1	1	0	+1	4.5	0.13	27.4	4.7	0.5
13	6	22	22	4	7	10	10	1	1	0	+1	6.3	0.13	16.1	16.9	0.5
13	6	42	22	4	7	10	10	1	1	0	+1	9.5	0.15	1.3	38.7	0.5
13	6	62	32	4	7	10	10	1	1	0	+1	15	0.23	–	34.6	0.5

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
9	5	4	6	4	7	10	8	1	1	0	+1	4	0.08	48.4	2.1	0.5
9	5	10	10	4	7	10	8	1	1	0	+1	4.5	0.09	40.8	2.8	0.5
9	5	22	22	4	7	10	8	1	1	0	+1	5	0.10	9.8	10.5	0.5
9	5	42	22	4	7	10	8	1	1	0	+1	8	0.13	0.5	20.2	0.5
9	5	62	32	4	7	10	8	1	1	0	+1	14	0.16	–	15	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. μmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
6	5	2	4	4	7	10	7	1	1	0	+1	3.5	0.08	36.8	0.96	0.5
6	5	6	10	4	7	10	7	1	1	0	+1	4	0.09	33.6	1.4	0.5
6	5	16	16	4	7	10	7	1	1	0	+1	4.5	0.10	11.4	3.4	0.5
6	5	32	22	4	7	10	7	1	1	0	+1	6.3	0.11	0.7	8.1	0.5
6	5	52	22	4	7	10	7	1	1	0	+1	11	0.13	0.3	6.7	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. μmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
4	4	2	4	5	6	10	7	1	1	0	+1	3	0.08	19.6	0.4	0.5
4	4	6	10	5	6	10	7	1	1	0	+1	3.5	0.08	13.4	0.74	0.5
4	4	16	16	5	6	10	7	1	1	0	+1	4	0.08	3.1	1.59	0.5
4	4	32	22	5	6	10	7	1	1	0	+1	5	0.08	0.4	2.27	0.5
4	4	52	32	5	6	10	7	1	1	0	+1	6.3	0.09	–	1.25	0.5

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. µmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
3	4	2	22	6	6	10	4	1	1	0	+1	2	0.03	35	0.19	0.25
3	4	4	22	6	6	10	4	1	1	0	+1	2.2	0.04	17.9	0.26	0.25
3	4	10	22	6	6	10	4	1	1	0	+1	2.5	0.04	7.3	0.49	0.25
3	4	22	22	6	6	10	4	1	1	0	+1	3.2	0.05	1.5	1.18	0.25
3	4	42	32	6	6	10	4	1	1	0	+1	4.5	0.06	0.8	1.08	0.25

MACHINING MATERIAL: CU–ST

IP									AR	LWF		S. R. µmRa	2–SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM³/MIN.	FLUSHING PRESSURE KG/CM²
2	4	2	22	6	6	10	3	1	1	0	+1	1.8	0.03	21.8	0.09	0.25
2	4	4	22	6	6	10	3	1	1	0	+1	2	0.04	14.8	0.13	0.25
2	4	10	22	6	6	10	3	1	1	0	+1	2.5	0.04	6	0.22	0.25
2	4	22	22	6	6	10	3	1	1	0	+1	3	0.04	1.1	0.38	0.25
2	4	42	32	6	6	10	3	1	1	0	+1	3.2	0.05	0.7	0.28	0.25

MACHINING MATERIAL: CU-ST

IP									AR	LWF		S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
1.5	4	2	22	6	6	10	3	1	1	0	+1	1.6	0.02	19	0.07	0.25
1.5	4	4	22	6	6	10	3	1	1	0	+1	1.8	0.03	12.4	0.09	0.25
1.5	4	6	22	6	6	10	3	1	1	0	+1	2	0.03	7.8	0.11	0.25
1.5	4	16	22	6	6	10	3	1	1	0	+1	2.2	0.04	4.3	0.21	0.25
1.5	4	32	22	6	6	10	3	1	1	0	+1	2.5	0.05	1.5	0.22	0.25

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
50	6	62	52	4	7	10	15	1	1	5	+1	16	0.365	–	96	0.2
43	6	62	52	4	7	10	15	1	1	5	+1	13	0.36	–	72	0.2
36	6	62	52	4	7	10	15	1	1	5	+1	12	0.30	–	64	0.2
28	6	52	42	4	7	10	15	1	1	5	+1	10.2	0.255	–	62	0.2
21	6	52	42	4	7	10	10	1	1	5	+1	10	0.225	–	39	0.2
17	6	52	42	4	7	10	10	1	1	5	+1	9.5	0.21	–	28	0.2
13	6	42	42	4	7	10	10	1	1	5	+1	8	0.205	–	16	0.2
9	6	32	32	4	7	10	8	1	1	5	+1	6.2	0.20	–	10.8	0.2
6	6	32	32	4	7	10	7	1	1	5	+1	4	0.14	–	4.9	0.3
4	4	32	32	5	7	10	6	1	1	5	+1	3.5	0.10	–	1.1	0.3

MACHINING MATERIAL: GR-ST

IP									AR	LWF	+ −	S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
50	6	22	32	4	7	10	15	1	1	0	+1	8.5	0.19	6.4	67	0.2
50	6	32	42	4	7	10	15	1	1	0	+1	10	0.24	2.0	70	0.2
50	6	42	42	4	7	10	15	1	1	0	+1	11	0.255	0.2	96	0.2
50	6	52	52	4	7	10	15	1	1	0	+1	12.5	0.30	-	58	0.2
50	6	62	52	4	7	10	15	1	1	0	+1	17	0.355	-	48	0.2

MACHINING MATERIAL: GR-ST

IP									AR	LWF	+ −	S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
43	6	22	32	4	7	10	15	1	1	0	+1	8	0.19	5.5	61	0.2
43	6	32	42	4	7	10	15	1	1	0	+1	9	0.24	1.8	63	0.2
43	6	42	42	4	7	10	15	1	1	0	+1	10	0.25	-	82	0.2
43	6	52	52	4	7	10	15	1	1	0	+1	11.5	0.30	-	82	0.2
43	6	62	52	4	7	10	15	1	1	0	+1	14	0.33	-	79	0.2

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
36	6	22	32	4	7	10	15	1	1	0	+1	7	0.175	5.3	32	0.2
36	6	32	42	4	7	10	15	1	1	0	+1	8.5	0.215	2.0	55	0.2
36	6	42	42	4	7	10	15	1	1	0	+1	9	0.235	0.2	64	0.2
36	6	52	52	4	7	10	15	1	1	0	+1	11	0.26	-	62	0.2
36	6	62	52	4	7	10	15	1	1	0	+1	12.5	0.265	-	52	0.2

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
28	6	16	22	4	7	10	15	1	1	0	+1	6.4	0.145	11.6	25	0.1
28	6	22	32	4	7	10	15	1	1	0	+1	6.8	0.185	5.5	34	0.1
28	6	32	32	4	7	10	15	1	1	0	+1	7.5	0.20	1.2	57	0.1
28	6	42	42	4	7	10	15	1	1	0	+1	8.8	0.23	-	52	0.1
28	6	52	42	4	7	10	15	1	1	0	+1	10.5	0.24	-	62	0.1

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
21	6	16	22	4	7	10	10	1	1	0	+1	6.3	0.17	11.1	20	0.1
21	6	22	32	4	7	10	10	1	1	0	+1	6.6	0.175	5.7	24	0.1
21	6	32	32	4	7	10	10	1	1	0	+1	7.4	0.18	1.0	38	0.1
21	6	42	42	4	7	10	10	1	1	0	+1	8.6	0.19	–	31	0.1
21	6	52	42	4	7	10	10	1	1	0	+1	10.2	0.21	–	34	0.1

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. μmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
17	6	16	22	4	7	10	10	1	1	0	+1	6.3	0.155	11.1	13	0.1
17	6	22	32	4	7	10	10	1	1	0	+1	6.5	0.17	5.7	16	0.1
17	6	32	32	4	7	10	10	1	1	0	+1	7.5	0.185	0.8	29	0.1
17	6	42	42	4	7	10	10	1	1	0	+1	9	0.19	–	22	0.1
17	6	52	42	4	7	10	10	1	1	0	+1	10	0.215	–	27	0.1

MACHINING MATERIAL: GR-ST

IP									AR	LWF	+ −	S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
13	6	10	16	4	7	10	10	1	1	0	+1	3.2	0.13	25.3	6	0.05
13	6	16	22	4	7	10	10	1	1	0	+1	3.5	0.17	11.1	12	0.05
13	6	22	32	4	7	10	10	1	1	0	+1	4	0.17	4.4	13	0.05
13	6	32	32	4	7	10	10	1	1	0	+1	7	0.175	0.2	19	0.05
13	6	42	42	4	7	10	10	1	1	0	+1	8.5	0.195	-	17	0.05

MACHINING MATERIAL: GR-ST

IP									AR	LWF	+ −	S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
9	6	6	16	4	7	10	8	1	1	0	+1	2.6	0.105	37	2.6	0.05
9	6	10	16	4	7	10	8	1	1	0	+1	3.1	0.13	23.5	4.3	0.05
9	6	16	22	4	7	10	8	1	1	0	+1	3.2	0.15	11.1	7.3	0.05
9	6	22	22	4	7	10	8	1	1	0	+1	3.5	0.155	-	13	0.05
9	6	32	32	4	7	10	8	1	1	0	+1	6.5	0.19	-	12	0.05

MACHINING MATERIAL: GR-ST

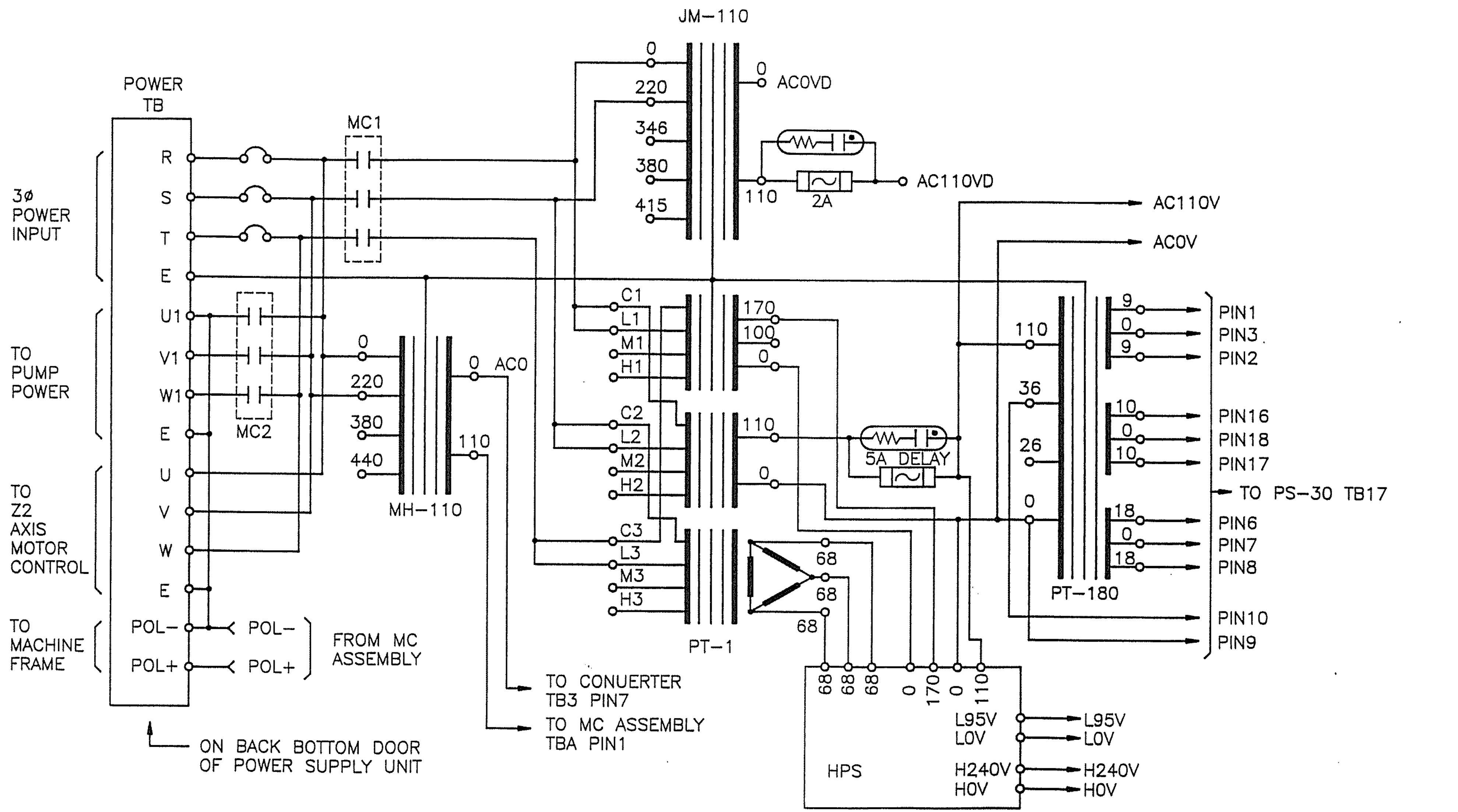
IP									AR	LWF		S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
6	6	6	16	4	7	10	7	1	1	0	+1	2	0.065	32.3	1.9	0.05
6	6	10	16	4	7	10	7	1	1	0	+1	2.2	0.15	25	2.5	0.05
6	6	16	22	4	7	10	7	1	1	0	+1	2.5	0.17	12.4	4.5	0.05
6	6	22	22	4	7	10	7	1	1	0	+1	3.5	0.175	5.3	6.5	0.05
6	6	32	32	4	7	10	7	1	1	0	+1	4.2	0.18	-	5.4	0.05

MACHINING MATERIAL: GR-ST

IP									AR	LWF		S. R. µmRa	2-SIDE GAP (MM)	WEAR RATIO %	REMOVAL RATIO MM^3/MIN.	FLUSHING PRESSURE KG/CM^2
4	4	6	16	5	7	10	6	1	1	0	+1	1.8	0.08	35	0.8	0.2
4	4	10	22	5	7	10	6	1	1	0	+1	2.1	0.09	32.6	0.7	0.2
4	4	16	22	5	7	10	6	1	1	0	+1	2.4	0.11	15	1.3	0.2
4	4	22	22	5	7	10	6	1	1	0	+1	3.2	0.13	4.2	1.6	0.2
4	4	32	32	5	7	10	6	1	1	0	+1	4	0.14	-	1.1	0.2

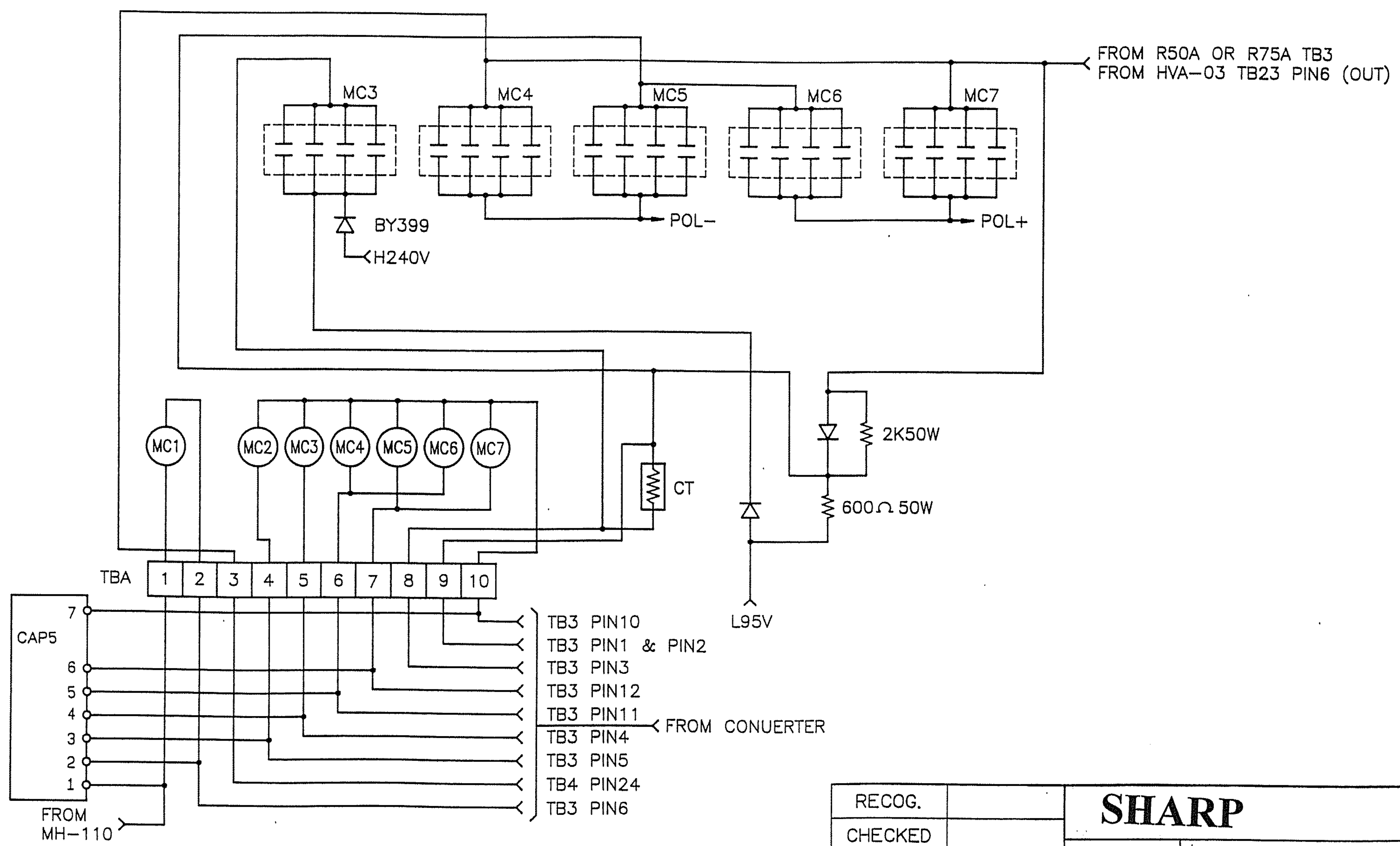
CHAPTER 8

CIRCUIT DIAGRAM

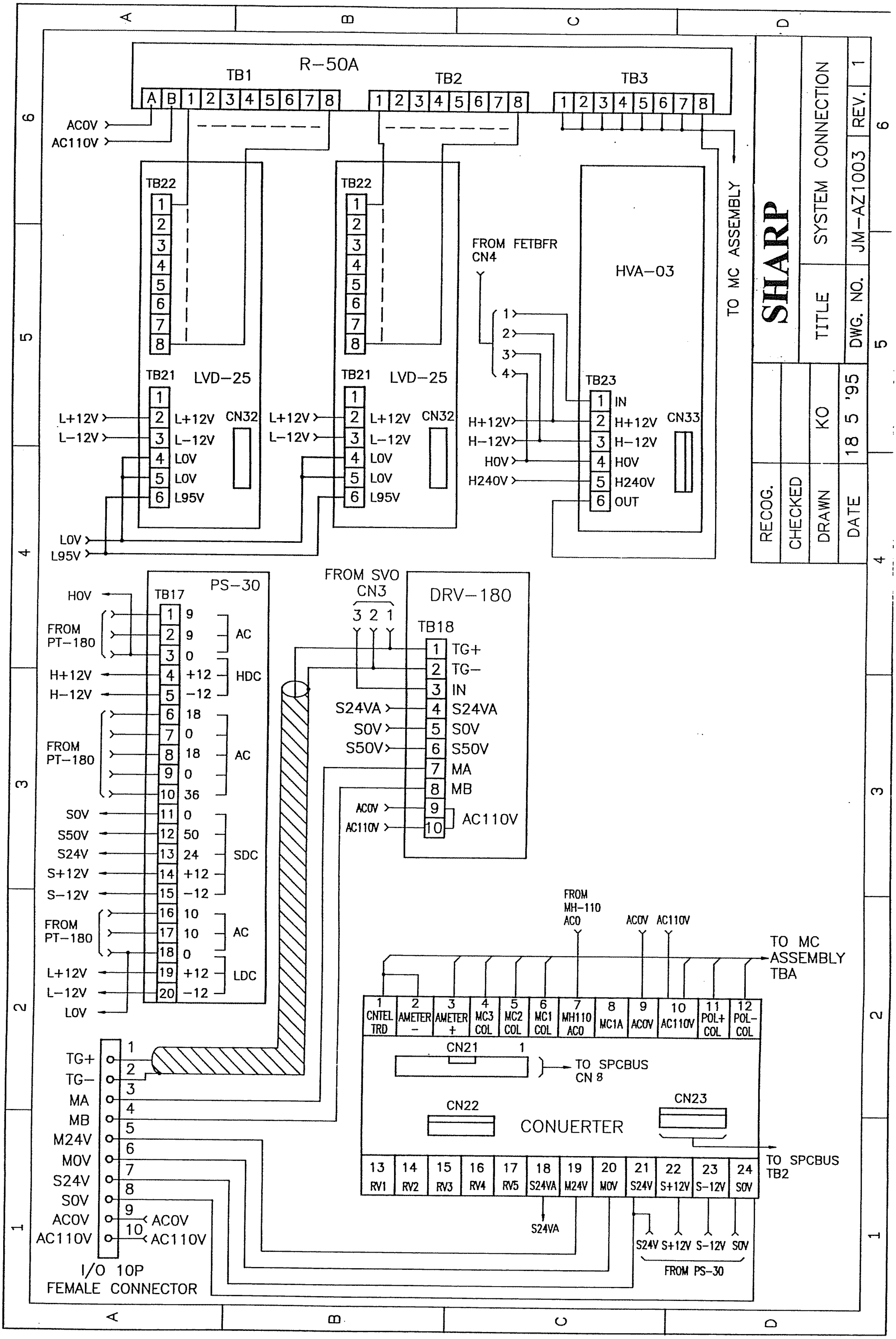


NOTE: 1.MC1 & MC2 IS ON THE MC ASSEMBLY
2.THE INPUT CONNECTION FOR PT−1 & MH−110 MUST BE ACCORDING TO ACTUAL POWER INPUT SPECIFICATION. THIS DIAGRAM SHOWS ONLY FOR 3ø 220V.

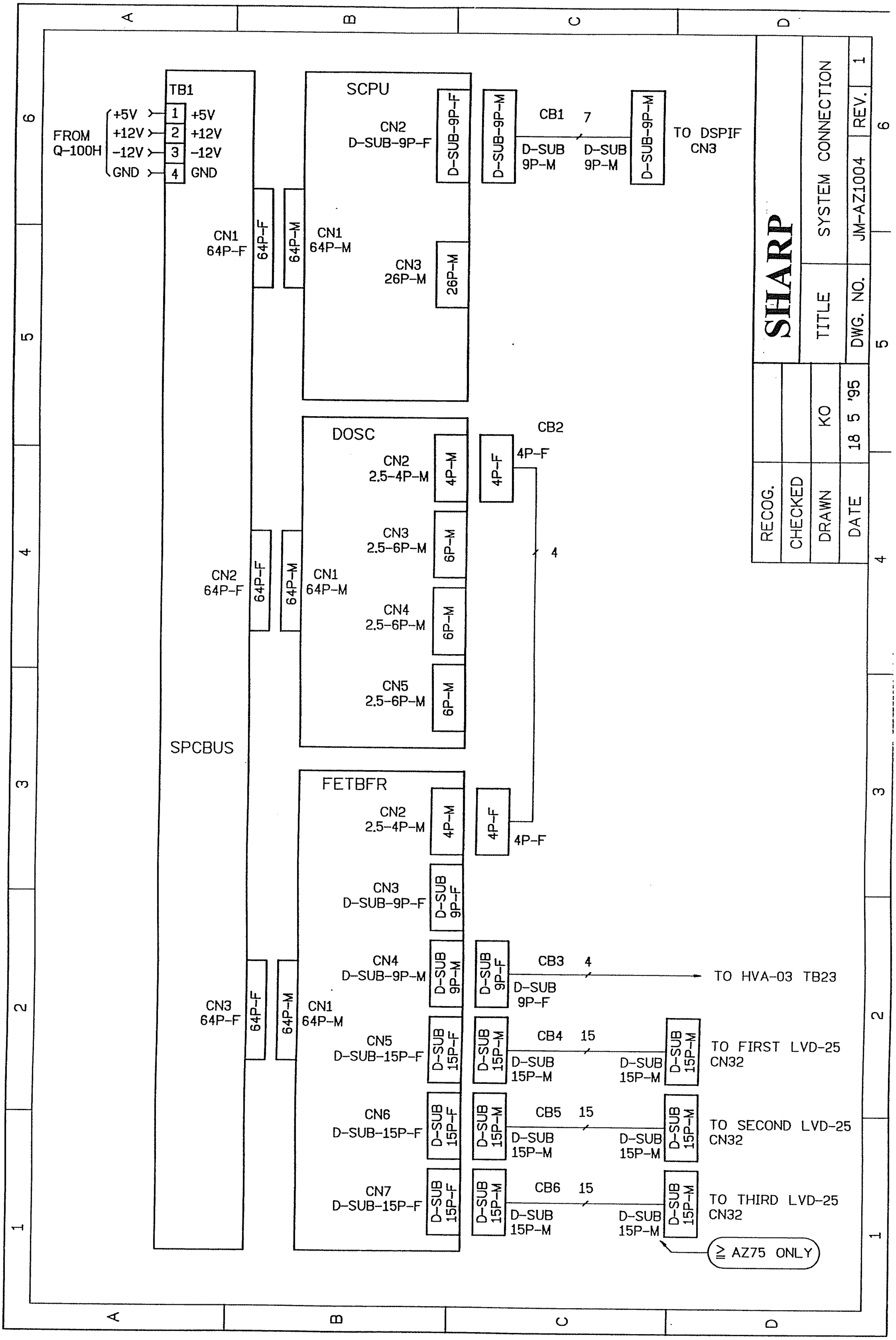
RECOG.		SHARP			
CHECKED					
DRAWN	KO	TITLE	SYSTEM CONNECTION		
DATE	19 5 '95	DWG. NO.	JM-AZ1001	REV.	1



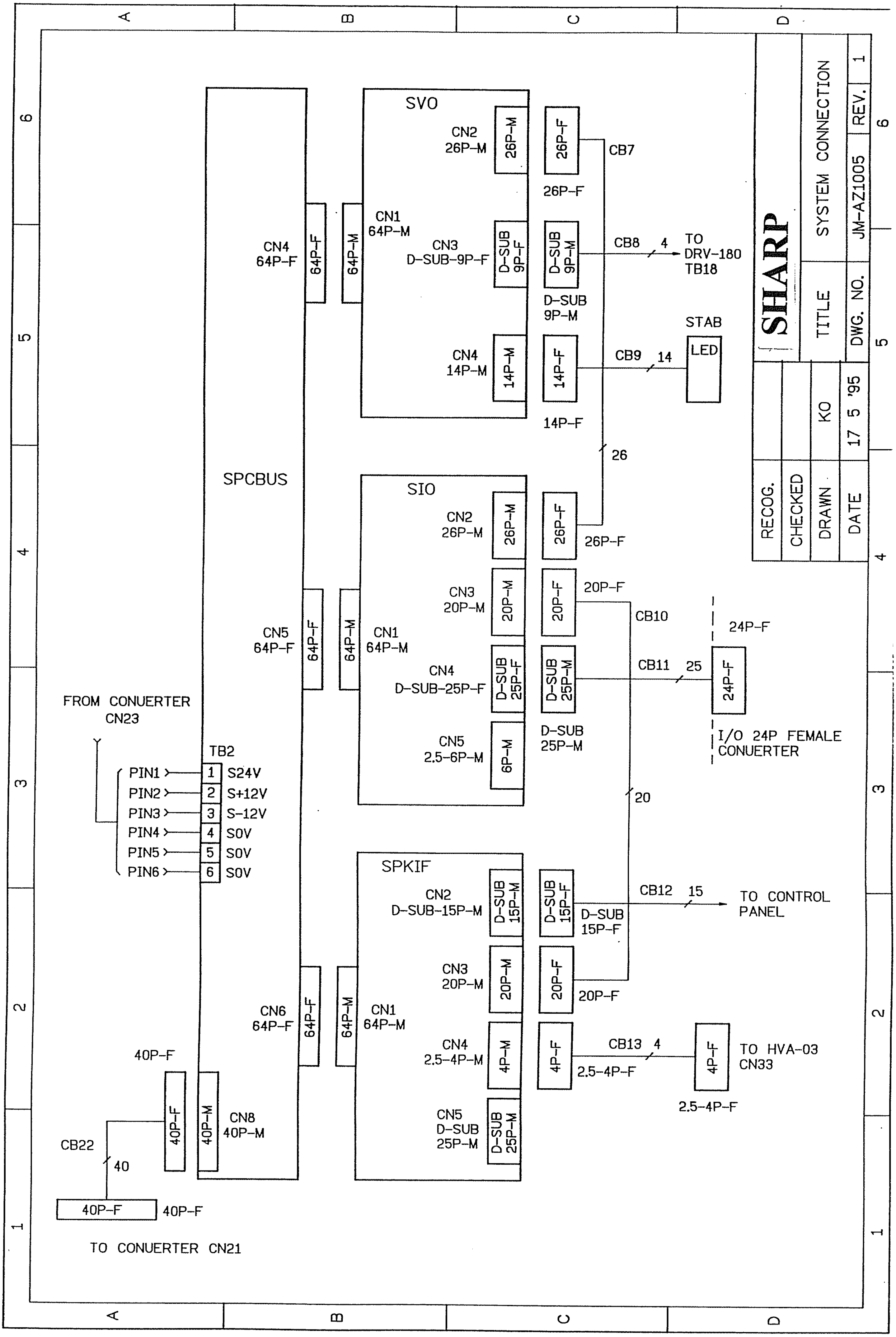
RECOG.		SHARP	
CHECKED			
DRAWN	KO	TITLE	MC ASSEMBLY
DATE	18 5 '95	DWG. NO.	JM-AZ1002 REV. 1

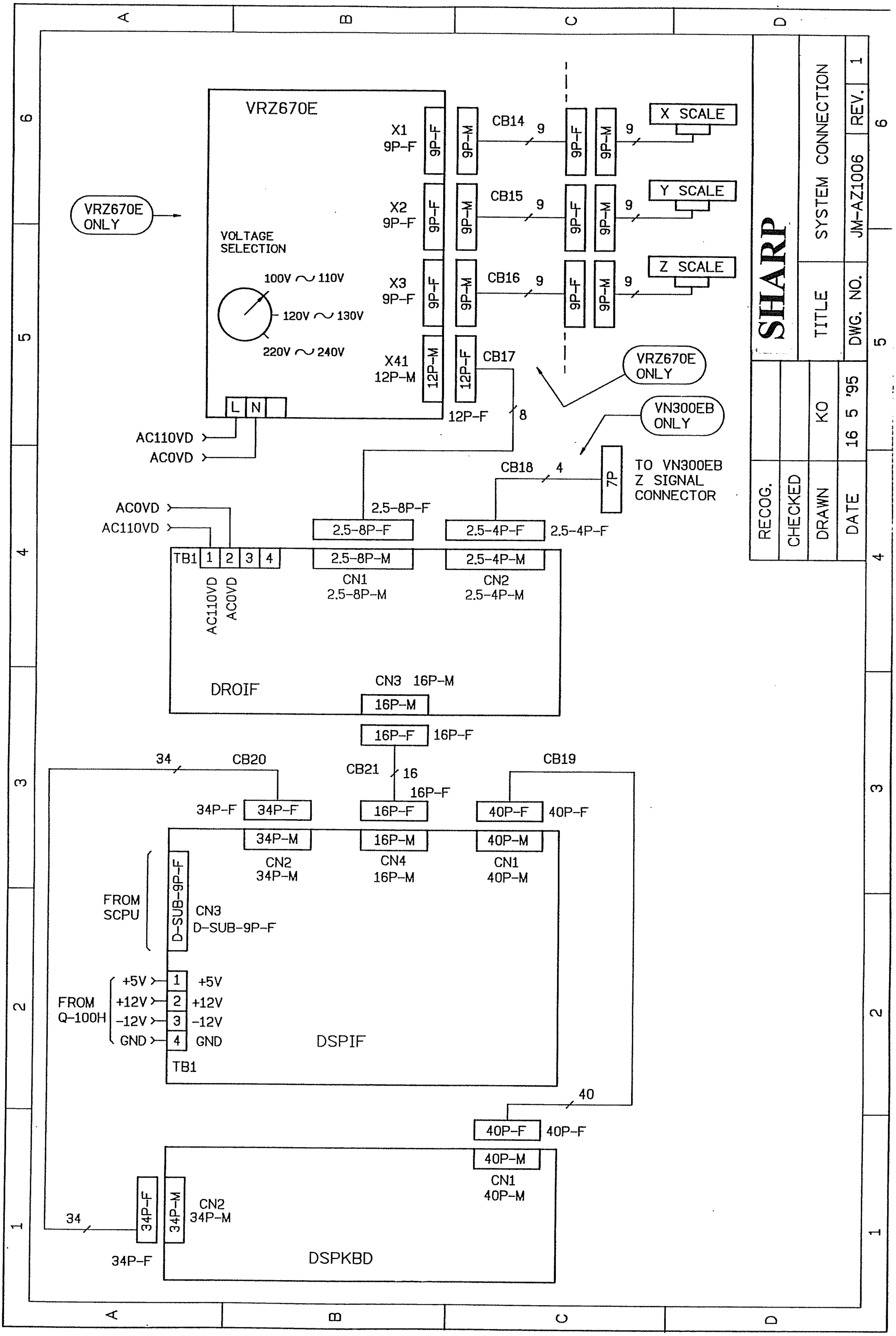


R-50A
TB1
TB2
TB3
A B 1 2 3 4 5 6 7 8
AC0V
AC110V
TO MC ASSEMBLY
TB22
TB21
LVD-25
CN32
L+12V
L-12V
L0V
L95V
FROM FETBFR CN4
HVA-03
TB23
IN
H+12V
H-12V
H0V
H240V
OUT
CN33
SHARP
TITLE SYSTEM CONNECTION
DWG. NO. JM-AZ1003
REV. 1
RECOG.
CHECKED
DRAWN KO
DATE 18 5 '95
PS-30
TB17
FROM PT-180
AC
HDC
SDC
LDC
H0V
H+12V
H-12V
S0V
S50V
S24V
S+12V
S-12V
L+12V
L-12V
L0V
FROM SVO CN3
DRV-180
TB18
TG+
TG-
IN
S24VA
S0V
S50V
MA
MB
AC0V
AC110V
FROM MH-110 AC0
TO MC ASSEMBLY TBA
1 CNTEL TRD
2 AMETER -
3 AMETER +
4 MC3 COL
5 MC2 COL
6 MC1 COL
7 MH110 AC0
8 MC1A
9 AC0V
10 AC110V
11 POL+ COL
12 POL- COL
CN21
TO SPCBUS CN 8
CN22
CONUERTER
CN23
TO SPCBUS TB2
13 RV1
14 RV2
15 RV3
16 RV4
17 RV5
18 S24VA
19 M24V
20 M0V
21 S24V
22 S+12V
23 S-12V
24 S0V
S24VA
FROM PS-30
TG+
TG-
MA
MB
M24V
M0V
S24V
S0V
AC0V
AC110V
I/O 10P FEMALE CONNECTOR

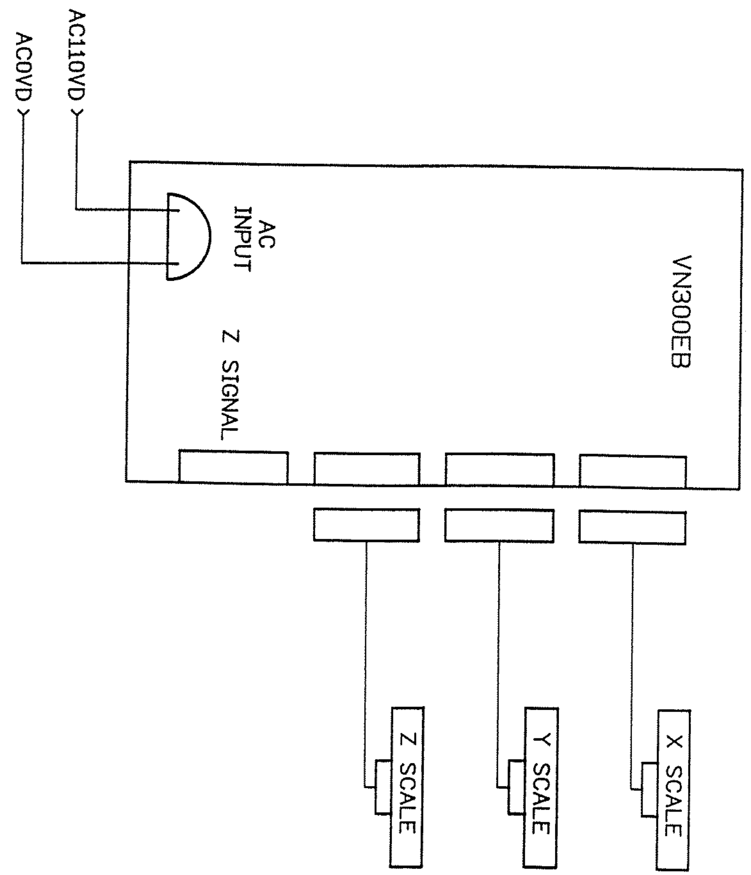


FROM Q-100H
+5V
+12V
-12V
GND
TB1
1 +5V
2 +12V
3 -12V
4 GND
SPCBUS
CN1 64P-F
CN2 64P-F
CN3 64P-F
SCPU
CN1 64P-M
CN2 D-SUB-9P-F
CN3 26P-M
CB1 7
D-SUB 9P-M
D-SUB 9P-M
TO DSPIF CN3
DOSC
CN1 64P-M
CN2 2.5-4P-M
CN3 2.5-6P-M
CN4 2.5-6P-M
CN5 2.5-6P-M
CB2
4P-F
4
FETBFR
CN1 64P-M
CN2 2.5-4P-M
4P-F
CN3 D-SUB-9P-F
CN4 D-SUB-9P-M
CB3 4
D-SUB 9P-F
TO HVA-03 TB23
CN5 D-SUB-15P-F
CB4 15
D-SUB 15P-M
TO FIRST LVD-25 CN32
CN6 D-SUB-15P-F
CB5 15
D-SUB 15P-M
TO SECOND LVD-25 CN32
CN7 D-SUB-15P-F
CB6 15
D-SUB 15P-M
TO THIRD LVD-25 CN32
≧ AZ75 ONLY
SHARP
TITLE SYSTEM CONNECTION
DWG. NO. JM-AZ1004
REV. 1
RECOG.
CHECKED
DRAWN KO
DATE 18 5 '95

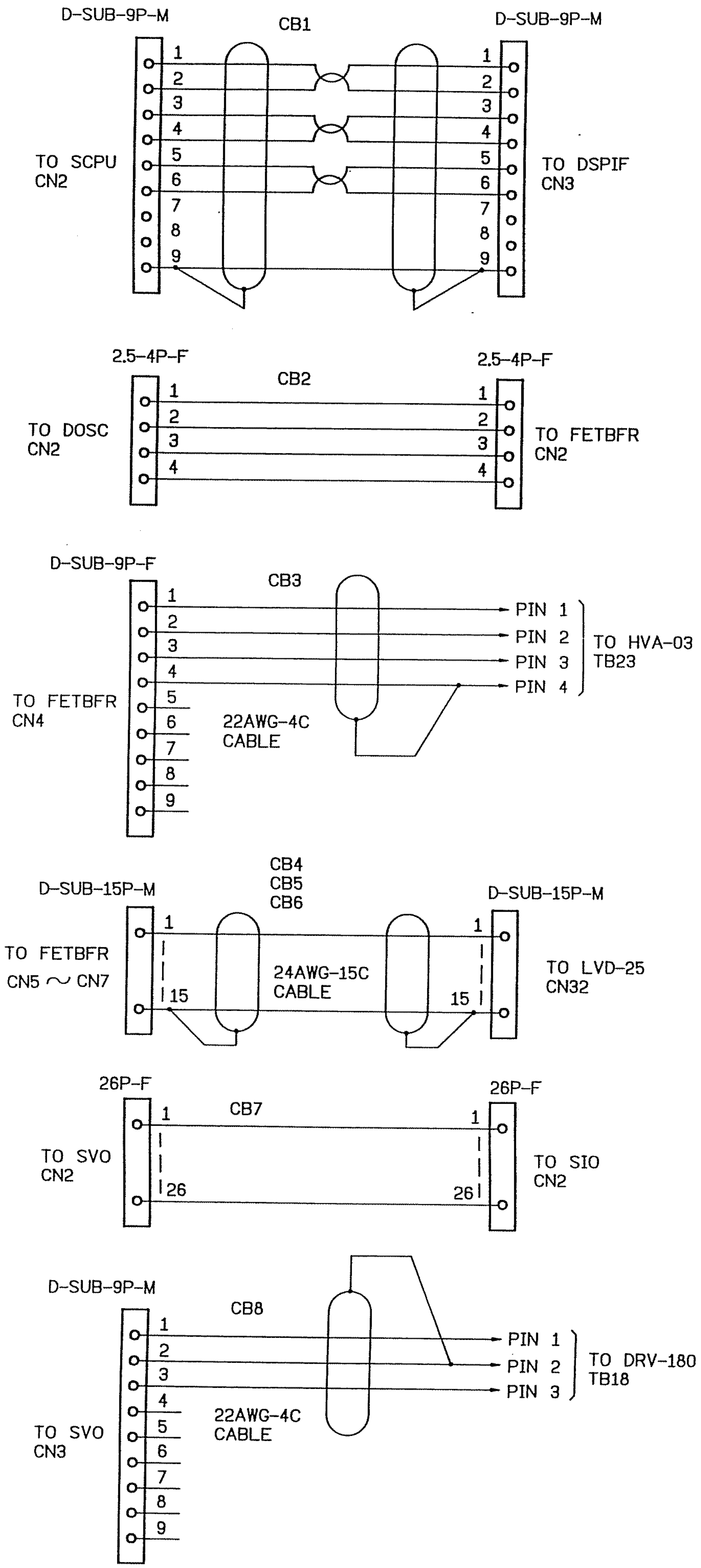

SHARP
TITLE SYSTEM CONNECTION
DWG. NO. JM-AZ1005
REV. 1
RECOG.
CHECKED
DRAWN KO
DATE 17 5 '95
SPCBUS
CN4 64P-F
CN5 64P-F
CN6 64P-F
CN8 40P-M
SVO
CN1 64P-M
CN2 26P-M
CN3 D-SUB-9P-F
CN4 14P-M
26P-F
CB7
CB8 4
TO DRV-180 TB18
D-SUB 9P-M
STAB LED
CB9 14
14P-F
26
SIO
CN1 64P-M
CN2 26P-M
CN3 20P-M
CN4 D-SUB-25P-F
CN5 2.5-6P-M
26P-F
20P-F
CB10
CB11 25
24P-F
D-SUB 25P-M
I/O 24P FEMALE CONUERTER
20
SPKIF
CN1 64P-M
CN2 D-SUB-15P-M
CN3 20P-M
CN4 2.5-4P-M
CN5 D-SUB 25P-M
CB12 15
D-SUB 15P-F
TO CONTROL PANEL
20P-F
CB13 4
2.5-4P-F
TO HVA-03 CN33
FROM CONUERTER CN23
TB2
PIN1 1 S24V
PIN2 2 S+12V
PIN3 3 S-12V
PIN4 4 S0V
PIN5 5 S0V
PIN6 6 S0V
40P-F
CB22
40
TO CONUERTER CN21



VRZ670E
X1
9P-F
X2
9P-F
X3
9P-F
X41
12P-M
9P-F
9P-M
12P-M
12P-F
CB14
CB15
CB16
CB17
9
8
X SCALE
Y SCALE
Z SCALE
VRZ670E ONLY
VOLTAGE SELECTION
100V ~ 110V
120V ~ 130V
220V ~ 240V
L
N
AC110VD
AC0VD
12P-F
VN300EB ONLY
CB18
4
7P
TO VN300EB Z SIGNAL CONNECTOR
2.5-8P-F
2.5-4P-F
2.5-8P-M
2.5-4P-M
TB1
1
2
3
4
CN1
2.5-8P-M
CN2
2.5-4P-M
DROIF
CN3 16P-M
16P-M
16P-F
CB20
34
CB21
16
CB19
34P-F
34P-M
16P-F
16P-M
40P-F
40P-M
CN2
34P-M
CN4
16P-M
CN1
40P-M
FROM SCPU
D-SUB-9P-F
CN3
D-SUB-9P-F
FROM Q-100H
+5V
+12V
-12V
GND
DSPIF
40
DSPKBD
SHARP
TITLE
SYSTEM CONNECTION
DWG. NO.
JM-AZ1006
REV.
RECOG.
CHECKED
DRAWN
KO
DATE
16 5 '95
A
B
C
D
1
2
3
4
5
6



RECOG.		SHARP			
CHECKED					
DRAWN	KO	TITLE	SYSTEM CONNECTION		
DATE	16 5 '95	DWG. NO.	JM-AZ1007	REV.	1



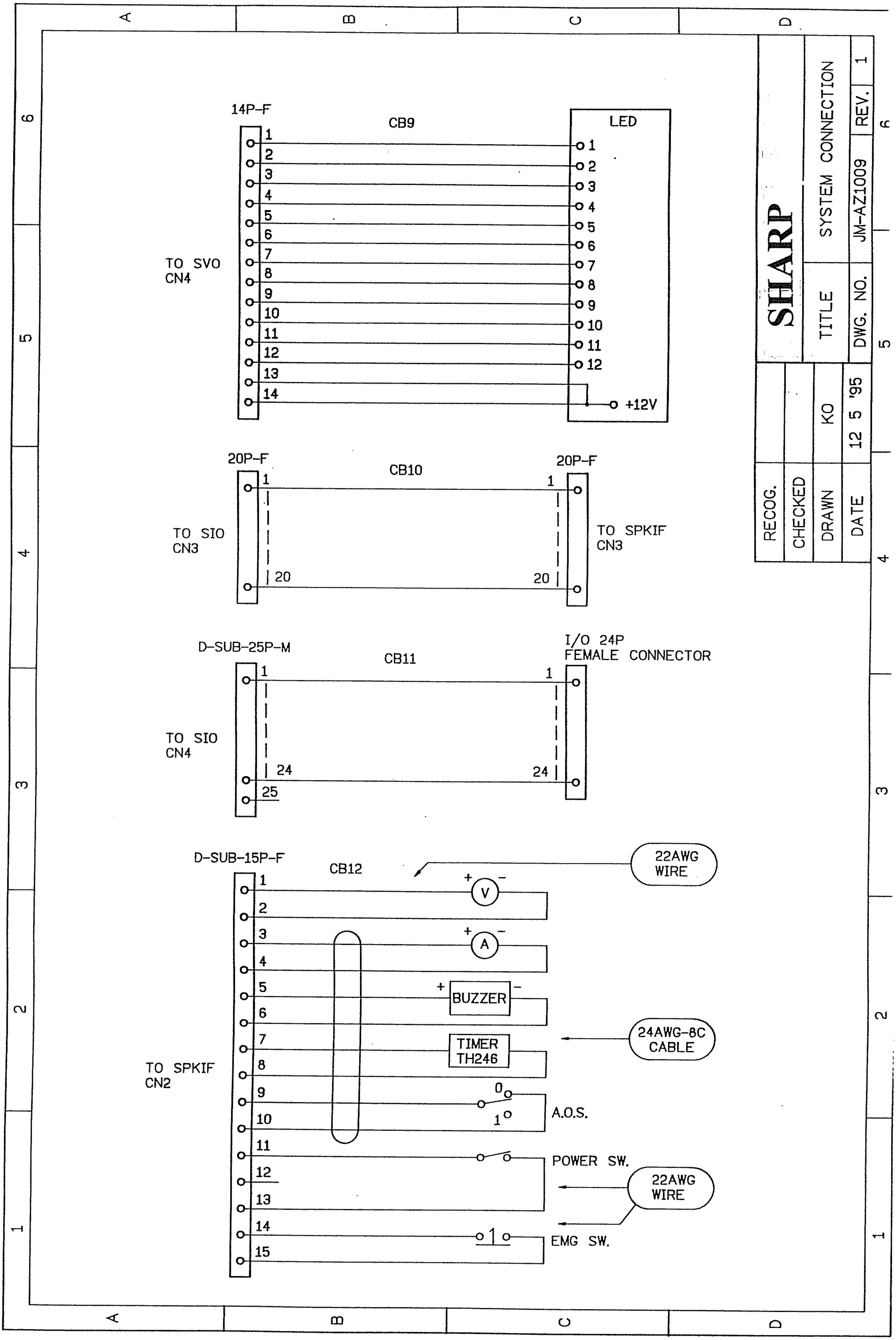
SHARP

TITLE: SYSTEM CONNECTION

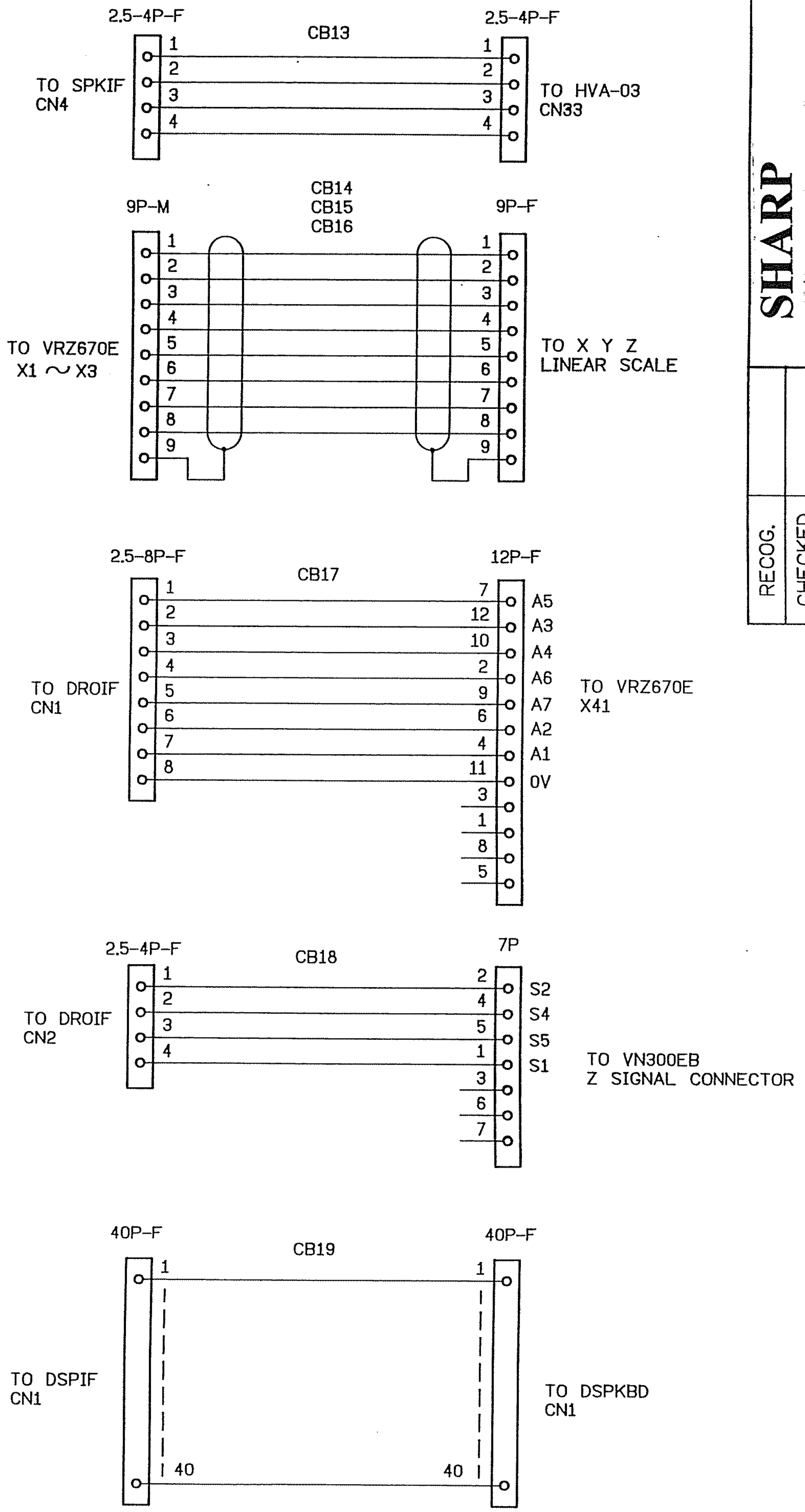
DWG. NO.: JM-AZ1008

REV.: 1

RECOG.	
CHECKED	
DRAWN	KO
DATE	13 5 '95

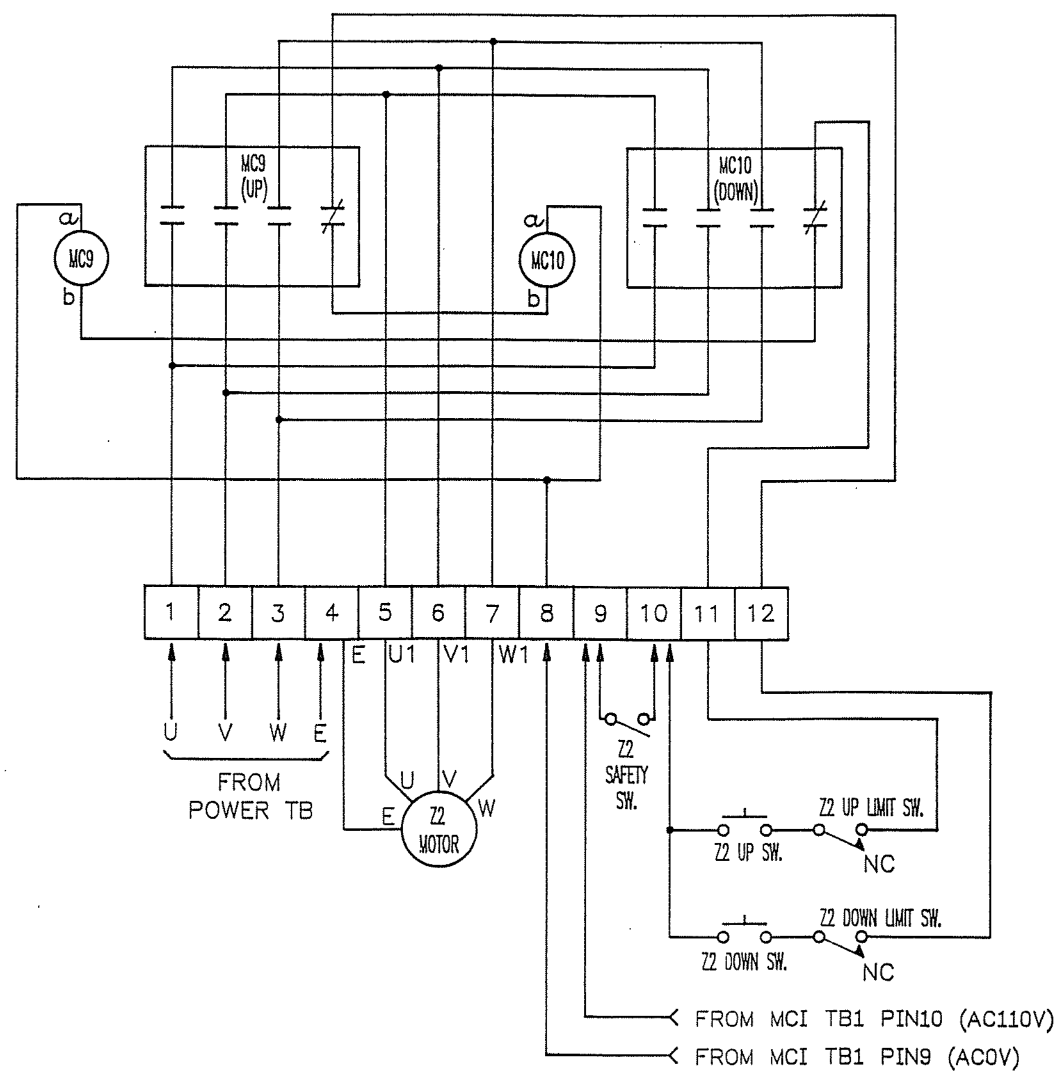


14P-F
CB9
LED
TO SVO
CN4
1 2 3 4 5 6 7 8 9 10 11 12 13 14
+12V
20P-F
CB10
20P-F
TO SIO
CN3
TO SPKIF
CN3
1
20
D-SUB-25P-M
CB11
I/O 24P
FEMALE CONNECTOR
TO SIO
CN4
1
24
25
D-SUB-15P-F
CB12
22AWG
WIRE
V
A
BUZZER
TIMER
TH246
24AWG-8C
CABLE
TO SPKIF
CN2
A.O.S.
POWER SW.
EMG SW.
SHARP
TITLE
SYSTEM CONNECTION
DWG. NO.
JM-AZ1009
REV.
1
RECOG.
CHECKED
DRAWN
KO
DATE
12 5 '95



SHARP

TITLE	SYSTEM CONNECTION
DWG. NO.	JM-AZ1010
REV.	1
RECOG.	
CHECKED	
DRAWN	KO
DATE	20 5 '95



REV.		SHARP	RECOG.		CHECKED		DRAWN	K.H.C.	TITLE	Z2 AXIS MOTOR CONTROL	DWG NO.	JM-AZ1014

三勝儀器公司承印(04) 3898021