Charmilles E110 - D10 Users Guide

CHARMILLES

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INDEX

1 - UNPACKING

It is recommended that the following procedure be observed for removal of the machine from the packing crate:

1. Remove the top cover of the crate (fig. 1).

2. Remove the two beams that hold the machine (fig. 2).

3. Remove the two long side-flats of the case (fig. 3).

4. Remove the two lateral head-pieces (fig. 4).

5. Cut the hoop-iron strips.

This will expose, from left to right on the bottom of the crate (fig. 5):

- 1 machine, type D 10,
- 1 case containing accessories,
- 1 generator (800),
- 1 tank for the dielectric fluid (500)
- 2 pipes (G & H),
- several hose clamps.

6. Remove the above units from the bottom of the crate in the following order: (first loosen the hold-down beams)

   - the case of accessories,
   - the generator (800) (refer to paragraph on "TRANSPORTATION"),
   - the pipes (G & H),
   - the tank (500) (refer to paragraph on "TRANSPORTATION"),

7. Remove the two wood beams that clamp down the metal bars used to secure the machine (fig. 6).

8. Lift the machine and remove it from the base of the crate.

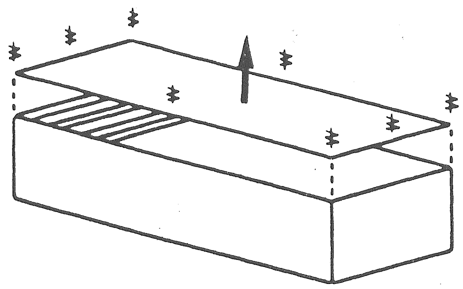
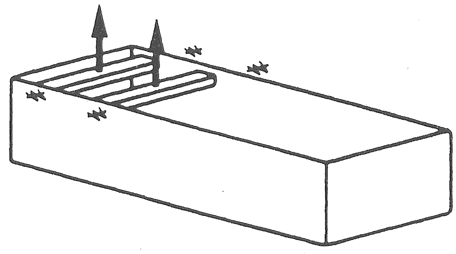


Fig 1



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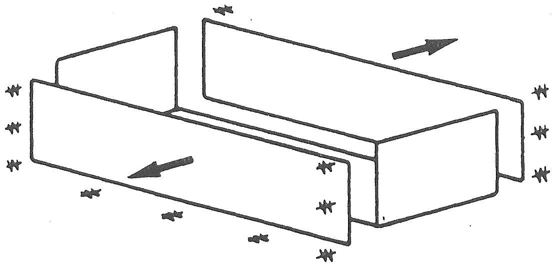

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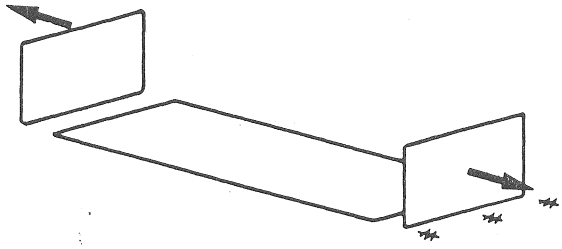

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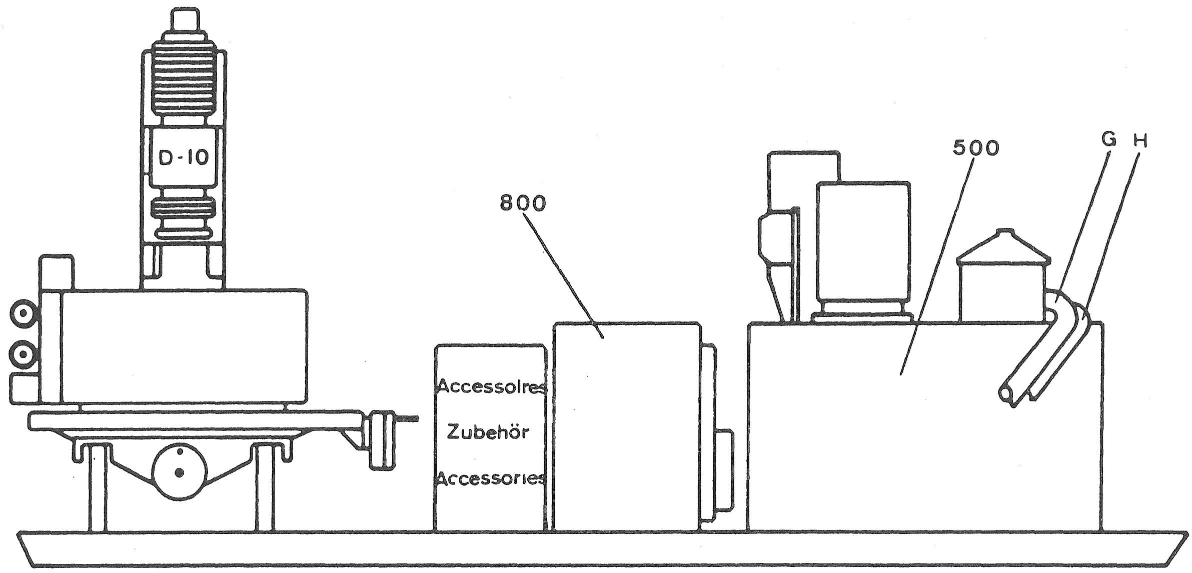

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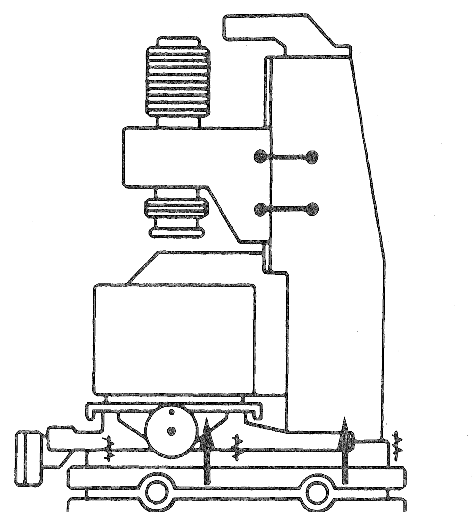


Fig 6

2 - TRANSPORTATION

The various units contained within the crate can be transported in the following manner:

2.1 The machine: weight: 500 lb (230 Kg)

2 through-holes (307), diameter $1\frac{1}{4}$" (30 mm), have been provided to permit of transportation by different means:

a) by means of a crane (figs. 1 & 2)

b) by means of a fork-lift (fig. 3)

c) manually, by 4 persons (fig.4)

2.2 The dielectric tank: weight: 260 lb (120 Kg)

remove the tank-cover (502) by means of the loop-handles (581), (fig. 5), and transport the tank-cover separately from the tank itself (501).

2.3 The generator: weight: P12 180 lb (80 Kg)
P25 270 lb (125 Kg)

the generator can be transported quite easily by fastening a rope through the holes of the two screws (802) (fig. 6).

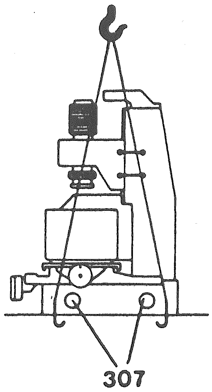
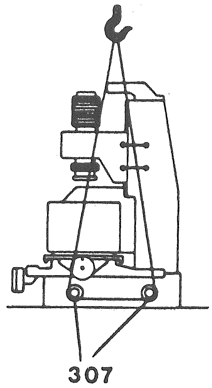


Fig 1



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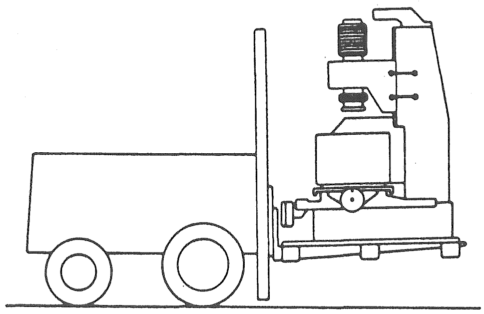

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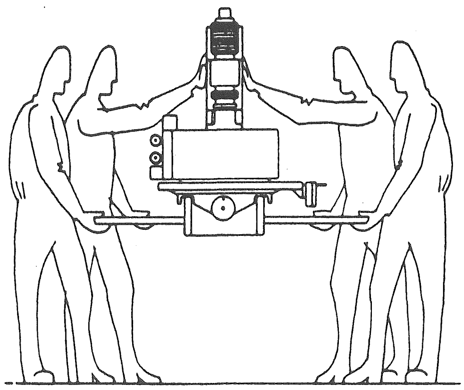

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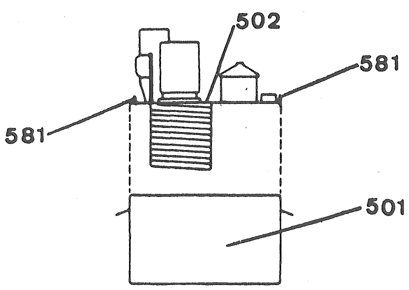

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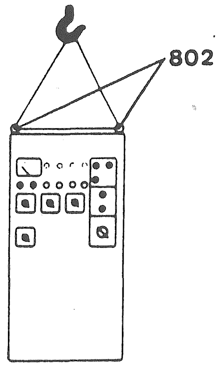


Fig 6

3 - OPERATING SITE

We recommend that the machine be installed in a closed and clean room, or at least, that it be located in a site that is well protected against the dirt, dust and grit usually encountered in workshops.

The floor plan (fig. 1) takes care of not only the actual space taken up by the machine, the generator and the dielectric tank, but also the space required for their correct location in relation to each other and the space necessary for normal operating and maintenance of the complete installation. The dotted line refers to cases in which the dielectric tank is located in the rear of the machine (refer to paragraph on "INSTALLATION").

On the site chosen, provision must be made for :

- A 3-phase, 3 KVA electrical supply outlet, complete with all necessary protective devices (fuses, overload relays), to power the installation.
- A suitable system for the supply and disposal of coolant water at a pressure not to exceed 120 PSI (10 Kg/cm^2), pipe Ø 3/8" (10 mm).
- Efficient ventilation or an installation for the exhaust of fumes.
- An adequate lighting installation.

4 - INSTALLATION

It is necessary to comply with two very important considerations :

a) The dielectric tank must always be located at a lower level than the machine.

b) The generator must be located as close as possible to, and on the right-hand side of the machine.

1st possibility : on a single workbench. Minimum dimensions of the bench area: 60" x 32" (1500 x 800 mm). If the dielectric tank (500) is located immediately underneath the machine, the height available below the workbench must be of at least 33" (830 mm) (fig. 2).

2nd possibility : on two workbenches. Minimum dimensions of the area of each workbench: 30" x 32" (1500 x 800 mm). If the dielectric tank (500) is located immediately underneath the machine, the height available below the workbench must be of at least 33" (830 mm) (fig. 3).

The tank for the dielectric fluid may be installed either :

a) immediately underneath the machine (fig. 4)

b) in the rear or at the side of the machine (figs. 5 & 6).

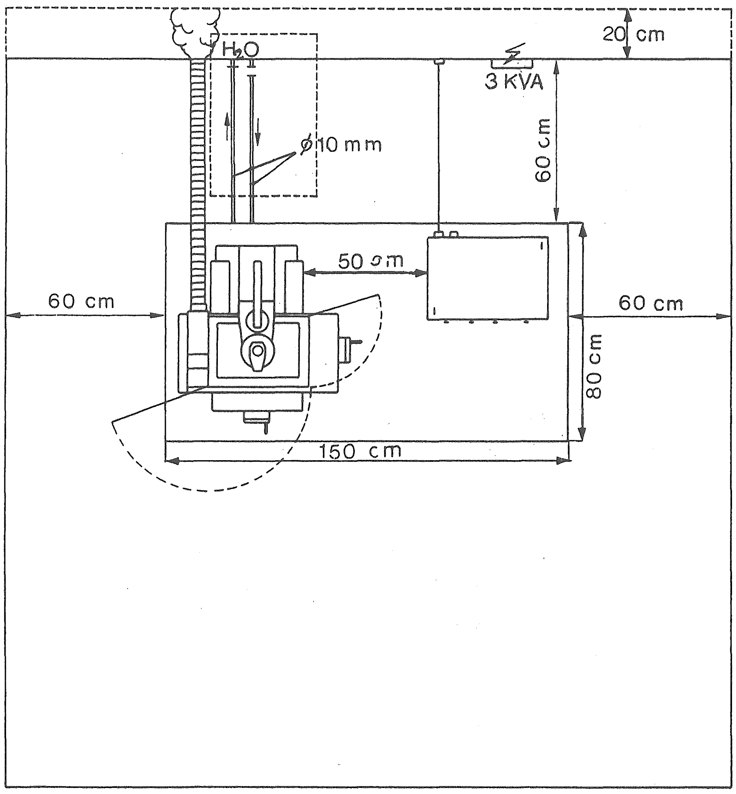
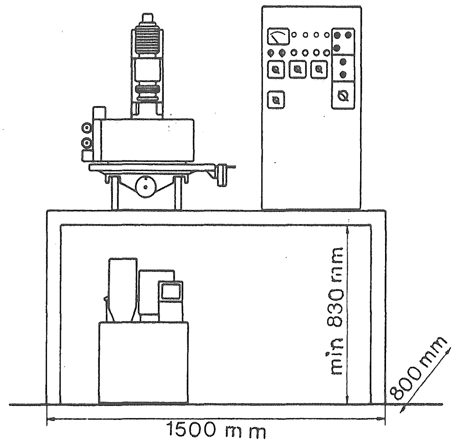


Fig 1



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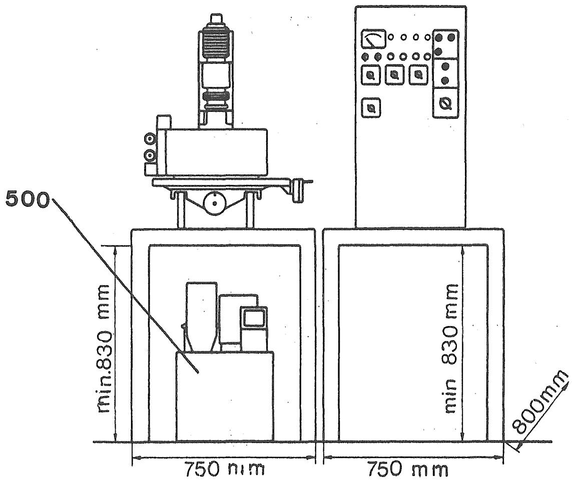

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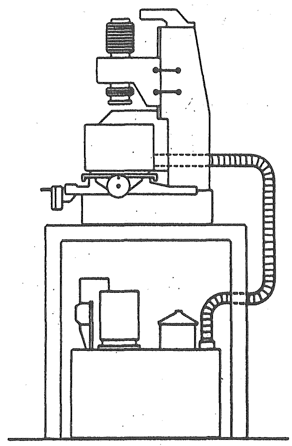


Fig 4

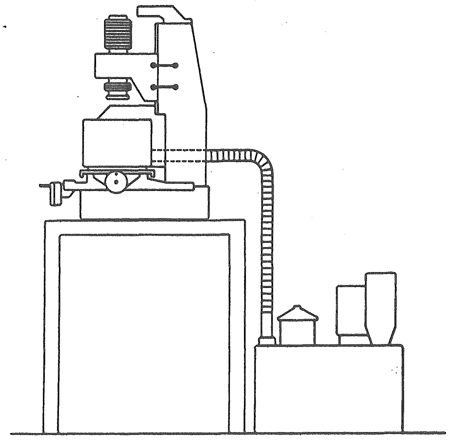


Fig 5

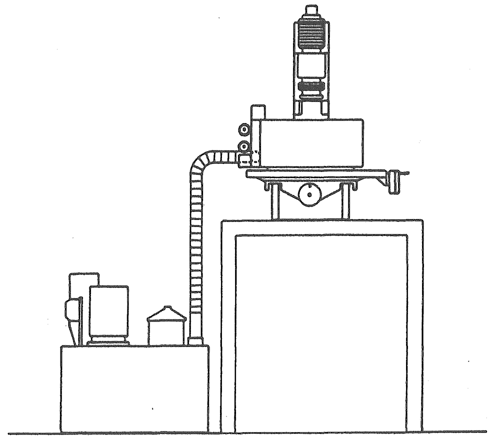


Fig 6

5 - LEVELLING OF THE MACHINE

The machine must never be fastened to the workbench by bolts or screws. It must stand free on the bench.

The frame of the machine must not touch the bench, it should rest firmly on the three feet provided for this purpose (fig. 1 a & b).

If the surface of the bench is not of sufficient hardness, bearing-plates should be placed under the feet to distribute the weight of the machine over a larger area. It is not advisable to place more than one bearing-plate under each foot.

The three following arrangements are suggested :

a) the use of a single metal sheet of 26" x 14" x 3/32" (650 x 350 x 2 mm) (fig. 2)

b) the use of 3 round discs Ø 2" x 1/8" (Ø 50 x 3 mm) (fig. 3)

c) the use of 3 square plates of 1/8" (3 mm) thickness (fig. 4)

The top of the workbench should be as nearly horizontal as possible. For more accurate levelling, make use of shim-stock placed either under the bench feet or under the bearing-plates or use bearing-plates of different thickness.

Levelling to an accuracy of 0.5% is sufficient, even 1% will be satisfactory if the slope helps the evacuation of the dielectric fluid.

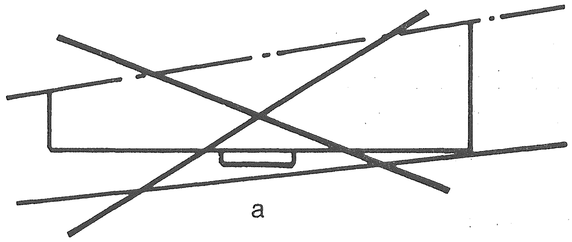
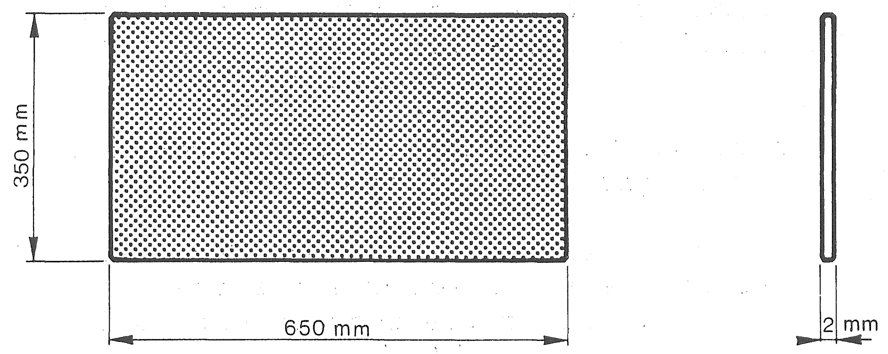


Fig 1



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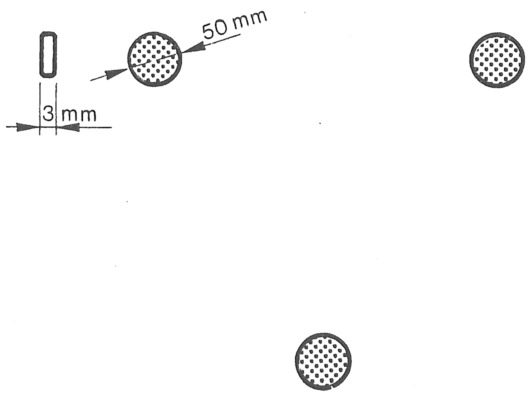

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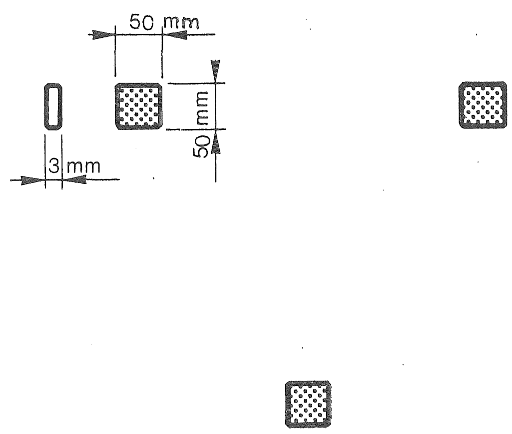


Fig 4

6 - DEGREASING

(fig. 1 a, b, & c)

In order to protect the machine against rusting, all the machined or scraped surfaces, and other delicate parts, have been coated with grease prior to delivery.

To remove this grease we recommend the use of :

- kerosene
- fuel oil
- gasoline

The principal parts to be degreased are shown marked in red in the three accompanying sketches.

Important : the lead-screws must be thoroughly cleaned.

After degreasing, the above parts must be oiled, particular attention being given to the lead-screws and the slide-ways of the machine.

The following oils are recommended though others, of similar characteristics, may be used :

for the slideways and lead-screws :

BP	ENERGOL	HP 20 c	BP
BP	ENERGOL	HP 10 c	BP
WAY	LUBRICANT MEDIUM		Chevron
FEBIS	K - 43		Esso
FEBIS	K - 53		Esso
GULF	52		Gulf
GULF	59		Gulf
VACTRA 1			Mobiloil
TONNA OIL 27			Shell

for the other degreased parts:

MOBILKOT	203	Mobiloil

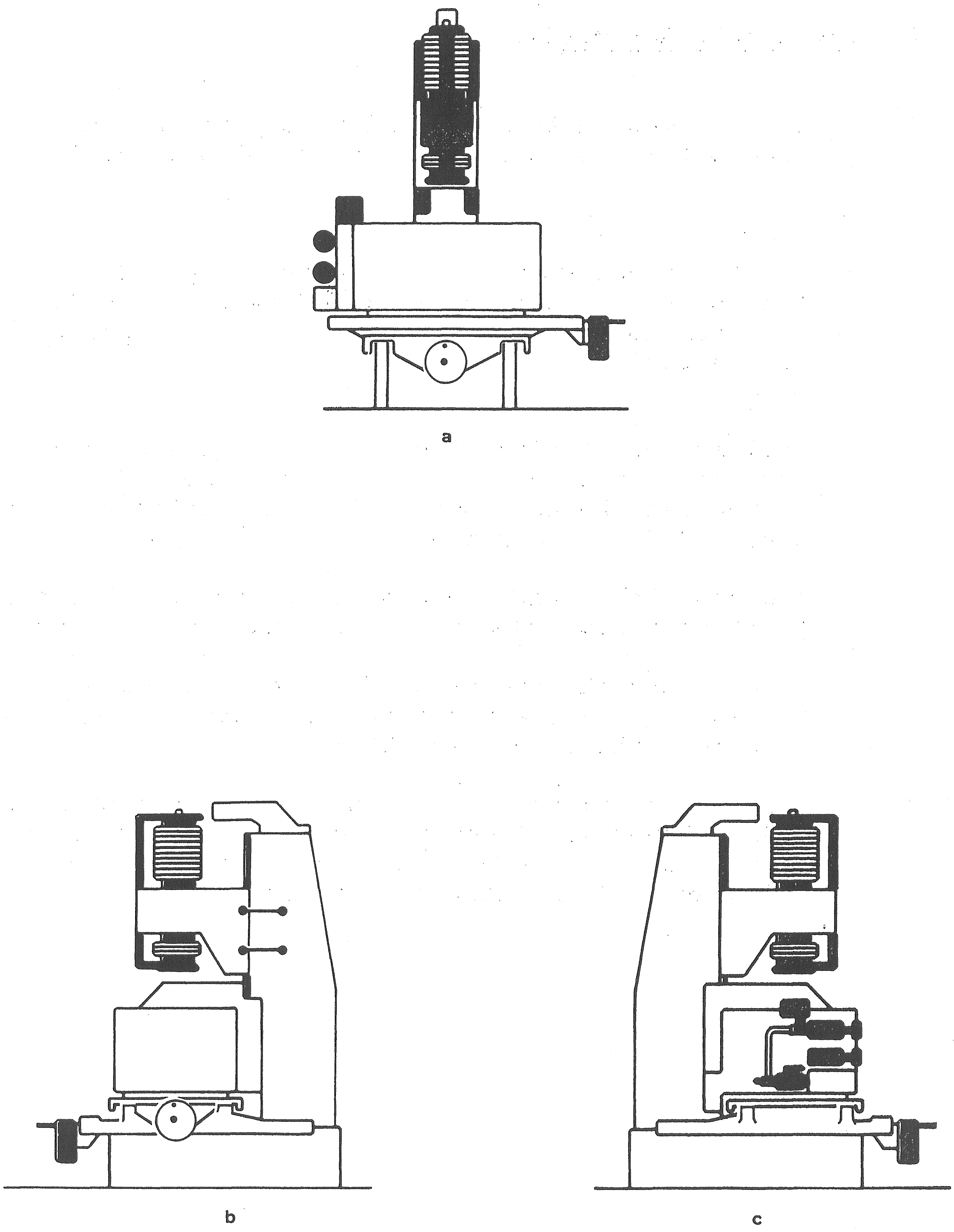


Fig 1

7 - MACHINE ERECTION

7.1 MECHANICAL ASSEMBLING

It is recommended that assembling of the machine be carried out in the order indicated below (fig. 1 & 2)

1. Fit the handles on the hand-wheels (606-633) and fit in their place the locking levers (308-604) that controls the longitudinal and the cross travel of the table.

2. Unclamp the locking levers (101) of the carriage (100) and raise it by hand (needed power about 90 lb), till it reaches the heigts to which the fastening of the chain (207) is possible.

   Tighten the looking levers (101) and attach the chain to the carriage. Remove the string retaining the chain.

   From undernath, the base of the column loosen the nut M10 and remove the plate and the threated rod. So as to unlock the counterweight (206).

   Free the carriage (100) by means of the locking levers (101). Lower it slightly by means of the rotating handle (219). Lock it again and remove the wooden block by rotating it a quarter of a turn.

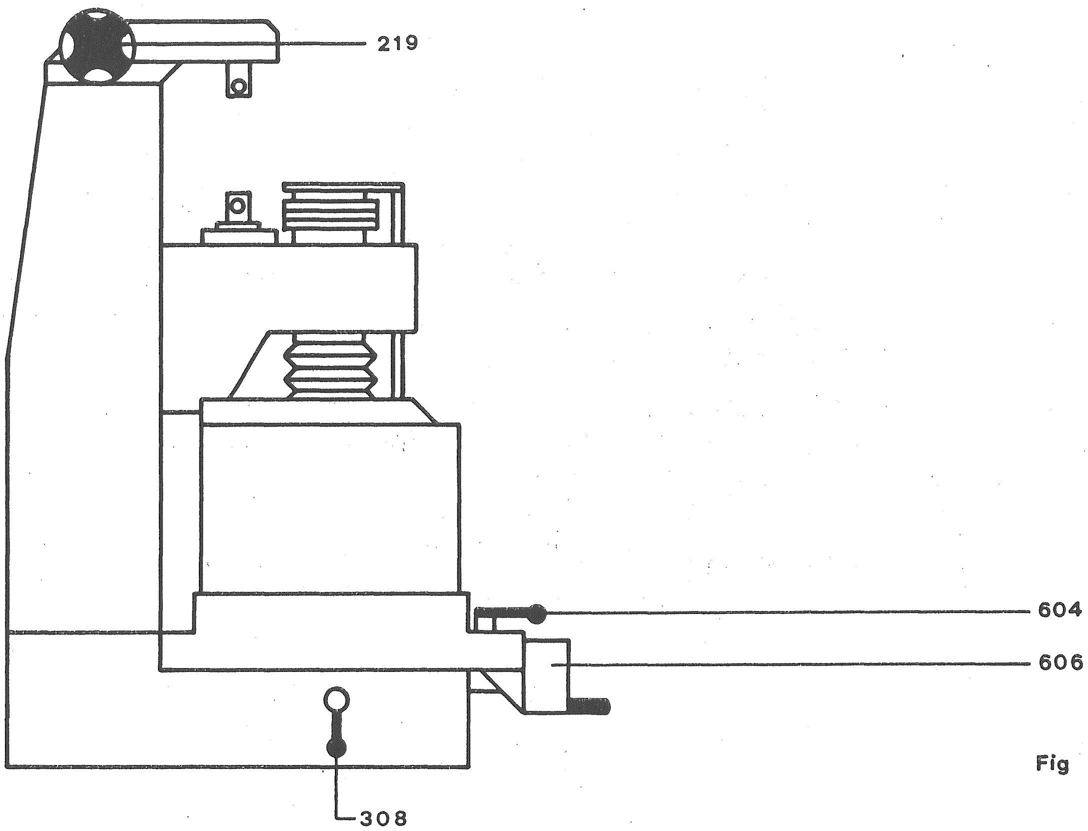


Fig 1

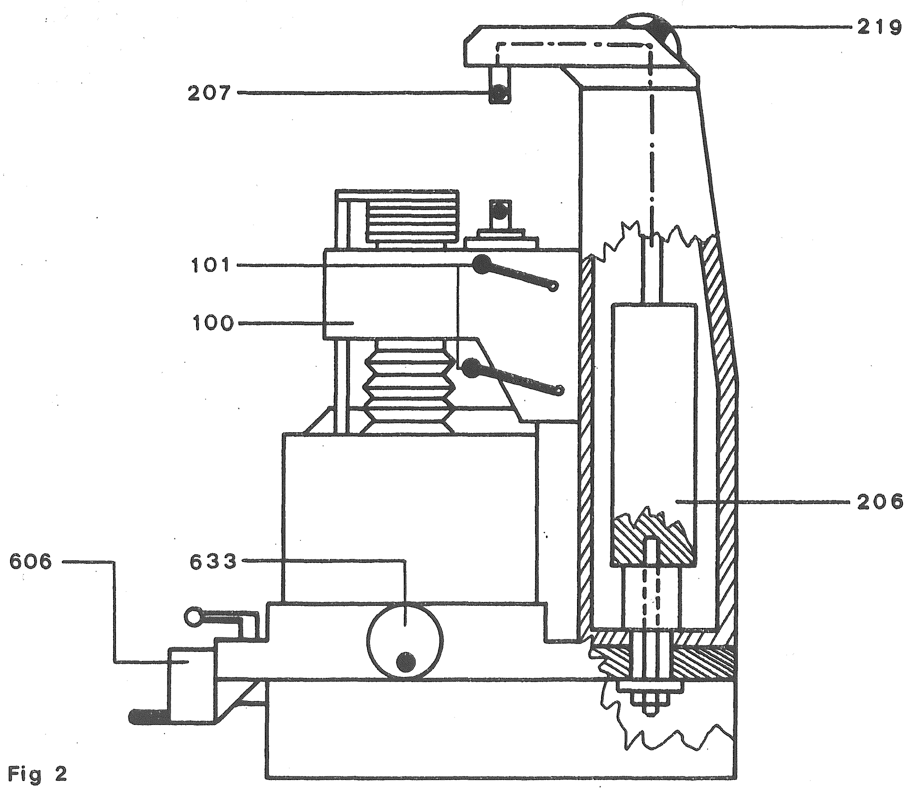


Fig 2

3. Set up the indicator (145) and the micrometer stop (141) (fig. 13).

4. Install the dielectric tank (500) in its final location.

5. Connect the pipes (H-G-I-J) and complete the connections between the dielectric tank (500) and the machine (fig. 14), (refer to paragraph 8.12 for details of connections).

6. Connect the dielectric tank (500) to the water supply (fig. 15). These hoses are to be furnished by the customers.

7. Install the generator (800) in its final location.

8. Set up the generator (800), (refer to chapter "SETTING UP OF THE GENERATOR").

9. Connect the cable (D), from the input of the junction box (851) on the generator (800) (fig. 16), to the electrical power outlet. The cable (D) and the plug are to be furnished by the customers.

0. Connect the control cable (A) of the machine to its socket (852) on the generator (800) (fig. 17).

1. Connect the control cable (B) of the dielectric tank to its socket (853) on the generator (800) (fig. 18).

2. Connect the control cable (F) of the magnetic chuck (fig. 19).

3. Connect the machining cable (E) to the machine, the black lead to the magnetic chuck, the yellow lead to the table (fig. 20).

4. Fill the dielectric tank (500) with 20 American gallons* (80 litres) of dielectric fluid (fig. 21). The following dielectric fluids are recommended, though others having the same characteristics may be used :

EDM 71	CHEVRON
LM	BP
HONILO-401	CASTROL
MENTOR-28	ESSO

5. Switch power on by means of the main switch (821) and start the pump (503) of the dielectric circuit (fig. 22 a & b) by means of its switch (824) which is located on the control panel (820) of the generator (fig. 22 b). Check, immediately, that the pump is rotating in the direction indicated by the arrow on the pump housing. If the direction of rotation is that indicated, let the pump operate for a few moments. If the pump is rotating in the reverse direction, immediately stop the pump and switch two of the 3-phase leads of the mains power line (fig. 22 c).

6. Proceed to set up the hydraulic system, as indicated below.

* American gallon = 1.2 British gallon.

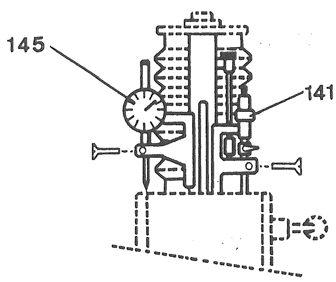
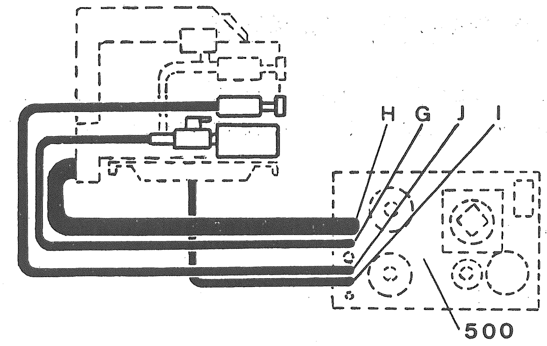


Fig 13



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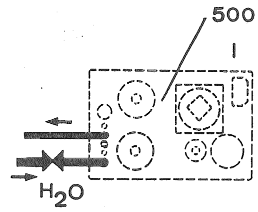

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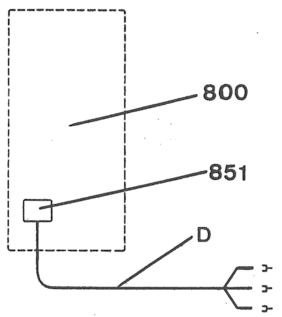
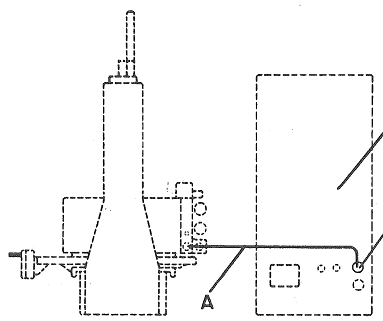


Fig 16



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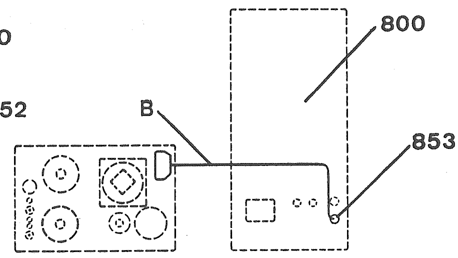

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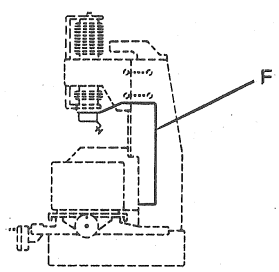

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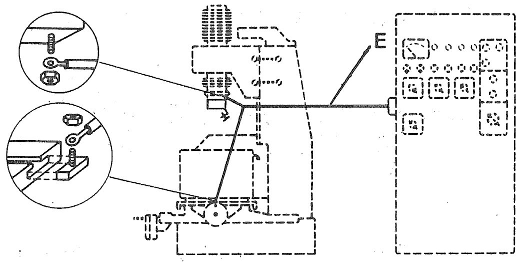

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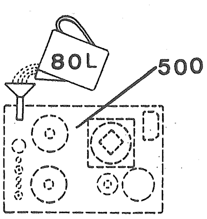


Fig 21

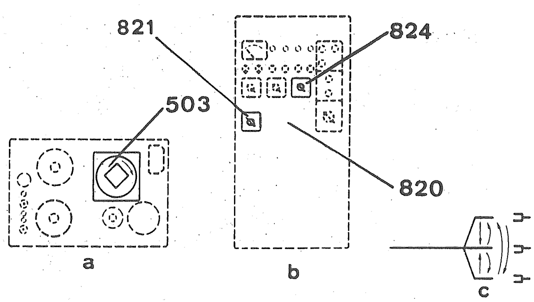


Fig 22

7.2 SETTING UP OF THE HYDRAULIC CIRCUIT

1. Remove the metal plug from the free end of the rubber pipe (M) but leave the diaphragm plug on rubber pipe (K) (fig. 23).

2. Fill a very clean can with 1.5 American gallon* (5 litres) of hydraulic oil. We recommend the use of the following oils though others having similar characteristics may be used:

ENERGOL-HYDRAULIC-40	BP
CHEVRON 5 X	Chevron
SPINESSO - 34	Esso
VELOCIT - 6	Mobiloil
PENNOL GC - 34	Pennsylvania
TELLUS OIL - 15	Shell
PURFINA-HYDRAU - 125/12	Socal

3. Insert the ends of the rubber pipes (M & K) into the can, without removing the diaphragm plug from pipe (K), then pour a small quantity of oil into the filter (593) (fig. 24).

4. Start up the pump (590) (fig. 25 a) of the hydraulic circuit by means of the switch (823) (fig. 25 b) located on the control panel (820) of the generator, make sure that the direction of rotation of the pump is correct and then let the oil circulate for at least two hours in order to filter out any impurities it may contain.

5. Having let the oil circulate for a period of two hours, switch off the hydraulic pump (590) by means of the switch (823).

6. Remove the adhesive tapes covering the openings (108-109-125) and also the rubber guard placed as protection over the nozzle (104) (fig. 26).

7. Remove the diaphragm plug from the end of pipe (K) and fit this rubber pipe onto nozzle (104) (fig. 27). Start up the pump (590) again by means of switch (823). The piston (121) will then rise automatically to the highest point of its stroke.

8. As soon as the oil within the indicator tube (107) reaches a level intermediate between 5" (125 mm) (minimum) and 5½ (140 mm) (maximum) (fig. 28), switch off the pump (590) of the hydraulic circuit by means of switch (823).

9. Remove the rubber guard from nozzle (106) and quickly insert the free end of the pipe (M) into the nozzle in order to prevent loss of oil (fig. 29).

10. Connect the cable (C) of the servo-mechanism to the socket (108) located at the upper end of the oil-level indicator tube (107) (fig. 30).

* American gallon = 1.2 British gallon

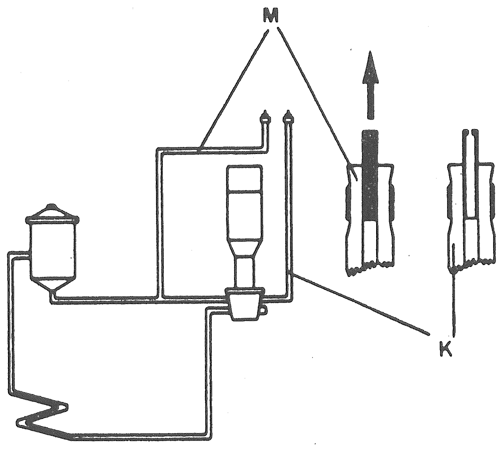
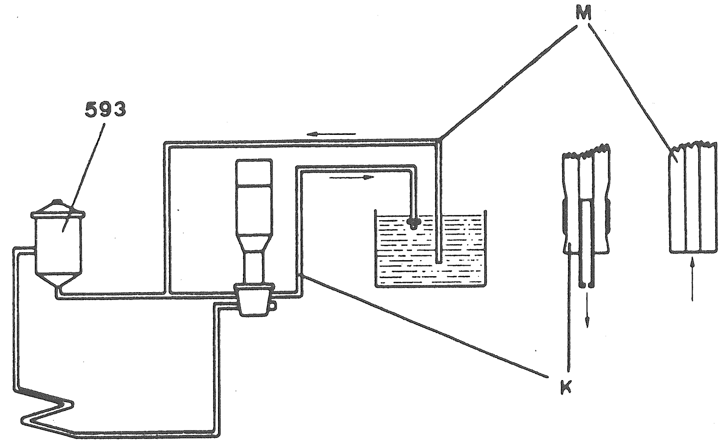


Fig 23



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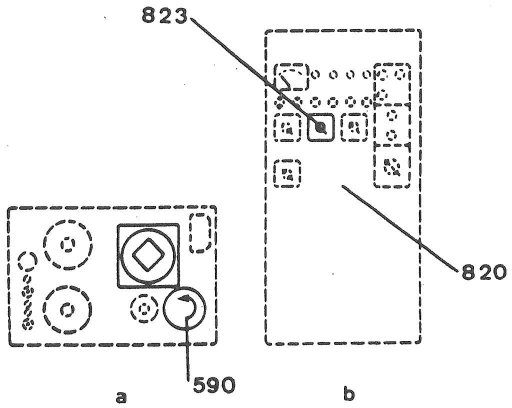


Fig 25

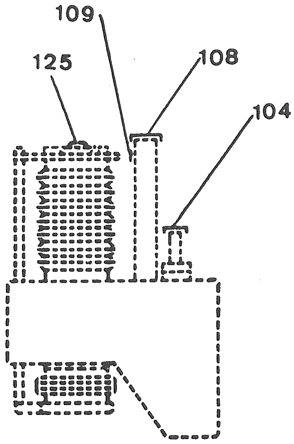
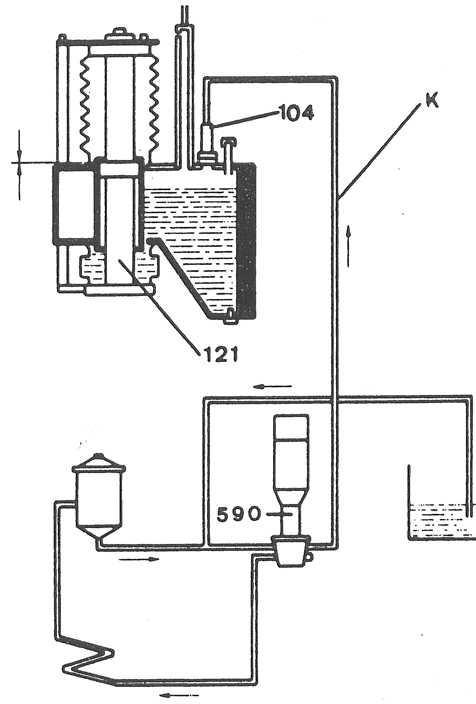


Fig 26



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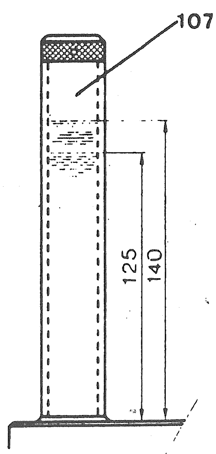

Fig 28

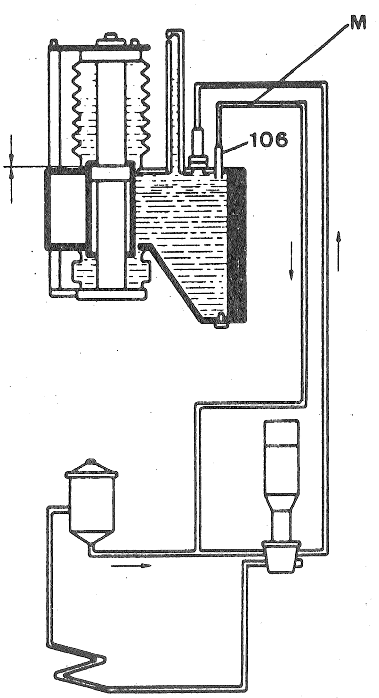

Fig 29

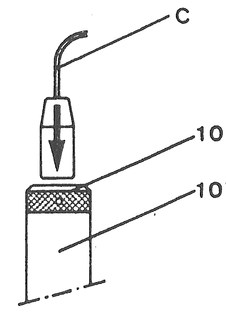

Fig 30

7.3 INSPECTION

In our opinion it is not necessary, after setting up the machine, to repeat all the checking operations listed in the specification sheets, since these have been carried out in our plant prior to delivery of the equipment and according to very severe standards.

Nevertheless, it is advisable to check certain circuits, i.e. :

- check the hydraulic circuit
- check the dielectric circuit
- check the generator
- check the angular setting of the magnetic chuck

These verifications can be made in the following manner after being sure that the machine is leveled (fig. 1).

7.3.1 Checking of the hydraulic circuit

- Turn the main control switch (821) of the generator to "ON".
- Start the hydraulic pump by means of switch (823) and make sure, immediately, that no leakages occur; if required, tighten all leaky connections.
- Turn the switch (822) of the auxiliary supplies of generator.
- Set the power rating switch (825) to the position (↓ ↑).
- Set the manual up and down switch (836) of the chuck to its mid position.
- Turn the servo control knob (831) clockwise.
- Turn the selector switch (836) to the left and check that the piston moves downwards.

7.3.2 Checking of the dielectric circuit

- Lock the doors giving access to the work tank.
- Start up the dielectric pump by means of switch (824), the valve (722) being closed; check for any leakages and, if necessary, tighten the connections.
- Open the valve (717) to fill the tank and make sure that the latter is leak-proof.
- Set the "injection mode" selector switch (837) to the right-hand position (———), open the injection valve (722) and check that the dielectric fluid flows from nozzle (721).

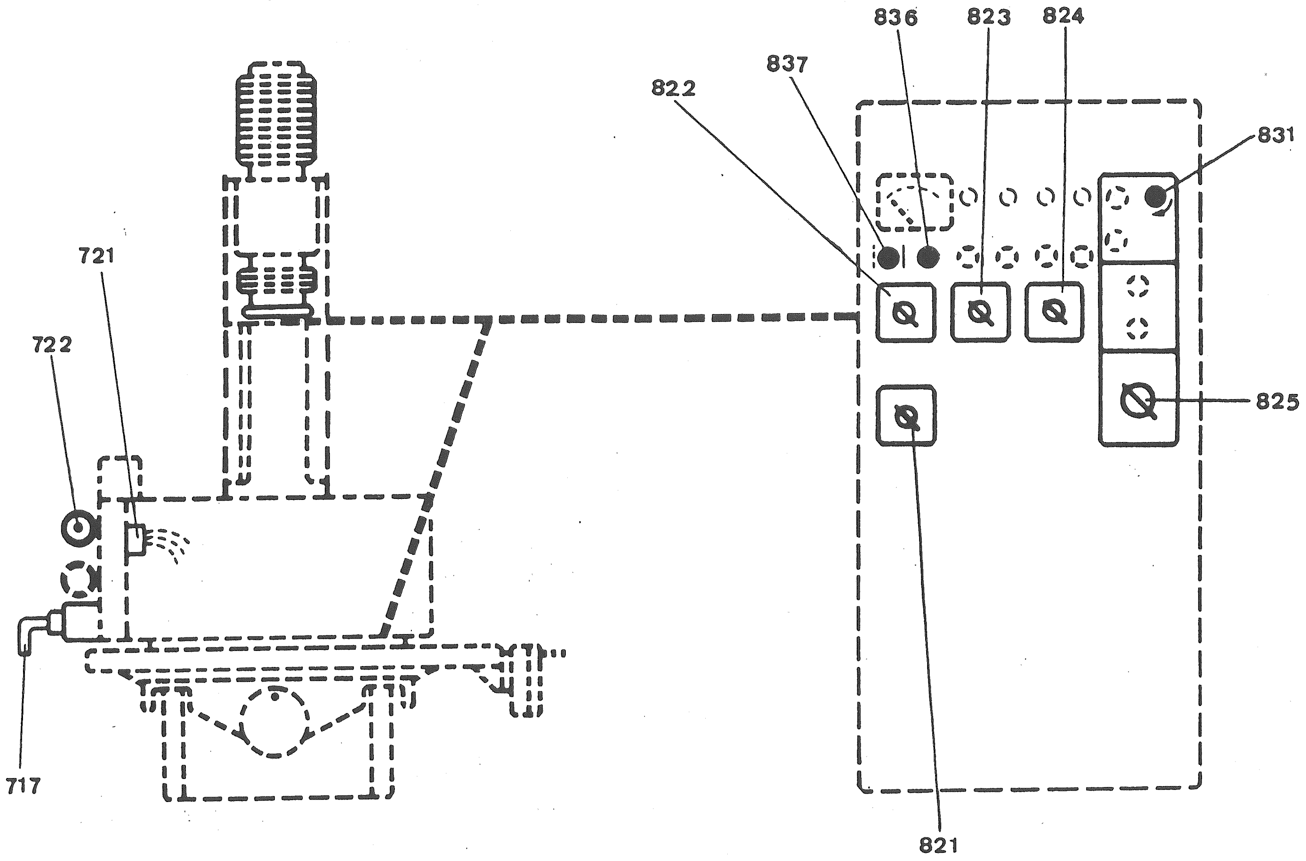

Fig 1

7.3.3 <u>Checking of the generator</u> (fig. 2)

- Fill the tank up to the overflow-pipe and leave the dielectric inlet valve open.
- Set the carriage to its uppermost position.
- Set the power rating selector switch (825) to position :

  (½ +) if using a type P12 generator, or to

  (1 +) if using a type P25 generator.

- Set :

  Selector switch B (827) to position 12

  Selector switch A (826) to position 6

- Set the pulsator switch (830) to position "0".
- Switch the machining current on by means of the green knob (832);

  the piston should now move downwards, the green pilot lamp (838) should be on and the red pilot lamp (841) should be off.

- Short-circuit the two outlet leads of the machining cable "E"; the ammeter (842) should indicate approximately 1 ampere.
- Turn the selector switch A (826) from position 6 to position 12; the ammeter (842) should now indicate :

  approximately 10 amps if using a P12 generator

  approximately 20 amps if using a P25 generator.

7.3.4 <u>Checking angular position of the magnetic chuck</u>

- Refer to the paragraph ALIGNMENTS under chapter "OPERATION".

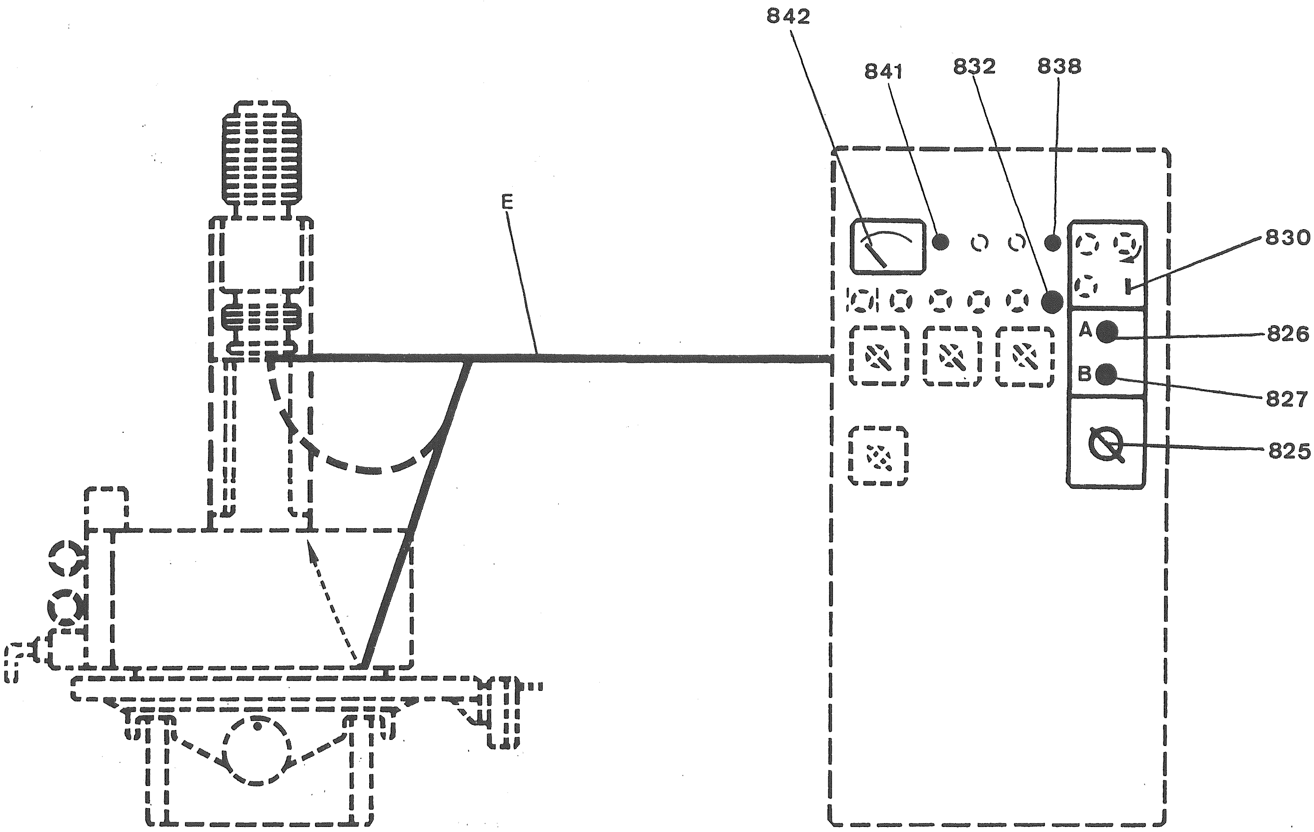

Fig 2

8 - DESCRIPTION

8.1 GENERALITIES

All of the cast parts used on the machine are made of stabilized cast iron; they are amply dimensioned and heavily ribbed.

All of the bearing surfaces and slideways have been very carefully machined.

The D10 can be devided into separate units (fig. 1) as listed herein under:

the "CARRIAGE"	unit (100)
the "COLUMN"	unit (200)
the "FRAME"	unit (300)
the "DIELECTRIC TANK"	unit (500)
the "X AND Y TABLE"	unit (600)
the "WORK TANK"	unit (700)
the "GENERATOR"	unit (800)

The first figure of the reference numbers of all component parts of the various units is always the hundred's digit of the reference number of the corresponding unit.

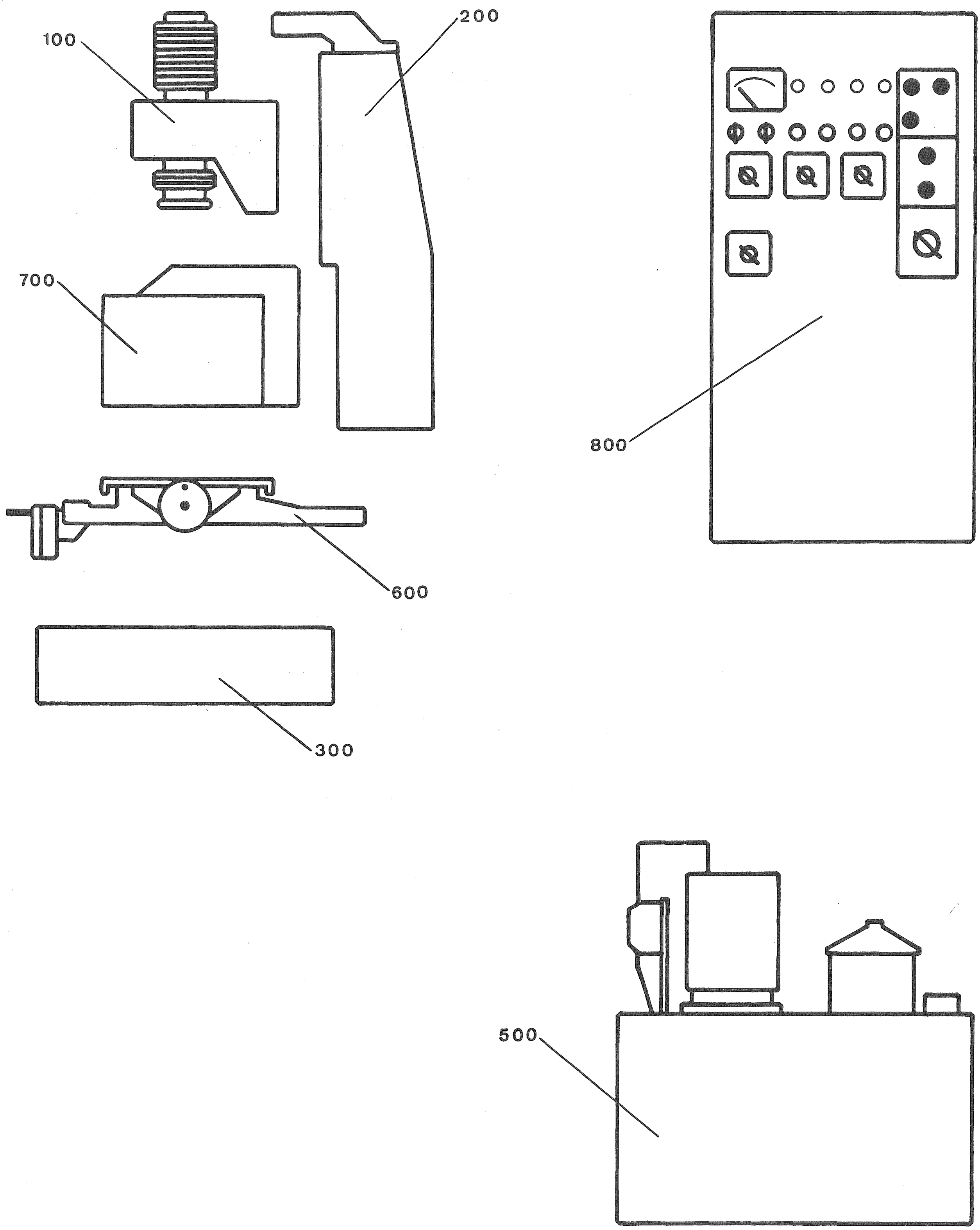

Fig 1

8.2 CARRIAGE Unit 100

The servo-mechanism is incorporated within the carriage unit.

The hydraulic oil tank is an integral part of the carriage (figs. 1, 2 & 3).

100 Carriage unit.
101 Locking levers.
102 Tank for hydraulic oil.
103 Cover of the tank (102).
104 Hydraulic oil inlet nozzle.
105 Hydraulic oil filter.
106 Hydraulic oil outlet nozzle.
107 Transparent oil-level indicator tube.
108 Actuator coil electrical socket.
120 Assembly controlling the electrode down and up feed.
124 Rubber bellows for protection of the mechanism.
130 Servo-mechanism control unit.
140 Depth-stop assembly.
141 Micrometric stop.
145 Indicator.
180 Angular guide rule.

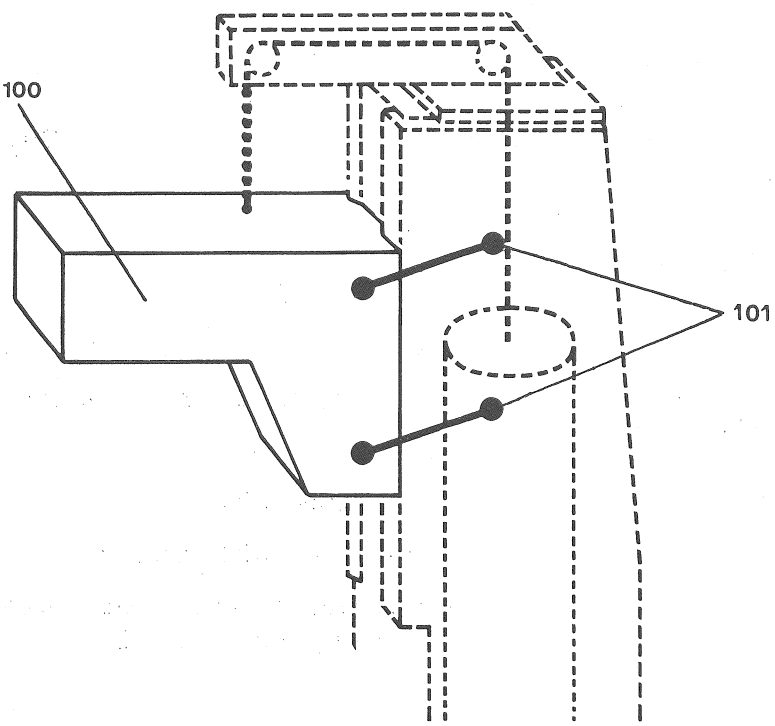

Fig 1

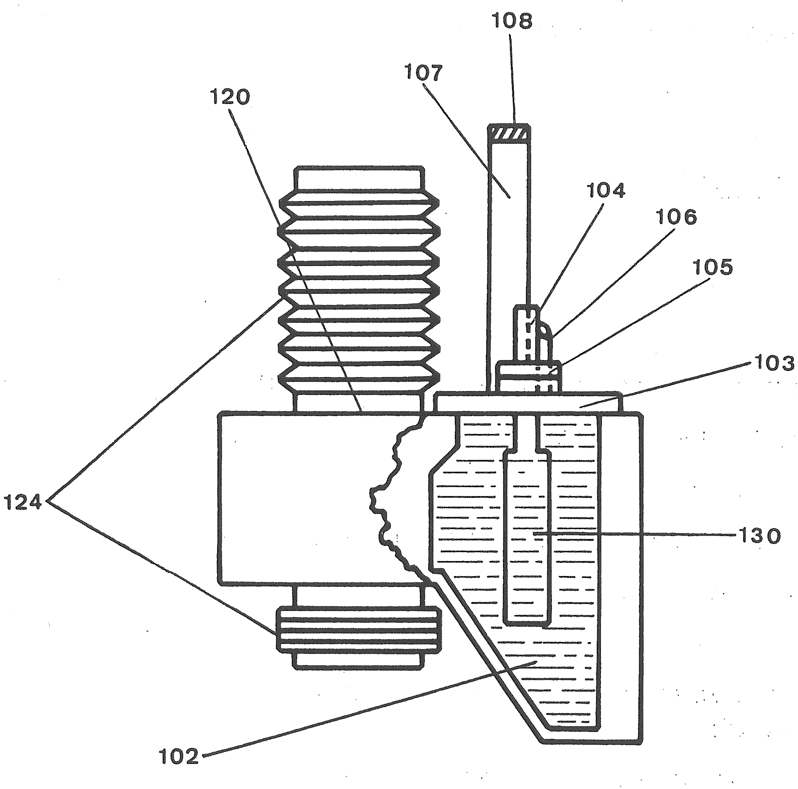

Fig 2

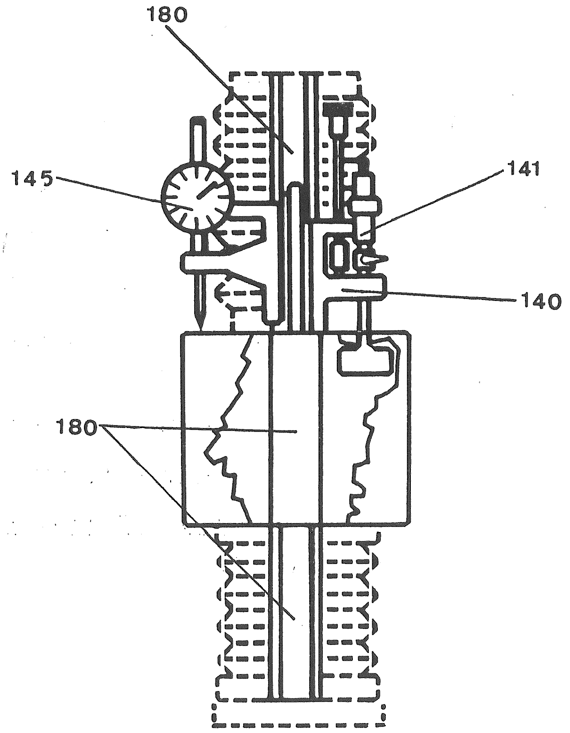

Fig 3

8.3 COLUMN Unit 200
(fig. 1)

200 Column unit.

201 Vee slideway for carriage travel.

202 Flat slideway for carriage travel.

203 Column cover.

206 Counterweight.

207 Counterweight chain.

219 Rotating handle for raising or lowering manually the carriage.

8.4 FRAME Unit 300
(fig. 2)

300 Frame unit.

301 Vee slideway supporting the cross slide of the table.

302 Flat slideway supporting the cross slide of the table.

303 Bearing area for the column (200).

304 4 holes for the attachment screws of the column.

305 4 screws for fastening the column.

306 3 machine-feet.

307 2 through holes for the passage of 2 bars during transportation of the machine.

308 Locking lever of the cross slide of the table.

309 Index of the rule (612) of the table cross slide.

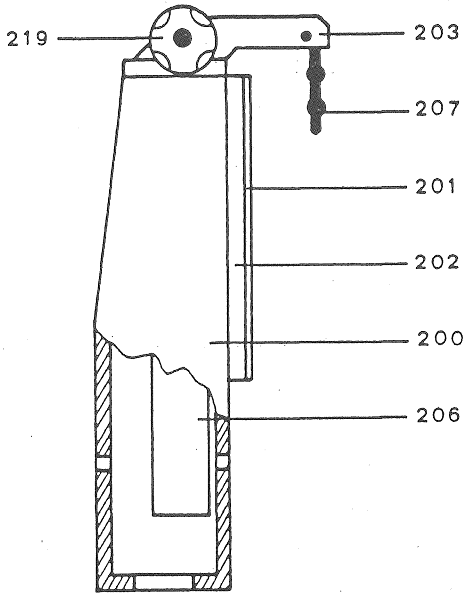

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Fig 1

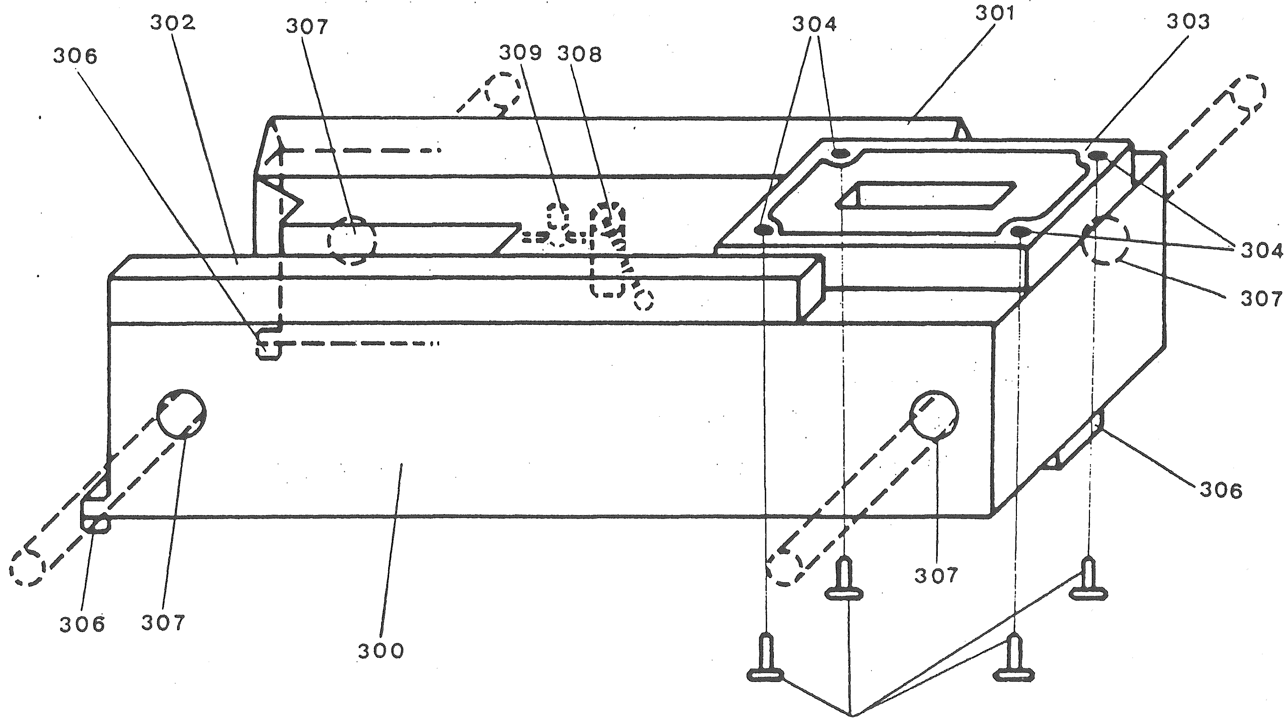

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Fig 2

8.5 DIELECTRIC TANK Unit 500

(fig. 1)

The hydraulic oil tank being incorporated within the carriage itself, the component parts of the hydraulic circuit are assembled on the top cover of the dielectric tank.

Dielectric circuit

500 Dielectric-fluid tank unit.

501 Dielectric-fluid tank.

502 Tank cover-plate used as support for various equipment.

503 Centrifugal pump.

504 Twin filter units connected in parallel.

505 Suction Venturi tube.

506 Outlet channel of the dielectric fluid (under pressure).

507 Inlet channel for the return of the dielectric fluid from the work tank.

508 Opening for the pipe collecting dielectric fluid from the gutter of the table.

509 Opening for the pipe (J) of the Venturi tube.

520 Coil of the temperature stabilization.

521 Coil of the coolant water circuit.

522 Thermostat for the control of the solenoid-valve (523).

523 Solenoid-valve of the coolant water circuit.

524 Inlet channel for the cooling water.

525 Outlet channel for the cooling water.

580 2 handles of the tank (501).

581 4 handles of the cover-plate (502).

582 Electrical connection box.

Hydraulic circuit

590 Gear type motor pump.

591 Screen unit incorporated within motor pump (590).

592 Pressure adjusting unit incorporated within motor pump (590).

593 Filter unit.

594 Outlet channel of the hydraulic oil (pressure).

595 Inlet channel for suction of the oil.

596 Connection for the pressure-gauge.

Characteristics of the dielectric fluid tank

Total capacity of the dielectric tank 20 American gallons* (80 litres)

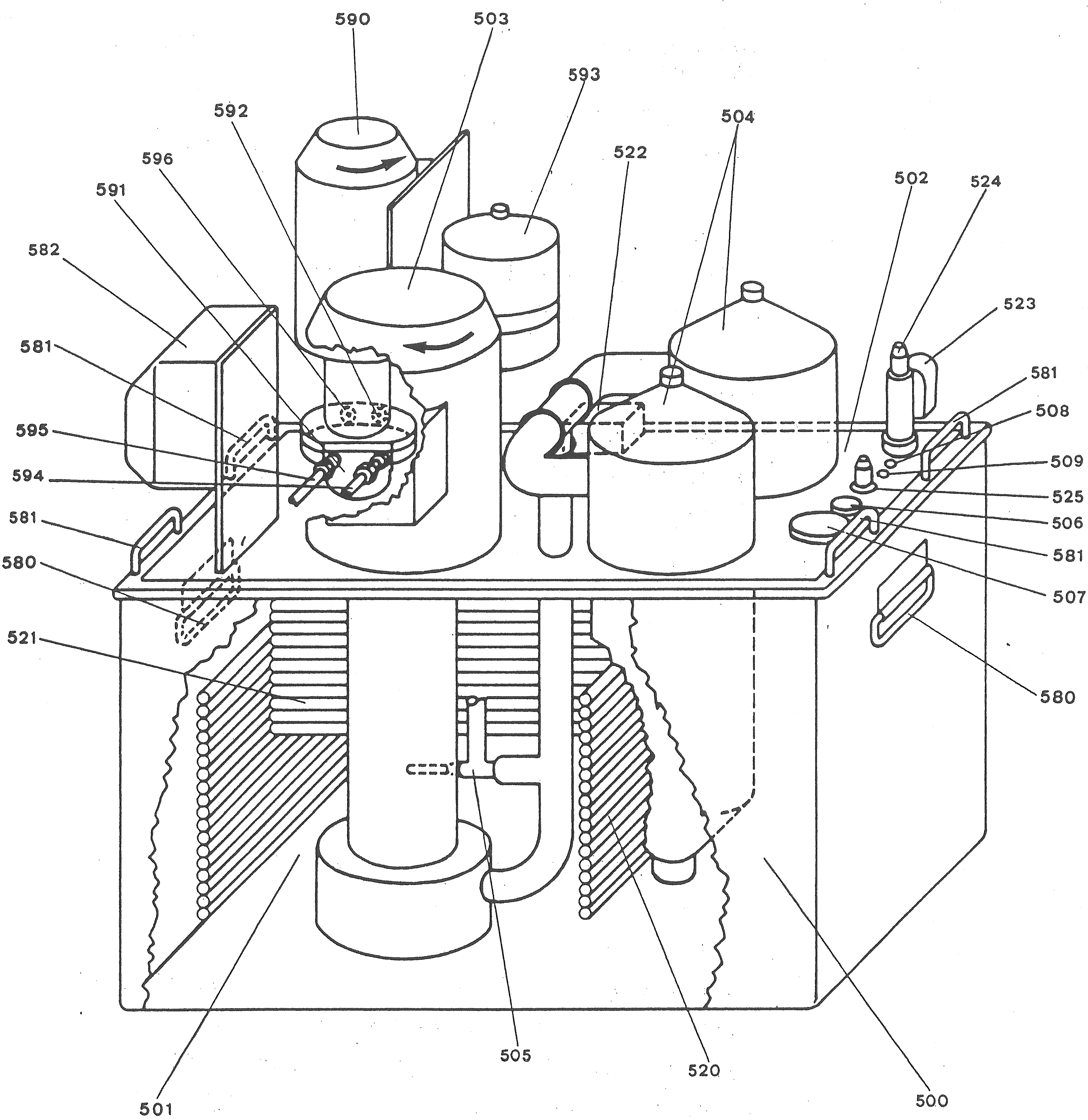
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Fig 1

8.6 X AND Y TABLE Unit 600

(fig. 1)

600 X and Y table unit.

601 Cross slide, supported by the Vee slideway (301) and the flat slideway (302) of the frame.

602 Vee slideway supporting the longitudinal slide.

603 Flat slideway supporting the longitudinal slide.

604 Locking lever of the longitudinal slide.

605 Adjustable index of the rule (638).

606 Hand-wheel for transversal travel of the table.

607 Wheel handle of the hand-wheel (606).

608 Lead-screw driven by hand-wheel (606).

609 Graduated dial of hand-wheel (606).

610 Vernier of the graduated drum (609).

611 Rule of the transversal travel.

612 Knurled locking screw of drum (609) on hand-wheel (606).

613 Knurled locking screw of the lead-screw (608).

630 Longitudinal slide, supported by the Vee slideway (602) and the flat slideway (603) of the cross slide.

631 Worktable.

632 3 "T" slots of the worktable (631).

633 Hand-wheel for longitudinal travel of the table.

634 Wheel handle of the hand-wheel (633).

635 Lead-screw driven by the hand-wheel (633).

636 Graduated drum of the hand-wheel (633).

637 Vernier of the graduated drum (636).

638 Rule of the longitudinal travel.

639 Knurled locking screw of drum (636) on hand-wheel (633).

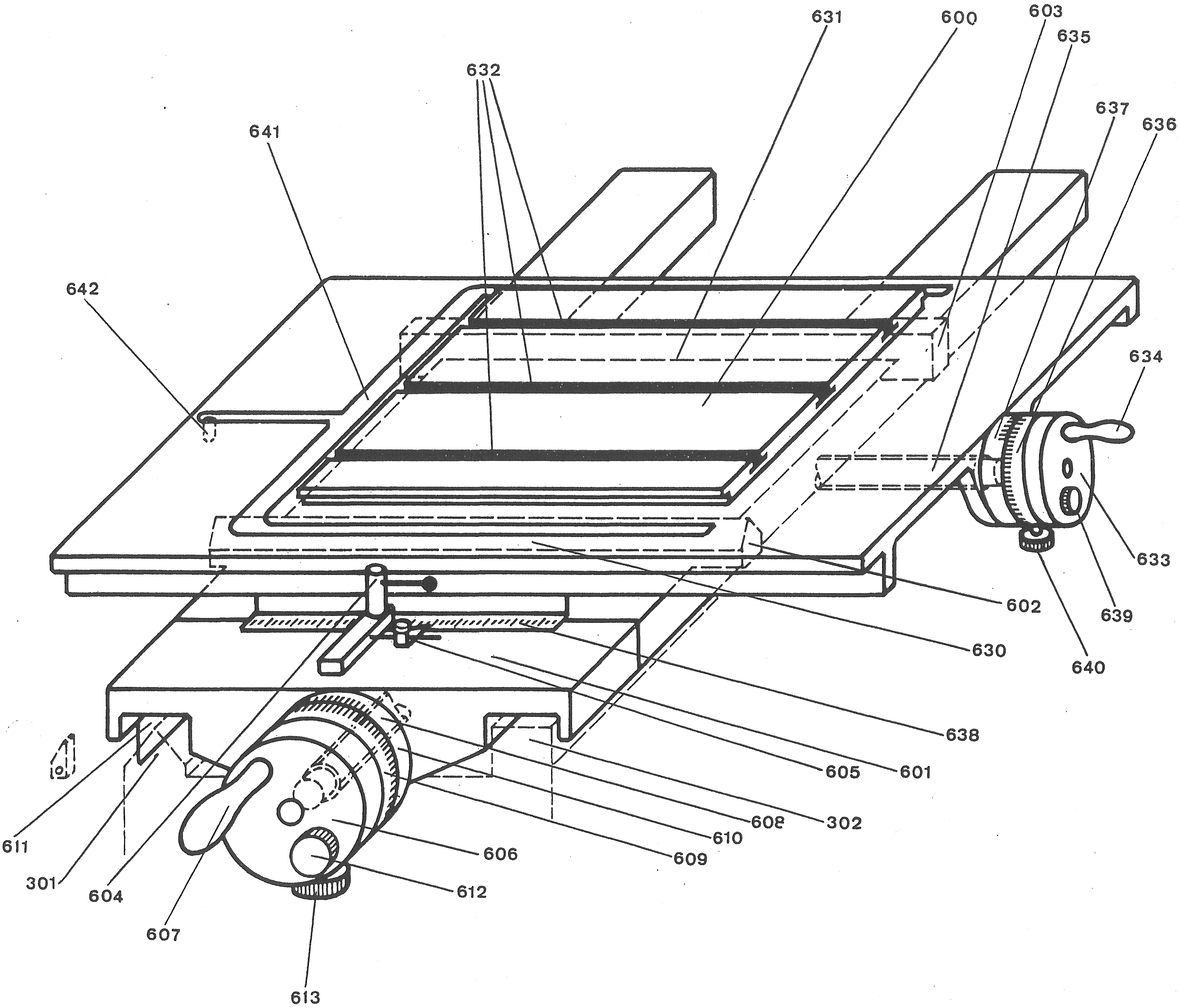
640 Knurled locking screw of the lead-screw (635).

641 Discharge gutter of the longitudinal slide (630).

642 Outlet for the fluid collected by gutter (641).

Characteristics of the indexing table

Dimensions of the table	14" x 9" (350 x 230 mm)
Three "T" slots, distance of centers 3" (75 mm)	width 25/64" (10 mm)
Longitudinal travel	8" (200 mm)
Cross travel	4 3/4" (120 mm)
Vernier resolution	.0001" (0.002 mm)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8.7 WORK TANK Unit 700

(fig. 1)

700 Work tank unit.

701 Front door.

702 Side door.

703 Locking device of the doors.

704 Door gaskets.

705 Table gasket.

706 Holding screws.

707 3 plexiglass guards fitted on the work tank.

710 Sliding door for drainage.

711 Handle of the sliding door (710).

712 Sliding door for dielectric fluid level adjustment.

713 Handle of the sliding door (712).

714 Safety float-switch for the dielectric fluid level adjustment.

715 Thermostat compartment.

716 Safety thermostat for the dielectric fluid temperature adjustment.

717 Fill up valve.

718 Inlet for fill-up.

719 Inlet for the dielectric-fluid pressure pipe.

720 Outlet for drainage or overflow of the tank.

721 Distribution box for injection pipes.

722 Valve for continuous and pulsated injection.

723 Solenoid-valve for pulsated injection.

724 Pipe connecting the nozzle (719) to the solenoid-valve (723).

725 Distribution box for connection of the suction pipes and the vacuum-gauge.

726 Suction valve.

727 Nozzle for the suction pipe.

728 Vacuum-gauge.

729 Connection of the vacuum-gauge pipe.

730 Outlet for the exhaust fumes.

Internal dimensions of the work tank : 16 1/2" x 11 3/4" (420 x 300 mm)

Maximum level of the fluid : 7" (180 mm)

Capacity : [illegible]

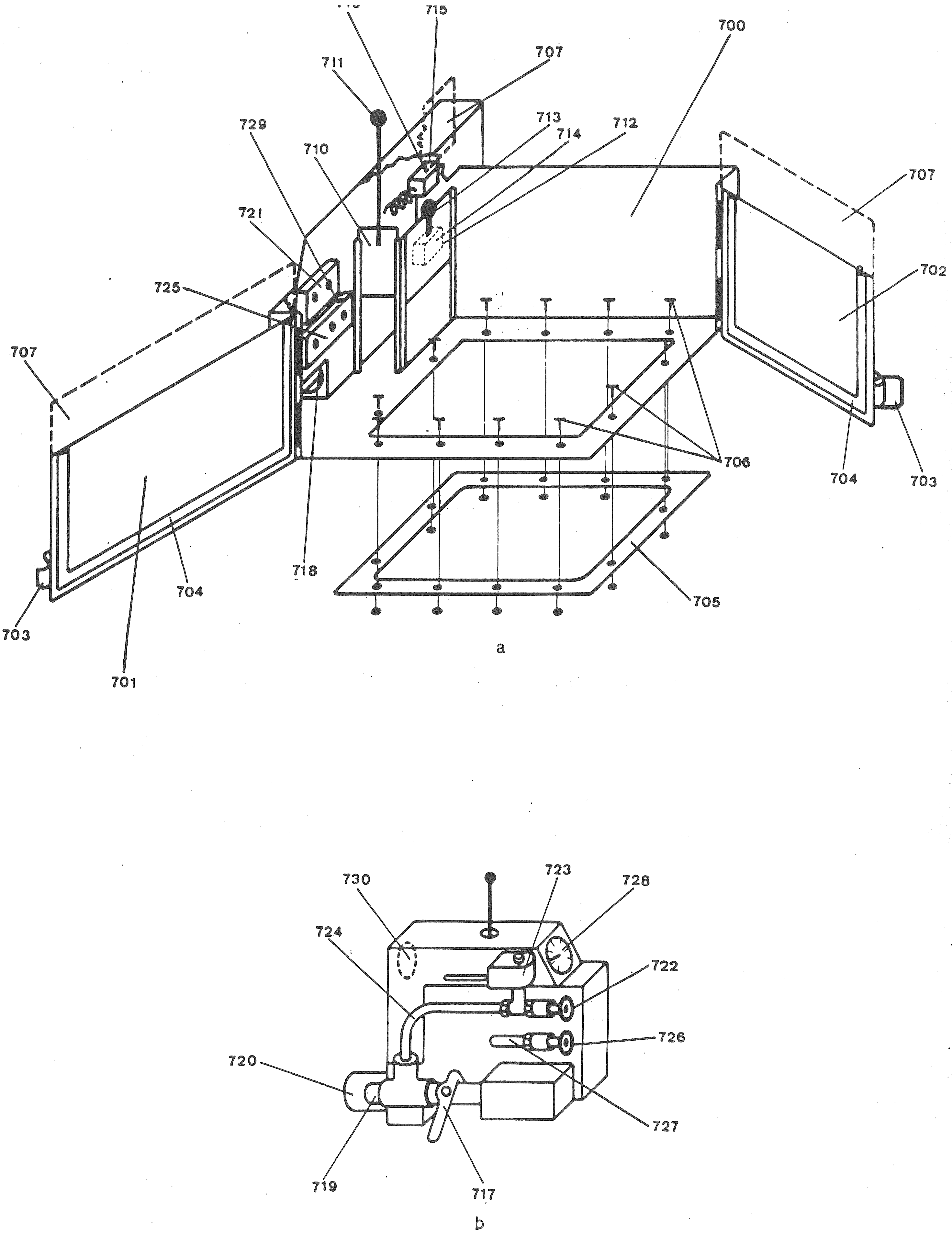

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Fig 1

8.8 SERVO-MECHANISM (fig. 1)

120 Up and down feed mechanism controlling the electrode travel, protected against dust by rubber bellows (124).

121 Differential piston.

122 Cylinder.

123 Hydrostatic bearings.

124 Bellows for protection against dust.

131 Actuator.

132 2 diaphragms of the actuator circuit.

133 One way self-cleaning valve.

134 Electrodynamic coil of the actuator, powered by cable C from the socket (108).

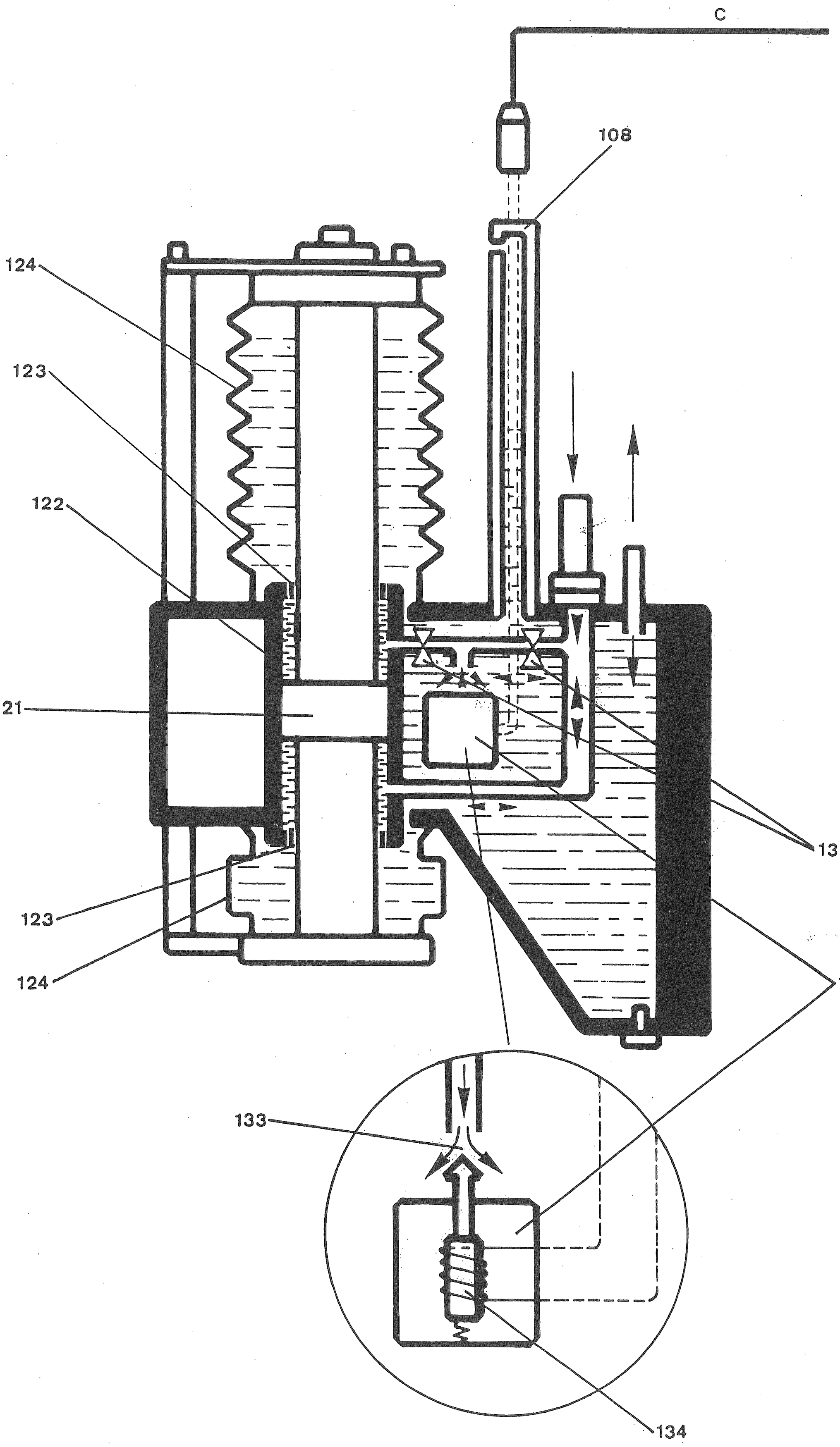

Fig 1

8.9 HYDRAULIC CIRCUIT (fig. 1)

100 Carriage.
102 Hydraulic oil tank.
104 Hydraulic oil inlet nozzle.
105 Hydraulic oil filter.
106 Hydraulic oil outlet nozzle.
107 Transparent oil-level indicator tube.
109 Air exhaust outlet at the upper end of tube (107).
121 Differential piston.
125 Air exhaust outlet at the top of the piston.
520 Coil of the temperature stabilization.
590 Gear-type pump.
591 Screen unit incorporated within the pump (590).
592 Pressure adjusting unit incorporated within pump (590).
593 Filter unit.
594 Outlet channel of the hydraulic oil.
595 Inlet channel for suction of the oil.
596 Connection for the pressure-gauge.

M Return hose for connection of the outlet channel (106) to the inlet channel (595).

K Pressure hose for connection of the outlet channel (594) to the inlet channel (104).

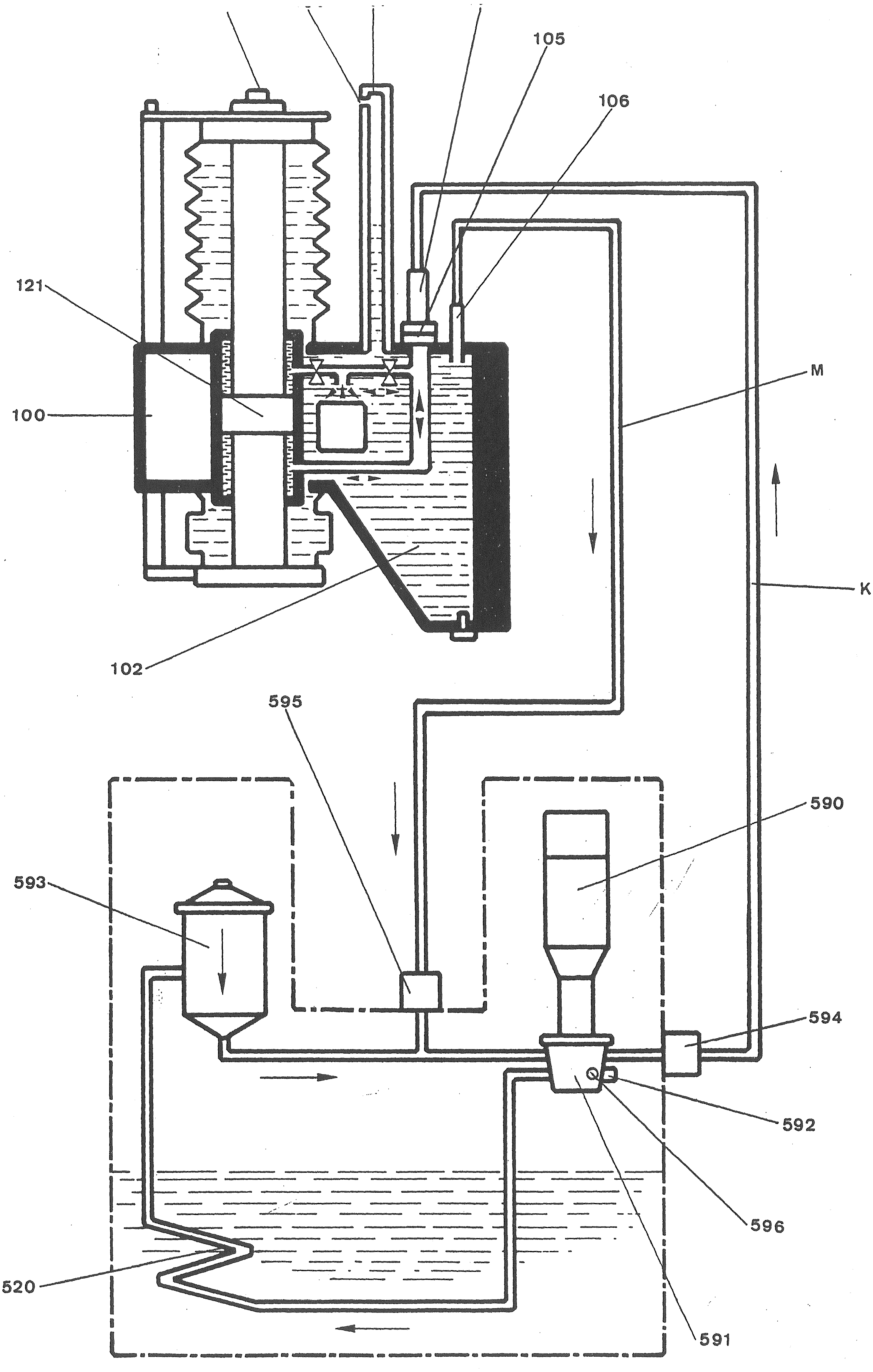

Fig 1

8.10 DIELECTRIC CIRCUIT (figs. 1 & 2)

500 Tank.

503 Centrifugal pump.

504 Twin filter units connected in parallel.

505 Suction Venturi tube.

521 Coil for cooling of the dielectric fluid.

522 Thermostat of the dielectric fluid cooling circuit.

523 Solenoid-valve of the cooling circuit, controlled by thermostat (522).

700 Work tank.

710 Sliding door for drainage of the tank.

712 Sliding door for adjustment of the level of the dielectric fluid in the tank.

714 Safety float-switch controlling the level of the fluid in the tank.

717 Fill up valve.

719 Inlet for the dielectric fluid.

721 Distribution box for the injection pipes.

722 Valve for continuous and pulsated injection.

723 Solenoid-valve for pulsated injection.

724 Pipe connecting the inlet channel (719) to solenoid-valve (723).

725 Distribution box for connection of the suction pipes.

728 Vacuum-gauge.

G Pipe for filling up of the tank.

H Pipe for drainage of the tank.

I Pipe for drainage of the gutter.

J Suction tube.

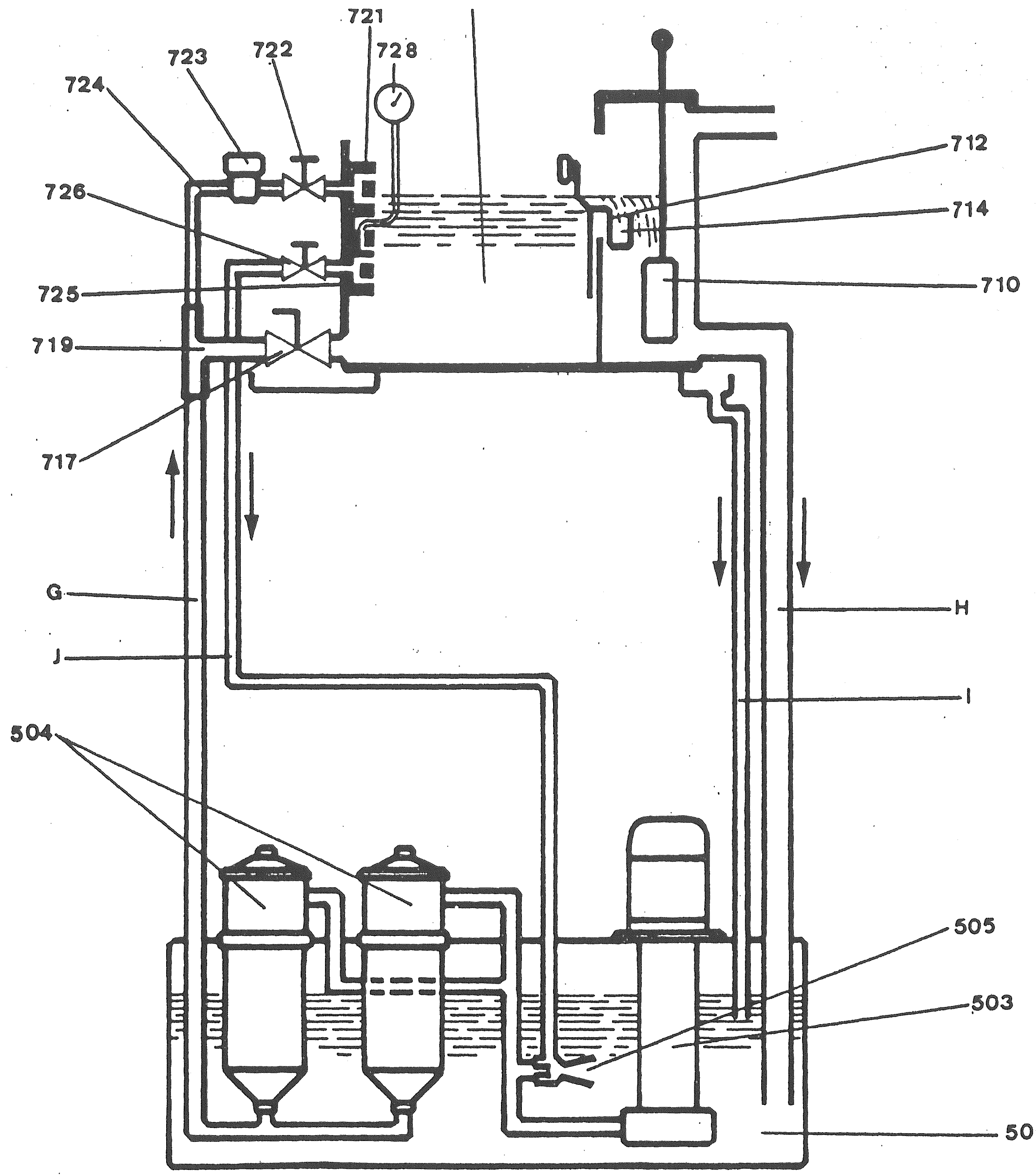

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Fig 1

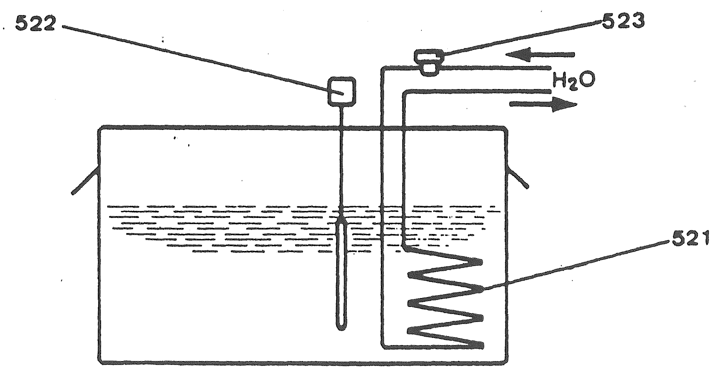

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Fig 2

8.11 ELECTRICAL CIRCUIT (fig. 1)

A - Control cable to machine.

B - Dielectric tank cable.

C - Actuator coil and depth-stop cable.

D - Main power cable.

E - Machining cable of the machine. This cable is an integral part of the generator. Two leads are provided : the yellow lead is for connection to the worktable, the black lead is for connection to the chuck.

F - The magnetic chuck cable.

582 Electrical junction box of the dielectric tank. From this junction box, connections are made to the motor pump units (503) (590), to the thermostat (522) and to the solenoid-valve (523).

851 Electrical junction box of cable "D".

852 Socket for the cable "A". The other end of this cable is part of the machine. A terminal strip is provided for the interconnections between cables "A", "C", and "F", and for those between the solenoid-valve (723), the thermostat (716) and the float-switch (714).

853 Socket for the cable "B". The other end of this cable is part of the dielectric tank.

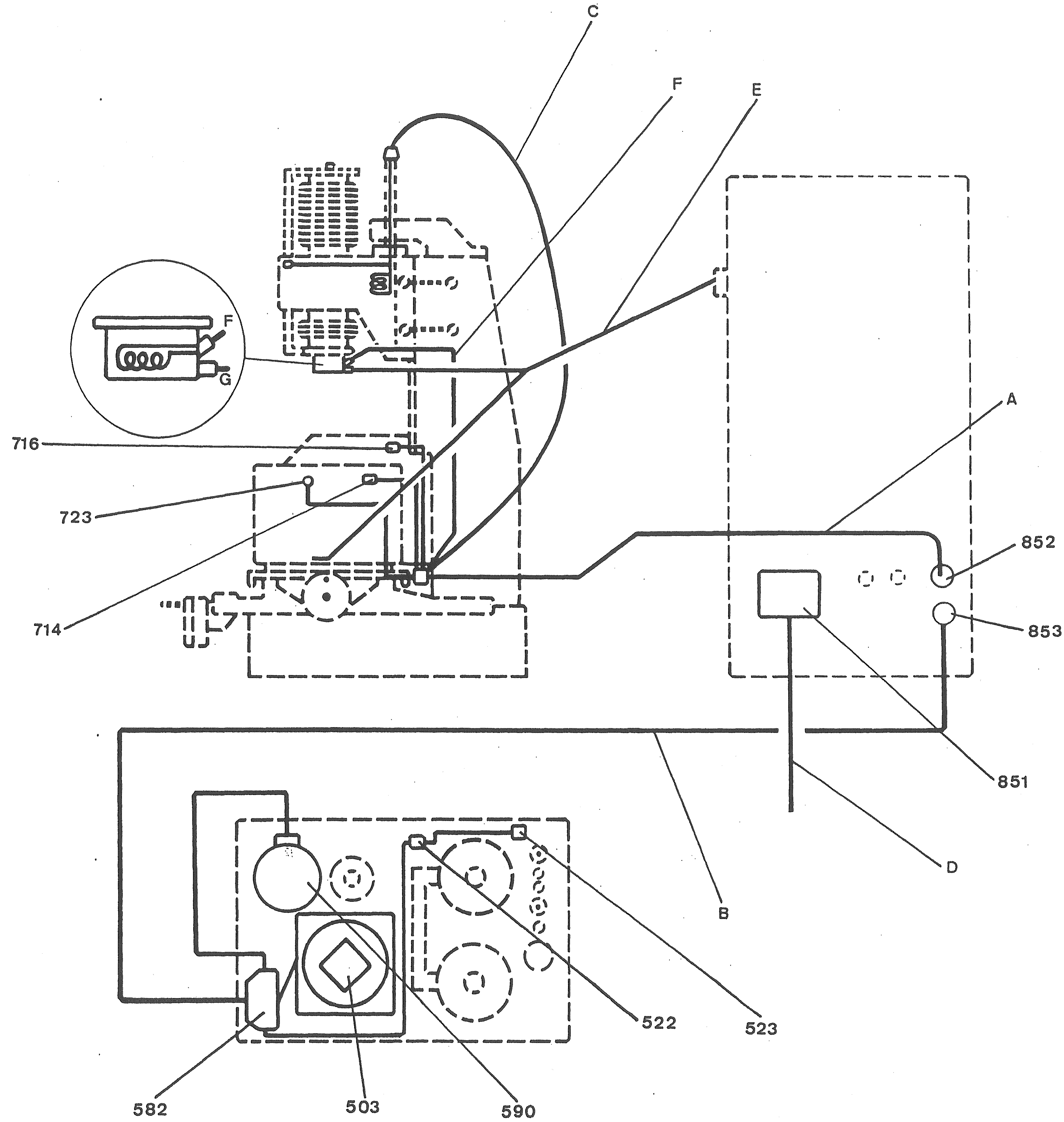


Fig 1

8.12 INTERCONNECTING HOSES AND ELECTRICAL CONNECTIONS

Machine - Dielectric tank (fig. 1)

The machine is connected to the dielectric tank by means of 6 rubber hoses :

- G fast-fill of the work tank
- H drainage of the work tank
- I drain hose for table trough
- J connection of the Venturi tube to the work tank
- K hydraulic oil supply, under pressure, to the machine
- M hydraulic oil return

Dielectric tank - Water circuit (fig. 1)

The two rubber hoses "L", to be supplied by the customer

Machine - Generator (fig. 2)

The machine is connected to the generator by means of two cables :

- A the control cable of the machine
- E the machining cable which delivers the power between the electrode and the workpiece

Generator - Mains power supply (fig. 2)

- D cable for general power supply to the generator

Generator - Dielectric tank (fig. 3)

The generator is connected to the dielectric tank by the cable :

- B control cable of the tank

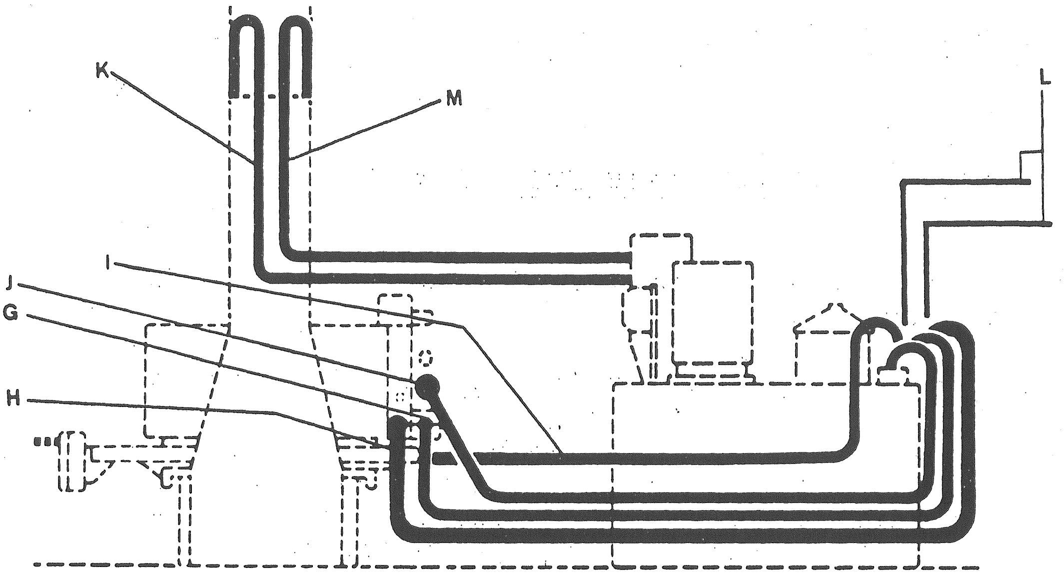


Fig 1

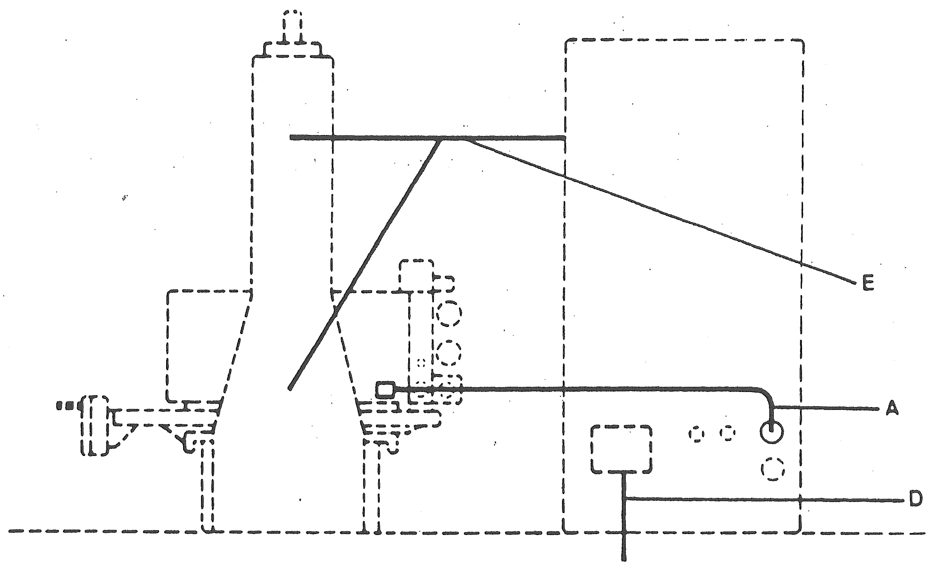


Fig 2

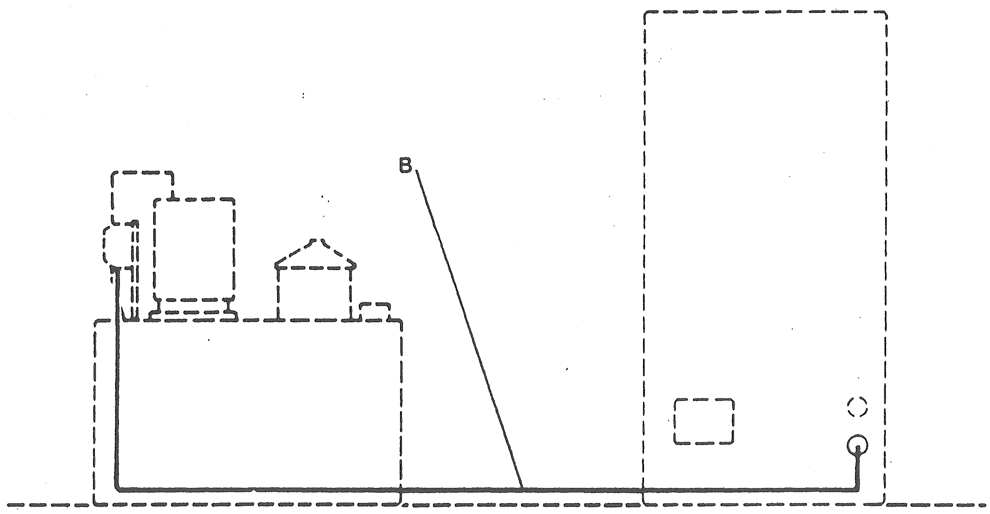


Fig 3

8.13 SAFETY DEVICES AND DEPTH STOP (fig. 1)

The installation is protected by means of the following safety devices :

Level control of dielectric fluid in the work tank

This device turns off the machining power, automatically, as soon as the dielectric level is lower than the preselected one. Machining cannot take place unless the level of the dielectric fluid in the tank is sufficient.

714 Float-switch.

Thermostat of the work tank

This device checks the temperature of the dielectric fluid in the work tank and cuts out the machining power, automatically, as soon as the temperature rises above a predetermined value.

716 Thermostat.

Plexiglass guards

Plexiglass guards are fitted to the front and to the sides of the work tank. They limit access to the machining area.

707 Plexiglass guards.

Depth stop

This device cuts out the machining power, automatically, as soon as the required machining depth has been reached.

141 Micrometric stop

142 Screw for fine setting

143 Microswitch

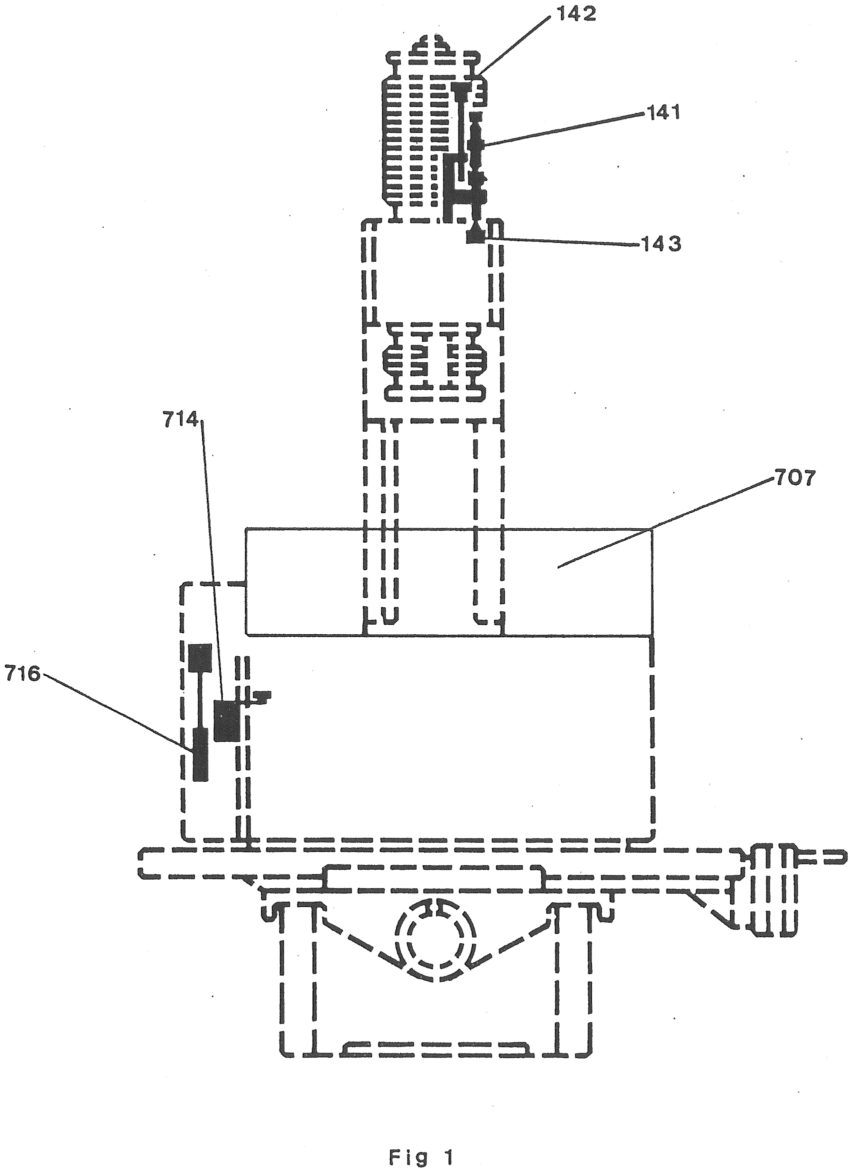


Fig 1

9 - LUBRICATION

(fig. 1)

The points that require lubrication are illustrated in fig. 1 which also shows the manner in which this should be done.

Clean all oil fittings prior to oiling.

An oil gun is supplied with the machine for lubricating the points marked (1).

Keep all the oil fittings, the oil, oil gun, perfectly clean.

We recommend the following oils though others of similar characteristics may be used :

BP ENERGOL HP 20 c	BP	GULF 52	Gulf
BP ENERGOL HP 10 c	BP	GULF 59	Gulf
WAY LUBRICANT MEDIUM	Chevron	VACTRA 1	Mobiloil
FEBIS K - 43	Esso	TONNA OIL 27	Shell
FEBIS K - 53	Esso		

10 - CLEANING

(fig. 2 a & b)

For cleaning, proceed as indicated below :

(3) Always use a clean rag for cleaning the slideways and the lead screws.

- for the hydraulic circuit :

(4) Dismantle and clean the filter with great care and cleanliness; replace the filter cartridges whenever the hydraulic oil is changed.

(5) Dismantle and clean the wire mesh carefully whenever the hydraulic oil is changed.

- for the dielectric circuit :

(6) We recommend that the dielectric tank be drained and cleaned after every 300 hours of machining, or sooner if heavy roughing work is being performed.
Proceed as described below :

  - Use the fill up hose of the tank to transfer the dielectric fluid into a drum, taking care not to suck up the residues that have settled on the floor of the tank. (After a suitable period for decanting, the fluid can be used again).

  - Thoroughly clean the tank, the cooling coils, etc.. to eliminate all deposits.

  - Fill the tank with fresh dielectric ...

11 - TROUBLE SHOOTING

HYDRAULIC CIRCUIT

(see fig. 2 q and b on page 46)

Trouble : Loss of sensitivity of the up and down feed mechanism controlling the electrode.

Cause : Too low pressure of the hydraulic oil.

Corrective measures : Clean or replace the filter unit (105).

Check the pressure at the vacuum-gauge socket (596).

The pressure at this point should be of 290 PSI (20 Kg/cm^2).

Should the same defect become apparent again within a few days time, clean the filter (593) and replace the filter cartridge (refer to paragraph "CLEANING").

DIELECTRIC CIRCUIT

Trouble : Decreasing of suction efficiency.

Causes : Plugged Venturi tube.

Loose joints.

Pipe "J", damaged.

Corrective measures : Dismantle and clean the Venturi tube (505).

Check and tighten up all pipe connections.

Replace pipe "J" if found damaged.

MACHINE OPERATION

12 - MACHINE OPERATION

12.1 CARRIAGE

Up and down movement

Raise or lower the carriage (100), by means of the rotating handle (219) after having unclamped the locking levers (101) to their full extent.
Do not forget to clamp again the carriage after every move.

12.2 X AND Y TABLE (fig. 2 a & b)

The specified accuracy is guaranteed only on condition that the lead screw be driven clockwise.

Cross slide

Displacement : turn the hand-wheel (606) that drives the lead-screw.

Locking of the lead-screw : tighten the knurled screw (613).

Locking of the drum : tighten the knurled screw (612).

Locking of the slide : clamp down the locking lever (308).

Longitudinal slide

Displacement : turn the hand-wheel (633) that drives the lead-screw.

Locking of the lead-screw : tighten the knurled screw (640).

Locking of the drum : tighten the knurled screw (639).

Locking of the slide : clamp down the locking lever (604).

12.3 WORK TANK

Opening of the access doors (fig. 3)

Unlock the hinged panels (701 - 702).

Inlet valve for the dielectric fluid (fig. 4)

To close the valve (717), rotate the handle clockwise; to open the valve, rotate the handle counter-clockwise.

Sliding door for drainage (710) (fig. 5)

For drainage of the tank, lift handle (711).

Sliding door for adjustment of level and overflow (712) (fig. 6)

The level of the dielectric fluid within the tank corresponds to the upper edge of this sliding door. This level should be set, by means of the handle (713) to a minimum of 1 5/8" (40 mm) above the workpiece.

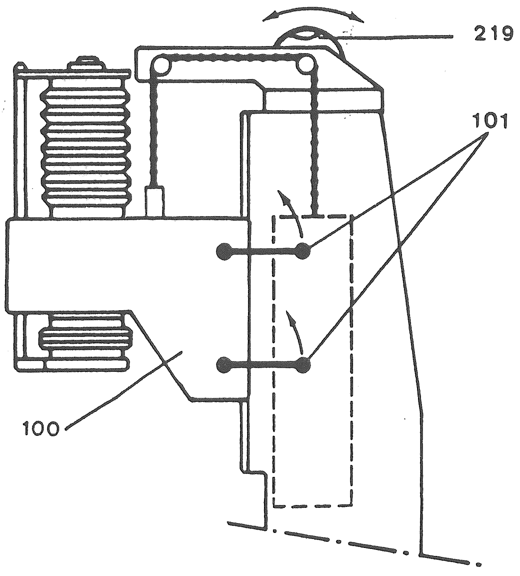


Fig 1

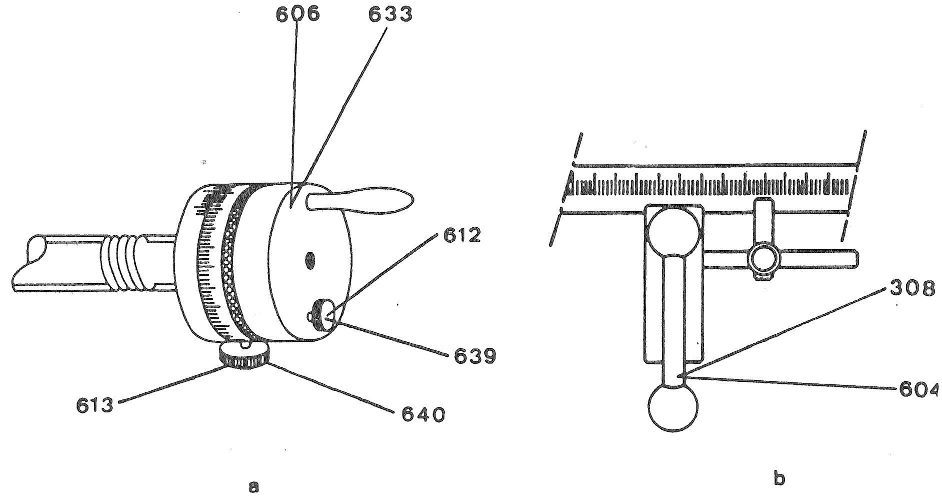


Fig 2

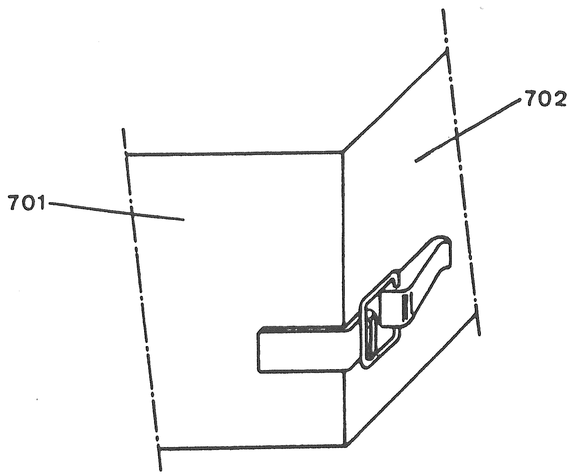


Fig 3

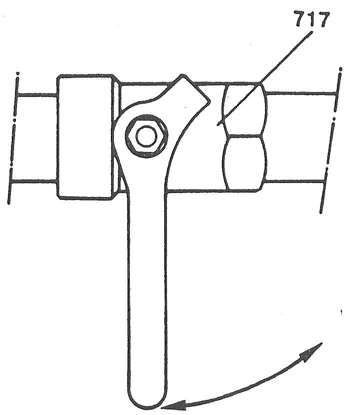


Fig 4

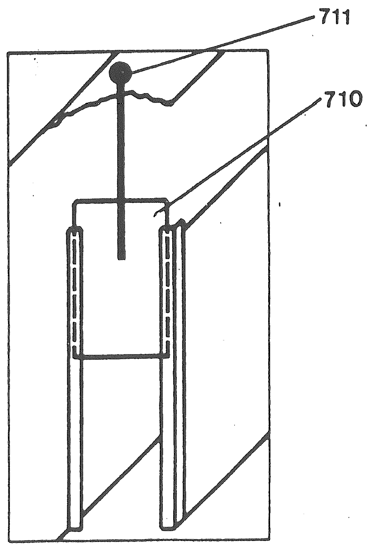


Fig 5

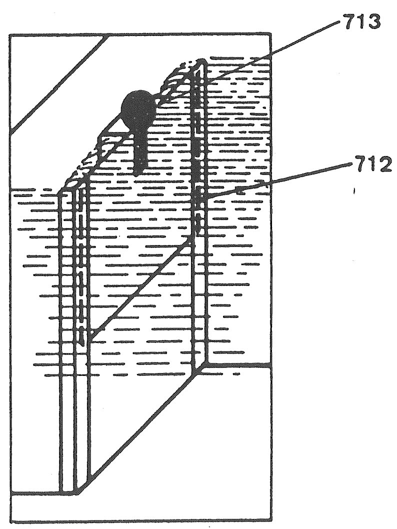


Fig 6

Distribution box (fig. 7)

- for injection (721) : two outlets are provided for connection to flexible hoses.
- for suction (725) : three outlets are provided, two for connection to the flexible hoses, and one for the vacuum-gauge pipe.

To obtain readings on the vacuum-gauge (pressure or vacuum) it is only necessary to connect the inlet pipe of the gauge to one of the injection or suction outlets.

12.4 MACHINE START (fig. 8)

- Turn the main power switch (821) to "ON".
- Turn the hydraulic pump switch (823) to "ON".
- Turn the dielectric pump switch (824) to "ON".
- Turn the power-supplies switch (822) to "ON".

In order to assure thermal stability, leave the machine under power for approximately fifteen minutes before starting machining.

12.5 CLAMPING OF THE WORKPIECE (fig. 9)

A special clamping device is provided with the machine. Fasten the workpiece securely to the table.

12.6 UP AND DOWN MANUAL CONTROL OF CHUCK TRAVEL

Set the power-rate selector switch (825) of the generator to one of the positions marked (↓ ↑).

Set the triple-position selector switch (836) to the required setting; the arrows indicate the direction of travel of the chuck.

The chuck can be set in balance in whatever position required by means of the rotary control knob (831) which acts on the sensitivity of the servo-mechanism.

12.7 EDGE FINDER

Electrical contact (fig. 11 a & b)

The power-rate selector switch (825) should be set to position (⊿ ↓ ↑). Then lower the electrode to a distance of approximately .04" (1 mm) away from the workpiece, by means of switch (836). Stabilize the electrode in this position by means of the control knob (831). Next, lower the chuck by pressing with both hands on the upper part of the swivel-seat.

As soon as the electrode makes contact with the workpiece, the light (839) will go on. It is possible to determine with great accuracy, the level at which machining will start.

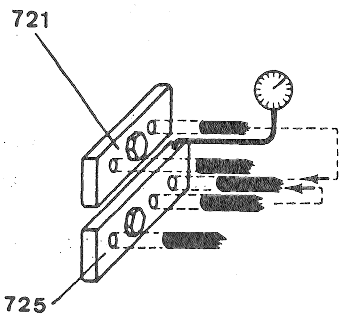


Fig 7

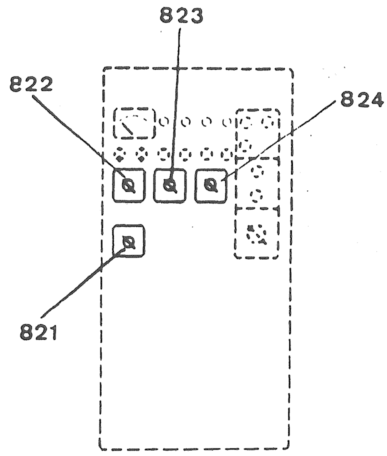


Fig 8

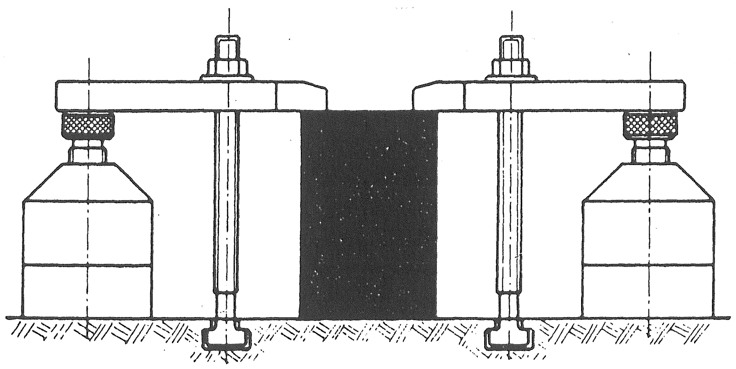


Fig 9

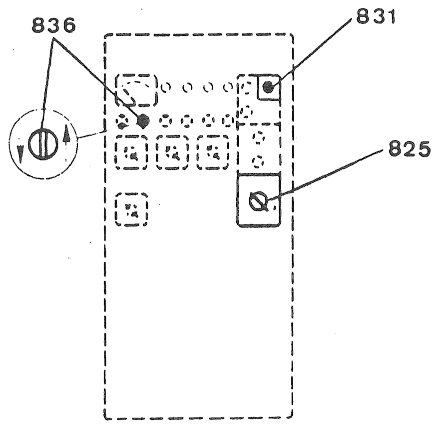
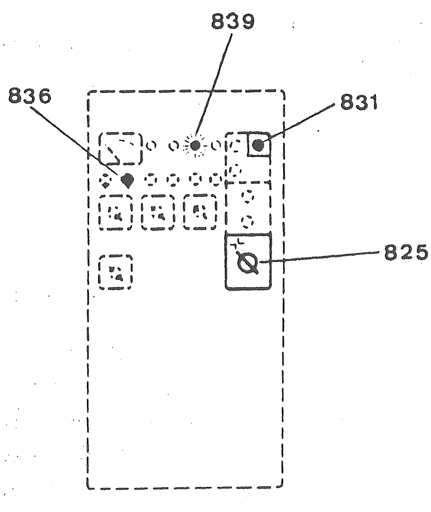


Fig 10



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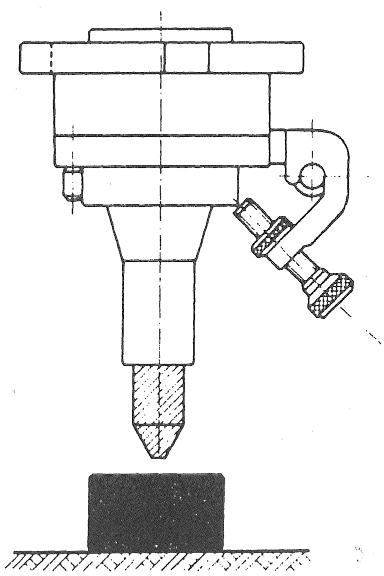


b

Fig 11

Electrical centering

For accurate location of the workpiece in relation to the electrode, proceed as follows with the edge finder device :

1. Align the electrode (refer to paragraph 12 - 15 "ALIGNMENTS").
2. Move the X and Y table in such manner as to bring the workpiece completely out of the alignment to the electrode.
3. Lower the electrode until its tip is lower than the top of the workpiece.
4. Move the X and Y table along the longitudinal axis until the workpiece touches the electrode on the plane or at the reference point necessarily chosen on the left-hand side of the workpiece.
5. Set the dial of the hand-wheel corresponding to this coordinate to zero. Repeat operation 3, to check that the zero setting on the dial has been set correctly.
6. Move the longitudinal slide in such manner as to move the workpiece away from the electrode.
7. Raise the electrode.
8. Move the slide until the dial of the hand-wheel again indicates zero setting.
9. Then move further the slide by the required distance "D". This operation should take into account the "sparking distance".
10. Lock the lead screw and the slide.
11. Repeat the same operations along the other coordinate and in such manner that the workpiece enters into contact with the electrode on the plane or at the reference point necessarily chosen on the rear part of the workpiece. After this operation, the workpiece will be perfectly centered in relation to the electrode.

12.8 DEPTH STOP

By means of the electrical edge finder bring the electrode to the initial machining position.

Micrometric stop (fig. 13 a)

- Zero setting
  - Adjust the micrometric stop (141) to zero.
  - Lower the micrometric stop close to the microcontact (143).
  - Lower the stop still further by means of the fine adjustment screw (142) until the microcontact operates. It is suggested, as a safety measure, to check the operation of the microcontact when the stop is set to zero; for this, unscrew the stop away from zero and then repeat the adjustment to obtain operation of the microcontact.

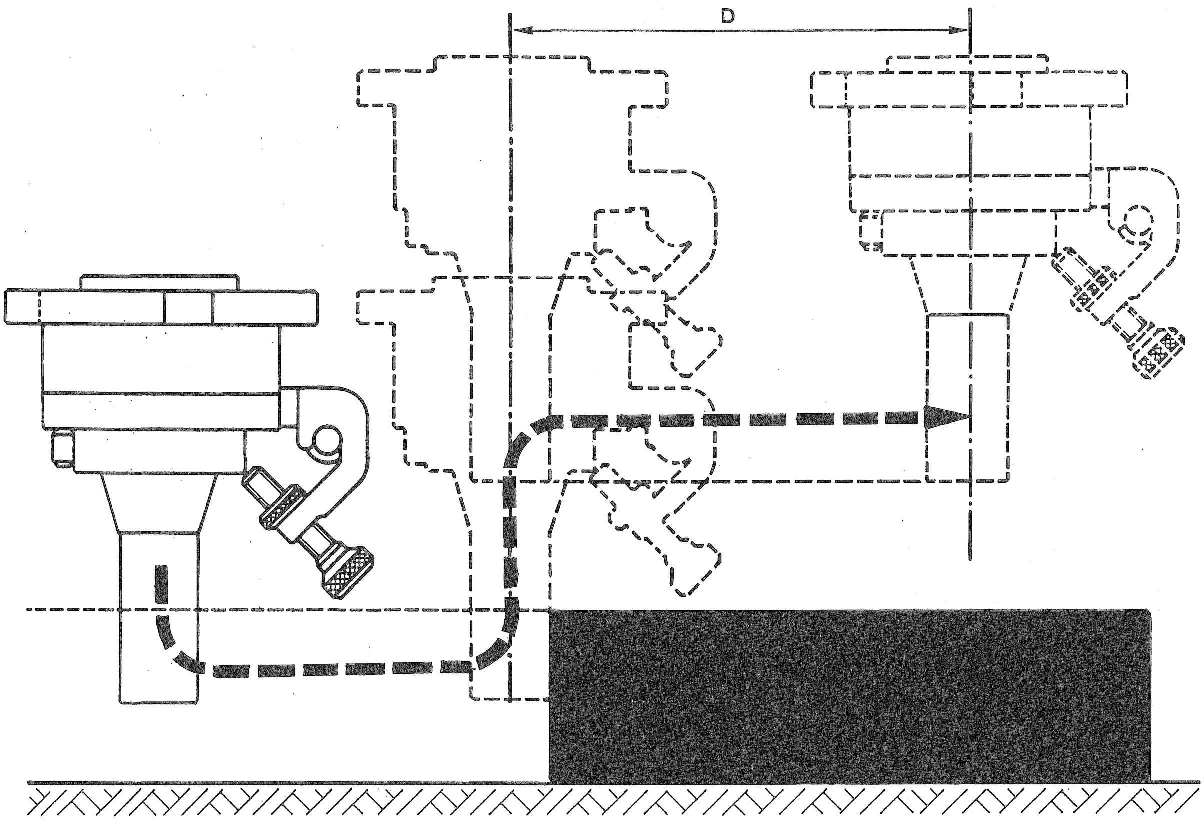


Fig 12

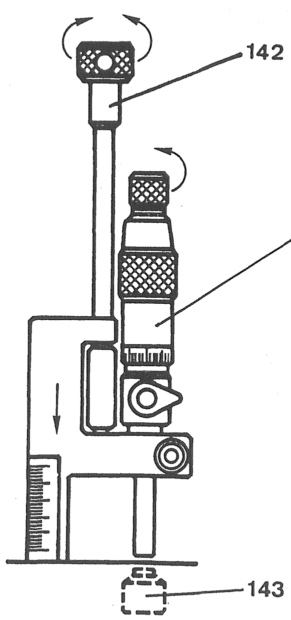


Fig 13a

- Adjustment of the machining depth (fig. 13 b)
  - Set the micrometric stop for the required depth of machining, taking the "sparking distance" into account.
  - If this depth overreaches the limits of the micrometer scale, make use of suitable gauge blocks, height "H".
- The support of the micrometric stop is graduated opposite to the rule which is located on the guide-strip, this arrangement allows a rough adjustment. The support can slide along the angular guide strip, thus preventing damage to the microswitch in case of misadjustment.

<u>Adjustment of the depth-stop during machining operations</u>

(fig. 14)

Should depth be readjusted during machining operations, proceed as follows :

- Place on the top of the workpiece, a shim of given height "H".
- Touch up with the edge finder against the shim.
- Make zero adjustment and reset the machining depth (refer to paragraph "DEPTH STOP"). Considering the fact that if "h" is the machining depth, the micrometric end-stop must be adjusted for "H + h" taking the sparking distance into account.
- For precision machining operations it is advisable, for the final setting, to measure the depth of machining and to make adjustments - if required - by means of the micrometric stop.

12.9 <u>INDICATOR (145)</u> (fig. 15)

- Lower the indicator attachment until the tip touches the reference surface, then rotate the dial to bring the zero of the scale opposite to the hand.
- During machining, the hand of the indicator will constantly indicate the depth reached by the electrode and, by its stability, indicate the regularity of the machining operation.
- In the same manner as for the micrometric stop, the indicator attachment can slide along the angular guide-strip, thus preventing damage to the tip in case of misadjustment.

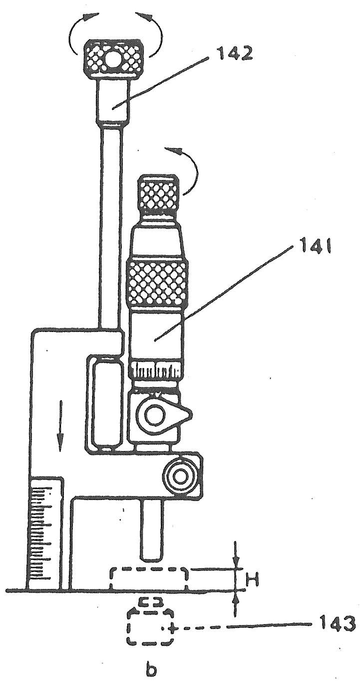


Fig 13

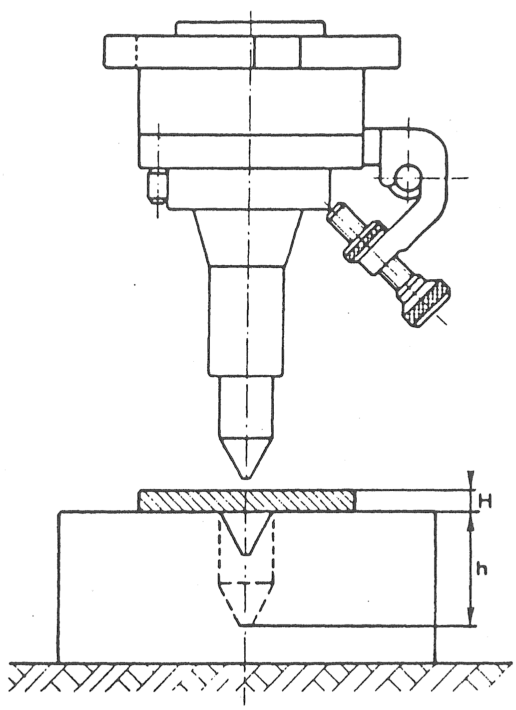


Fig 14

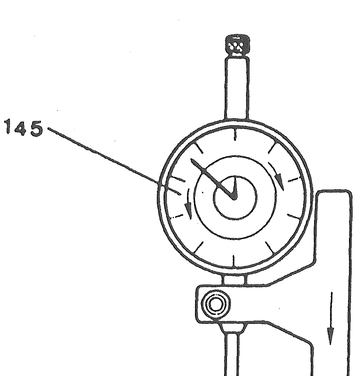


Fig 15

12.10 FLUSHING MODES

The different modes of flushing are discussed in the section "TECHNOLOGY", with reference to the most appropriate modes for various purposes.

In operation, the machine has provision for four principal modes of flushing :

- by continuous injection
- by pulsated injection in synchronism with pulsation of the electrode
- by suction
- by injection and suction together

Both devices for injection (continuous or pulsated) and for suction are provided with separate valves for flow adjustment, together with junction box for the connection of flexible piping.

The mode of injection depends of the setting of the selector switch (837) located on the control panel of the generator (fig. 16 a) :

- right-hand setting : continuous injection (———)
- left- hand setting : pulsated injection (------)
- Whenever flushing is not required, selector switch (837) should be set to its mid position in order to prevent overheating of the solenoid-valve.

Continuous injection (fig. 16 a & b)

Set selector switch (837) to position (———)

The solenoid-valve (723) remains permanently open.

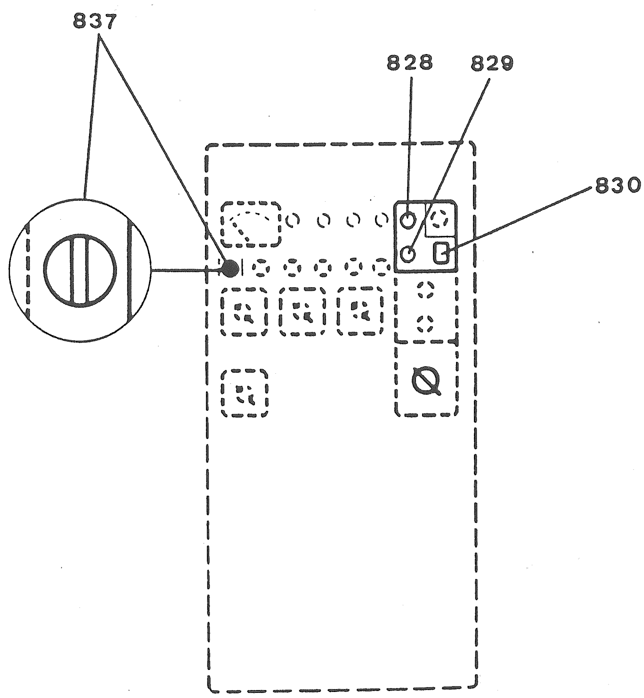
The injection rate is adjusted by means of valve (722).

Synchronous pulsated injection (fig. 16 a & b)

Set selector switch (837) to position (------), switch on the pulsator by means of switch (830) and, by means of the two potentiometers (829 - 828), adjust the working and withdrawal periods of the electrode. The pulsator relay, the rhythm of which is controlled by the potentiometers, operates the solenoid-valve by which the flushing rate is controlled.

Injection will take place during the time the electrode is withdrawn and will be interrupted when the electrode is machining the workpiece.

The pulsated injection rate is controlled by means of the valve (722).



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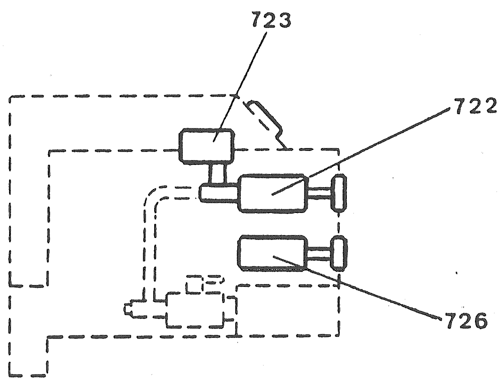


b

Fig 16

Suction (fig. 16 b)

Suction takes place when the valve (726) inserted in the conduit connected with the vacuum tube is opened. This valve regulates the suction discharge.

Combined injection and suction (fig. 16 b & c)

It is often useful to combine injection with suction for certain machining operations.

This possibility is available when the two nipples (721 - 725) are connected together by a flexible hose and junction made to one or other nipple by a pipe leading to the machining area.

The injection and the suction rates are adjusted separately by means of the two valves (722 - 726).

The vacuum-gauge (728) then measures the pressure resulting from this combination of injection and suction, on condition that its inlet pipe be connected to the nipple provided for this purpose on junction box (725).

12.11 ATTACHMENT OF THE SWIVEL-SEAT (fig. 17)

The swivel-seat may be fastened to the bottom of the piston by means of 4 screws.

12.12 ATTACHMENT OF THE CHUCK (fig. 18)

The magnetic chuck may be attached either directly to the botton of the piston or to the lower part of the swivel-seat. Attachment is made in both cases by means of four screws.

12.13 ATTACHMENT OF THE ELECTRODE HOLDER TO THE MAGNETIC CHUCK (fig. 19 a & b)

Prior to attachment of the electrode holder to the magnetic chuck, always make perfectly sure that the areas in contact are absolutely clean.

Press the electrode holder against the magnetic chuck, making sure that the "flat" (reference surface) of the electrode holder bears firmly against the keeper block. Then slide the electrode holder sideways until it makes contact with the cylindrical peg (second reference setting point).

Magnetic attachment of the electrode holder (fig. 19 c & d)

Operate the push-button (834).

When rather heavy electrodes are used it is advisable to secure attachment of the electrode holder by means of light pressure on the clamping lever.

Magnetic release of the electrode holder (fig. 19 c & d)

Hold the electrode holder prior to releasing the locking lever and operation of the push-button (835).

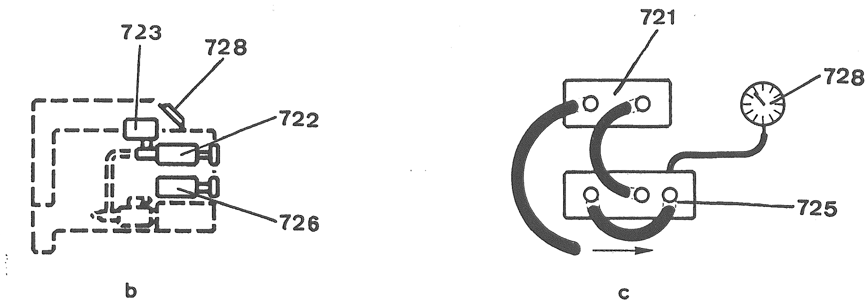


Fig 16

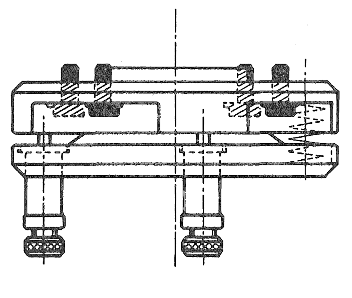


Fig 17

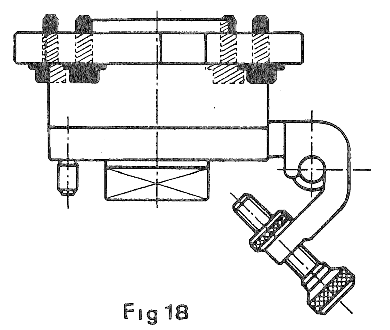


Fig 18

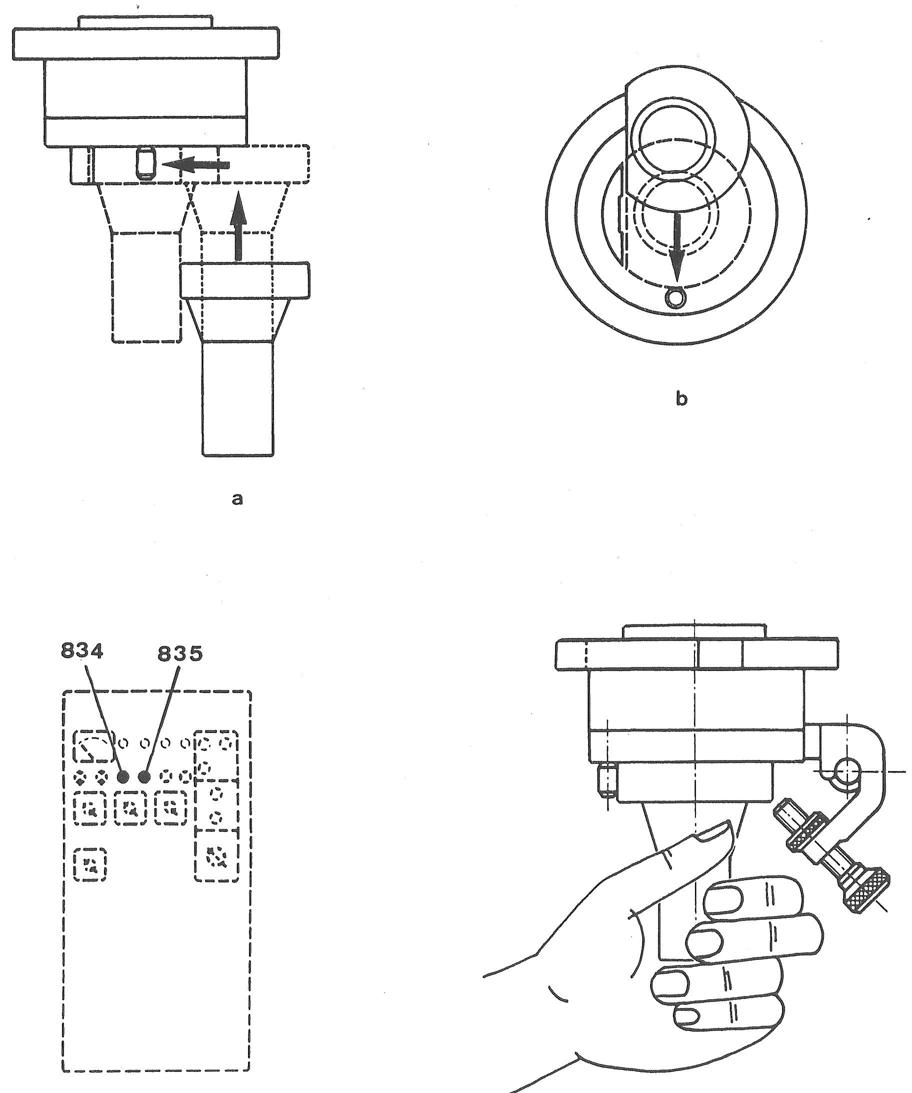


Fig 19

12.14 ANGULAR SETTING OF THE MAGNETIC CHUCK (fig. 20)

When making this adjustment, the piston must not be in contact with either the upper or the lower end-stop.

The reference plane, as determined by the flat surface of the keeper block on the chuck, must be parallel to the longitudinal travel of the table.

To check and, if necessary, to correct the angular setting of the magnetic chuck, proceed as indicated below :

- Fasten, by magnetic attraction, a rectilinear rectangular rule of approximately 6" (150 mm) length, to the magnetic chuck; make sure that the rule and the keeper block are in perfect contact.
- Fasten an indicator on the table in such manner that its tip touches the free edge of the rule.
- Set the indicator dial to zero.
- Move the X and Y table longitudinally while watching the hand of the indicator.
- If the hand remains still opposite the zero on the scale of the indicator, the angle set of the electrode holder is correct.
- If the hand deviates from the zero mark, the angular setting of the magnetic chuck calls for readjustment which should be carried out as follows :
  - Rough adjustment :

    Loosen the screws that fasten the magnetic chuck and, within the limits of play afforded by the screws, make the best possible compensation for the error.
  - Fine adjustment :

    Carry out this adjustment by means of the two screws (126). After adjustment, firmly tighten the screws.

    Check for parallelism and, if necessary, repeat the above operations until the hand of the indicator remains still at zero for the full travel of the table.

12.15 ALIGNMENTS

The objective of these alignment adjustments is to assure not only the accuracy of machining with the electrodes, but also the checking operations carried with the accessories.

It is again brought to your attention that all the adjustments described later are to be made without the piston being in contact with either the upper or the lower end-stop.

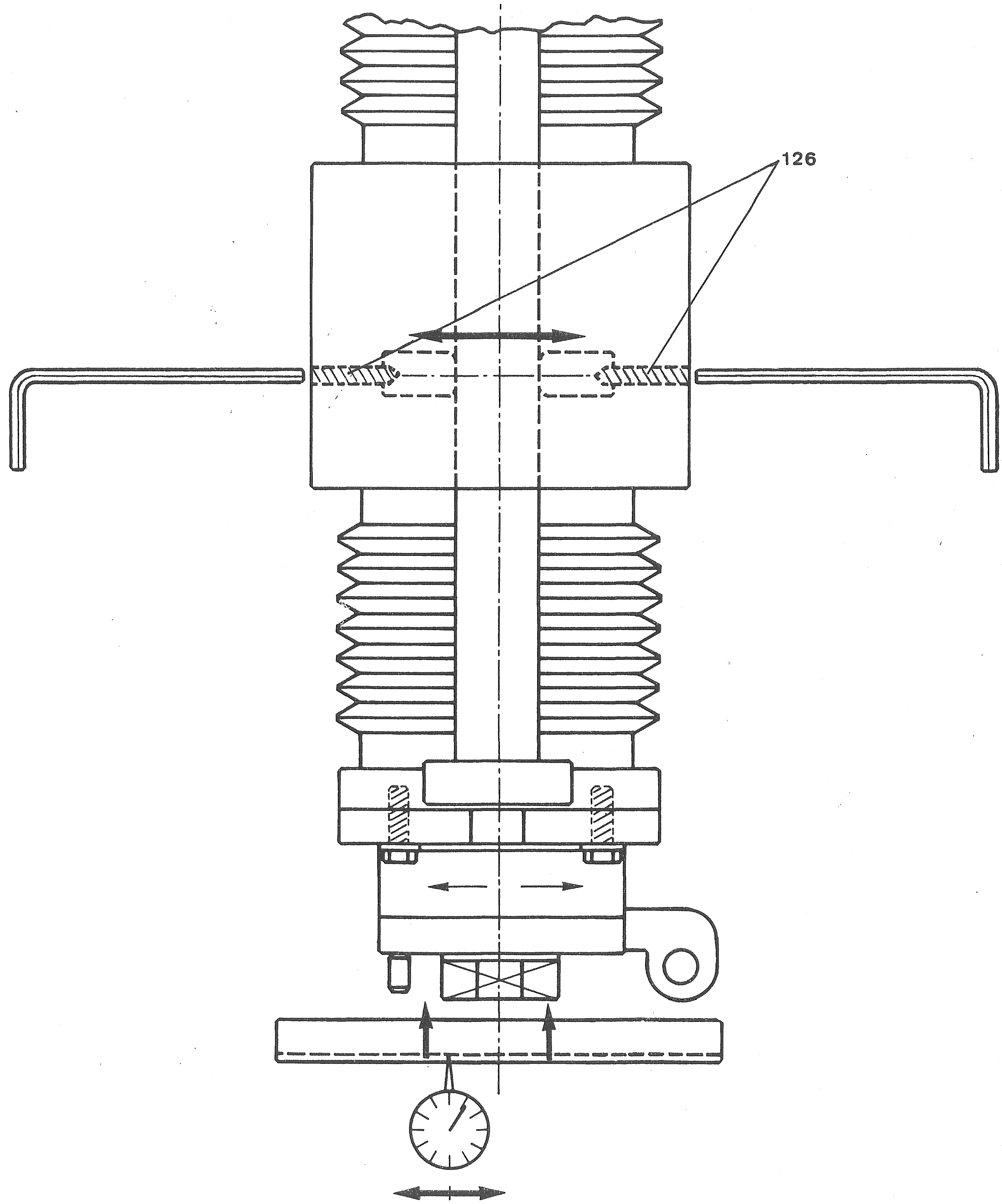


Fig 20

a) Alignment of the magnetic chuck (fig. 21 a & b)

This adjustment is carried out with the help of the swivel-seat which, can be positioned as desired by using the two knurled adjusting screws. Since the swivel-seat carries the magnetic chuck it is possible to set the plane of its magnetic clamping surface parrallel to the plane of the table.

Proceed as follows :

- Fasten the alignment bar (920) to the magnetic chuck.
- Set up an indicator on the table, by means of a magnetic stand, in such manner that its tip touches the alignment bar along a generating line situated in the plane passing through the axis of one of the knurled screws of the swivel-seat (904).
- Set the hand of the indicator to zero.
- By means of the up and down chuck travel switch (836) make the alignment bar travel past the tip of the indicator.
- Adjust the knurled screw of the swivel-seat (904), corresponding to this plane of adjustment, in the appropriate direction and until the hand of the indicator remains still during the full travel of the alignment bar.
- Repeat this operation for the other coordinate and, after adjustment, recheck both settings.
- Tighten the clamping nut of both knurled screws.

The alignment of the magnetic chuck is thus completed.

b) Alignment of the electrodes

Align the magnetic chuck as described above, then replace the alignment bar by an electrode complete with its electrode holder.

- Electrodes that have been machined complete with an electrode holder :

  In this case the electrodes do not need to be aligned since they are perfectly perpendicular to the base of the electrode holder.

- Electrodes machined prior to fitting of an electrode holder :

  These electrodes may not be perfectly perpendicular to the base of the electrode holder. Determine two reference faces along the electrode and then proceed to the alignment as described above for the magnetic chuck.

- Electrodes of very small calibre :

  In general, these electrodes are not of sufficient rigidity to allow of alignment by means of an indicator since they may bend under pressure of the tip. In such cases it is necessary to use a microscope for alignment.

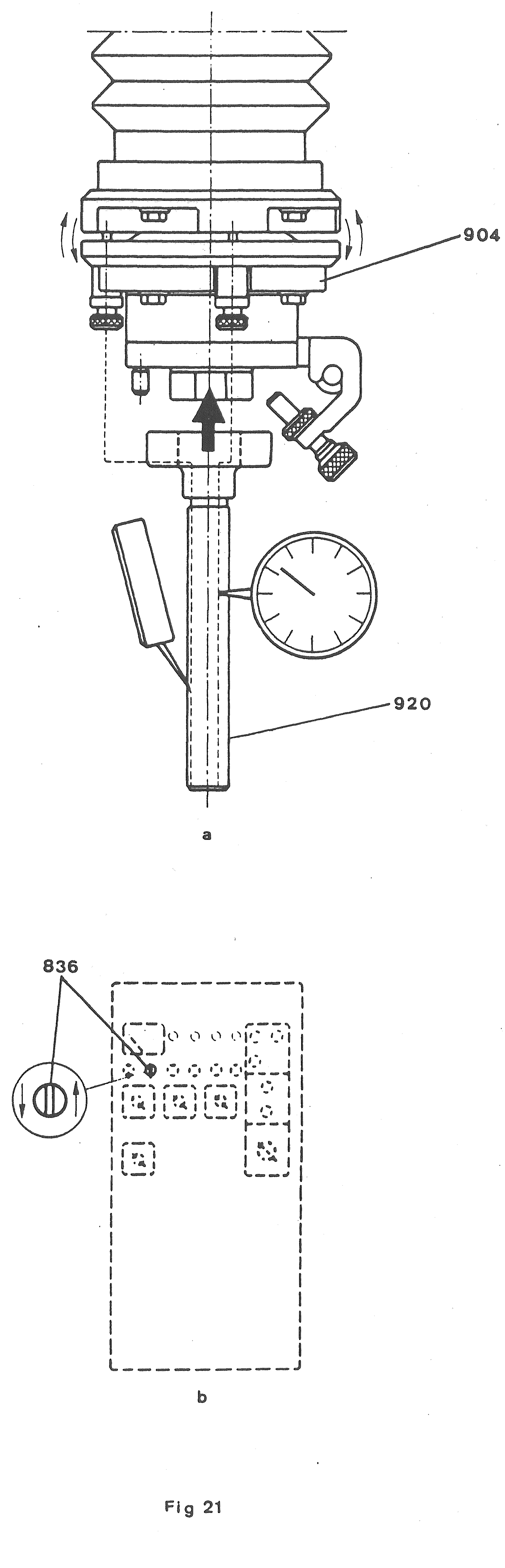


Fig 21

1. Adjust the microscope (refer to paragraph "ADJUSTMENT OF THE MICROSCOPE").

   Place the microscope (923 or 924) upon its magnetic stand (976), then fasten it to the table (fig. 22 a).

2. Set the vertical axis of the reticle of the microscope to correspond with a reference line on the electrode. For this, first bring the electrode into the field of view of the microscope eye-piece and then operate the hand-wheels of the table to properly focus the electrode.

3. Observe the travel of the electrode, through the micro-scope, operating the up and down motion of the chuck.

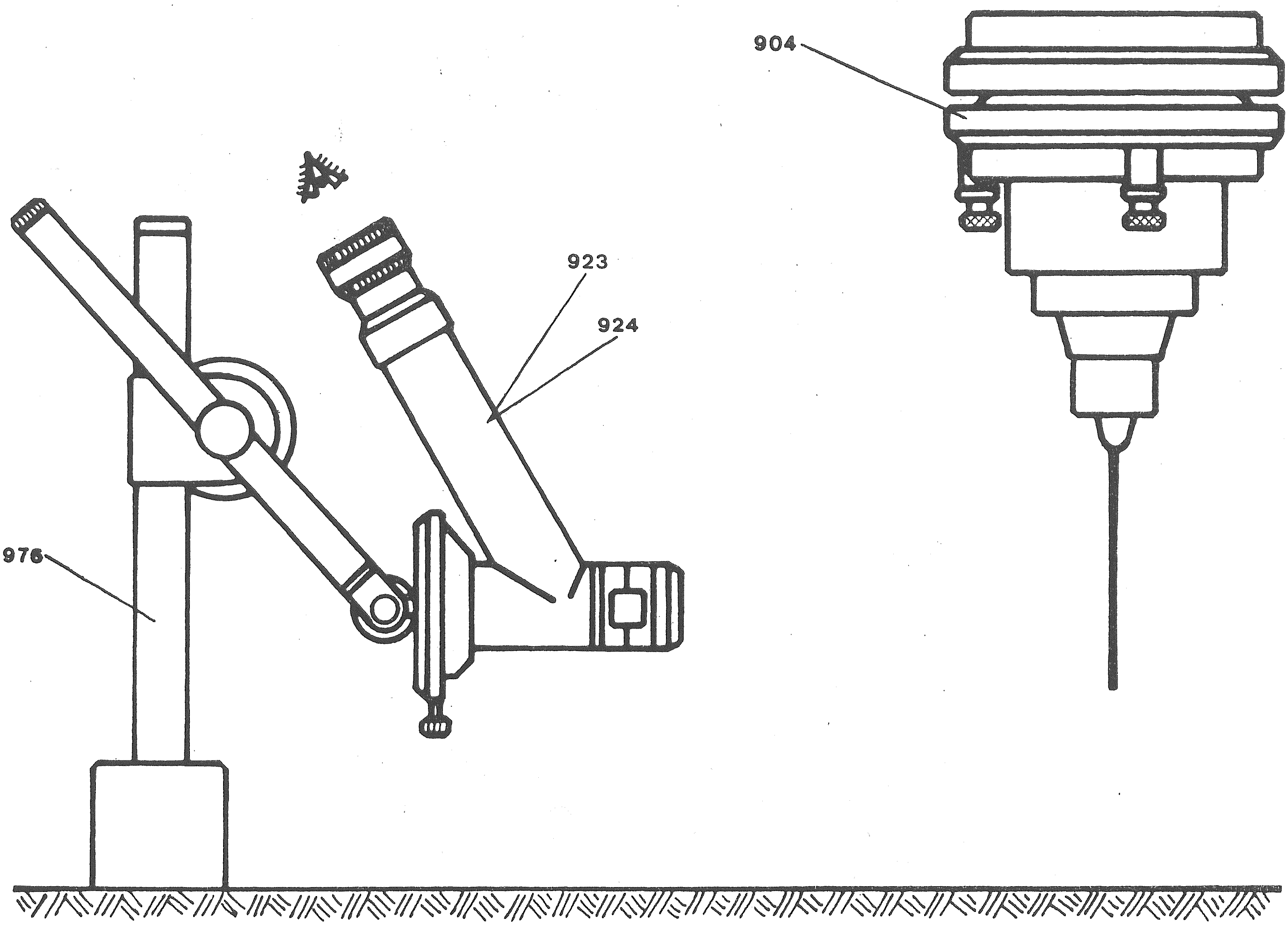
4. If the vertical axis of the reticle of the microscope coincides with the reference line on the electrode during the full stroke, then the electrode is properly aligned (fig. 22 b). Should this not be the case, (fig. 22 c), turn the knurled screws of the swivel-seat (904) in the appropriate direction so as to establish coinci-dence during the full travel.

- Alignment of an electrode on the rotating spindle:

  It is necessary to make sure that the axis or the electrode is in line with that of the spindle so that, during rota-tion, no error can be introduced. For this, make the spindle revolve and, using an indicator, measure the eccentricity of the electrode in relation to the axis of the rotating spindle.

c) Alignment of the accessories

The accessories such as electrode holder, etc... come into alignment automatically as soon as the magnetic chuck itself is properly aligned.



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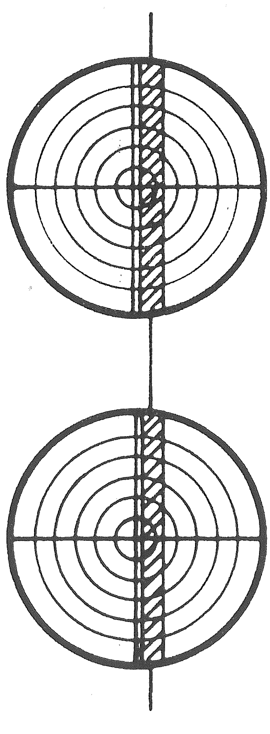

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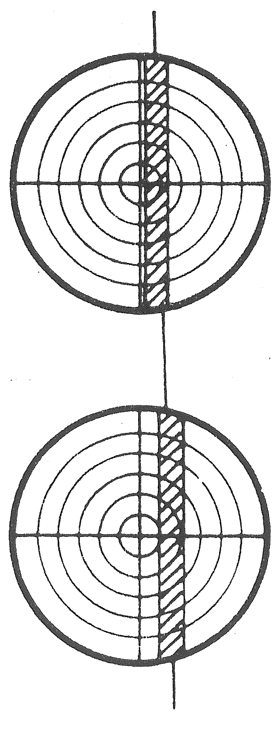


c

Fig 22

13 - ACCESSORIES

13.1 GENERALITIES

Various accessories are available for use with the type D10 spark-erosion machine, they are suitable for a very wide range of machining operations.

The complete set of accessories (900) can be subdivided into groups according to their use.

- The chucks

  are provided for the attachment of the various accessories to the piston.

  The swivel-seat (904) and the magnetic chuck (902) are supplied with the machine.

- The electrode holders

  are provided for the attachment of any type of electrode to the chuck (901) or (902).

- Accessories for checking and measurement purposes

  These are provided for carrying out the various measurement and checking operations necessary for ensuring the perfect operation of the machine.

- The rotary spindle attachment

  guarantees very round holes by rotating the electrode during machining.

- The tapping attachment

  allows the entirely automatic machining of tapped holes.

- The injection and suction pots

  allow the most efficient flushing mode in each particular case.

- The magnetic stands

  allow for magnetic fastening of measuring and checking devices on the table.

13.2 DESCRIPTION

CHUCKS

901 Mechanical chuck
902 Magnetic chuck
903 "Vee" type chuck
904 Swivel-seat
905 Rectangular T slot swivel-platen

ELECTRODE HOLDERS

910 Electrode holder, type 4A Ø 3/4" or 4M Ø 20 mm
911 Electrode holder, type 3A Ø 3/8" or 3M Ø 10 mm
912 Electrode holder, type 2A Ø 1/2" or 2M Ø 12 mm
913 Electrode holder for SCHAUBLIN collet holder, type E-25
914 Collet Ø 1/4" or 5 mm
915 Collet Ø 3/8" or 10 mm
916 Collet Ø 5/8" or 15 mm
917 "Vee" type holder
918 Electrode holder for STIEBER chuck holder
919 Electrode holder for small calibre electrodes

ACCESSORIES FOR CHECKING & MEASUREMENT PURPOSES

920 Alignment rod, precision ground
921 Centering electrode holder cum indicator holder
922 Center punch
923 Microscope, AUBER type
924 Microscope, HAUSER type

ROTARY SPINDLE ATTACHMENT (930)

931 Rotary spindle, type AC-3
932 Electrical control box
933 Morse cone adapter, No. 2, for SCHAUBLIN collet holder type F, 4.5
934 Morse taper cone No. 2 for SCHAUBLIN collet holder type F, 4.5
935 Collet Ø 1/32" or 0.5 mm

936 Collet Ø 1/16" or 1 mm

937 Collet Ø 1/8" or 2 mm

938 Morse cone adapter, No. 2, for SCHAUBLIN collets type E-25

939 Morse taper cone No. 2, for SCHAUBLIN collets type E-25

940 Collet Ø 3/16" or 4 mm

941 Collet Ø 1/4" or 6 mm

942 Collet Ø 3/8" or 10 mm

943 Morse cone adapter No. 2 cum indicator holder

944 Morse taper cone No. 2 for indicator holder

945 Indicator complete with holder

946 Morse taper cone No. 2, high precision type H-5, bore : 1/4" or 6 mm

947 Morse taper cone No. 2, high precision type H-5, bore : 3/8" or 10 mm

948 Brace for fastening the rotary spindle to the piston

TAPPING ATTACHMENT

951 Tapping device

952 Lead screw and nut for pitch of 20 threads per inch or 0.5 mm

953 Lead screw and nut for pitch of 18 threads per inch or 1 mm

954 Lead screw and nut for pitch of 13 threads per inch or 1.5 mm

955 Lead screw and nut for pitch of 8 threads per inch or 2 mm

956 Blank lead screw and nut for special purposes

INJECTION AND SUCTION POTS

970 Injection and suction pots with set of bored sole plates Ø 13/16" & 13/8" (20 & 40 mm)

971 Injection and suction pots with two "T" slots and bored sole plate of Ø 2 7/16" (60 mm), plus two reduction sleeves for Ø 13/8" & 13/16" (40 & 20 mm)

MAGNETIC STANDS

975 Magnetic stand type SUM 2 for use as indicator holder

976 Magnetic stand type SUM 4 for microscope, with electrode holder for attachment to magnetic chuck.

13.3 HANDLING OF THE ACCESSORIES

The accessories have been designed with the utmost regard to simplicity of utilization, therefore, no difficulty should be encountered in their handling.

Nevertheless, the following remarks concerning the handling of the rotary spindle and the tapping attachment may be found useful.

Rotary spindle, type AC-3

The rotary spindle can be fastened either to the magnetic chuck (902), to the mechanical chuck (901), or directly to the piston (fig. 1 a & b).

In the first two cases, thoroughly clean the contact and the reference surfaces of both the chuck and the rotary spindle and fasten the spindle to the chuck as if it were an electrode holder (fig. 1 a).

Lock the rotary spindle to the chuck by means of the clamping hook.

In the third case, fasten the brace (948) to the rotary spindle and then attach this assembly to the piston by means of the screws provided for this purpose (fig. 1 b).

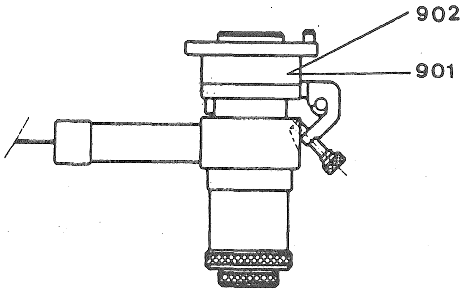
Connect the power supply cable of the motor of the rotary spindle to the appropriate socket on the generator (fig. 2 a); the spindle will then revolve. If a separate control unit is available for the tapping attachment, the connection should be made as illustrated in fig. 2 b. The rotary spindle will then revolve as soon as power is switched on by means of the switch located on the control unit; the selector switch should be set to position 3, i.e. full right. Both the direction of rotation and the speed of the spindle can be controlled by the knob provided for this purpose.

Tapping attachment

This attachment is to be fastened to the shoulder of the rotary spindle (fig. 4); a clamping screw is provided. The disposition of the various parts of the unit (lead screw, nut, etc....) is illustrated in fig. 5.

The 3-way selector switch located on the control panel or on the control unit of the rotary spindle makes provision for either left- or right-hand threading, the third position being reserved for use of the rotary spindle (see fig. 3)

A power switch is provided for over-all control of the device.



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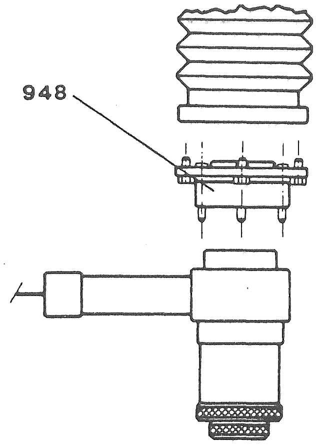


Fig 1

b

Fig 2a

Fig 2b

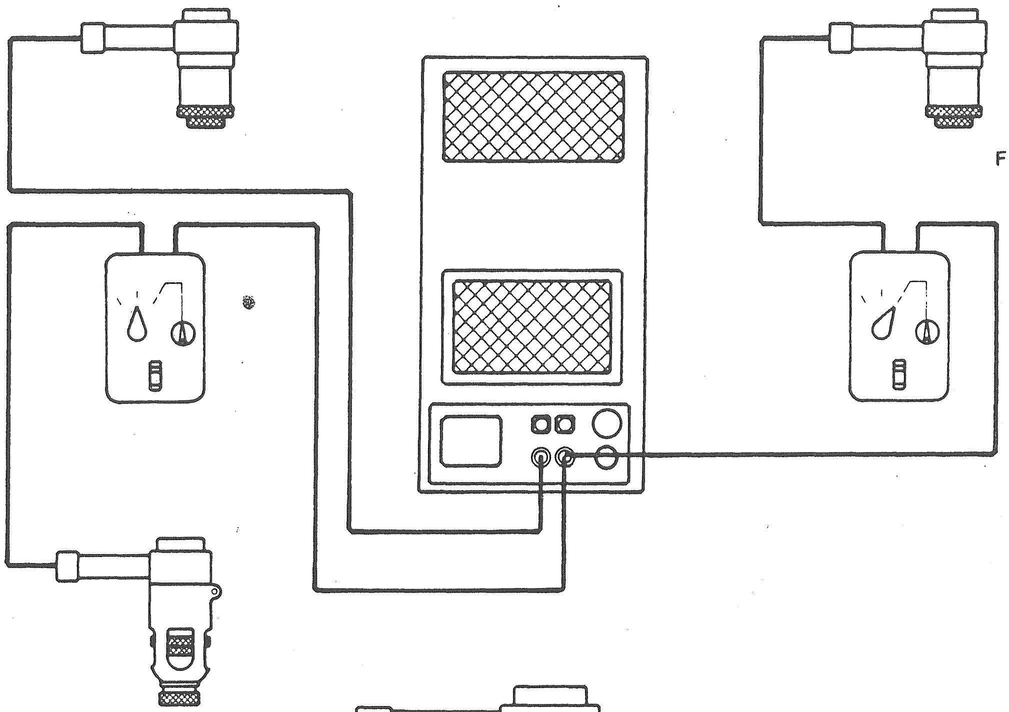


Fig 3

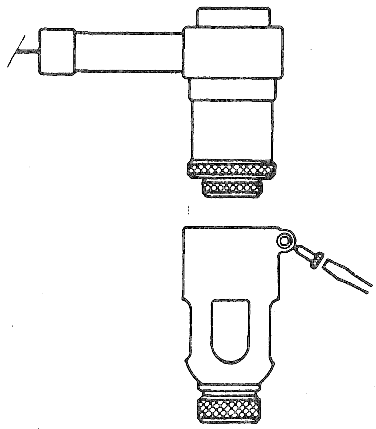


Fig 4

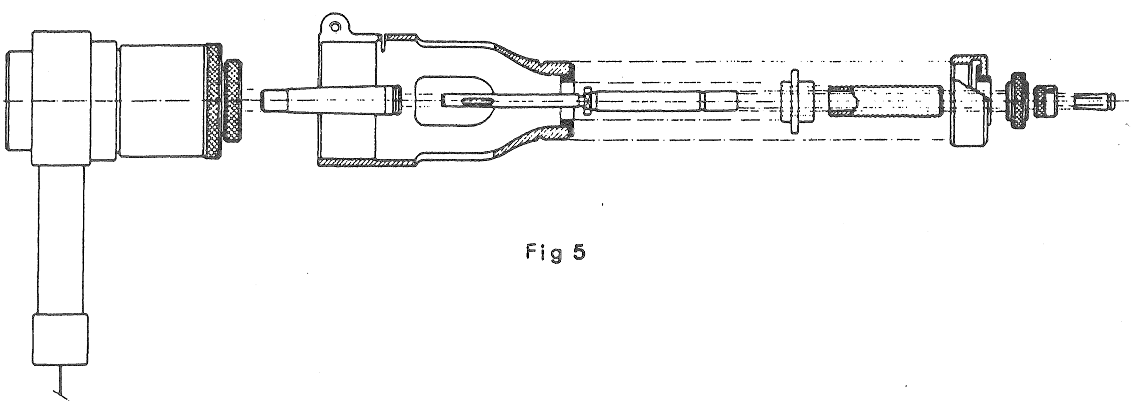


Fig 5

13.4 CHECKING AND ADJUSTMENT OF THE ACCESSORIES

With the exception of the microscope, the accessories do not require checking or adjustment.

ADJUSTMENT OF THE MICROSCOPE

Adjustment of the microscope calls for two operations :

- Centering of the reticle
- Orientation of the reticle

CENTERING OF THE RETICLE

Proceed as indicated below :

1. Align the magnetic chuck.
2. Check the angular setting of the magnetic chuck.
3. Fasten onto the table a non-hardened steel plate, the upper and lateral surfaces of which have previously been ground. The edges of the plate should be free of burrs and the surfaces should be perfectly polished.
4. Fasten the center-punch to the magnetic chuck.
5. By means of the table, bring the polished surface under the center-punch.
6. Lock the indexing table.
7. By means of the manual control for up and down feed of the chuck, lower the center-punch so that it leaves its imprint on the polished surface.
8. Lift the chuck, remove the center-punch and set up the microscope in its place.
9. By means of the manual control for up and down feed of the chuck, move the microscope in the appropriate direction to bring the polished surface into focus in the eye-piece. By means of the sensitivity control knob of the servo-mechanism, stabilize the chuck, observing the depth indicator. Observe the polished surface through the microscope and sharpen the focusing by using light hand pressure either upwards or downwards against the upper part of the swivel-seat to move the chuck.
10. If the imprint of the center-punch appears in the center of the reticle, the latter is correctly centered (fig. 1 a). If this is not the case, (fig. 1 b), center the reticle with respect to the imprint by means of the adjusting screws (fig. 1 c).

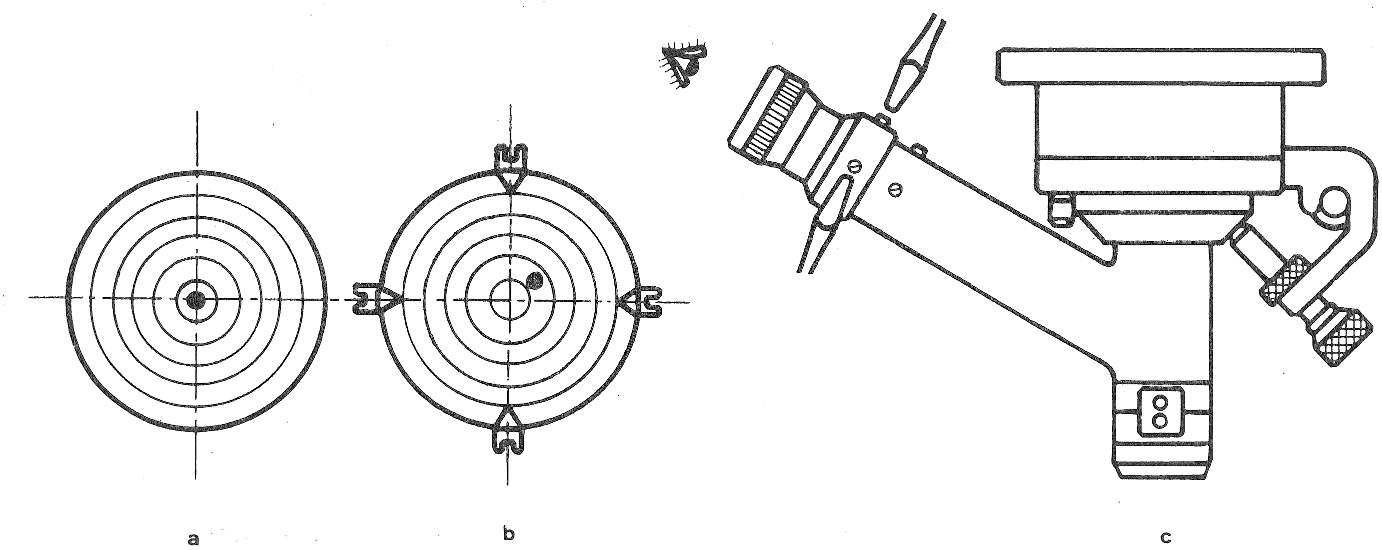


Fig 1

ORIENTATION OF THE RETICLE

Making use of the same non-hardened steel plate, proceed as follows :

1. Check the parallelism of one of the edges of the plate in relation to the longitudinal travel of the table (fig. 2 a). For this, fasten an indicator by means of a support onto the chuck, in such manner that its tip bears against the lateral surface chosen.

   Displace the longitudinal slide and check that the hand of the indicator remains still for the full travel of the plate.

   If such is not the case, adjust the plate and again check for parallelism by means of the indicator.

2. Fasten the polished plate firmly onto the table.
3. Fasten the microscope onto the chuck (fig. 2 b).
4. Bring the reference edge chosen on the plate into the field of view of the microscope eye-piece and focus properly as described under "CENTERING OF THE RETICLE", point 9.
5. Move the table to bring the reference edge into close proximity of the reticle cross-wires.
6. If the edge is perfectly parallel to the longitudinal coordinate of the reticle during the full longitudinal travel of the plate, then the orientation of the reticle is correct.

   If such is not the case, (fig. 2 c & d), loosen the locking screws of the eye-piece and rotate the latter to bring one of the cross-wires to coincide with the reference edge of the plate; then tighten the screws.

7. Recheck the centering of the reticle to make sure that it has not been disturbed by adjustment of the orientation; should this be the case, repeat the above adjustments until both settings are correct.

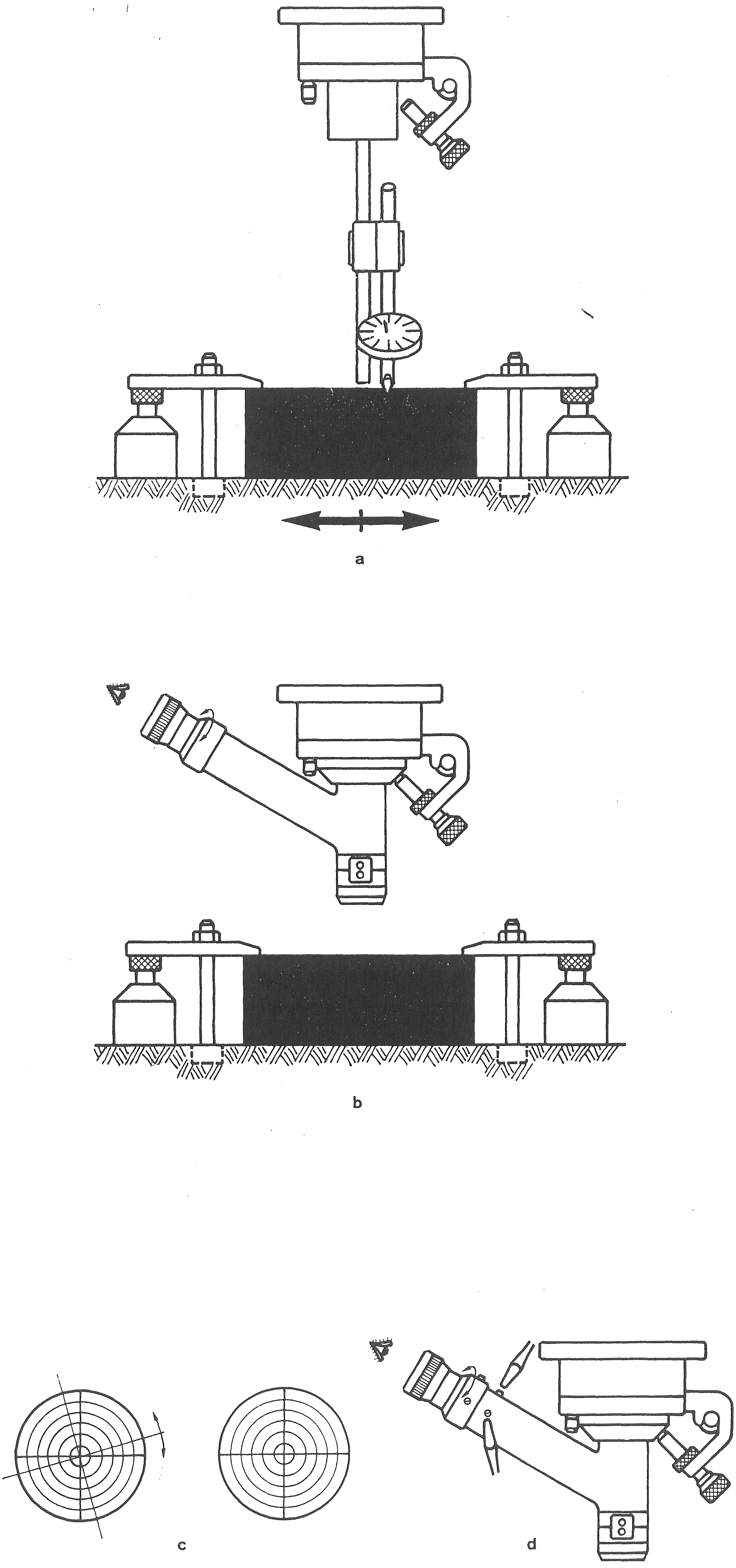
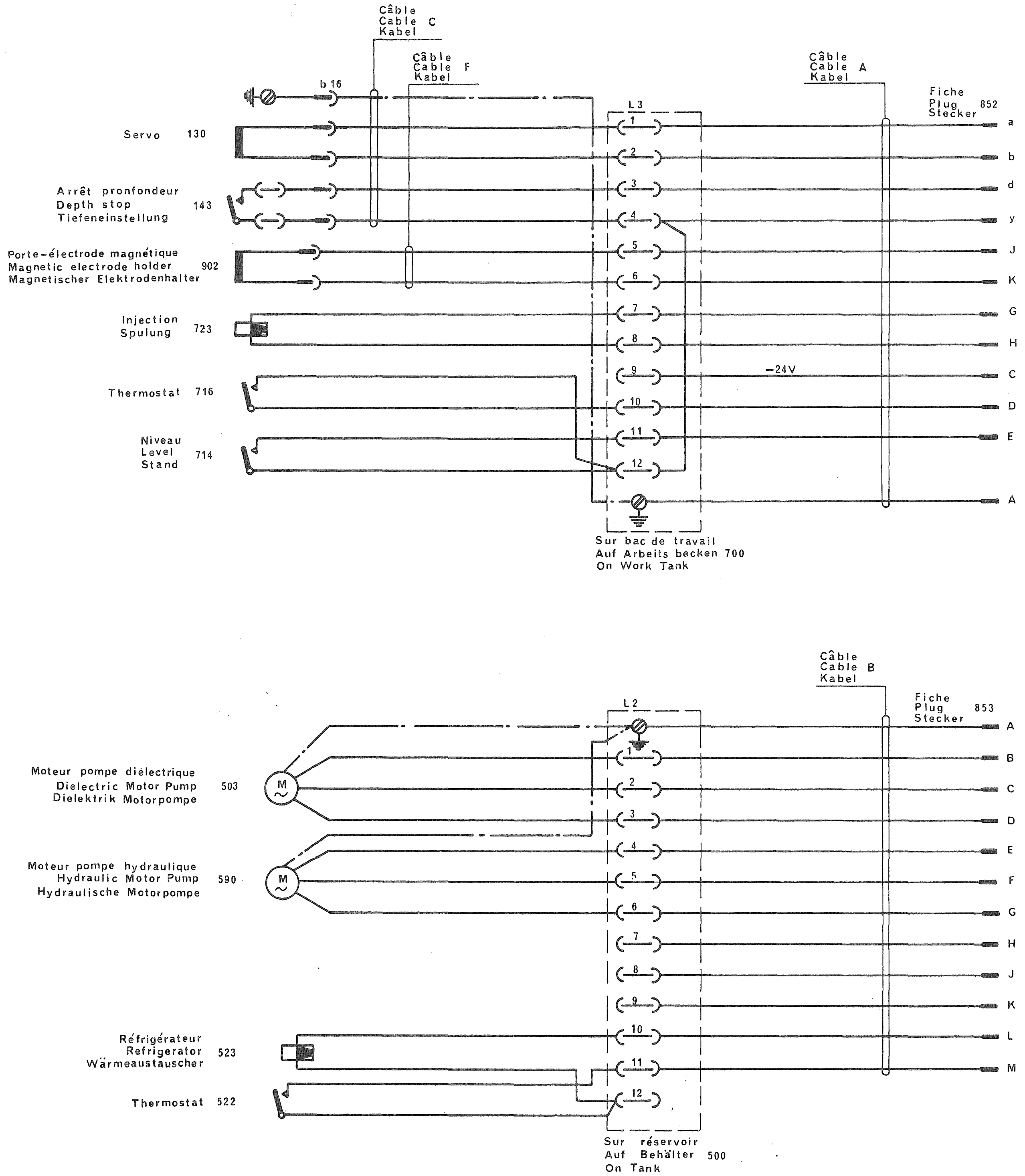


Fig 2



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CABLAGE MACHINE

WIRING OF MACHINE

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CHARMILLES

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ISOPULSE GENERATOR 25

ISOPULSE 25 Generator

INDEX

1 - INSTALLATION

ISOPULSE 25 Generator

Install the generator to the right-hand side of the machine; the ventilation duct (807) must have a space of at least 16" (40 cm) from the wall.

1.1 Fitting of the printed circuit boards

Loosen the "camlock" fasteners and remove the rear top cover plate and the ventilation duct (807).

Make sure that the printed circuit boards are secure in their plug mounts.

- on the pilot unit (870) :

  (853.053) Amplifier unit (876)

  (853.054 A) Stabilized power supply unit (871)

  (853.047 A) "A" Impulse time base unit (873)

  (853.047 A) "B" Interval time base unit (874)

  (853.048) Detector unit (872)

  (853.050 A) Pulsator unit (875)

A keying arrangement prevents erronous fitting of the units.

- on the power section:

  loosen the two "camlock" fasteners that hold the panel to which are fastened the switching units and swivel the panel backwards.

  Set up one of these switching units (862) and fasten it by means of the 4 plastic screws (863).

  Raise the panel, set up the second switching unit (862) and fasten it by means of the 4 plastic screws. The two switching units are identical and interchangeable.

- MICROFIN circuit :

  Place the bridge (805) in the terminals (804).

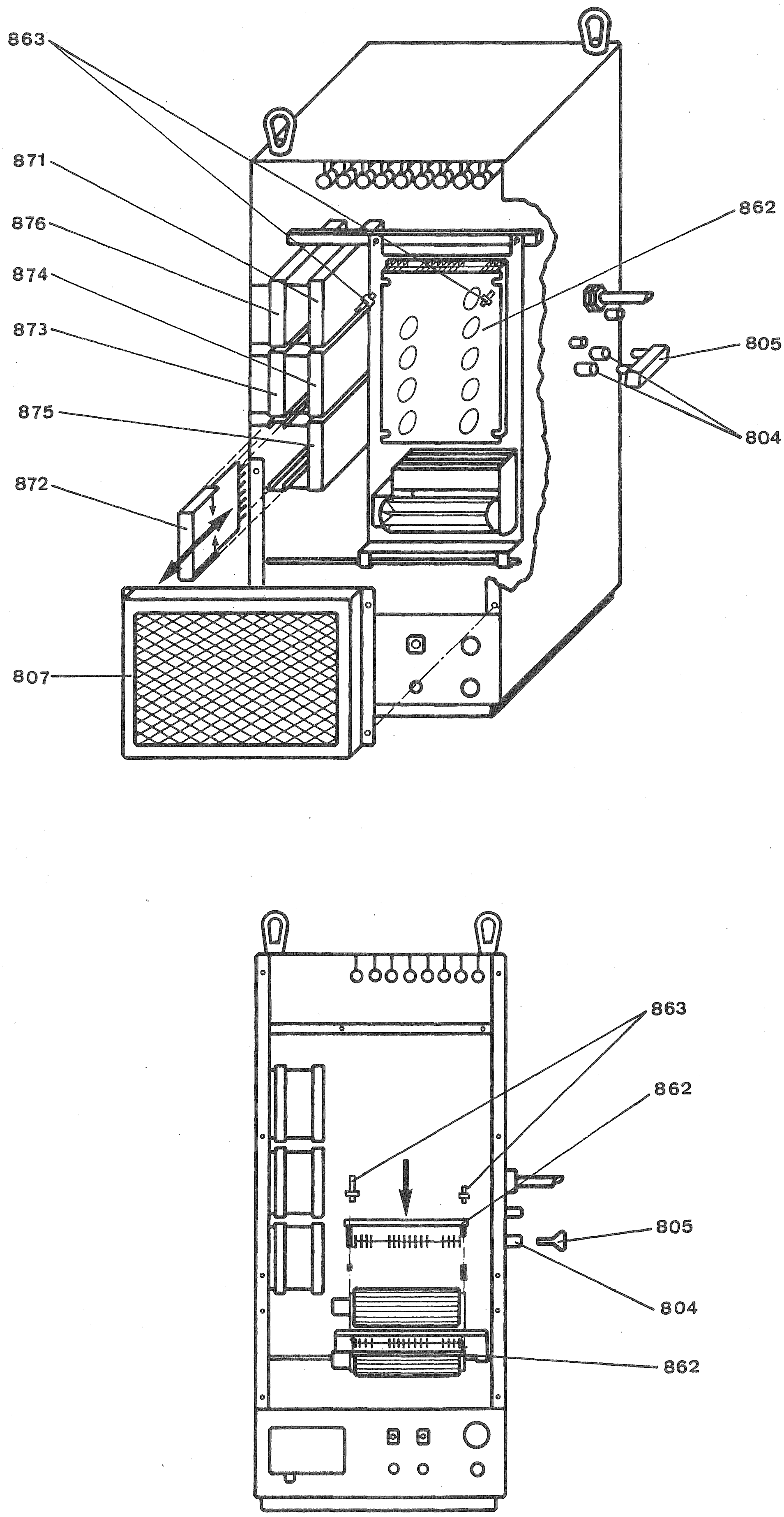


Fig 1

1.2 Connection of the generator to the mains supply

The mains supply voltage for the generator is specified with the order, this determines the choice of the electrical components and their connections.

The various possible connections of the input transformer (860) are illustrated in fig. 1 for the different standard main voltages.

Checking of the connections

- Make sure that the input transformer (860) primary connections are correct for the voltage available (fig. 1). For this, remove the lower front panel after having loosened the "camlock" screws (fig. 2).
- Make sure that all terminal screws are firmly tightened down; they may have become loose from vibration during transportation of the equipment.

Connection to the main line

The cable for this connection is to be supplied by the customer (cable gauge : 4 x .023 sq. inch (1.5 mm^2)). Connect the terminals N-R-S-T in the terminal box (851) located on the rear panel (850) to the phase conductors of the mains supply (fig. 3). Also connect the ⏚ terminal to "ground".

The two terminals L.L. in the terminal box are provided for lighting purposes. They should be connected to the workshop lighting main through a suitable safety device.

1.3 Connection of the generator to the machine

This subject has been dealt with under the paragraph "INSTALLATION OF THE MACHINE".

1.4 Checking of the generator

This subject has been dealt with under the paragraph "CHECKING OF THE MACHINE".

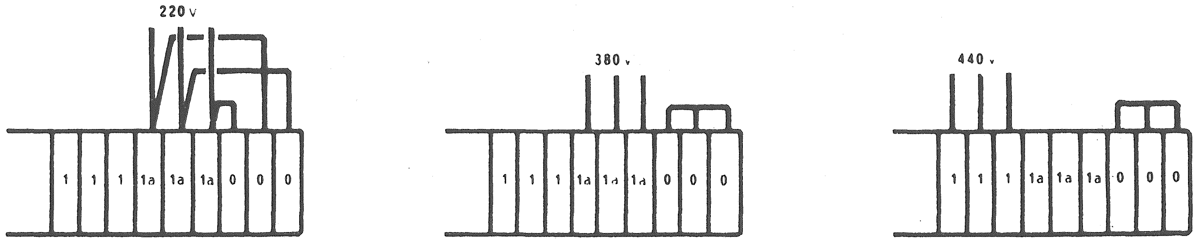


Fig 1

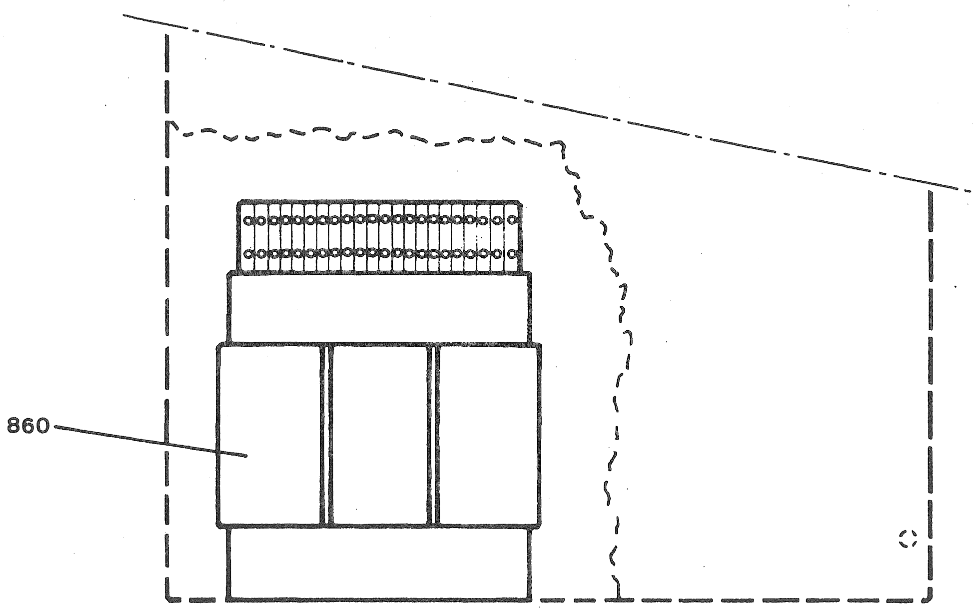


Fig 2

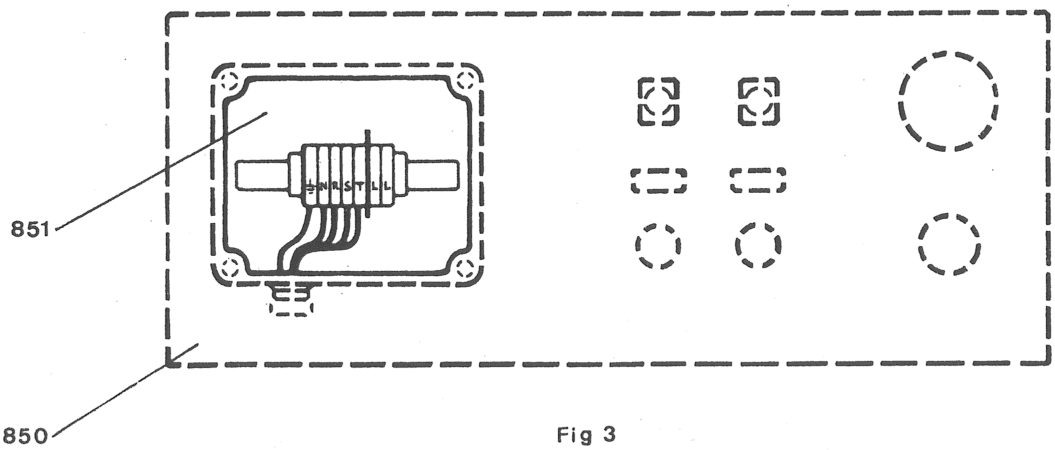


Fig 3

2 - DESCRIPTION

ISOPULSE 25 Generator

800 Generator unit

801 Cabinet

802 Bolts for transportation

803 Packing for machining-cable outlet (E)

804 Terminals for connection of resistor to MICROFIN circuit

805 Bridge for terminals (804)

806 Terminals for connection of capacitor to MICROFIN circuit

807 Air intake of ventilation duct

808 Air outlet of ventilation duct

820 Control panel

821 Main switch

822 Switch of auxiliary supplies

823 Switch of the hydraulic motor pump

824 Switch of the dielectric motor pump

825 Power rating and polarity selector switch

826 Impulse time "A" selector switch

827 Interval time "B" selector switch

828 Potentiometer for adjustment of the duration of up feed of the electrode under pulsated working conditions

829 Potentiometer for adjustment of the machining time of the electrode under pulsated working conditions

830 Switch of the pulsator circuit

831 Potentiometer for adjustment of the sensitivity of the servo-mechanism

832 Push-button for switching-on of the machining power

833 Push-button for switching-off of the machining power

834 Push-button for energizing of the magnetic electrode holder

835 Push-button for releasing clamping power of the magnetic chuck

836 Switch for raising or lowering the quill

837 Selector switch for setting of the mode of injection

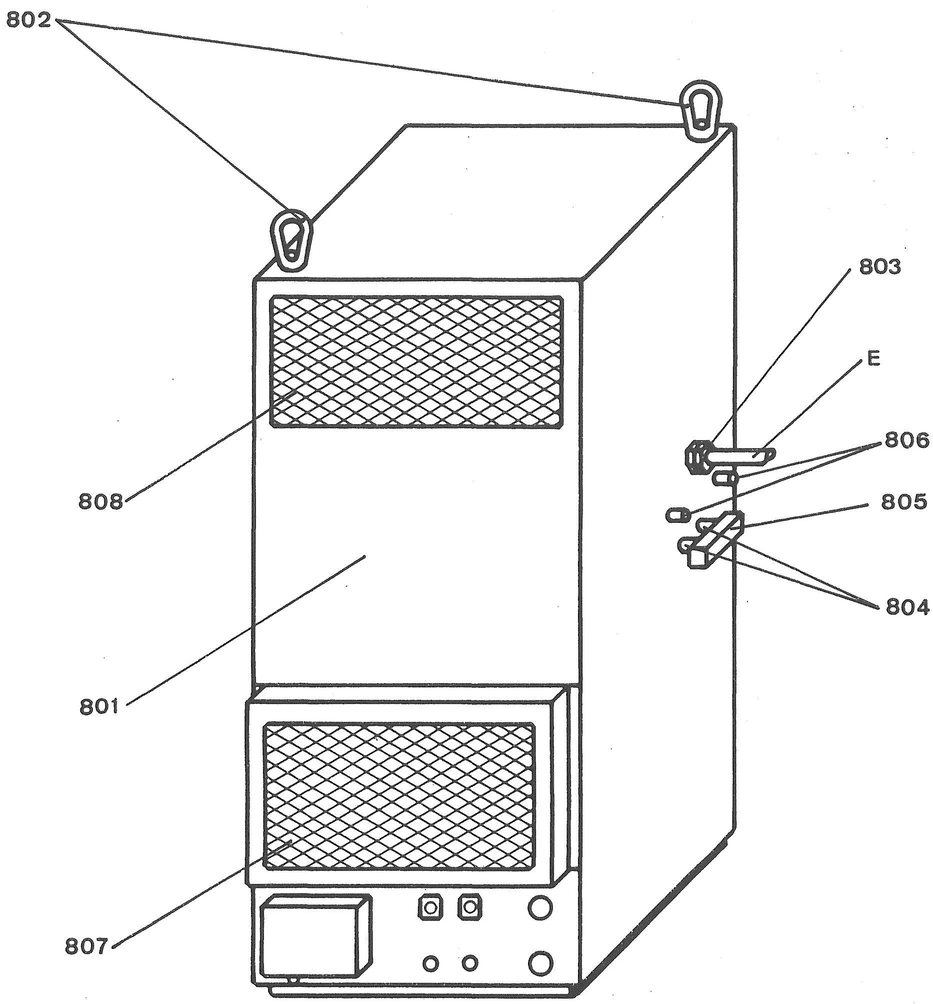
838 Pilot lamp for monitoring of machining power

839 Pilot lamp for monitoring of the edge finder

840 Pilot lamp for monitoring of the depth stop

841 Pilot lamp for monitoring of the safety devices and of the level and temperature of the dielectric fluid

842 Ammeter for monitoring of the average machining current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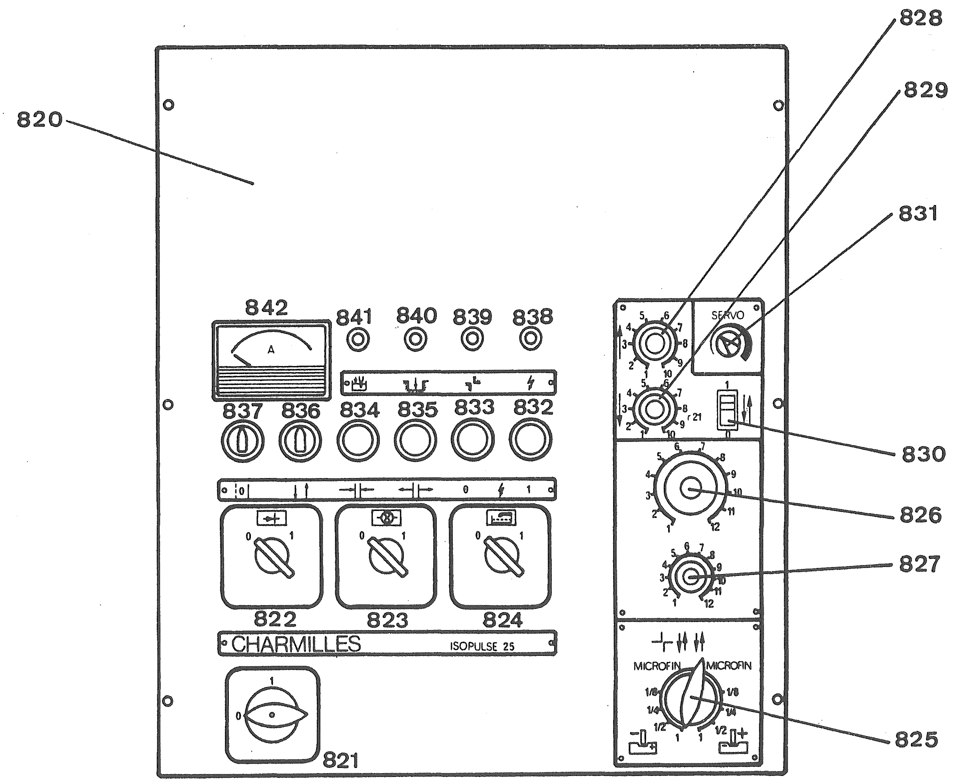
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When the machine is equipped with a built in rotary spindle, the generator is provided with an additional control panel (845) which fits underneath the main control panel on the front of the generator.

845 Control panel of the rotary spindle device

846 Control switch of the rotary spindle

847 Selector switch for the mode of operation of the spindle

848 Potentiometer for control of the speed of rotation and the direction of rotation under free running conditions

850 Rear connection panel

851 Junction box of cable (D) : general power line

852 Socket, 26 poles, for cable (A) : control cable of the machine

853 Socket, 17 poles, for cable (B) : control cable of the dielectric tank

854 Socket, 2 poles, for rotary spindle or lighting of the optical devices

855 Socket, 5 poles, for tapping attachment

856 Microfuse, 24 volt D.C. source

857 Microfuse, 110 volt A.C. source

860 Input transformer

861 Machining current D.C. source

862 Switching units

863 Plastic screws for fastening of the units (862)

864 Current limiting resistors

865 Ventilation fans

870 "Pilot" section

871 Power supply unit of the pilot circuit

872 Detector unit

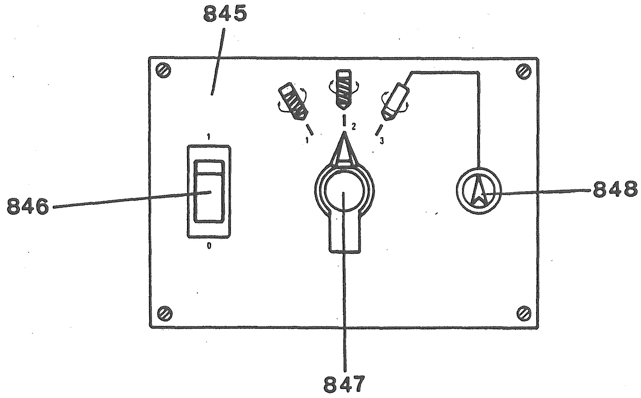
873 "A" Impulse time-base unit

874 "B" Interval time-base unit

875 Pulsator unit

876 Amplifier unit

880 MICROFIN circuit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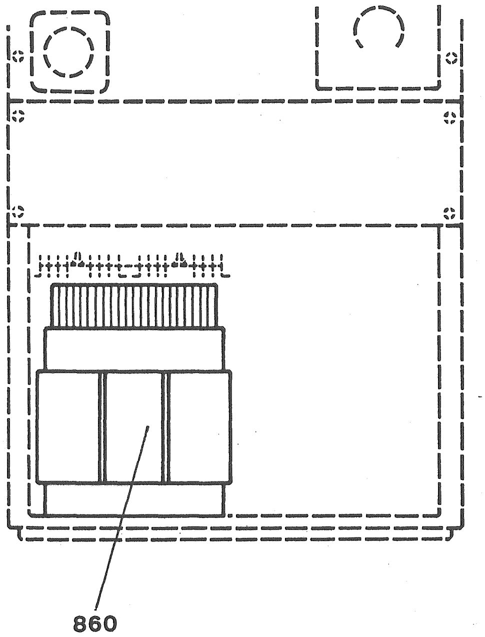
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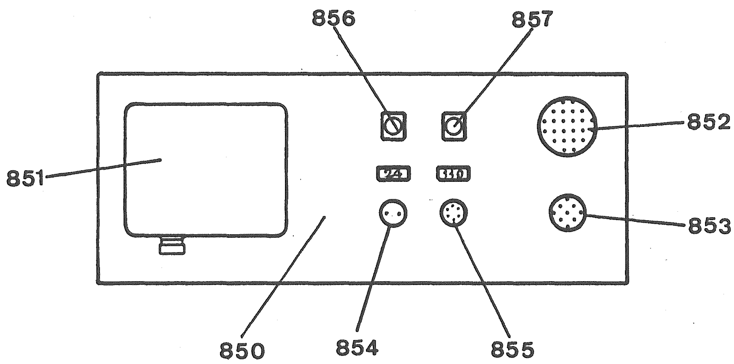
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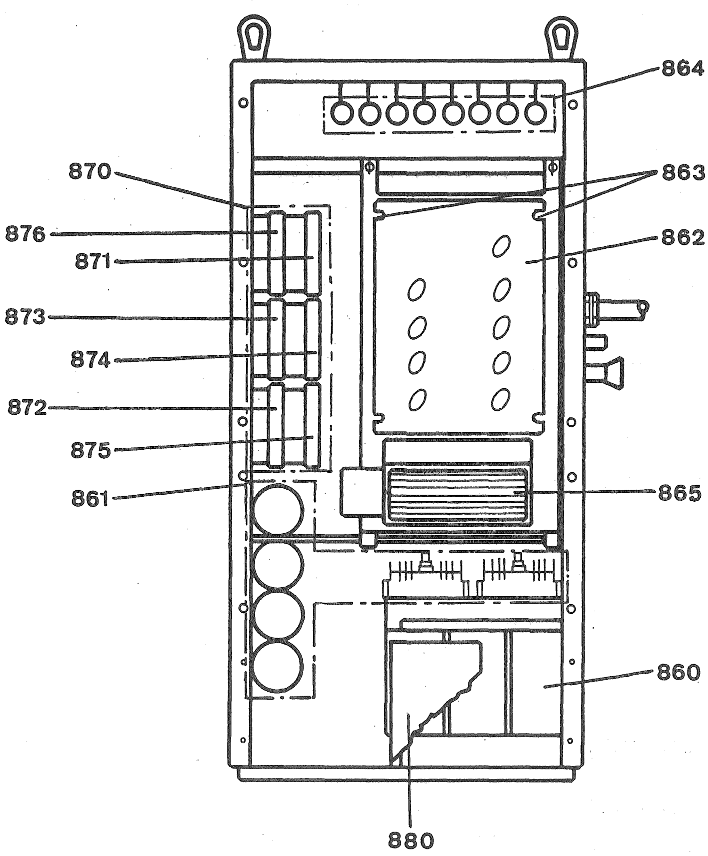
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3 - OPERATING INSTRUCTIONS

ISOPULSE 25 Generator

3.1 General power supply

Turn the main switch (821) to position (I).

3.2 Starting of the hydraulic motor pump

Turn the switch (823) to position (I).

3.3 Starting of the dielectric motor pump

Turn the switch (824) to position (I).

3.4 Auxiliary supplies

Turn the switch (822) to position (I).

3.5 Machining controls

Press on the green push-button (832) for switching-on of the machining voltage.

Press on the red push-button (833) for switching-off of the machining voltage.

3.6 Magnetic energizing to the electrode-holder

Press on the red push-button (834).

3.7 Magnetic release of the electrode-holder

Press on the green push-button (835).

3.8 Control of the manual feed of the electrode-holder assembly

Actuate the switch (836) to the left for lowering the electrode.

Actuate the same selector switch (836) to the right for raising the electrode.

3.9 Setting of the mode of injection

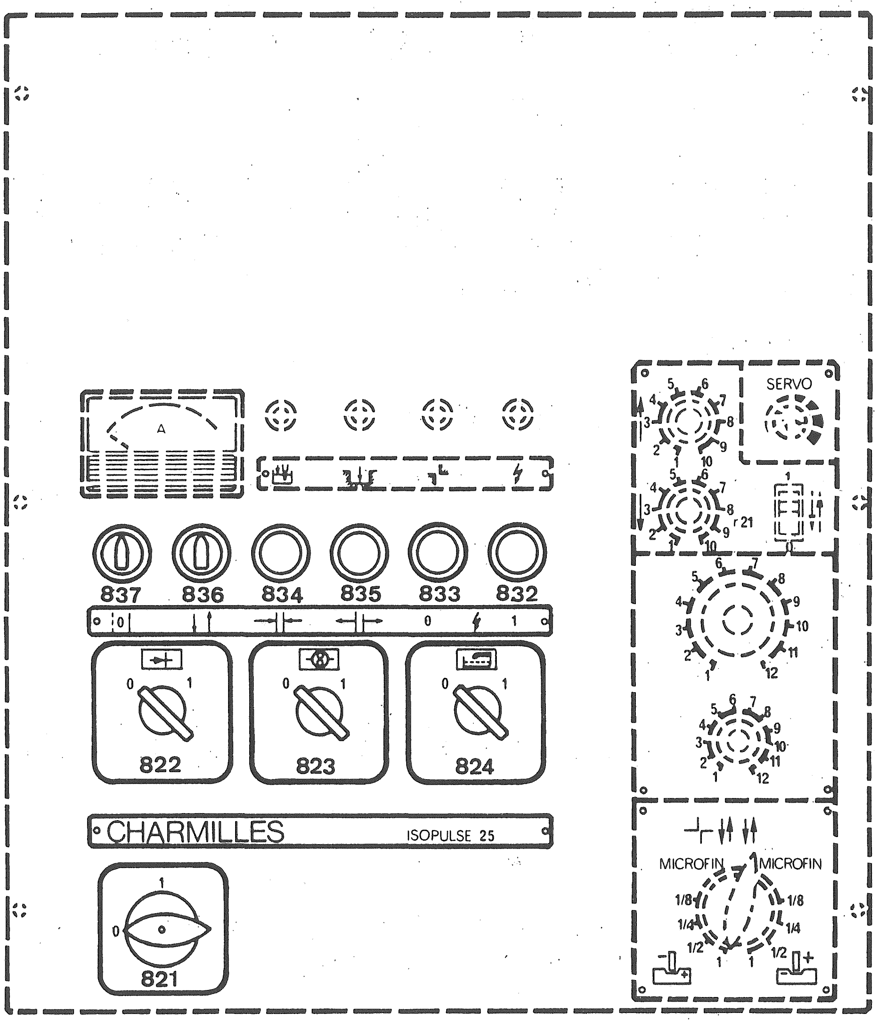
- Pulsated injection :

  Turn the selector switch (837) to the left-hand position. The solenoid-valve of the injection system will then be energized by the pulsator through a relay.

- Continuous injection :

  Turn the selector switch (837) to the right-hand position. The solenoid-valve will then remain permanently open.

- With the selector switch in the vertical position, the solenoid-valve remains closed.



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3.10 Selection of the power rate, the current intensity level, the polarity and the function

- ISOPULSE isoenergetic power rates :

  Set the selector switch (825) to one of the power rate positions, 1/8, 1/4, 1/2 or 1, on the left-hand range for negative polarity on the electrode, on the right-hand range to obtain positive polarity on the electrode

  The various settings, 1/8, 1/4, 1/2 and 1, correspond to the current intensity levels standardized by CHARMILLES.

- MICROFIN "superfinish" power rate :

  Set the selector switch (825) to one of the MICROFIN settings. In the left-hand position the polarity on the electrode will be negative, in the right-hand position the electrode will be positive.

- Edge finder :

  Set the selector switch (825) to the position (◢◤ ↓↑).

- Manual up and down of the electrode-holder assembly :

  Set the selector switch either to position (↓↑) or to position (◢◤ ↓↑).

3.11 Impulse timing A

Set the selector switch A (826) to one of the 12 settings, chosen in accordance with the data given in the manual "TECHNOLOGY".

3.12 Interval timing B

Set the selector switch B (827) to one of the 12 settings, chosen according to machining requirements.

3.13 Control of the pulsator

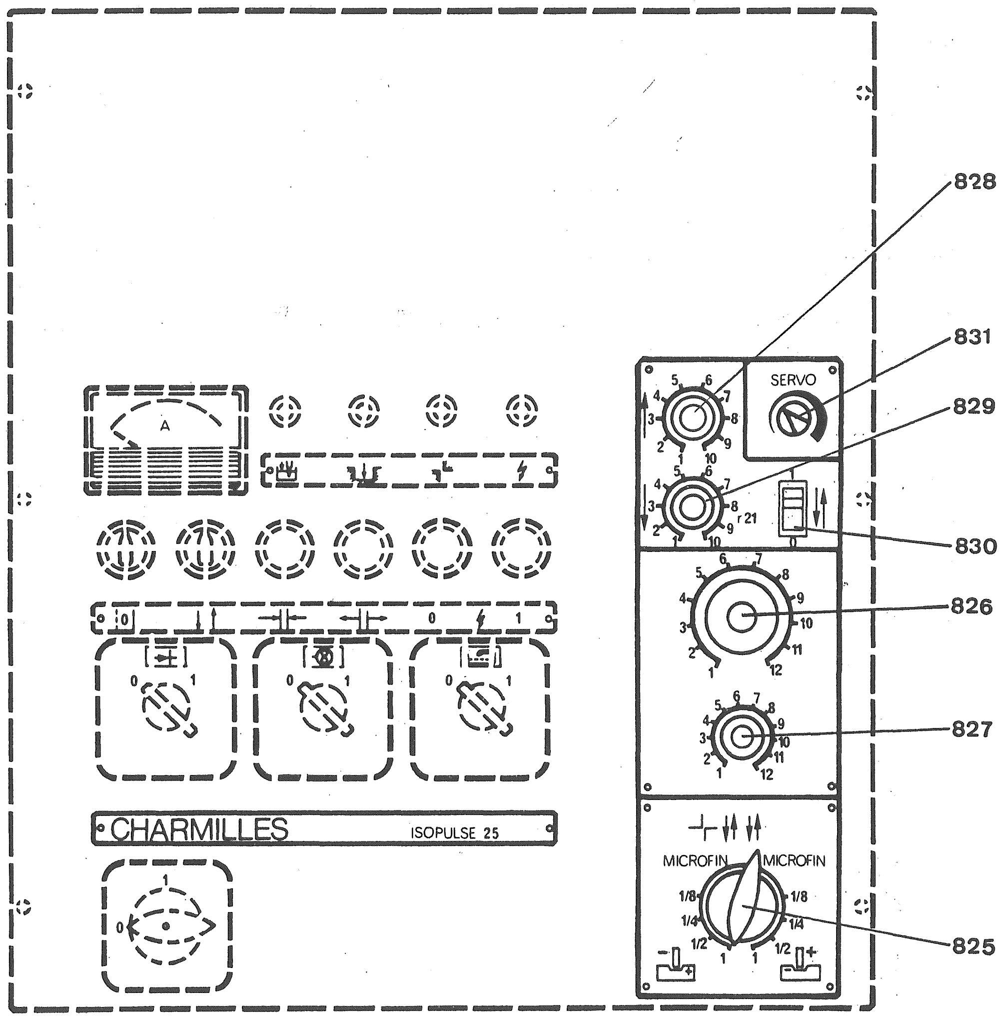
Press on the thumb-switch (830) and set it to position (I).

The duration of machining by the electrode is adjustable by means of potentiometer (829).

The time during which the electrode is withdrawn is adjustable by means of the potentiometer (828).

3.14 Sensitivity of the servo-mechanism

Rotation of potentiometer (831) towards the left increases the distance between the tip of the electrode and the face of the workpiece; by turning this potentiometer towards the right, the distance is decreased.



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3.15 Visual monitors for the various functions

When on, the green pilot lamp (838), indicates that the machining power is switched "ON".

The white pilot lamp (839) will glow, during a centering operation, as soon as the electrode is in contact with the workpiece.

The red pilot lamp (840) will glow as soon as machining is interrupted by the depth stop.

The red pilot lamp (841) will glow when the overflow from the dielectric fluid tank falls below a predetermined rate or when the temperature of the dielectric fluid is excessive.

The ammeter (842) indicates the average value of the machining current.

3.16 Machining under ISOPULSE isoenergetic working conditions

The various adjustments suitable for different machining conditions are indicated in the manual "TECHNOLOGY". When in doubt, please refer to this manual.

- Switch-on the equipment by using the following control switches (821) (822) (823) (824).

- By means of the selector switch (825), select the required polarity of the electrode and set the current intensity (CHARMILLES standard).

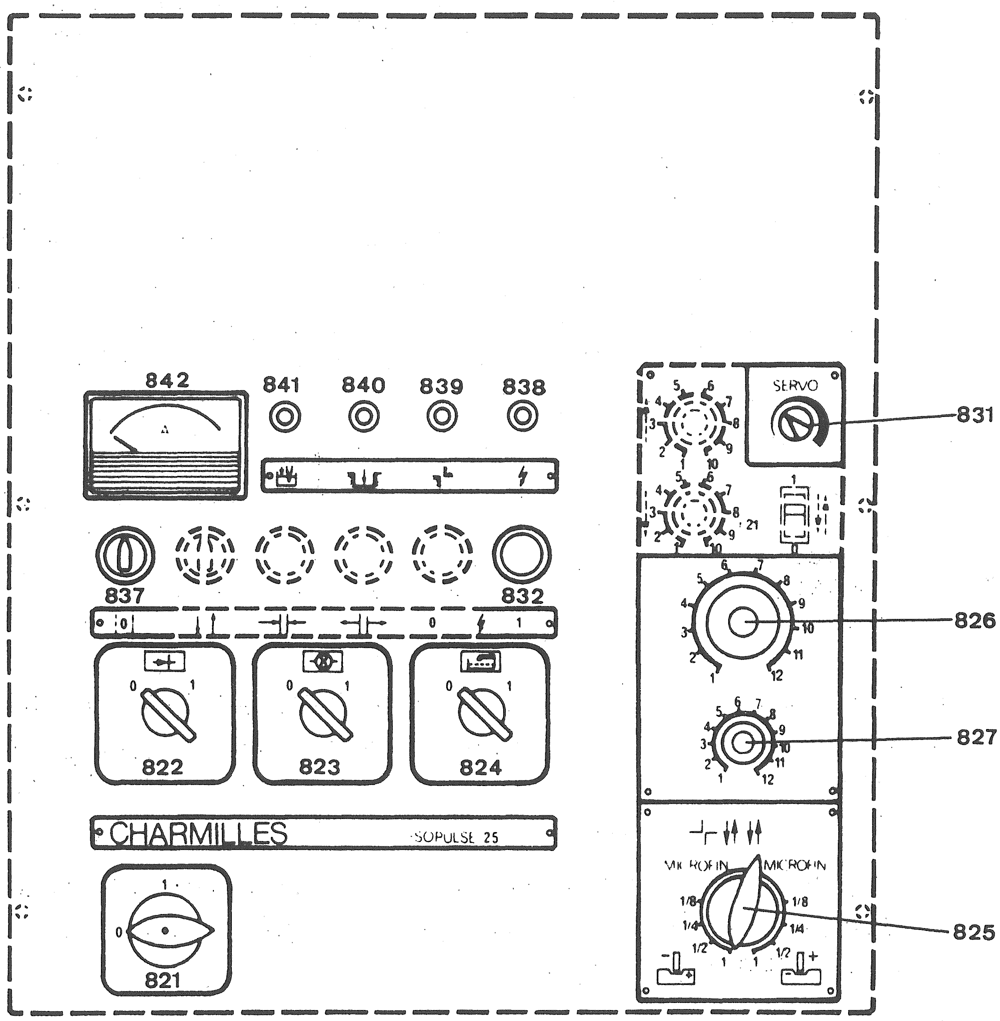
- By means of selector switch A (826), select the required impulse time.

- By means of the selector switch B (827), select the required interval time.

- By means of selector switch (837), choose the mode of injection.

- By means of the push-button (832), switch the machining power "ON".

- Optimum machining speed and stability is obtained by adjustment of the servo-mechanism by means of potentiometer (831).



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3.17 Machining under MICROFIN "superfinish" conditions (fig. 1)

The various settings suitable for different machining purposes are indicated in the manual "TECHNOLOGY". When in doubt, please refer to this manual. The parameters relative to "superfinish" MICROFIN machining operations will be found in chapter 2 of the MICROFIN procedures described in the "TECHNOLOGY" manual.

- Switch on the equipment by using the following control switches : (821) (822) (823) (824).
- The required polarity of the electrode is obtained by setting the selector switch (825) to the left- or right-hand position for MICROFIN operation. Negative polarity is that most commonly used.
- Choose the mode of injection by means of selector switch (837).
- Switch-on the machining power by means of push-button (832).

NOTE : It is possible, if necessary, to modify the operating characteristics of RLC "superfinish" circuit for particular machining operations (fig. 2) :

- By insertion of a resistor between terminals (804), after having removed the bridge (805).
- By connecting a capacitor across terminals (806), after having disconnected the capacitor - inside the generator - factory mounted across the internal tags of terminals (806). The latter capacitor can, subsequently, be mounted externally.

3.18 Machining under "pulsated" working conditions (fig. 1)

Both the ISOPULSE and the MICROFIN machining processes can be carried out under "pulsated" working conditions.

- Set the "pulsator" switch (830) to position (I).
- Adjust the machining time by means of potentiometer (829).
- Adjust the withdrawal time of the electrode by means of potentiometer (828).

3.19 Operation of the rotary spindle (fig. 3)

If a rotary spindle attachment is incorporated in the machine, it can be operated in the following manner :

- To start operation of the spindle, clockwise rotation, set the selector switch (847) to position (1).
- To start operation of the spindle, counter-clockwise rotation, set the selector switch to position (2).
- Free running operation, set the selector switch (847) to position (3). Both the speed and the direction of rotation of the spindle are controlled by means of potentiometer (848).
- All the above operating modes of the rotary spindle take place when switch (846) is set to position (I). When switch (846) is in position (0), the spindle is inoperative.

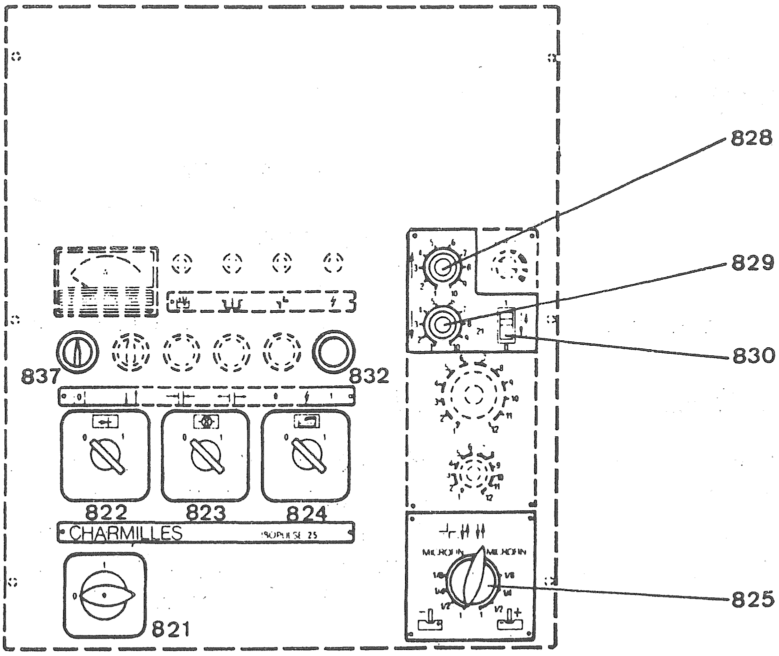


Fig 1

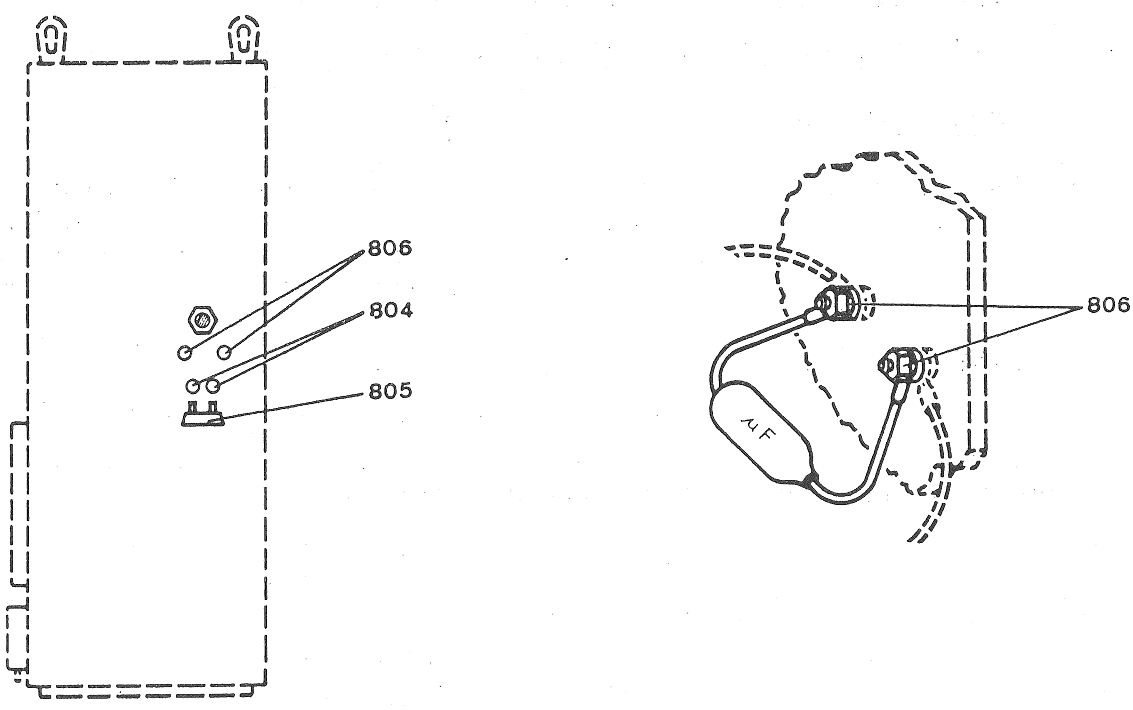


Fig 2

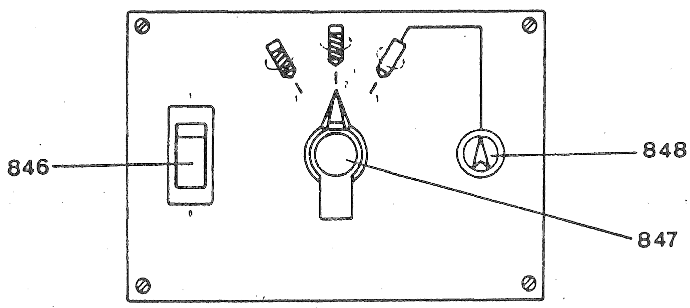


Fig 3

4 - SAFETY DEVICES

ISOPULSE 25 Generator

The following safety devices are provided :

Thermic safety devices

Thermic and magnetic safety devices are provided in the circuits of the power supply rectifiers, of the hydraulic pump and of the dielectric pump to protect these units against damage from overload current. They are incorporated in the switches (822), (823), and (824) (fig. 1).

Fuses

- power supply lines (fig. 2)

  110 volt A.C., fuse (857), 2 amps.

  24 volt D.C., fuse (856), 2 amps.

- switching units (fig. 3)

  9 fuses protect each switching unit (862). In fact, these components are visual detectors which indicate faulty operation. Blowing-out of one or other of these fuses indicates that the associated transistor is defective.

Keying of plugs and sockets

All the plugs and sockets of the printed circuit boards and the distribution cables are "keyed" in order to prevent the possibility of erronous connection.

5 - MAINTENANCE

ISOPULSE 25 Generator

Under normal operating conditions, the filter of the ventilation system requires cleaning once every week. For this, remove the air intake duct and the rear top panel of the generator after having loosened the "camlock" screws. Thoroughly clean the filter, using a compressed-air gun (fig. 4).

Clean the ventilation fans and ducts of the converter units using a clean dry brush.

If necessary, clean the units of the "pilot" assembly.

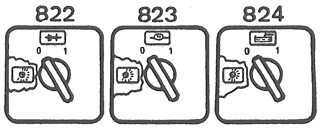


Fig 1

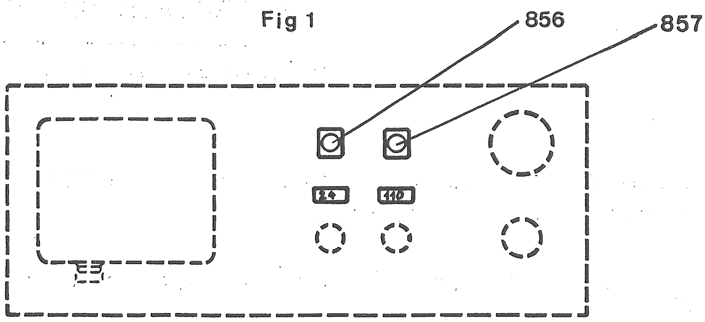


Fig 2

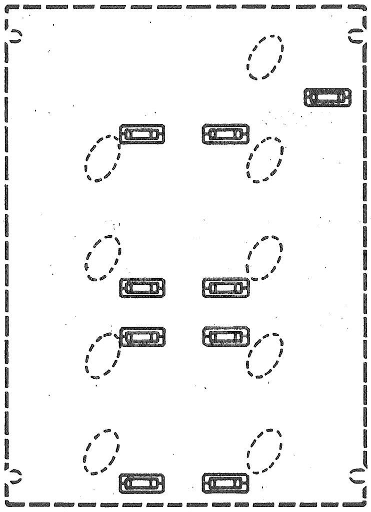


Fig 3

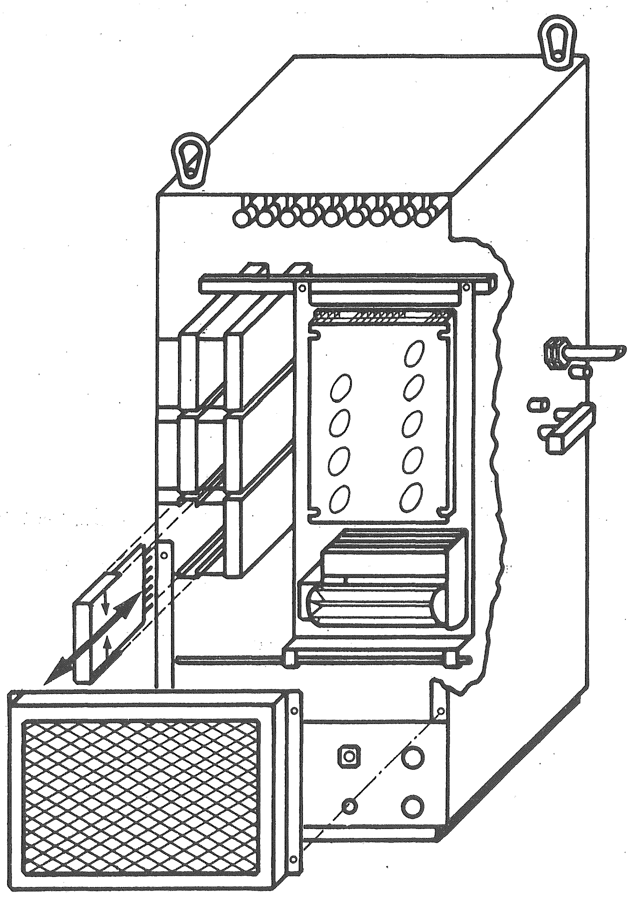


Fig 4

6 - TROUBLE SHOOTING

ISOPULSE 25 Generator

In case of defective operation, start by checking all electrical connections.

6.1 Fault : Failure of the hydraulic pump.

Remedy : Reset switch (823). If the control knob does not engage on position (I), then it will be necessary to check the setting of the thermic cut-out incorporated in the switch.

For this check, remove the switch lever and the switch cover-plate (fig. 1).

The hand of the setting screw should indicate :

0.65 A if the mains supply voltage is 380 V.

1.10 A if the mains supply voltage is 220 V.

Refit the cover-plate and the switch lever, then switch-on again.

6.2 Fault : Failure of the dielectric pump.

Remedy : Reset switch (824). If the control knob does not engage on position (I), then it will be necessary to check the setting of the thermic cut-out incorporated in the switch.

For this check, remove the switch lever and the switch cover-plate (fig. 1).

The hand of the setting screw should indicate :

- For a type D10 machine.

  0.9 A if the mains supply voltage is 380 V.

  1.55 A if the mains supply voltage is 220 V.

- For a type D20 machine.

  1.65 A if the mains supply voltage is 380 V.

  2.9 A if the mains supply voltage is 220 V.

Refit the cover-plate and the switch lever, then switch-on again.

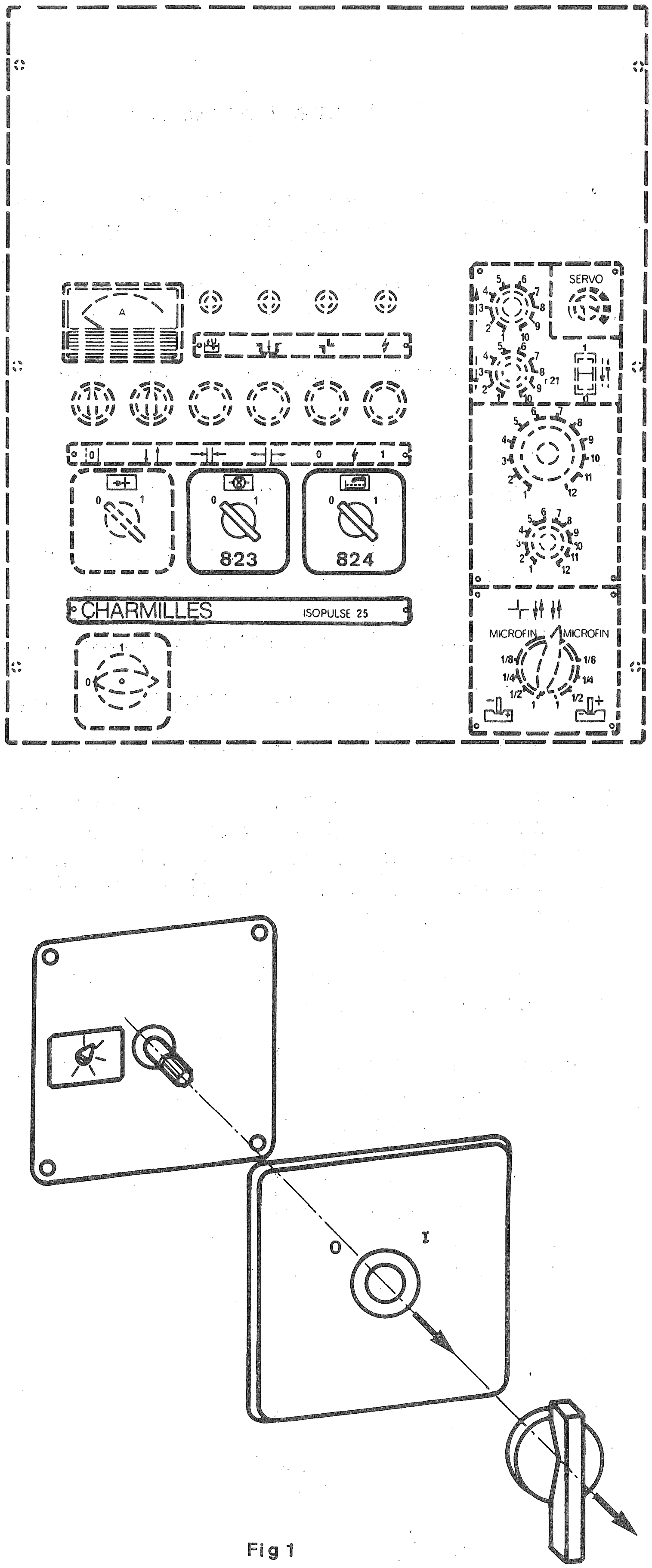


Fig 1

6.3 Fault : Failure of both the hydraulic and the dielectric pumps.

Remedy : Make sure that voltage is present between the three phases of the mains supply. For this, check the different voltages between the terminals R.S.T. in the junction box (851) located on the rear distribution panel (850) (fig. 1).

6.4 Fault : The generator cannot be started up.

Remedy :

1 - Check the adjustment of the thermic cut-out incorporated in switch (822).

For this, remove the switch lever and the switch cover-plate (fig. 2).

The hand of the setting screw should indicate :

4.8 A if the mains supply voltage is 380 V.

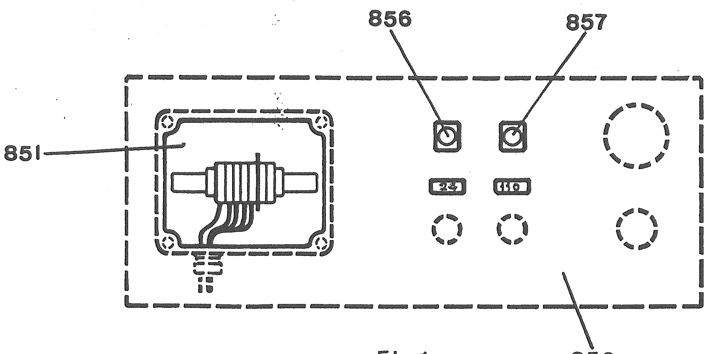
8.3 A if the mains supply voltage is 220 V.

2 - It is also necessary to check the fuses (856) of the 24 V. D.C. circuit, and the fuses (857) of the 110 V. A.C. circuit. These fuses are located on the rear distribution panel (850) (fig. 1).

3 - Refit the cover-plate and the switch lever, then switch-on again.

NOTE : The various pilot units and switching units are standardized types. They can, therefore, be replaced without delay.

Any unit that may have been repaired or modified by unauthorized persons other than members of CHARMILLES staff or their recognized agents will no longer be covered by our guarantee.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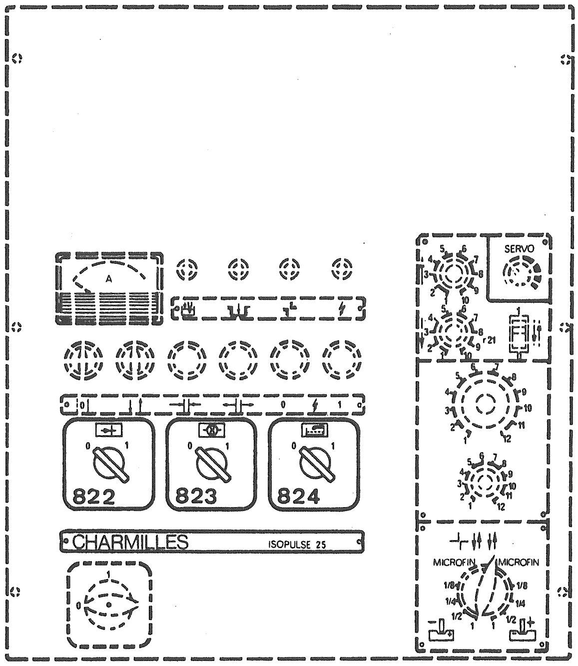
850

Fig 1


A
SERVO
822
823
824
CHARMILLES
ISOPULSE 25
MICROFIN
MICROFIN

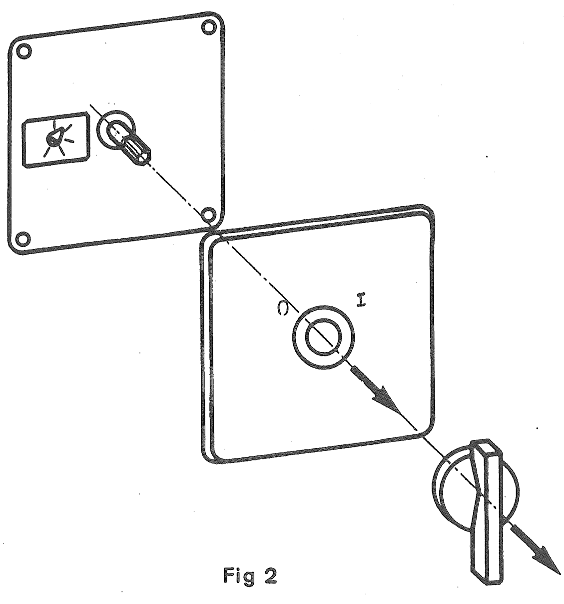


Fig 2

ISOPULSE TECHNOLOGY

The data contained in this section has been compiled to provide the department responsible for planning the work with the information required for the choice of the working conditions and of the procedure to be followed in order to carry out a given machining problem. It also makes available the data required by the department for the pre-evaluation of costs to permit prior calculation of the machining times and costs; finally, it provides the electrode manufacturing department with information concerning the lengths and the under-sizings to be complied with for the different machining rates.

All the values given in the recapitulatory sheets as well as the curves were determined in funtion of the discharge on-time (button "A" of the ISOPULSE generator), with the exception of the combined curves AGMO.

Each recapitulative sheet is concerned with one electrode material, one polarity, one workpiece material and one machining power, whilst each sheet of curves relates to one electrode and workpiece material, one polarity, one condition of working (injection or suction) and to several machining powers.

We give herein the explanations needed concerning the items, the column headings and the sheets of curves related to this technology.

ELECTRODE

Under this item we indicate the nature of the electrode material that was used during the tests.

ELECTRODE POLARITY

The polarity of the electrode may be negative or positive with respect to the workpiece.

WORKPIECE

Under this item we give the nature of the material forming the workpiece used during the tests.

POWER

The code of power indication is the following: The first figure indicates the power selected by means of the loggle switches marked 1/2, located on the ISOPULSE Power supply. The second figure relates to the open gap voltage of the power supply (60 or 80 V).

CALCULATION OF THE DIAMETRICAL DIMENSIONS OF THE ELEKTRODES

$$d_1 = D - F_1 \qquad d_2 = D - E_2$$

The formulae given under this item permit a very easy calculation of the diametrical dimensions of the electrodes. All the signs which are noted with the index "1" relate to machining values under roughing or semi-finishing conditions, the signs noted with index "2" all relate to machining values for the final operation (finishing).

After having chosen the rate of machining with which a roughing job is to be carried out, e.g. a round drilling operation, deduct from the diameter of the finished hole the figure corresponding to the chosen rate, figure which will be found in column "F" if the work is done under suction, or in "F'" if working with injection.

Determination of the diameter for a semi-finishing electrode is carried out in the same manner.

The diameter of the finishing electrode is determined by making use of columns "E" or "E'" starting from the diameter of the finished hole, as for calculation of the roughing electrodes.

COLUMN "A"

Column "A" indicates the setting of knob "A" on the ISOPULSE generator, knob which fixes the duration of each discharge. Together with the switches for selection of the machining power, and which are marked 1/2, they fix the machining rate.

COLUMN "B"

Column "B" indicates, for each setting of knob "A", the lowest position of knob "B" (duration of interval) recommended for the type of work as indicated in the test conditions. In cases where large areas which permit intensive flushing are to be machined, a lower setting than that indicated in column "B" can be chosen. The divergence between the positions of knob "A" and knob "B" should not, however, ever be greater than 4 steps.

COLUMN "C"

The values given in column "C" are related to the active electrode lengh, being multiples of the thickness of the workpiece to be drilled. Experience has proved that when machining a cylindrical through-hole, the electrode does not only show wear at its extremety but also laterally along a certain distance. It is this distance that we call the active electrode lengh. The plug of an electrode which has a rearward clearance must have a lengh at least equal to the active electrode lengh if the geometry of the finished part is not to be affected by the lateral electrode wear.

A cylindrical electrode without rearward clearance must have a lengh at least as long as the active electrode lengh plus the thickness of the part to be drilled.

These precautions will ensure that in both cases the active part of the elektrode will traverse the workpiece from side to side.

COLUMNS "E", "E'"

The mean diametrical sparking gap E or E' (suction or injection) in the difference between the diameter d of the electrode and the diameter D of the eroded hole. Diameter D has been measured by means of a measuring microscope. A theoretical center-line through the irregularities of the surface defined the measured diameter.

COLUMNS "F", "F'"

The values given in columns "F" and "F'" (suction and injection) represent the difference between the diameter (d) of the electrode and the diameter D of the hole drilled and then ground until all traces of spark erosion have disappeared.

This value which is called the diametral influence limit, is used to determine the diametrical dimensions of the roughing and semi-finishing electrodes.

COLUMNS "G", "H", "K", "L"

These columns give data relating to the roughness of the machined surfaces. The surface finish is not exactly the same, for frontal or lateral machined surfaces; what has been taken into account in these columns.

Columns "G" and "K" give reference marks in relation with the CHARMILLES sample-plate on which is printed a selection of twelve numbered surface finished.

For the numerotation of the surface finishes the criterium of Center line average (CLA) has been chosen. All surfaces has been measured with a Perth-o-Mater, using a diamond stylus having a radius of 10 μm, cut-off being of 0,75 mm. The difference of roughness between two surface finishes having to successive numbers is 12,2 %.

COLUMN "M"

This column indicates the amount of materiel in mm^3 removed per minute under the conditions stipulated on the sheet. These figure are, therefore, practical values and not the maximum values available under other machining conditions.

COLUMN "O"

Column "O" indicates the relative volumetric electrode wear as recorded during the tests under column "M" for removal of material. The figures given are minimum values.

COLUMN "R"

These figures are particularly useful as they show the values of specific removal of material - in mm^3 perminute - and per ampère. They permit the prior calculation of the machining times when the total power of the generator cannot be entirely used, for example when the dimensions of the electrodes are such that high values of current cannot be allowed.

SHEETS OF CURVES "E", "E'", "F", "F'", "R"

These curves give a graphic representation of the figures on the recapitulatory sheets. They provide the user with an over all view of the influence of several parameters.

SHEETS OF CURVES "AGMO"

These combined curves provide the user with an easy means of choosing the machining rates. The curves in the upper part show, for each machining rate, the removal rate in function of the CHARMILLES standardized surface finish whilst the curves in the lower part indicate the relative volumetric electrode wear for the same machining rates. The figures which appear close to the dots of the curve correspond to the position of button "A" on the ISOPULSE generator and the output power (1/4, 1/2, 1, 2) plays the role of parameter.

Considerations on the influence of machining conditions

1. Forced feed renewal of the dielectrid fluid.

   In this technology we have taken into account two modes of dielectric fluid renewal; renewal under depression (suction) and renewal under pressure (injection), In both cases, clean dielectric fluid is forced through the machining area.

   The working conditions are easily reproducible by indicating the injection pressure or the depression (suction); both states can be accurately adjusted.

   We have not, however, taken into account the other possible modes of renewal such as pulsed injection, lateral flushing or even absence of flushing, the results in these cases being higly affected by the geometry of the workpieces and the reproductibility of the fluid flow being difficult to ensure.

   As a general rule, the sparking gaps and the influence limits increase as the efficiency of the flushing decreases and they may well become two or three times greater than those which result with forced-feed injection.

The electrode wear is also affected by renewal of the dielectrid fluid: When working with graphite electrodes it is best to provide for abundant renewal of the dielectrid fluid, thus, the machining area is less endangered by pollution with consequent reduction of the risk of formation of short-circuits or sustained arc discharges and the electrode wear is also slightly decreased.

With copper electrodes, however, the behaviour is different: the wear ratio increases considerably with increasing renewal of the dielectric fluid. It is best, therefore, to work with very low pressures or under pulsed injection conditions in order to increase the life of the electrodes. The removal rate decreases slightly as flushing is decreased, but this defect receives considerable compensation in many cases where the wear on the electrode has to be taken into consideration (shaped electrodes, accurate roughing without wear on the electrodes, etc.).

Pulsing the dielectric feed is recommended even for lateral flushing as the wear of copper electrodes can be severely restricted, for certain roughing settings.

In cases where the electrode wear is not important, it is best to work with abundant renewal of the dielectric fluid as this leads to increased removal rate.

2. Influence of the type of dielectric fluid.

If a dielectric fluid other than Mentor 28 is used, the values such as surface finish, sparking gaps and influence limits, can be directly related with the removal rate resulting from use of said fluid. If the ratio of machining rates is of

$$\rho = \frac{\text{rate with oil X}}{\text{rate with Mentor 28}},$$

then the values of rugosity as well as those of sparking gaps and influence limits are to be multiplied by $\sqrt[3]{\rho}$

3. Influence of the graphite grade.

The only differences encountered between different grades of graphite will be the amount of wear and the arc striking ability. The graphite used is Type Ellor 9 manufactured by Carbone Lorraine, it has the following characteristics:

density:	1.8 gr/cm^3
tensile strength:	700 kg/cm^2
resistivity:	1500 $\mu\Omega$ cm.

4. Steel used for the technological tests.

The steel used is Böhler type MST, treated to 65 RC. Herein under we supply data relating to similar steels:

Country	Standard	Name	C	Mn	Cr	Si	V	Mo
Germany	Böhler	MST	0,9	1,9	0,4		0,1	
France	AFNOR	90 M8	0,9	2,0		0,3		
USA	US-Norm	02	0,9	1,6	0,35	0,25	0,2	0,3
England	Atlas-Works	TMS	0,92	1,75		0,3		

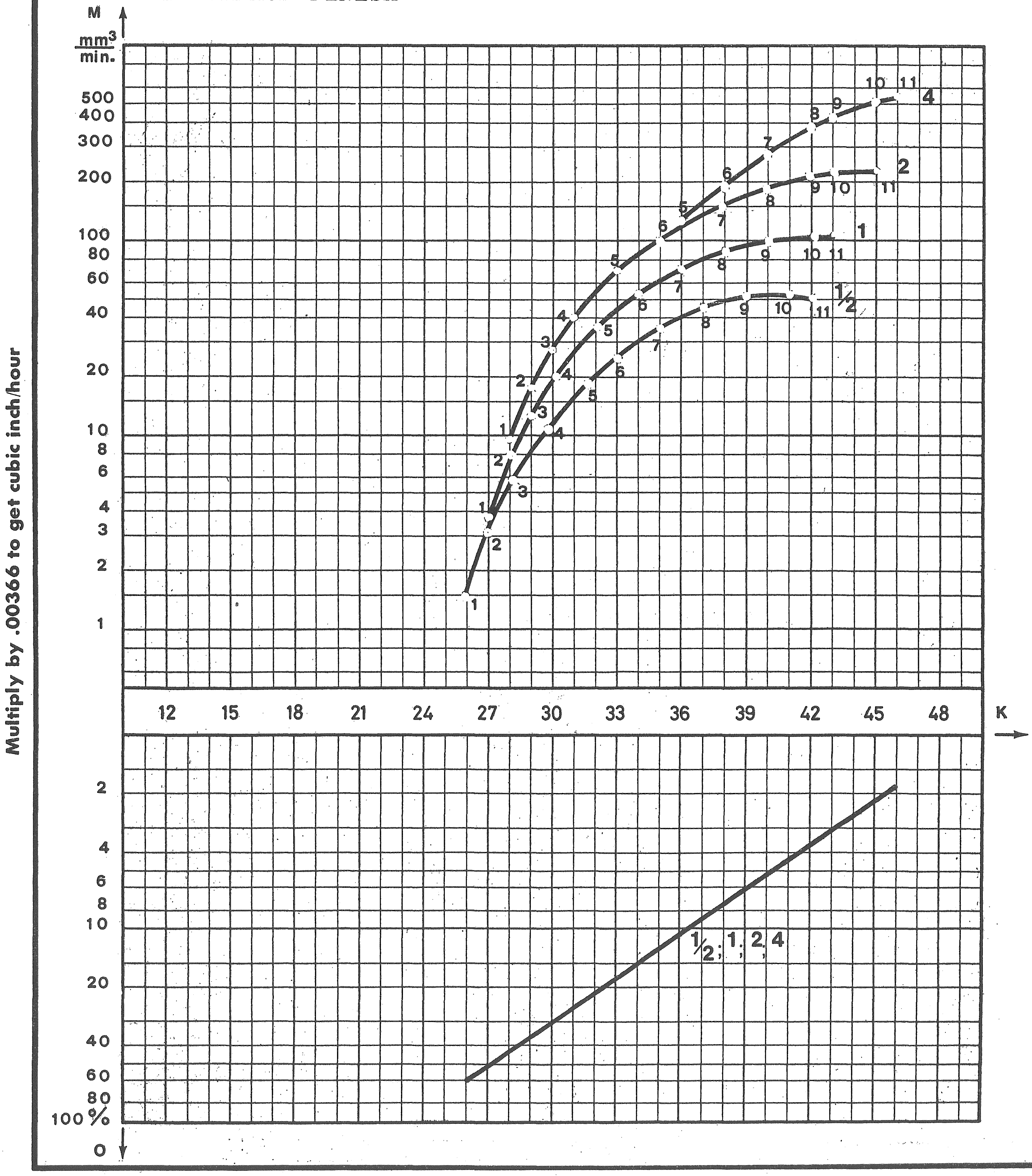
CHARMILLES
TECHNOLOGIE ISOPULSE

AKMO
Steel+
Steel

ELECTRODE : Steel
POLARITY ELECTRODE : positive
WORKPIECE : Steel

TEST CONDITIONS :
Tubular electrode : Ø = 40 x 18
Dielectric : Chevron EDM Fluid 71
Injection : 0 to 0,05 kg/cm2

METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



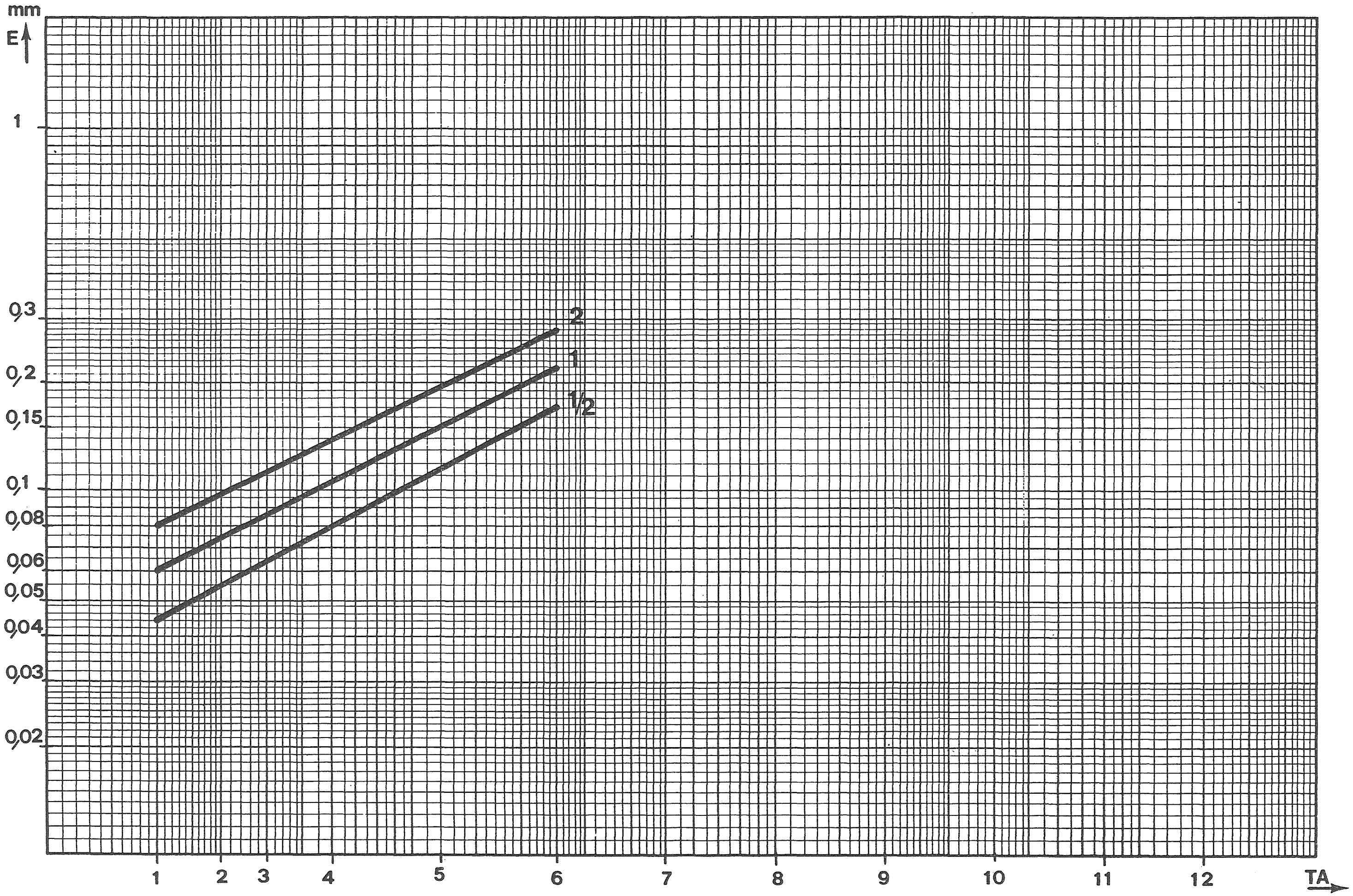
CHARMILLES - TECHNOLOGIE ISOPULSE

E

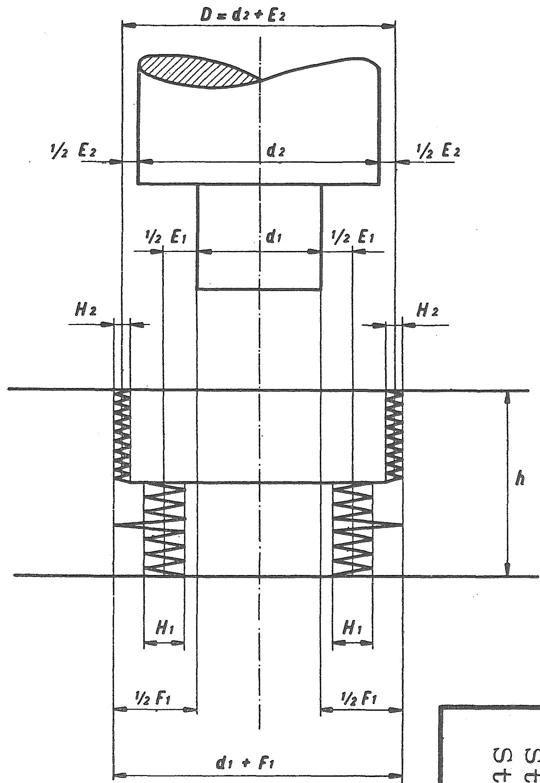
Steel +
Steel

ELECTRODE	: Steel		TEST CONDITIONS	: D = 25mm
POLARITY ELECTRODE	: positive		Dia. pre-hole	: Ø = 24,8 mm
WORKPIECE	: Steel		Dielectric	: Chevron EDM Fluid 71
SUCTION			Suction	: 0,2 to 0,4 kg/cm2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)



Multiply by 40 to get .001"



E
Steel +
Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

Steel +
Steel
1/2 ; 80 V

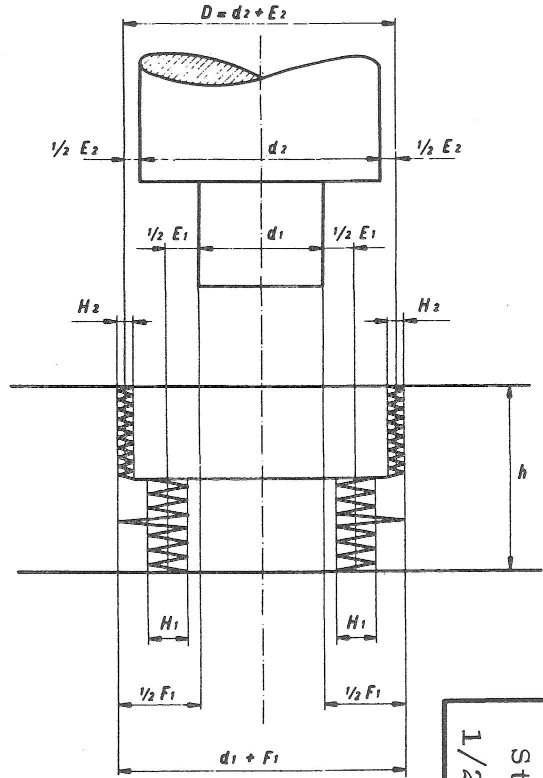
ELECTRODE : Steel
POLARITY ELECTRODE : positive
WORKPIECE : Steel
POWER : 1/2 ; 80 V

TEST CONDITIONS :

For A,B,C,E : D = 25 mm
pre-hole : Ø 24,8 mm
Dielectric : Chevron EDM 71
Suction : 0,2 to 0,4 kg/cm2

For A,B,M,O :
Tubular electrode : Ø 40 x 18
Dielectric : Chevron EDM 71
Injection : 0 to 0,05 kg/cm2

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
Position A	Pos. B mini	active electrode length mini (..Xh)	Suction mean diam. sparking gap (mm)				Surface finish		frontal CH		metal removal rate (mm3/min.)	relative volumetric electrode wear (%)	
1	5	0,5	0,044						26		1,5	60	
2	5	0,5	0,055						27		3,6	48	
3	5	0,5	0,065						28		6	40	
4	5	0,5	0,08						30		10	32	
5	5	0,5	0,11						32		16	24	
6	5	0,5	0,17						33		23	18	
7	5								35		35	13	
8	6								37		45	10	
9	8								39		50	6	
10	9								41		50	5	
11	9								42		50	4	
12	10												



Steel +
Steel
1/2 ; 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

Steel + Steel

1 ; 80 V

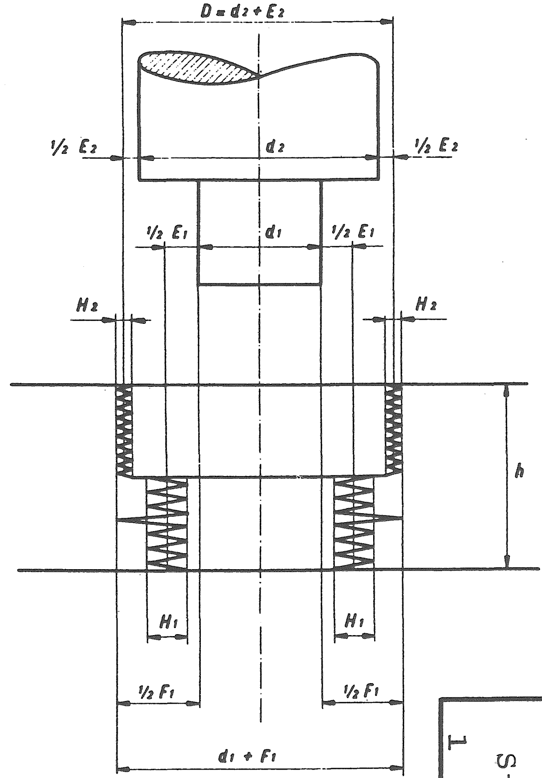
ELECTRODE : Steel
POLARITY ELECTRODE : positive
WORKPIECE : Steel
POWER

TEST CONDITIONS :

For A,B,C,E : D = 25 mm
pre-hole : ∅ 24,8 mm
Dielectric : Chevron EDM 71
Suction : 0,2 to 0,4 kg/cm2

For A,B,K,M,O :
Tubular electrode : ∅ 40 x 18
Dielectric : Chevron EDM 71
Injection : 0 to 0,05 kg/cm2XC

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
Position A	Pos. B mini	active electrode length mini (..Xh)	Suction: mean diam. sparking gap (mm)				Surface finish		frontal CH		metal removal rate (mm3/min.)	relative volumetric electrode wear (%)	
1	6	0,5	0,06						27		4	50	
2	6	0,5	0,075						28		8	42	
3	6	0,5	0,086						29		11	38	
4	6	0,5	0,11						30		20	28	
5	6	0,5	0,15						32		35	20	
6	6	0,5	0,22						34		52	13	
7	6								36		70	10	
8	7								38		88	8	
9	8								40		100	5	
10	9								42		105	4	
11	10								43		105	3	
12	11												



Steel + Steel

1 ; 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

Steel +
Steel
2 ; 80 V

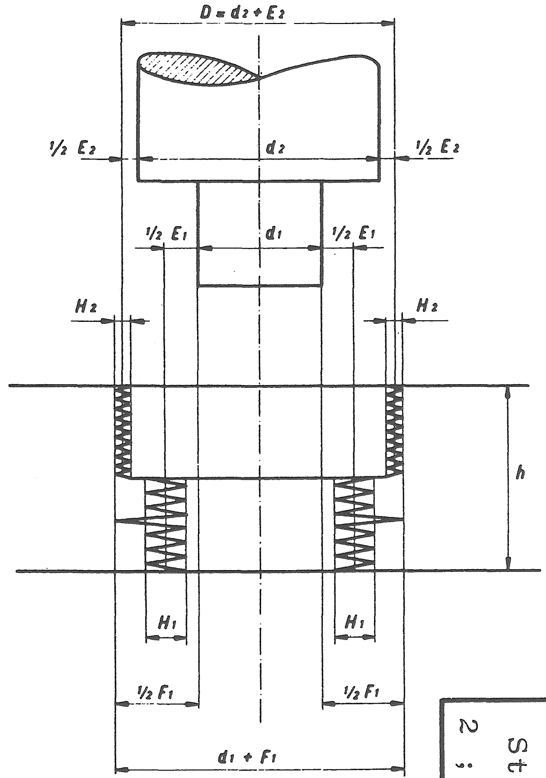
ELECTRODE : Steel
POLARITY ELECTRODE : positive
WORKPIECE : Steel
POWER : 2 ; 80 V

TEST CONDITIONS :

For A,B,C,E : D = 25 mm
pre-hole : Ø 24,8 mm
Dielectric : Chevron EDM 71
Suction : 0,2 to 0,4 kg/cm2

For A,B,K,M,O :
Tubular electrode : Ø 40 x 18
Dielectric : Chevron EDM 71
Injection : 0 to 0,05 kg/cm2

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			Suction				Surface finish						
Position A	Pos. B mini	active electrode length mini (..Xh)	mean diam. sparking gap (mm)						frontal CH		metal removal rate (mm3/min.)	relative volumetric electrode wear (%)	
1	6	0,5	0,08						28		9	40	
2	6	0,5	0,1						29		16	35	
3	6	0,5	0,11						30		23	30	
4	6	0,5	0,14						31		40	23	
5	6	0,5	0,2						33		70	17	
6	7	0,5	0,28						35		100	12	
7	7								38		135	8	
8	8								40		175	5	
9	8								42		200	4	
10	9								43		210	3	
11	10								45		220	2	
12	11												



Steel +
Steel
2 ; 80 V

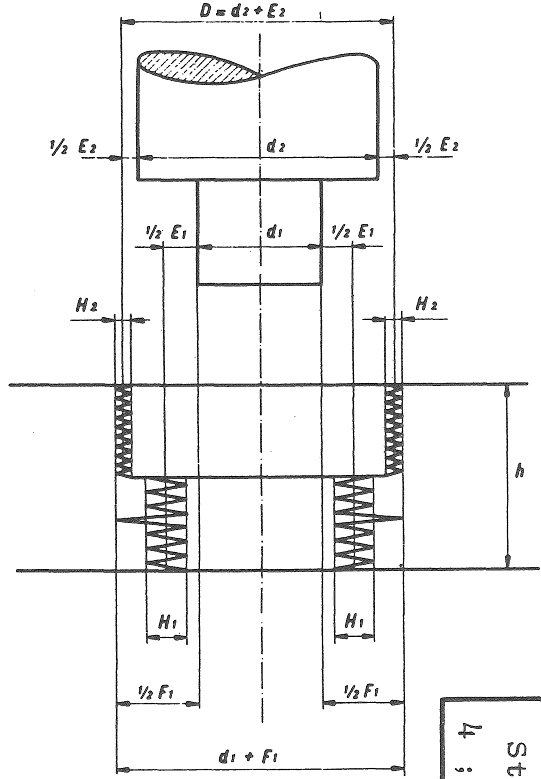
CHARMILLES - TECHNOLOGIE ISOPULSE

Steel +
Steel
4 ; 80 V

ELECTRODE : Steel
POLARITY ELECTRODE : positive
WORKPIECE : Steel
INJECTION

TEST CONDITIONS :
Tubular electrode : Ø 40 x 18
Dielectric : Chevron EDM 71
Injection : 0 to 0,05 kg/cm2

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
Position A	Pos. B mini	active electrode length mini (..Xh)	Suction: mean diam. sparking gap (mm)	Suction			surface finish		surface finish: frontal CH		metal removal rate (mm3/min.)	relative volumetric electrode wear (%)	
1													
2													
3													
4													
5	6								36		120	10	
6	7								38		195	8	
7	7								40		290	6	
8	8								42		380	4	
9	8								43		460	3	
10	9								45		500	2	
11	10								46		510	2	
12													

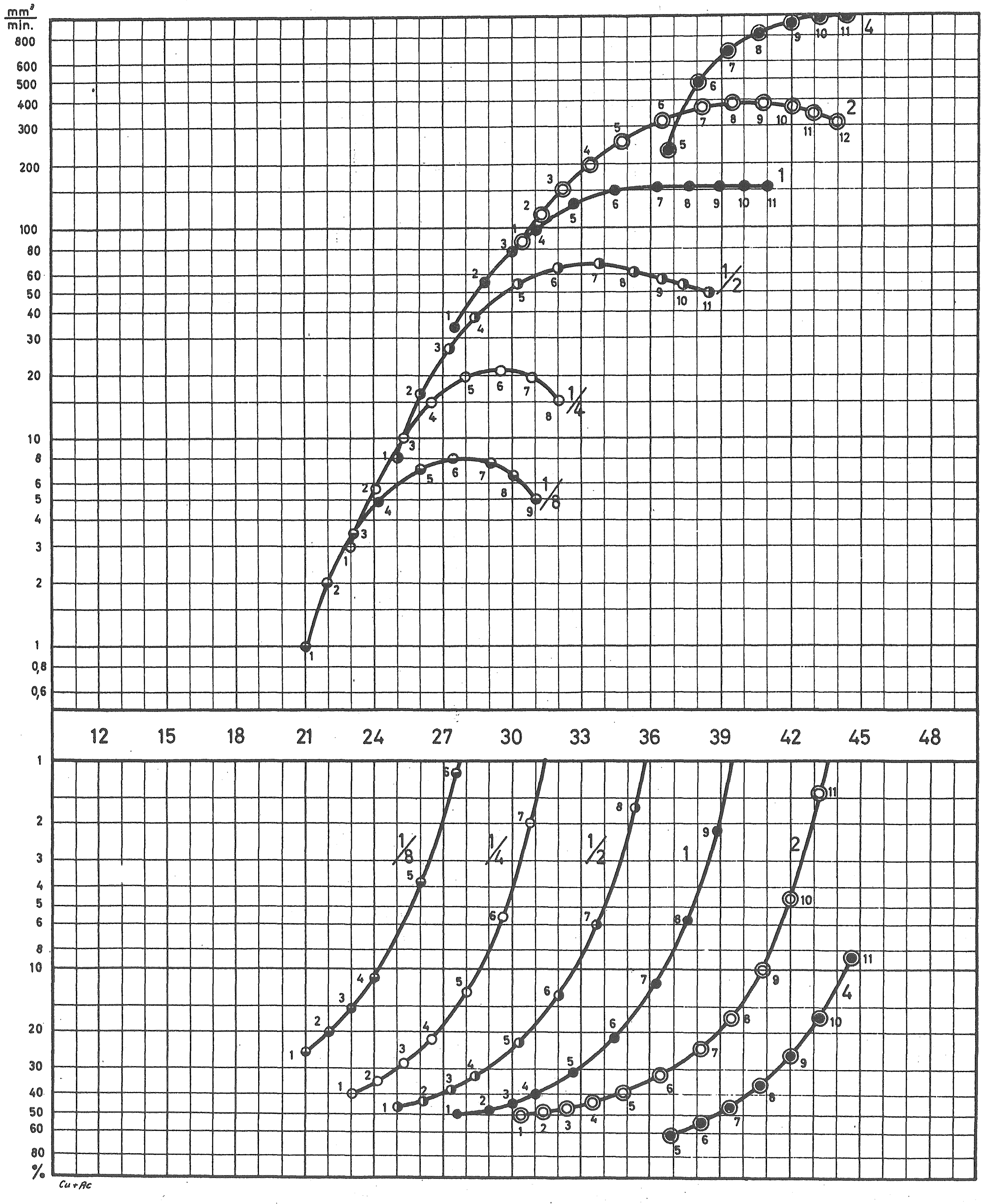


Steel +
Steel
4 ; 80 V

CHARMILLES
TECHNOLOGIE ISOPULSE

AGMO
Copper+
Steel

ELECTRODE: Electrolytic copper
POLARITY ELECTRODE: Positive
WORKPIECE: Steel MST 65 RC
TEST CONDITIONS: D = 20 mm, Diameter pre-hole:15 mm
Dielectric: Mentor 28 (Esso - Standard)
Injection or suction: 100 gr/cm^2
METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



Multiply by .00366 to get cubic inch/hour

CHARMILLES - TECHNOLOGIE ISOPULSE

E
Copper +
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

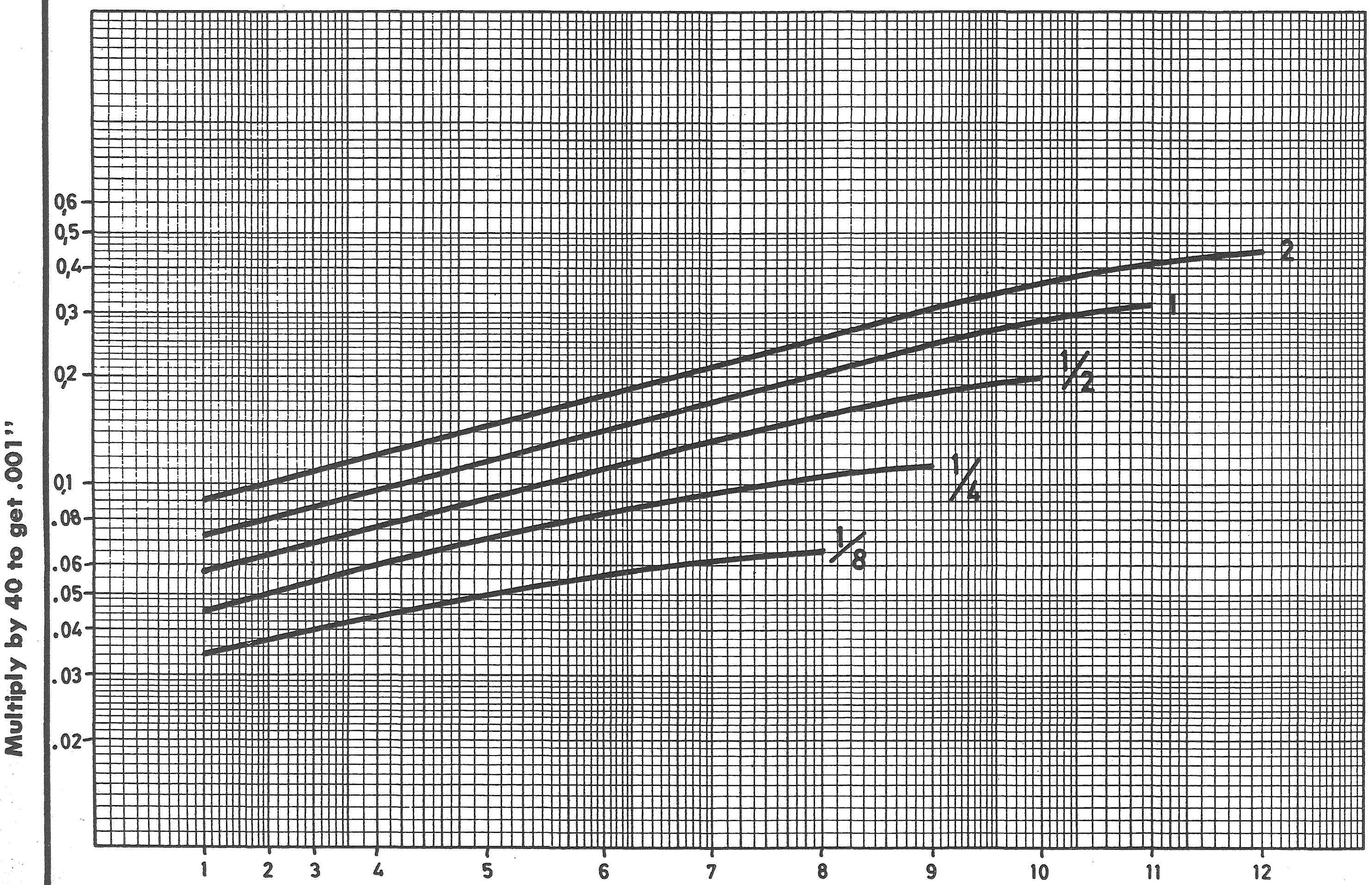
SUCTION

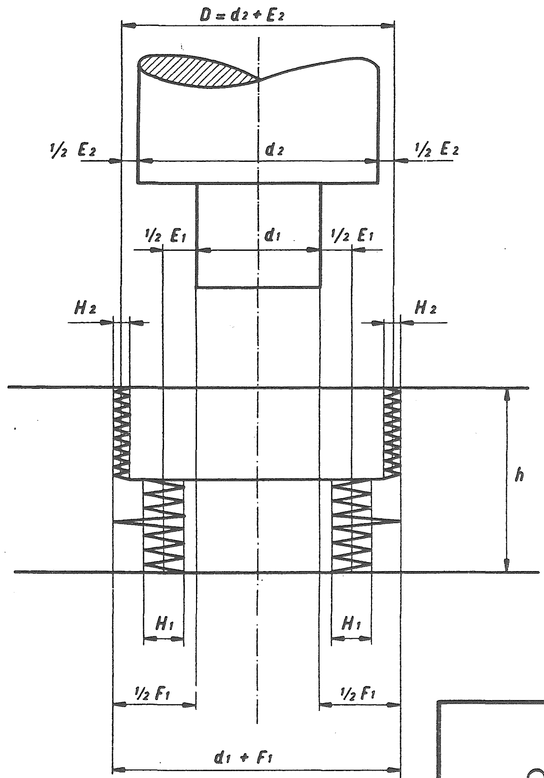
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Suction: 100 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E
Copper +
Steel

E Cu+Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

E'
Copper +
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

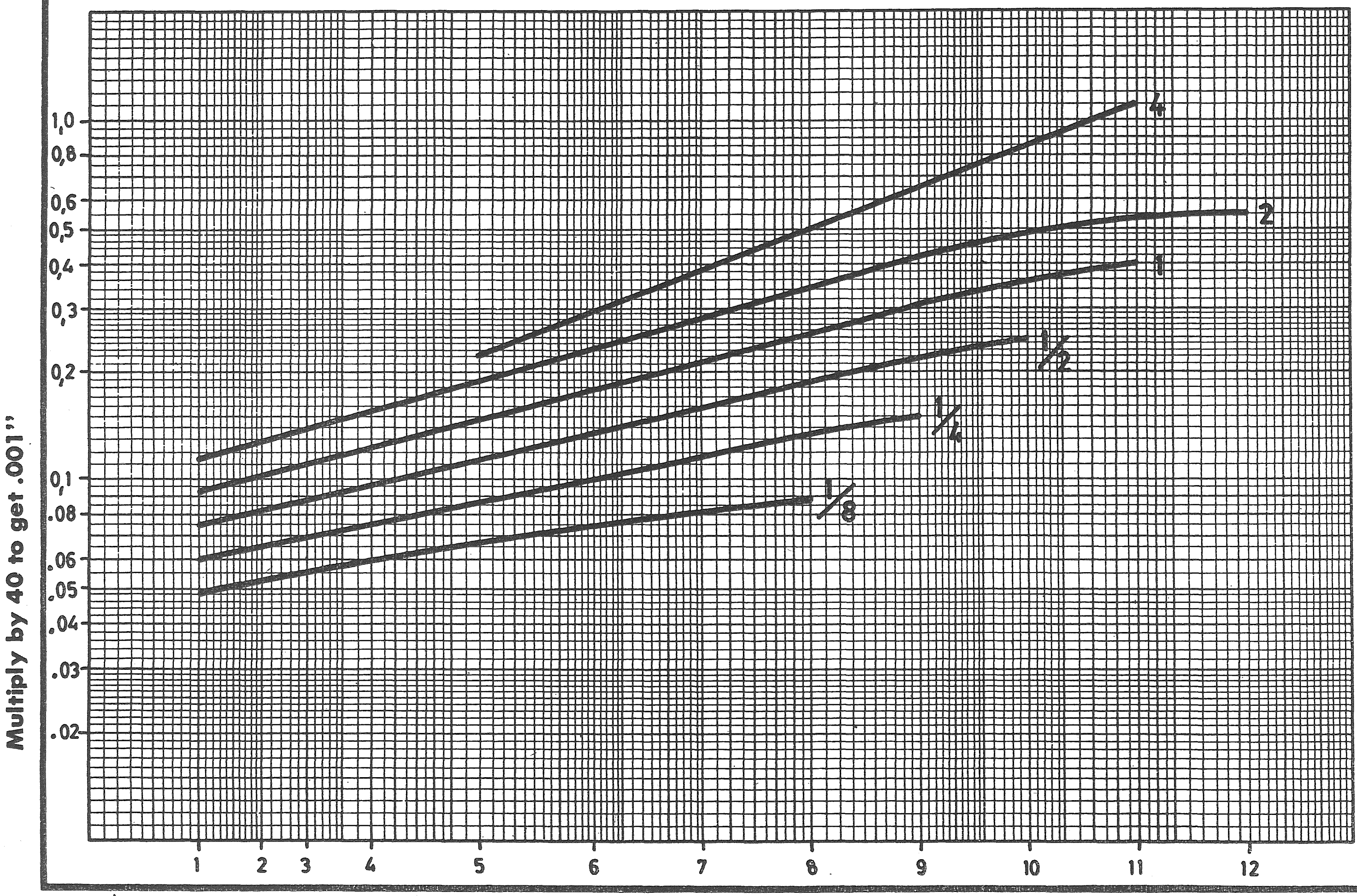
INJECTION

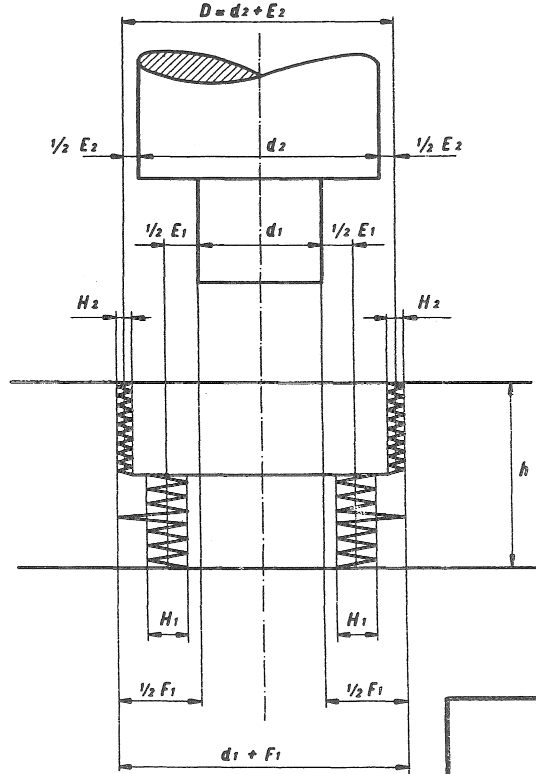
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Injection: 200 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E'
Copper +
Steel

E'Cu + Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

F
Copper +
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

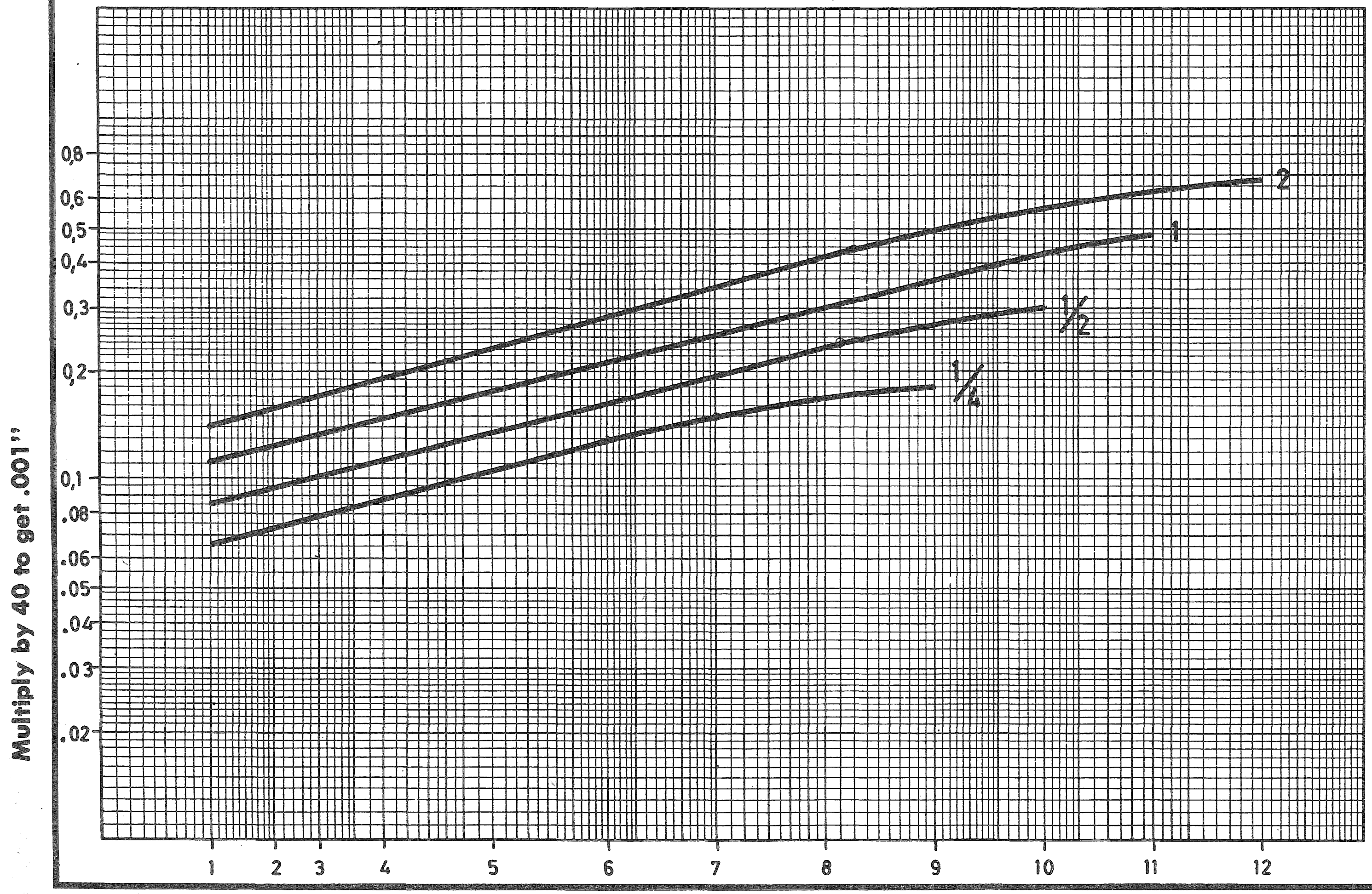
SUCTION

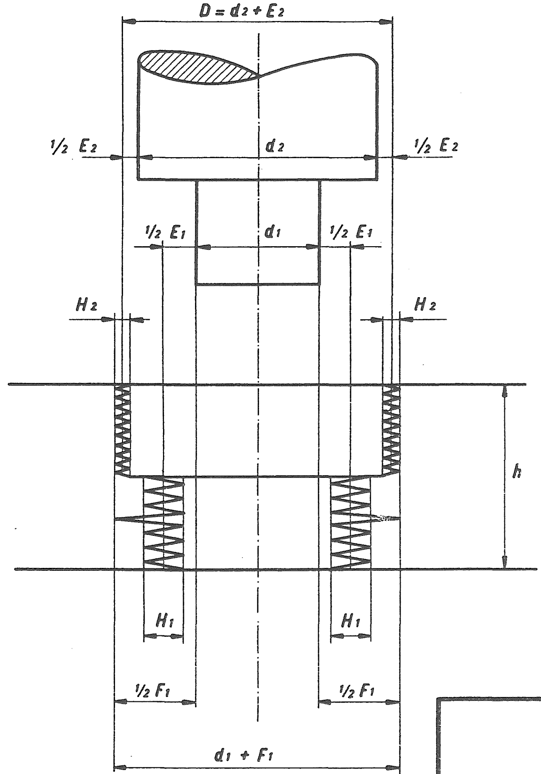
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Suction: 100 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





F
Copper +
Steel

F Cu + Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

F'
Copper +
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

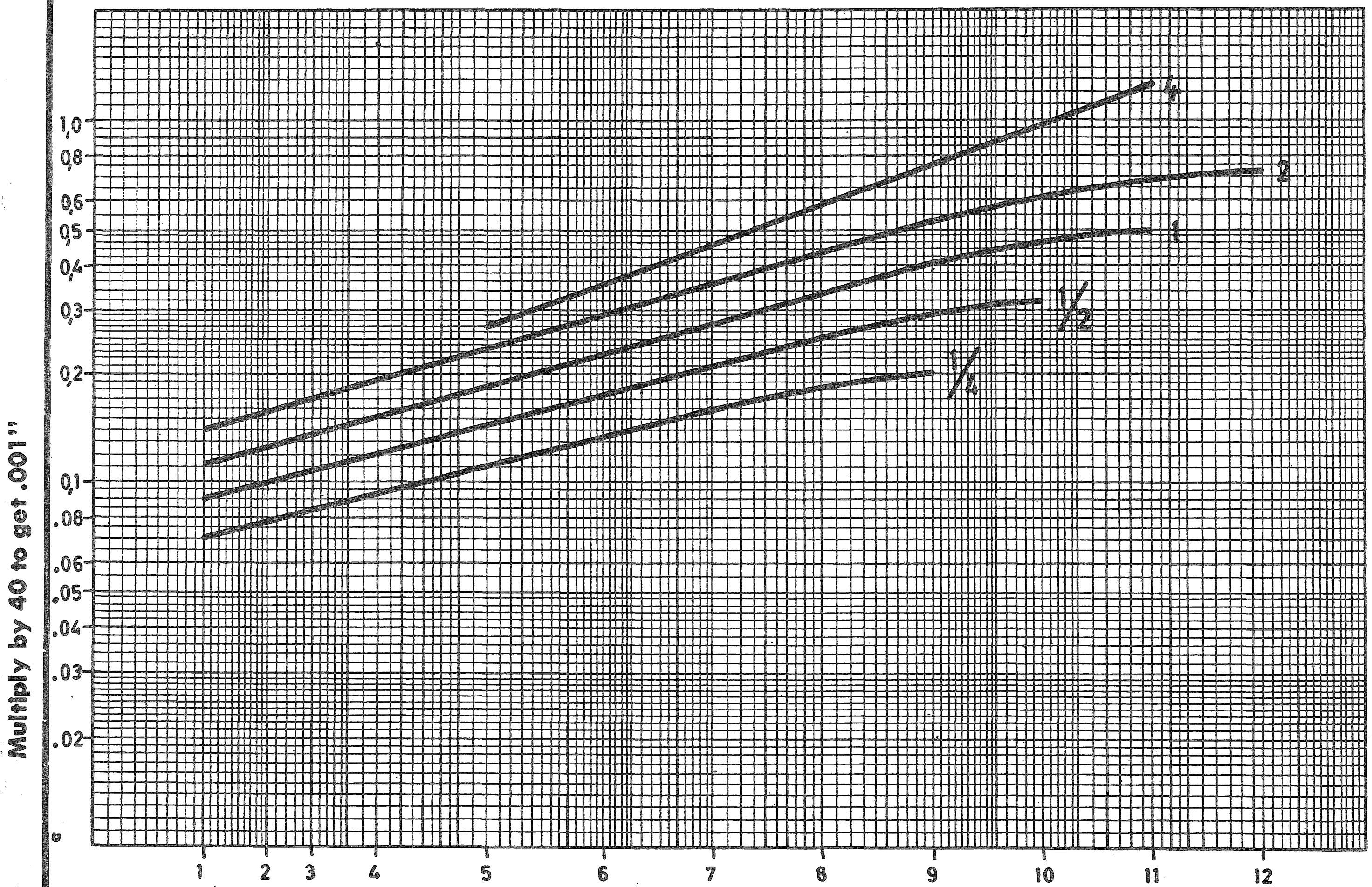
INJECTION

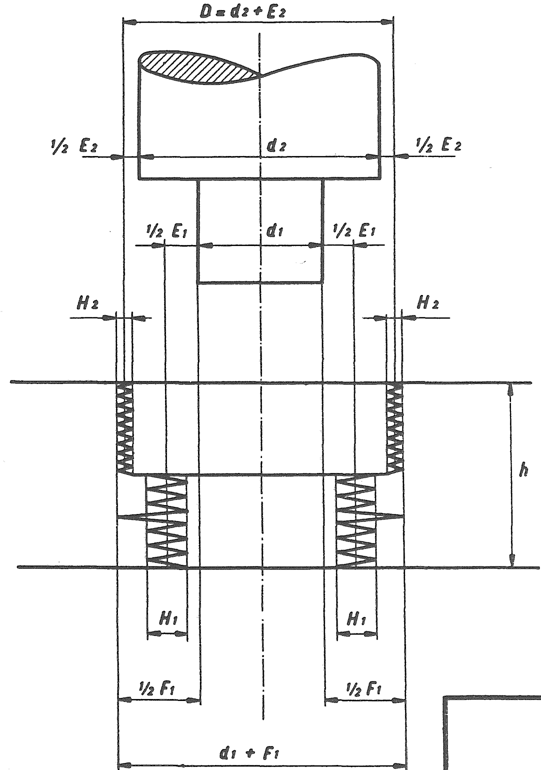
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Injection: 200 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





F'
Copper +
Steel

F' Cu + Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

R
Copper +
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: +

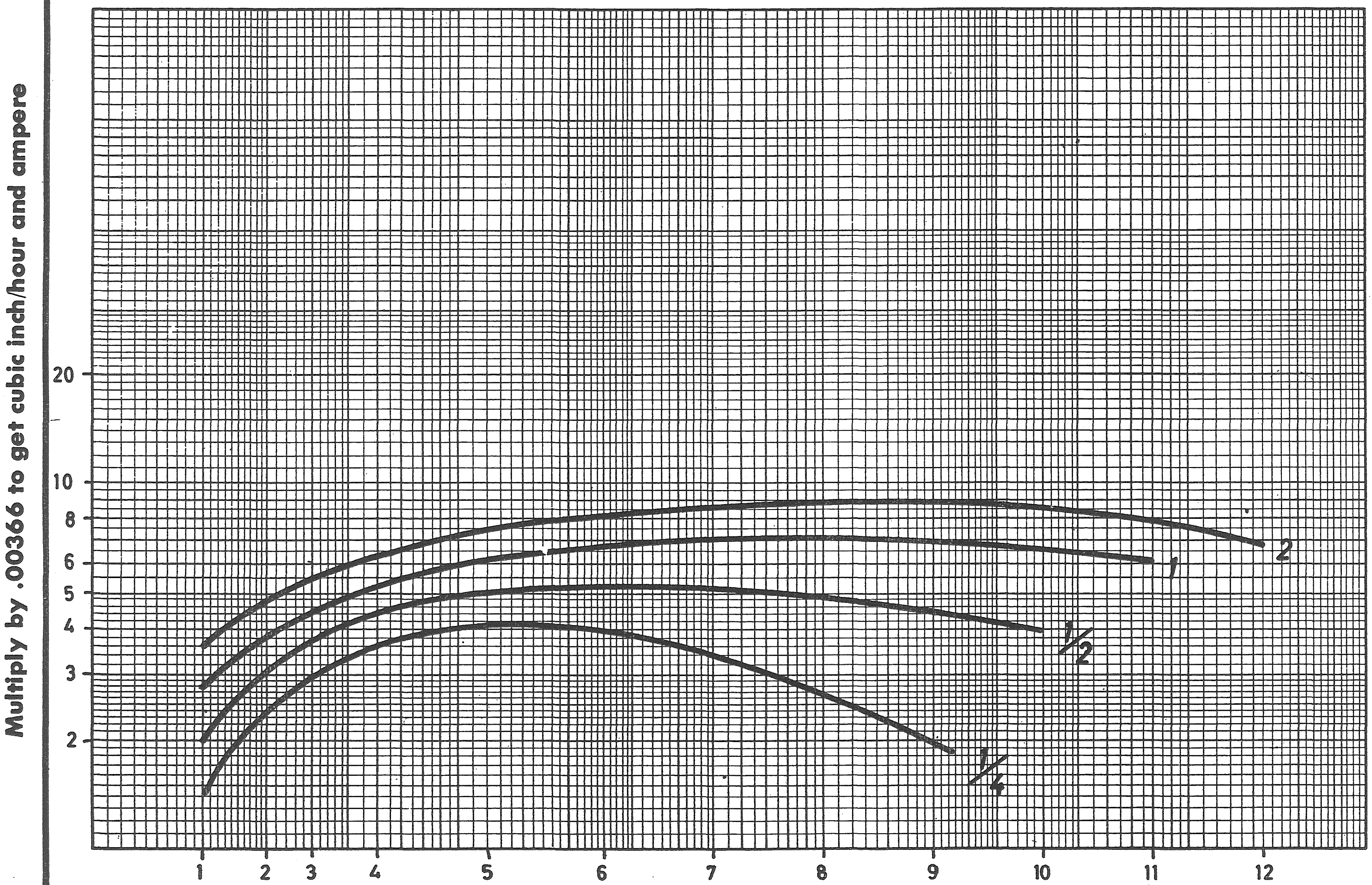
WORKPIECE: Steel MST 65 RC

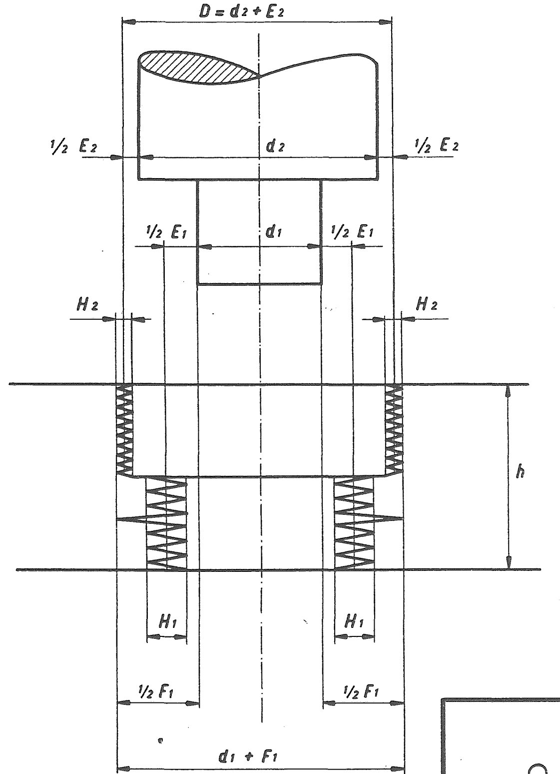
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 15 mm

Dielectric: Mentor 28 (Esso - Standard)

Injection or suction: 100 gr/cm^2

SPECIFIC METAL REMOVAL RATE IN MM^3 PER MINUTE AND PER AMPERE - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





R
Copper +
Steel

R Cu+ Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER +
STEEL
1/8 - 80V

ELECTRODE : Copper

POLARITY ELECTRODE : +

WORKPIECE : Steel MST 65 RC

POWER : 1/8 - 80V

TEST CONDITIONS : D = 20 mm h = 12 mm

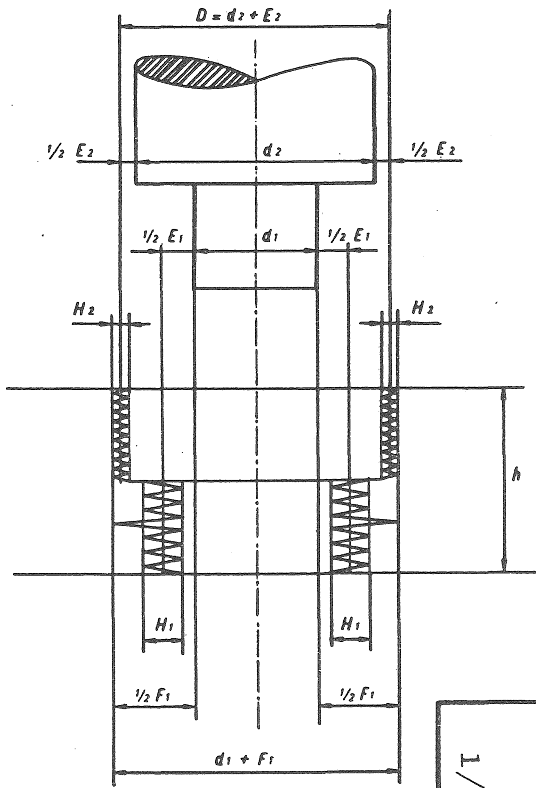
DIELECTRIC : Mentor 28 (Esso-Standard)

ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			Suction		Injection		Surface finish						
							Lateral		Frontal				
POS. A	POS. B mini	Active electrode length (...Xh)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No	Rt (/um)	CH No	Rt (/um)	metal removal rate (mm3/min.)	Relative volumetric electrode wear (%)	specific metal removal rate (mm3/min./A)
1	2	1,3	0,034		0,05		21		21		1	25	0,77
2	2	1,0	0,037		0,052		22		22		2	20	1,45
3	2	0,9	0,04		0,055		23		23		3,4	15	1,88
4	2	0,7	0,044		0,058		24		24		5	12	2,3
5	3	0,5	0,05		0,066		26		26		7	4	2,8
6	4	0,35	0,056		0,075		27		27		8	1,3	2,8
7	4	0,25	0,061		0,082		29		29		7,7	-	2,3
8	4	0,2	0,065		0,087		30		30		6,5	-	1,8
9													
10													
11													
12													



COPPER +
STEEL
1/8 - 80V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER + STEEL 1/4 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1/4 - 80 V

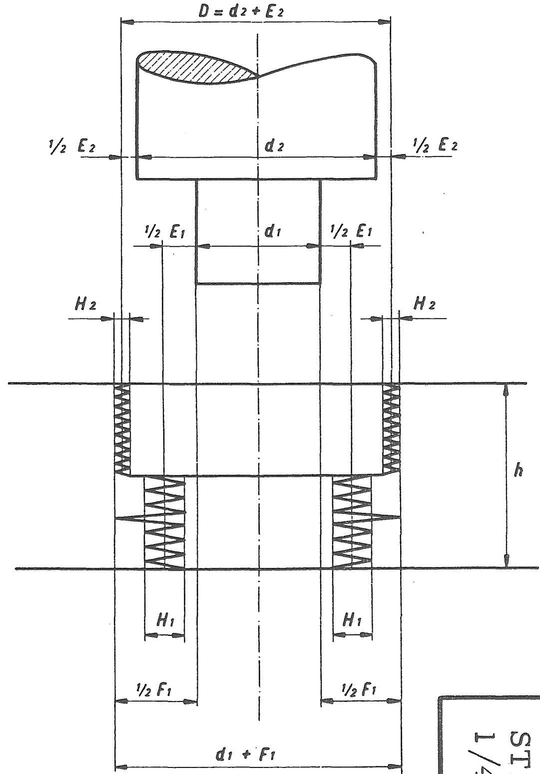
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No	R_t (µm)	CH No	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	1,8	0,045	0,065	0,06	0,07	22		23		4	45	1,4
2	1	1,3	0,05	0,073	0,065	0,078	23		24		7	40	2,4
3	1	1,0	0,055	0,08	0,07	0,085	24		25		10	35	3,0
4	2	0,8	0,06	0,088	0,075	0,093	26		26		14	28	3,6
5	2	0,5	0,07	0,105	0,085	0,11	28		28		20	15	4,1
6	3	0,4	0,085	0,13	0,10	0,13	29		29		22	6	4,0
7	3	0,3	0,095	0,15	0,115	0,16	31		31		19	2	3,4
8	4	0,2	0,105	0,17	0,135	0,18	32		32		12	0,8	2,7
9	5	0,2	0,11	0,18	0,15	0,20	33		33		7	-	1,9
10													
11													
12													



COPPER + STEEL 1/4 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER +
STEEL
1/2 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1/2 - 80 V

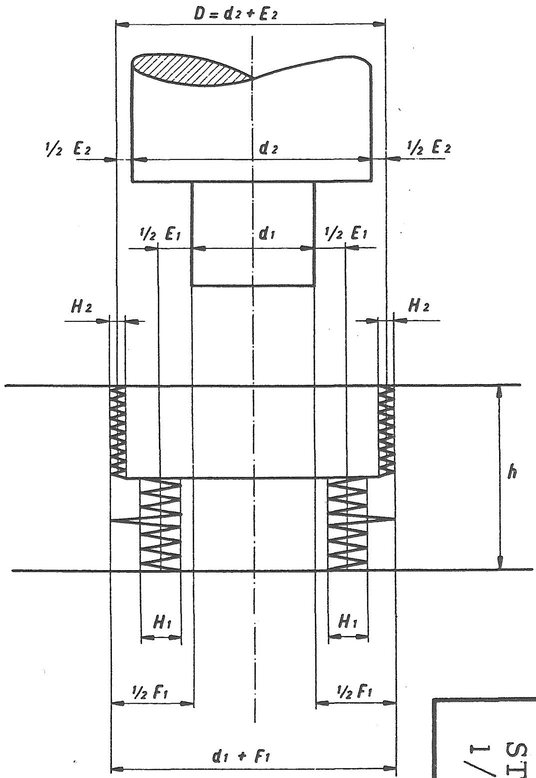
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific removal rate (mm^3/min./A)
1	1	2,5	0,058	0,085	0,075	0,090	25		28		8	45	2,0
2	1	1,8	0,064	0,094	0,082	0,10	26		29		17	42	3,1
3	1	1,3	0,070	0,10	0,088	0,11	27		29		26	38	3,7
4	2	1,0	0,076	0,112	0,095	0,12	28		30		36	33	4,4
5	2	0,7	0,091	0,135	0,112	0,145	30		32		53	24	5,0
6	3	0,5	0,11	0,160	0,135	0,172	32		34		67	13	5,2
7	3	0,4	0,13	0,19	0,16	0,21	34		35		70	4,8	5,1
8	4	0,4	0,155	0,23	0,19	0,25	35		37		62	1,7	4,9
9	5	0,3	0,18	0,27	0,22	0,29	36		38		55	-	4,4
10	6	0,3	0,20	0,30	0,25	0,32	37		39		52	-	4,0
11													
12													



COPPER +
STEEL
1/2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER +
STEEL
1 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1 - 80 V

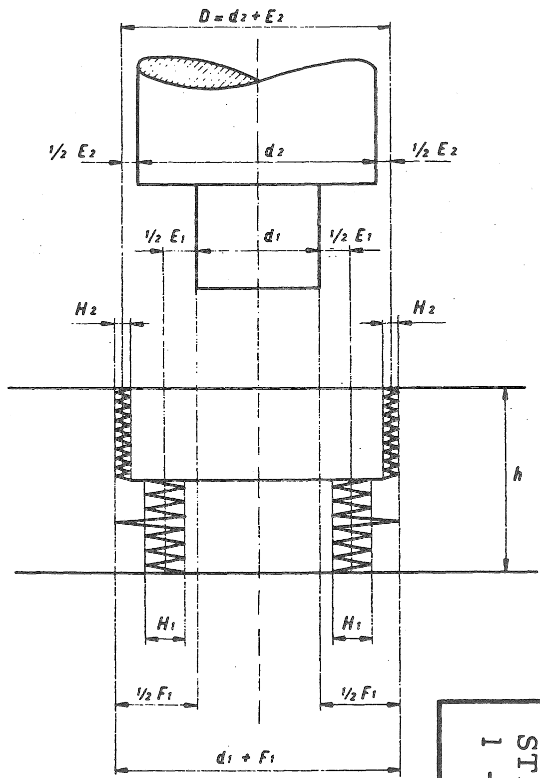
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (... X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	2,0	0,072	0,11	0,092	0,112	28		30		30	45	2,8
2	1	1,7	0,080	0,123	0,102	0,127	29		31		48	43	3,8
3	2	1,5	0,086	0,132	0,110	0,137	30		31		70	40	4,5
4	2	1,3	0,095	0,148	0,123	0,15	31		32		90	38	5,2
5	2	1,0	0,118	0,175	0,148	0,18	33		34		130	31	6,1
6	3	0,8	0,14	0,21	0,178	0,23	35		35		150	24	6,7
7	3	0,7	0,17	0,25	0,21	0,27	36		37		150	14	7,0
8	4	0,6	0,20	0,30	0,255	0,33	38		38		150	6	7,0
9	5	0,5	0,25	0,36	0,31	0,40	39		40		155	2,2	7,0
10	6	0,4	0,28	0,42	0,36	0,46	40		41		155	0,4	6,5
11	7	0,3	0,32	0,48	0,40	0,50	41		42		155	-	6,1
12													



COPPER +
STEEL
1 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER +
STEEL
2 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 2 - 80 V

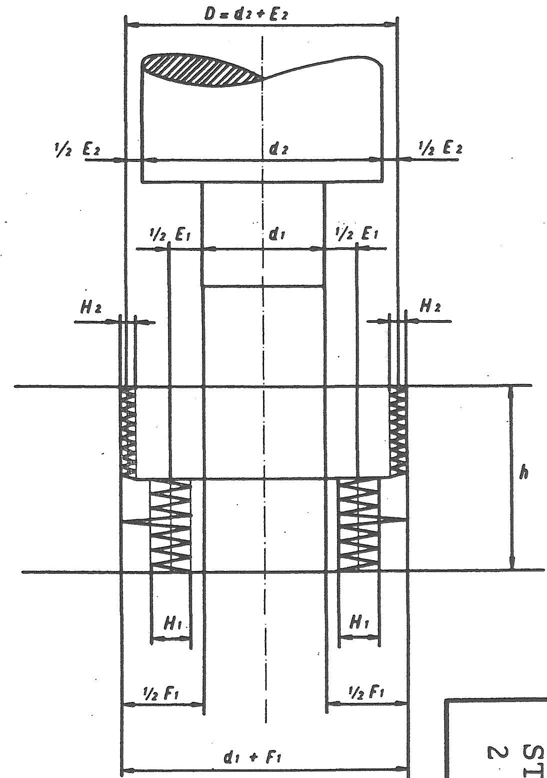
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	2	1,5	0,09	0,14	0,115	0,14	30		31		82	50	3,6
2	2	1,4	0,10	0,16	0,13	0,16	31		32		117	47	4,8
3	2	1,3	0,11	0,17	0,14	0,17	32		33		150	45	5,5
4	2	1,3	0,12	0,19	0,155	0,19	33		34		195	42	6,3
5	2	1,2	0,145	0,23	0,19	0,235	35		36		255	38	7,4
6	3	1,0	0,175	0,28	0,23	0,29	37		37		310	32	8,1
7	4	0,9	0,210	0,34	0,28	0,35	38		39		350	25	8,5
8	4	0,8	0,26	0,42	0,34	0,43	39		40		370	20	8,9
9	5	0,7	0,31	0,50	0,42	0,52	41		42		390	10	8,9
10	6	0,6	0,36	0,56	0,48	0,61	42		43		380	4,5	8,5
11	7	0,5	0,41	0,62	0,54	0,69	43		44		370	1,4	7,9
12	8	0,4	0,44	0,67	0,55	0,72	44		45		330	-	6,8



COPPER +
STEEL
2 - 80 V

CHARMILLES

TECHNOLOGIE ISOPULSE

AGMO
Copper -
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: Negative

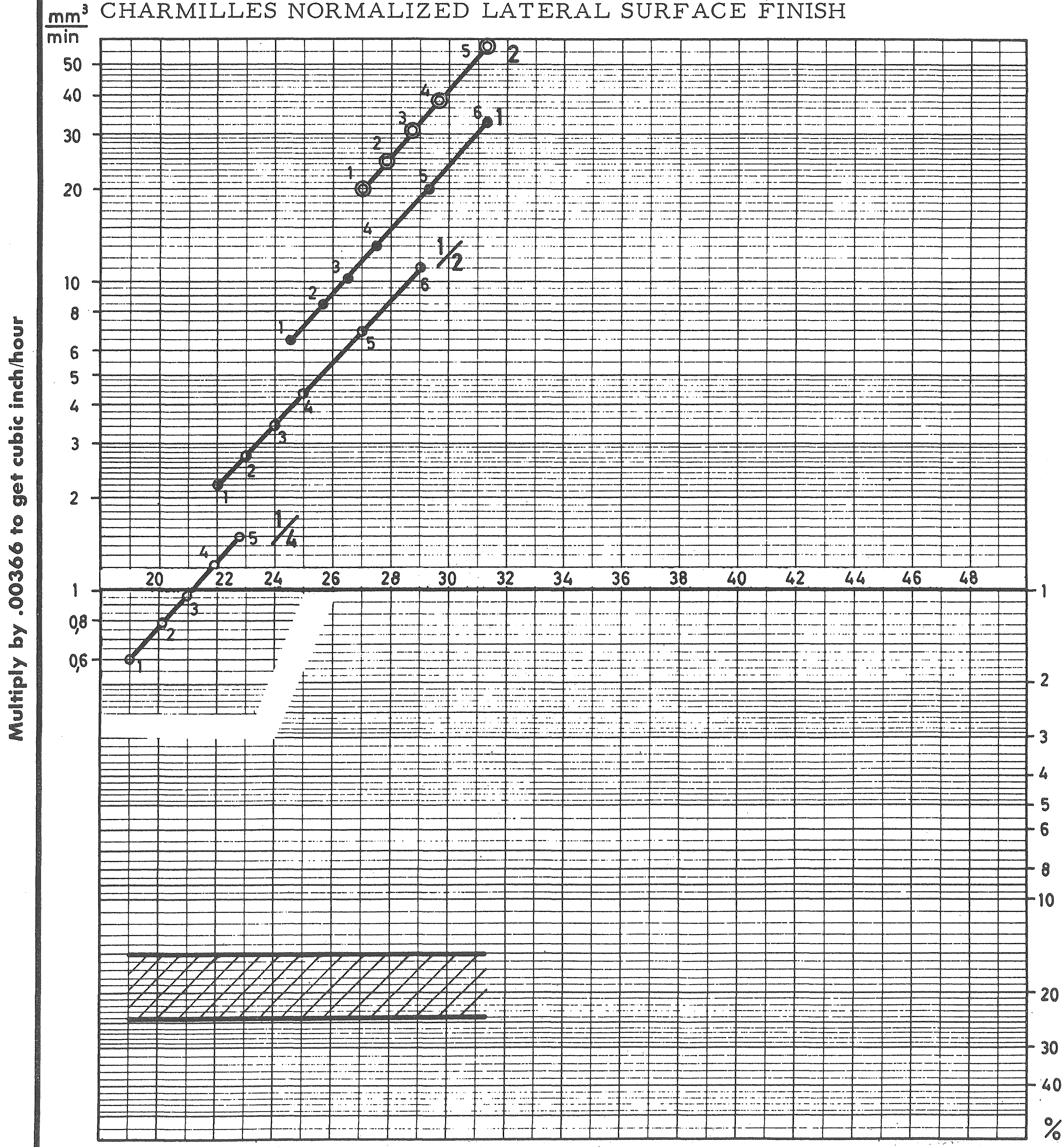
WORKPIECE: Steel MST 65 RC

TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Injection or suction: 100 gr/cm^2

METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



Cu - Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

E
E Copper - Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

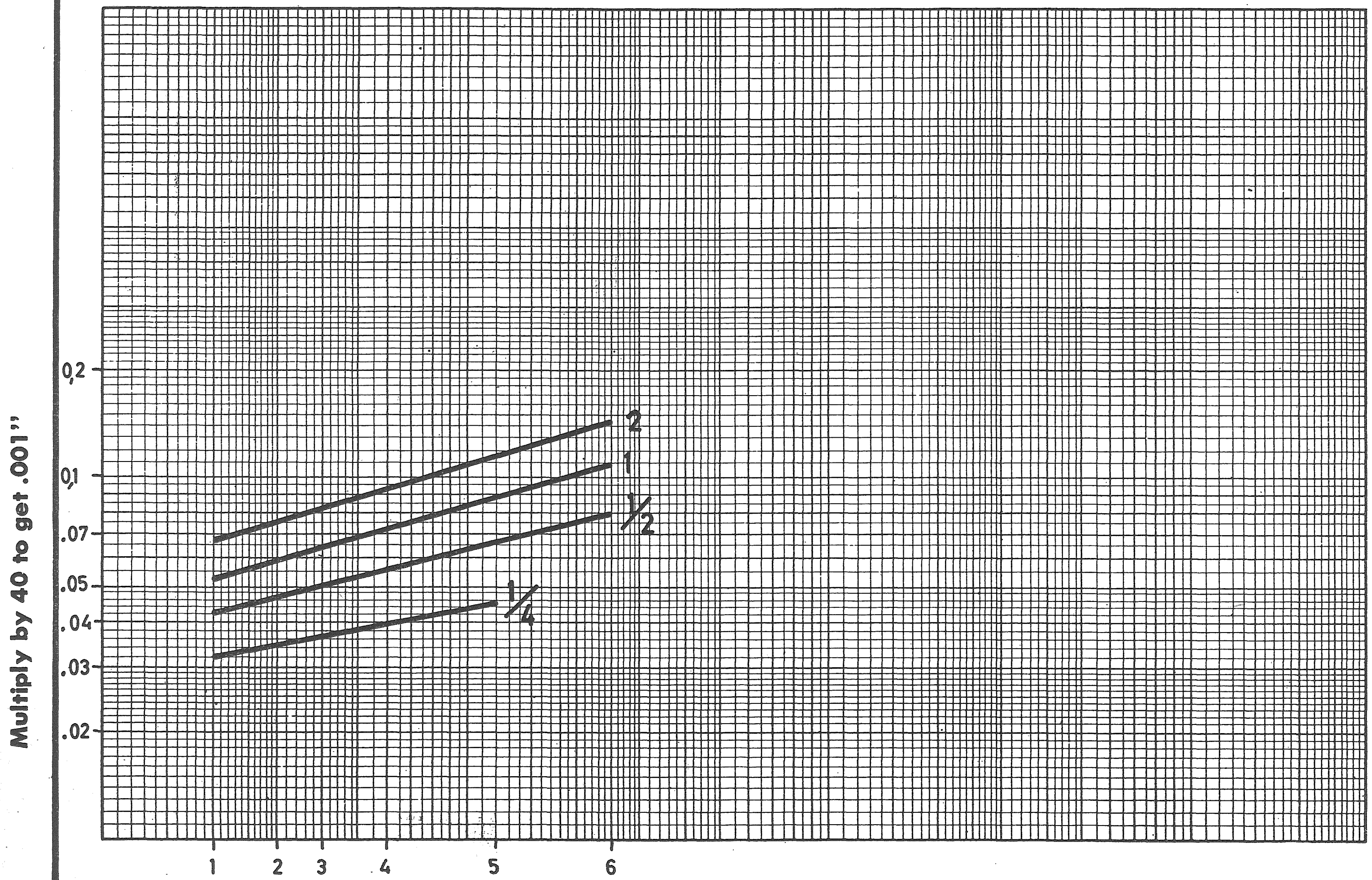
SUCTION

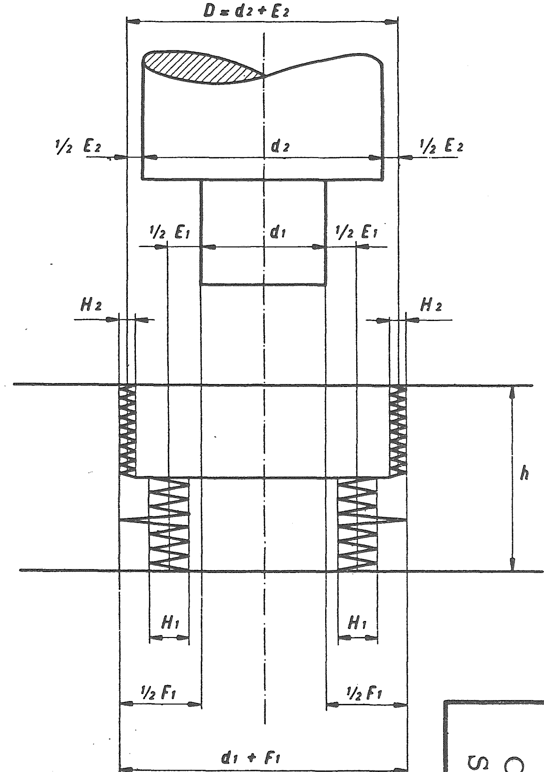
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Suction: 100 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E
Copper -
Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

F
Copper -
Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

SUCTION

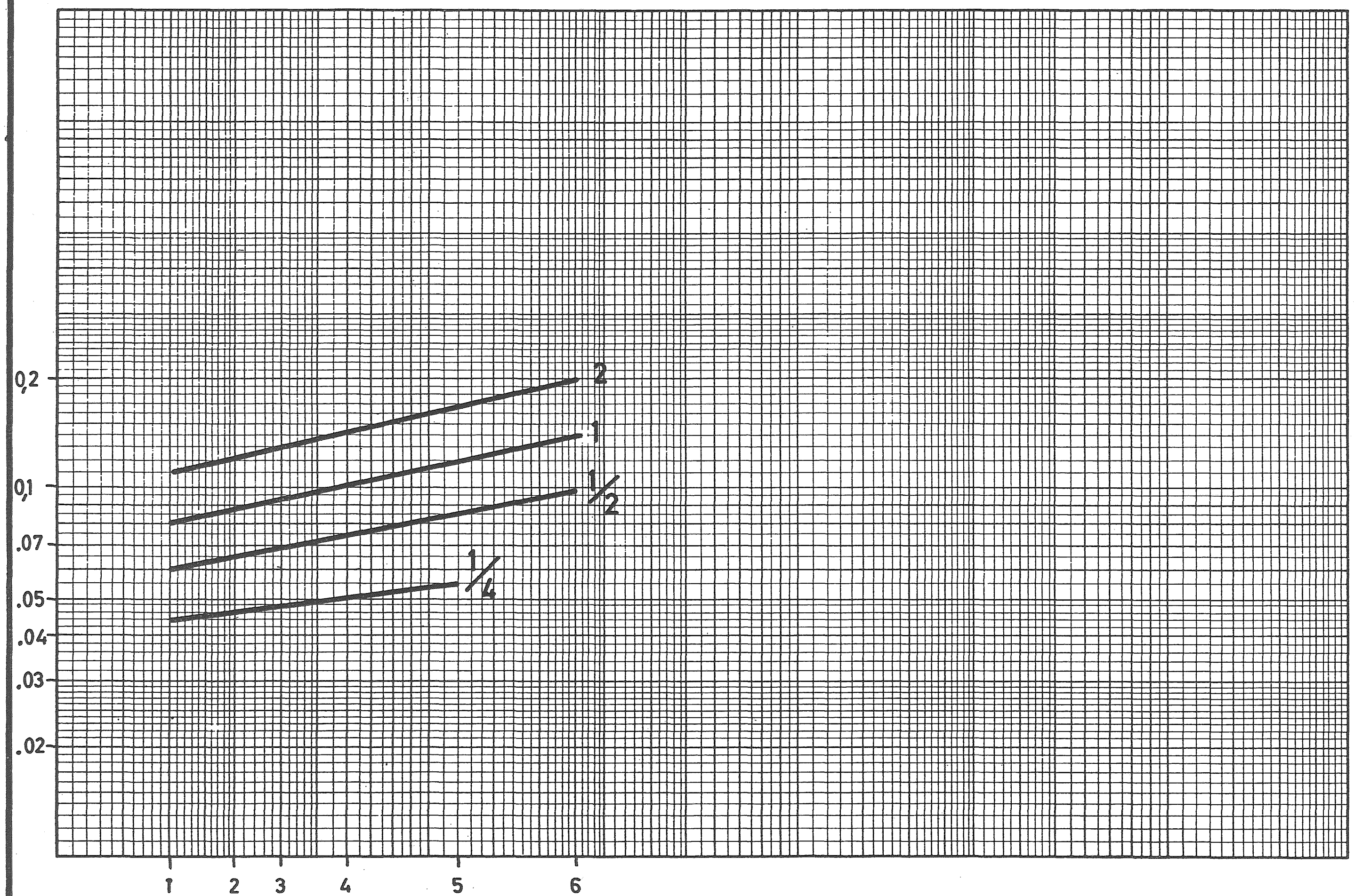
TEST CONDITIONS: D = 20 mm   Diameter pre-hole: 18 mm

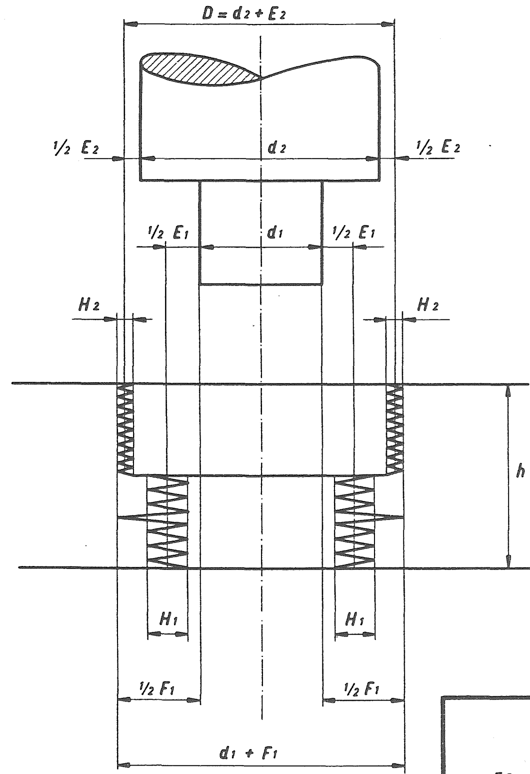
Dielectric: Mentor 28 (Esso - Standard)

Suction: 100 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)

Multiply by 40 to get .001"





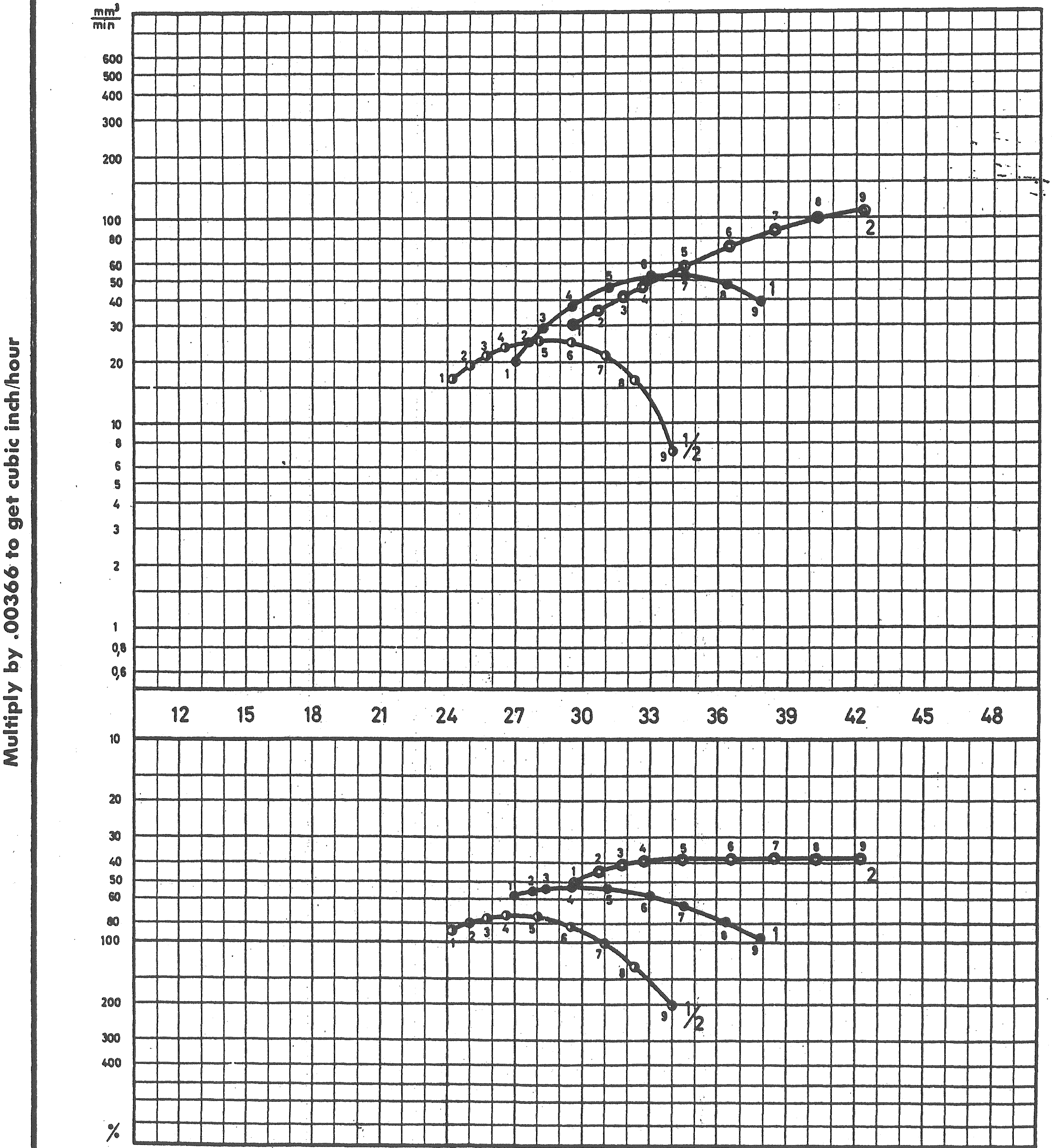
F
Copper -
Steel

F Cu - Ac

AGMO
Graphite -
Copper

CHARMILLES
TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite
POLARITY ELECTRODE: Negative
WORKPIECE: Copper
TEST CONDITIONS: D = 20mm, Diameter pre-hole: 15 mm
Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9
Injection:1 kg/cm2
METAL REMOVAL RATE IN MM3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



CHARMILLES - TECHNOLOGIE ISOPULSE

R
Copper - Steel

ELECTRODE: Electrolytic copper

POLARITY ELECTRODE: -

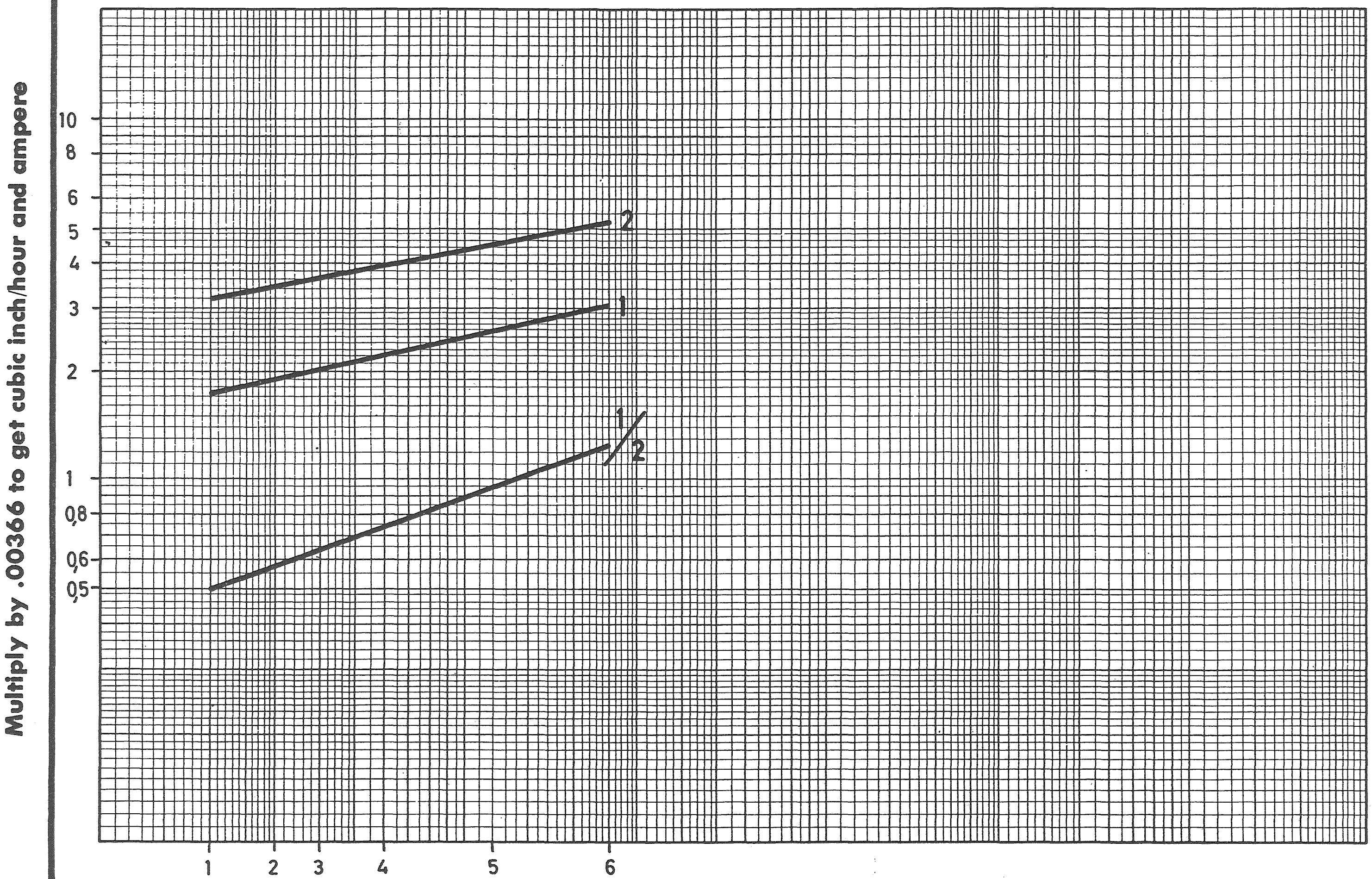
WORKPIECE: Steel MST 65 RC

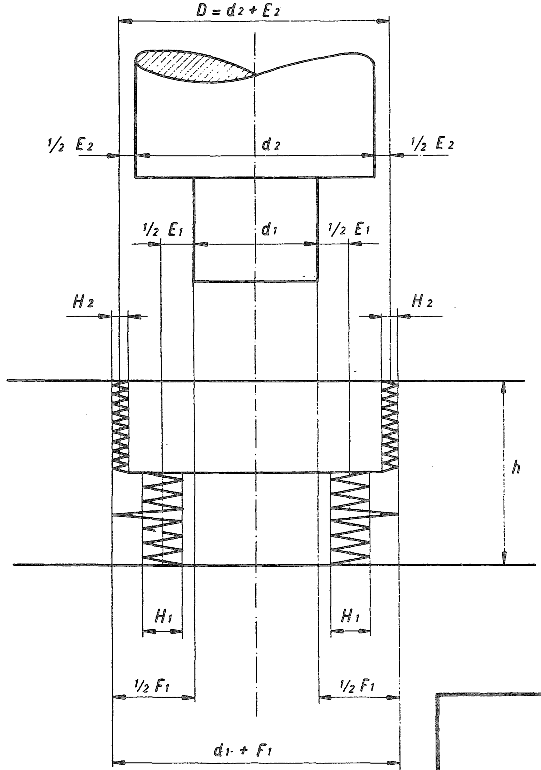
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard)

Injection or suction: 100 gr/cm^2

SPECIFIC METAL REMOVAL RATE IN MM^3 PER MINUTE AND PER AMPERE - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





R
Copper - Steel

R Cu - Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER - STEEL 1/4 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1/4 - 80 V

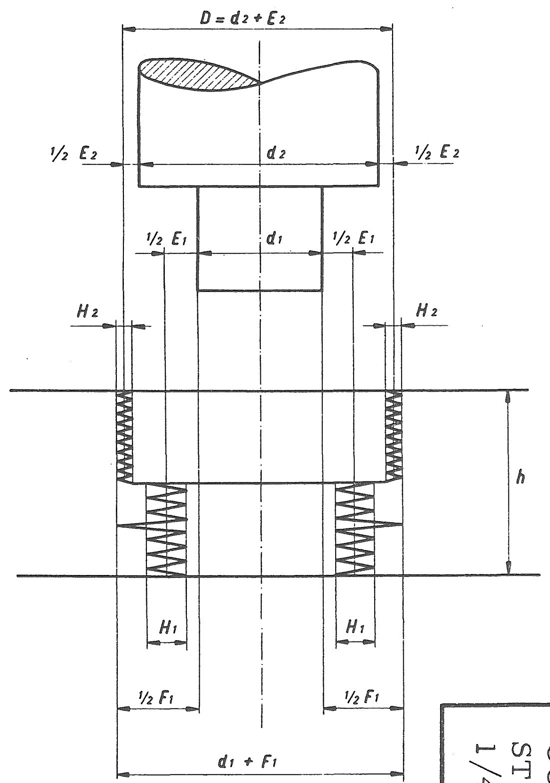
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (. . . X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (μm)	CH No.	R_t (μm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	3	1,0	0,032	0,044			19		20		0,6	20	
2	4	1,0	0,035	0,046			20		21		0,75	20	
3	4	1,0	0,037	0,048			21		22		0,9	20	
4	4	1,1	0,040	0,051			22		23		1,2	20	
5	5	1,1	0,046	0,056			23		24		1,5	20	
6													
7													
8													
9													
10													
11													
12													



COPPER - STEEL 1/4 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER - STEEL 1/2 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1/2 - 80 V

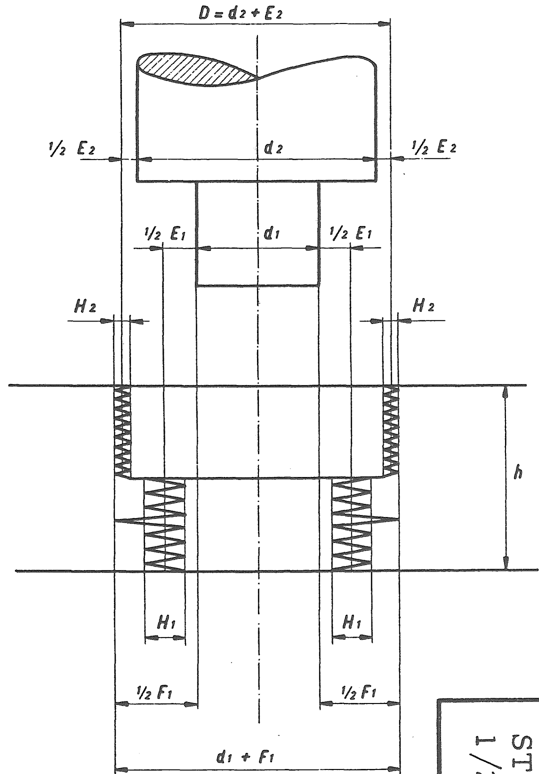
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish lateral		surface finish frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	3	1,4	0,042	0,060			22		23		2,2	20	0,5
2	4	1,5	0,046	0,066			23		24		2,8	20	0,55
3	4	1,5	0,050	0,070			24		25		3,4	20	0,63
4	4	1,5	0,055	0,076			25		26		4,5	20	0,73
5	5	1,6	0,065	0,088			27		27		7	20	0,95
6	6	1,7	0,080	0,104			29		29		11	20	1,3
7													
8													
9													
10													
11													
12													



COPPER - STEEL 1/2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

COPPER - STEEL
1 - 80 V

ELECTRODE: Copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1 - 80 V

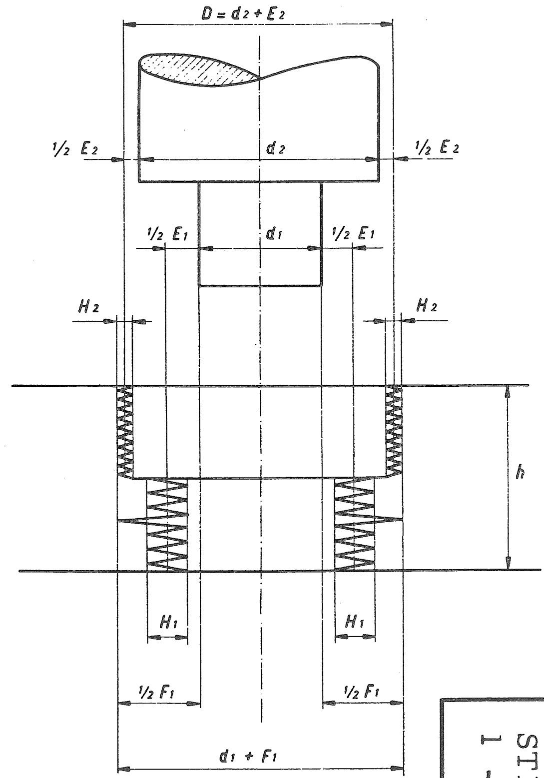
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (... X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	4	1,3	0,055	0,081			24		25		6,6	20	1,7
2	4	1,4	0,061	0,090			25		26		8,5	20	1,9
3	5	1,4	0,066	0,095			26		27		10	20	2
4	5	1,4	0,073	0,103			27		28		13	20	2,2
5	5	1,5	0,09	0,12			29		29		20	20	2,6
6	6	1,6	0,110	0,14			31		31		33	20	3,2
7													
8													
9													
10													
11													
12													



COPPER - STEEL
1 - 80 V

COPPER - STEEL 2 - 80 V	

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Copper

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 2 - 80 V

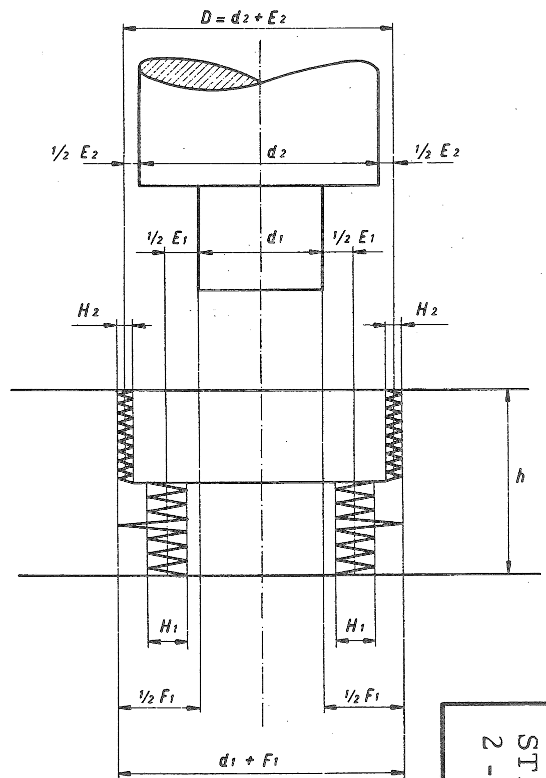
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE: Electrolytic copper

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (... X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (μm)	CH No.	R_t (μm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	5	1,2	0,066	0,11			27		28		20	20	3,3
2	5	1,1	0,075	0,12			28		29		25	20	3,5
3	5	1,1	0,081	0,13			29		30		30	20	3,7
4	5	1,0	0,092	0,14			30		31		40	20	4
5	6	0,9	0,112	0,165			31		32		57	20	4,5
6	6	0,9	0,14	0,195			33		33		90	20	5,2
7													
8													
9													
10													
11													
12													



COPPER - STEEL 2 - 80 V

CHARMILLES
TECHNOLOGIE ISOPULSE

AGMO
Copper — Copper

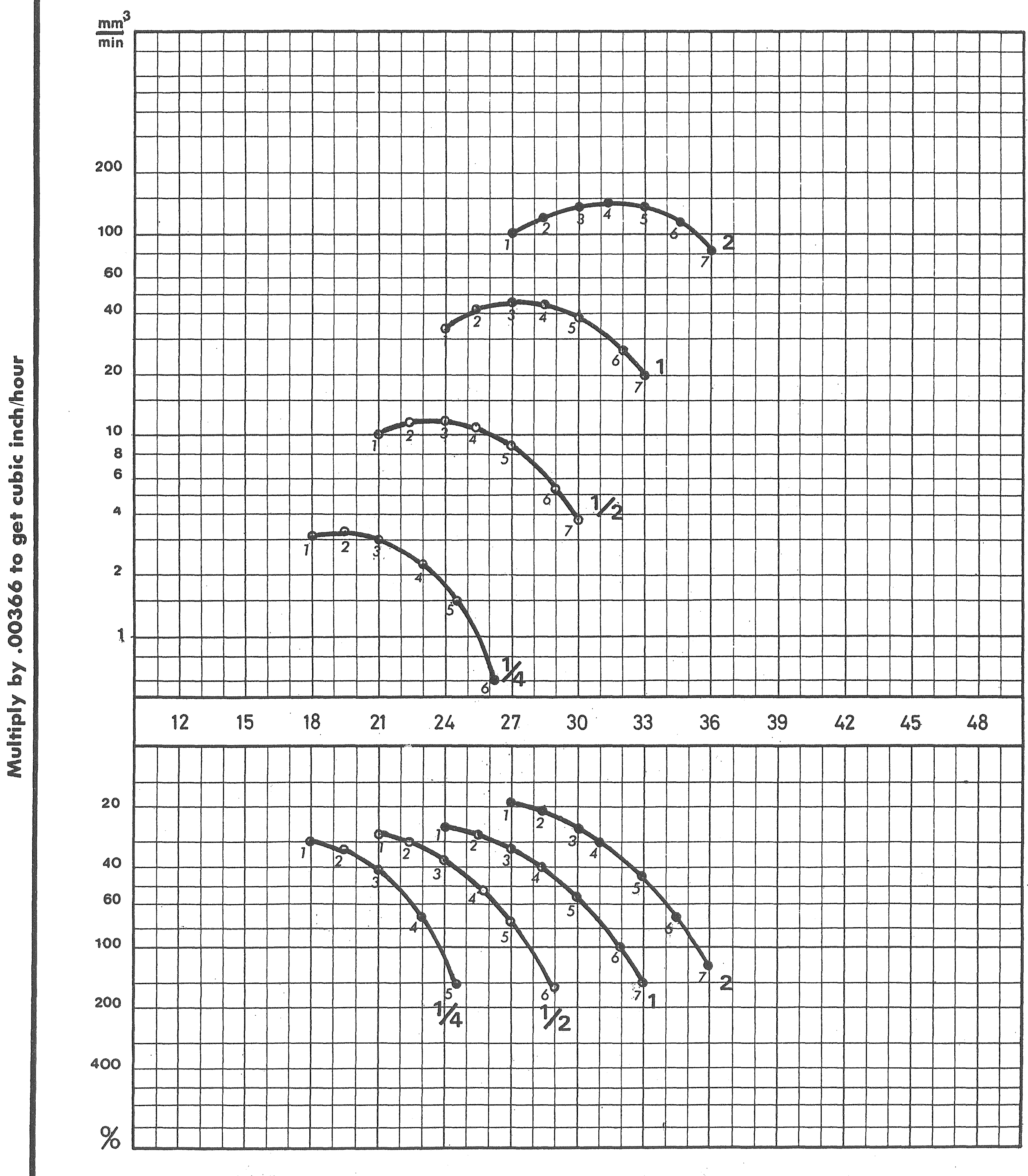
ELECTRODE : Electrolytic copper

ELECTRODE POLARITY : Negative

WORKPIECE : Electrolytic copper

TEST CONDITIONS : dia E1 : 30mm .Pre-hole dia 12mm

METAL REMOVAL RATE IN MM^3/MIN AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE ESTIMATED CHARMILLES NORMALIZED FRONTAL SURFACE FINISH.



CHARMILLES - TECHNOLOGIE ISOPULSE

E
Copper — Copper

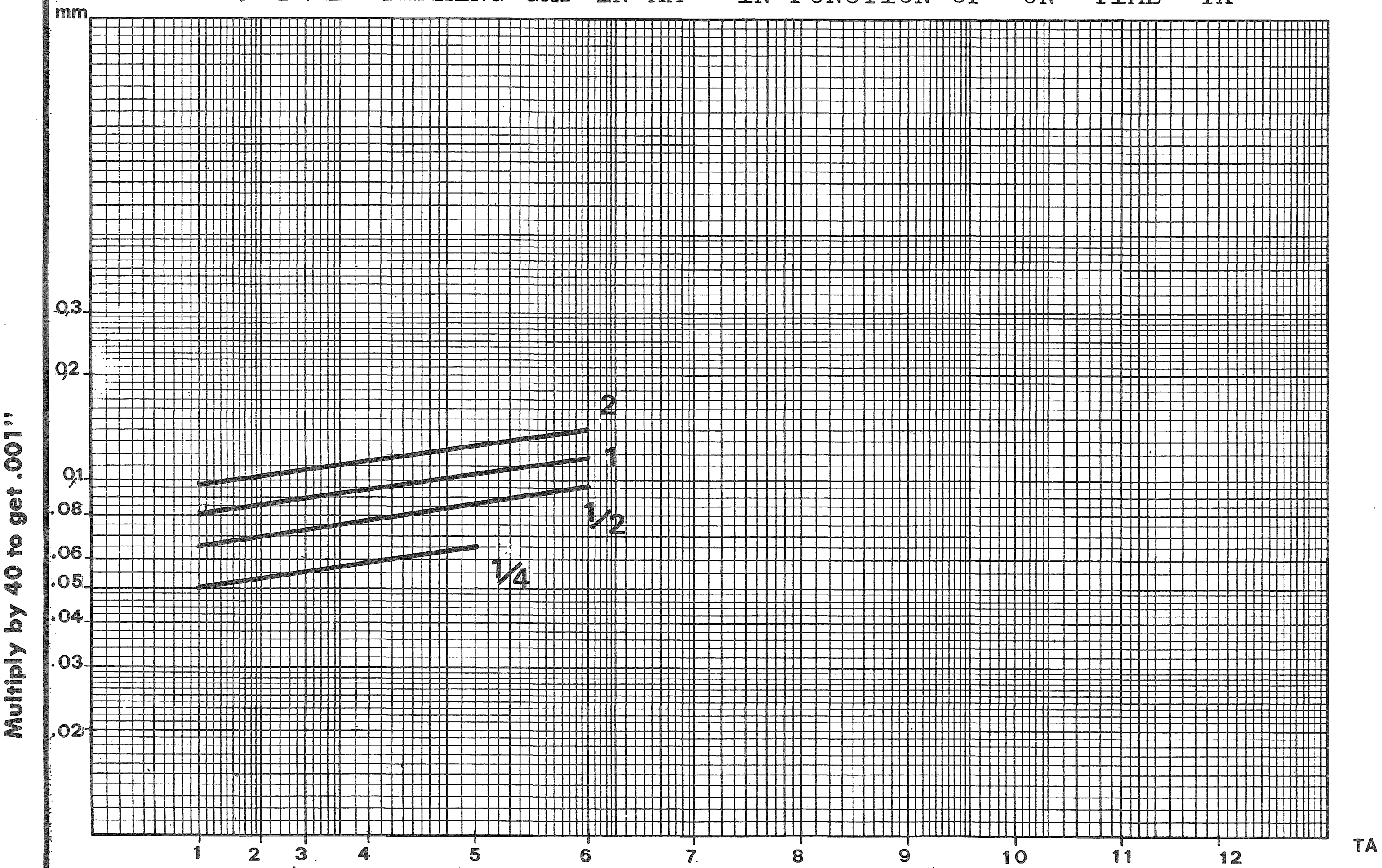
ELECTRODE: Electrolytic copper dia 23.50mm

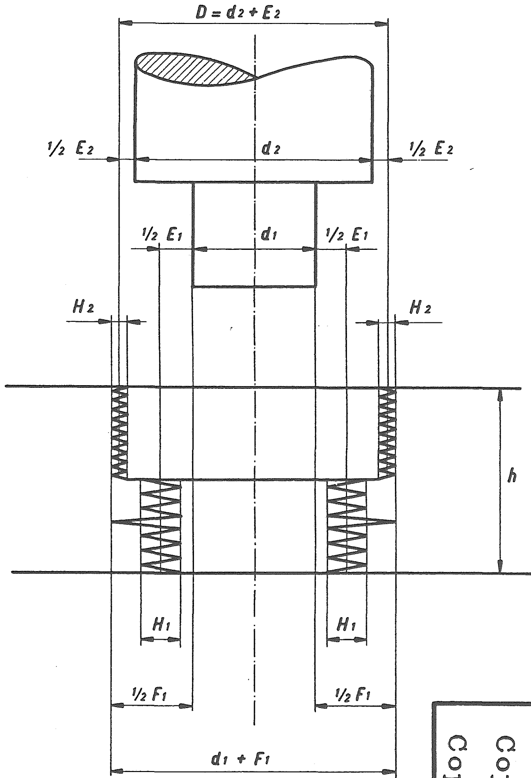
ELECTRODE POLARITY: Negative

WORKPIECE: Electrolytic copper. pre-hole dia 23mm

SUCTION

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF "ON" TIME TA





E
Copper — Copper

CHARMILLES - TECHNOLOGIE ISOPULSE

E' Copper — Copper

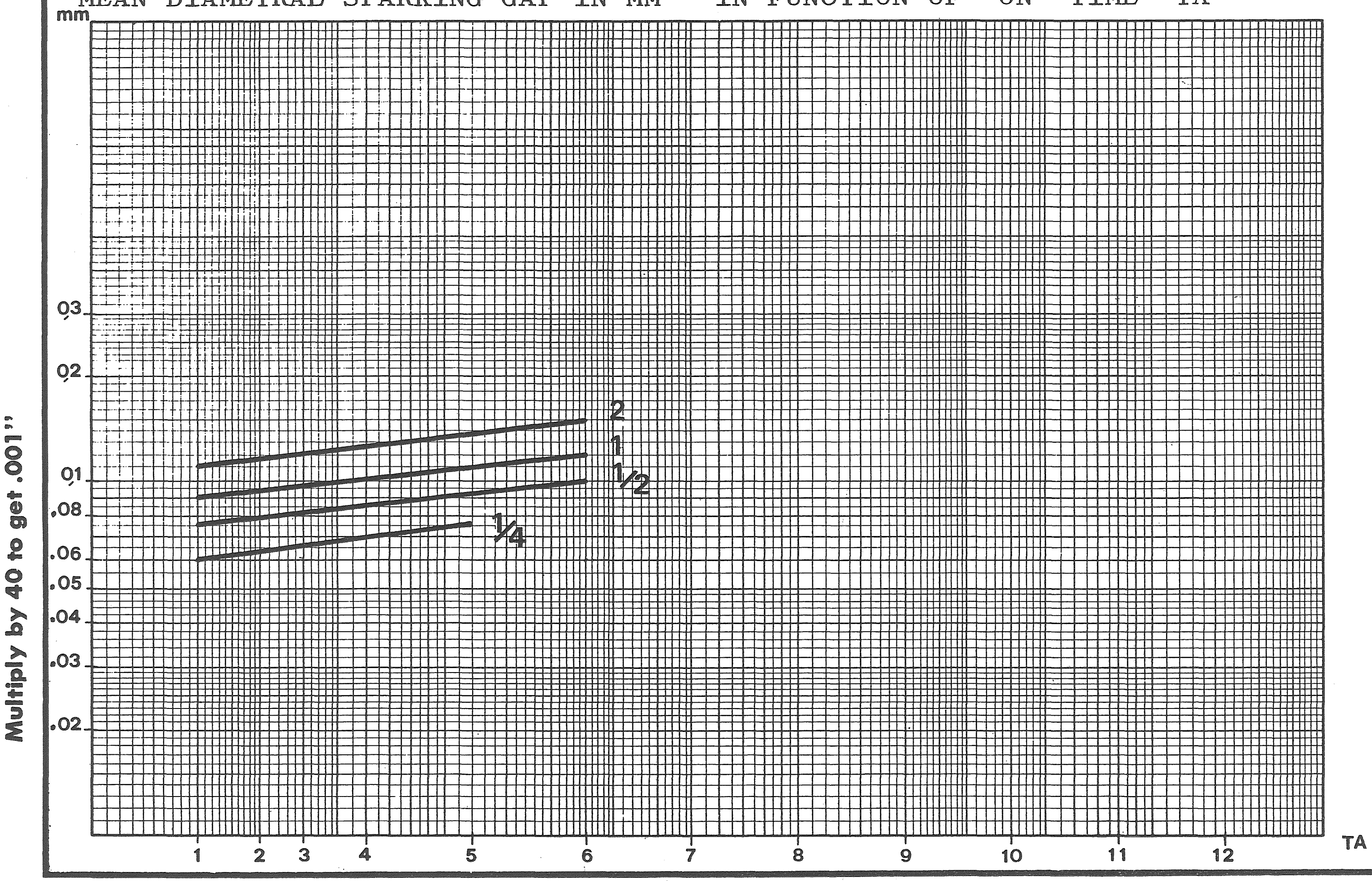
ELECTRODE: Electrolytic copper dia 24.00mm

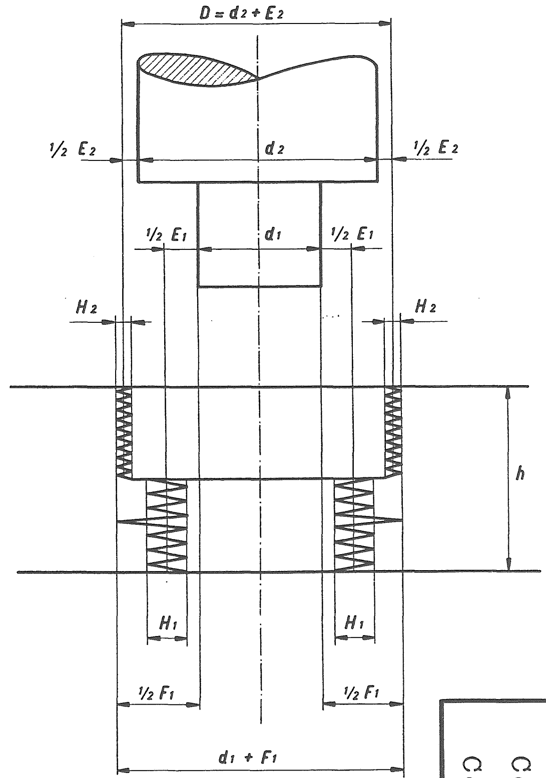
ELECTRODE POLARITY: Negative

WORKPIECE: Electrolytic copper. pre-hole dia 23.50mm

INJECTION

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF "ON" TIME TA





E' Copper — Copper

CHARMILLES - TECHNOLOGIE ISOPULSE

R
Copper —
Copper

ELECTRODE: Electrolytic copper dia 30mm

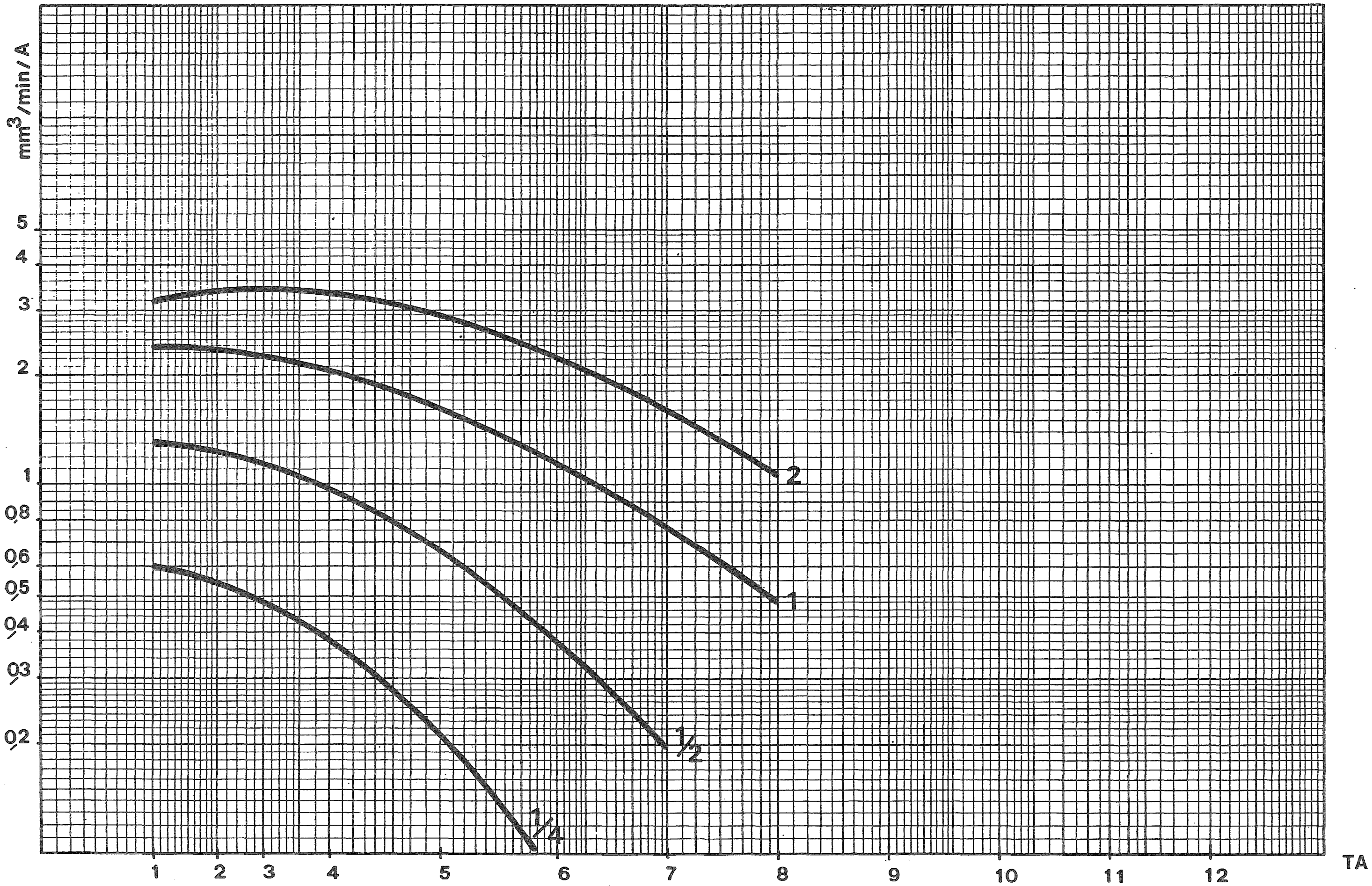
ELECTRODE POLARITY: Negative

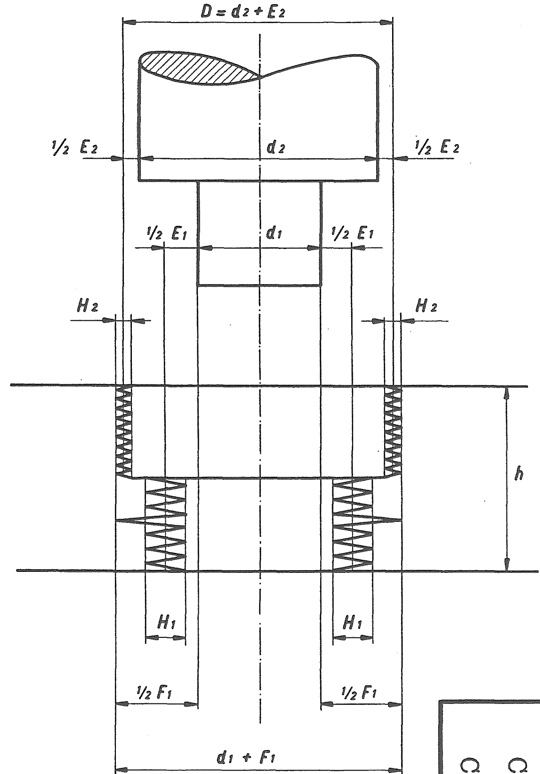
WORKPIECE: Electrolytic copper   pre-hole dia 12mm

INJECTION

SPECIFIC REMOVAL RATE IN $MM^3/MIN/A$ IN FUNCTION OF "ON" TIME TA

Multiply by .00366 to get cubic inch/hour and ampere





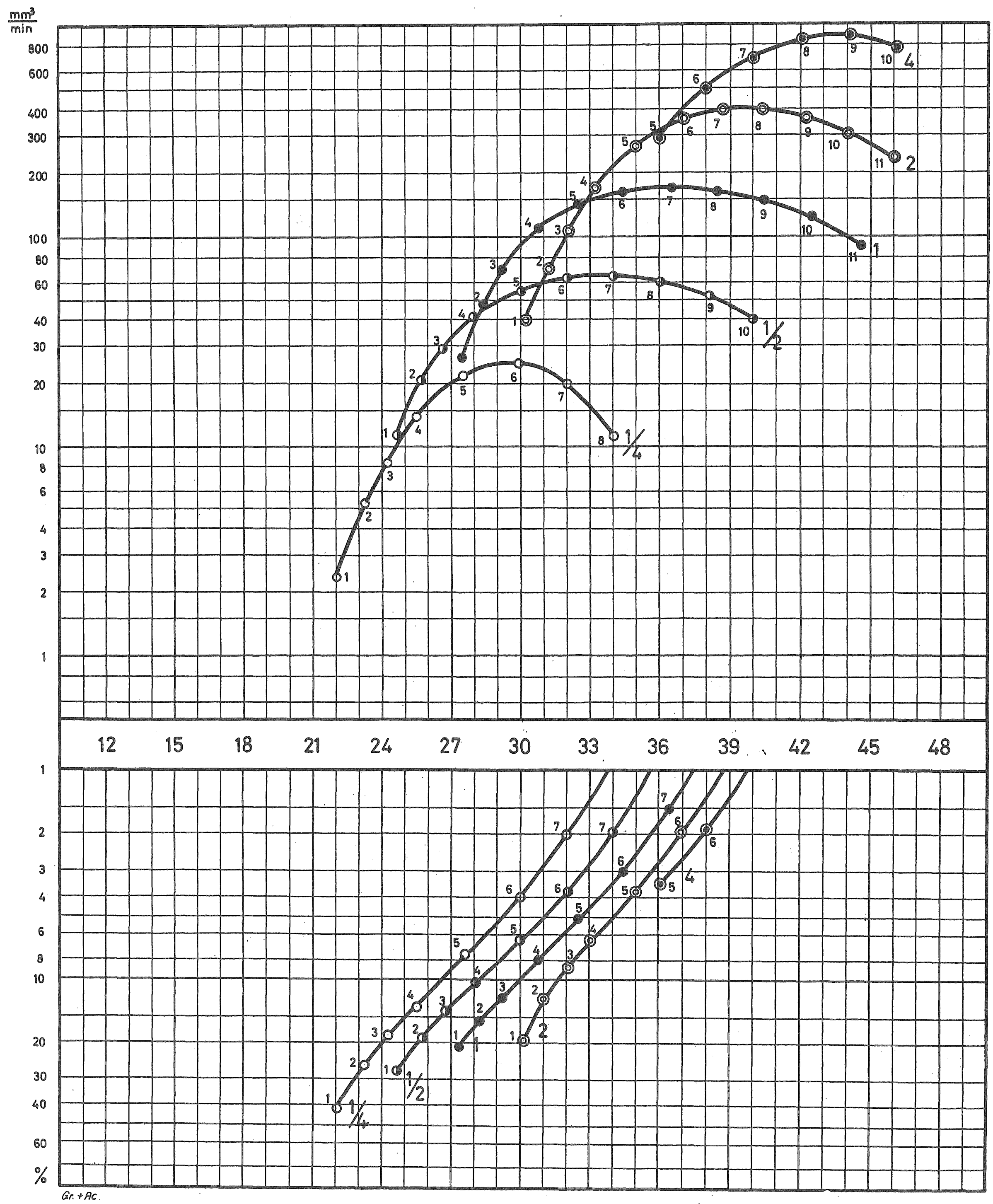
R
Copper —
Copper

CHARMILLES

TECHNOLOGIE ISOPULSE

AGMO
Gra-phite+
Steel

ELECTRODE : Graphite
POLARITY ELECTRODE : Positive
WORKPIECE : Steel MST 65 RC
TEST CONDITIONS : D = 20 mm, Diameter pre-hole : 15 mm
Dielectric : Mentor 28 (Esso - Standard) Graphite type : Ellor 9
Injection or suction : 200 to 400 gr/cm^2
METAL REMOVAL RATE IN MM3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



Multiply by .00366 to get cubic inch/hour

E Graphite + Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELEKTRODE: +

WORKPIECE: Steel MST 65 RC

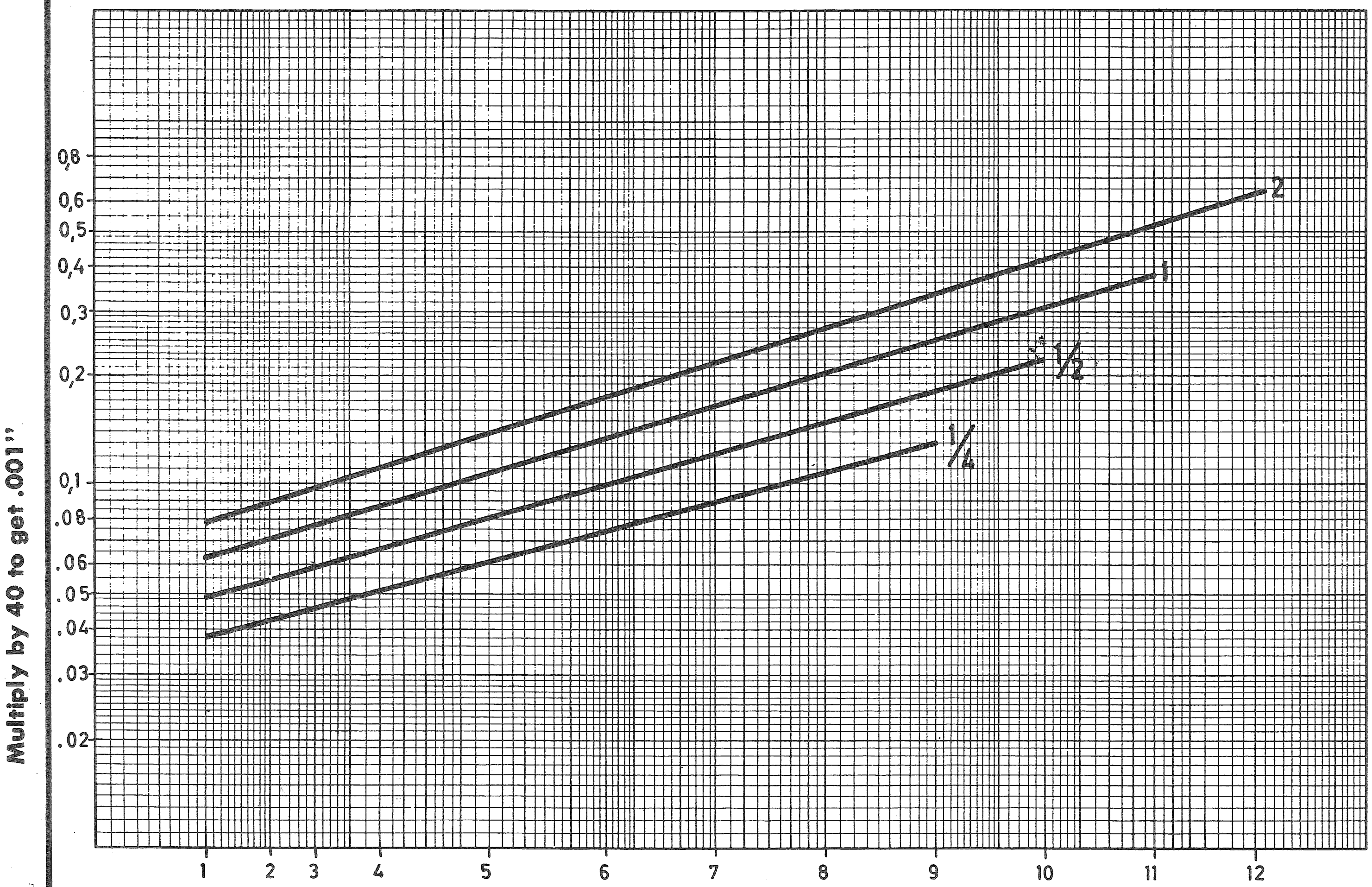
SUCTION

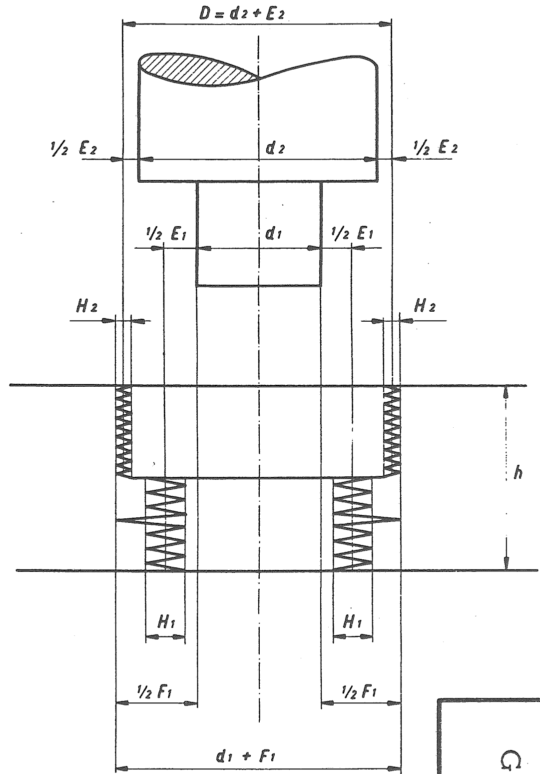
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Suction: 200 to 400 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E
Graphite +
Steel

E Gr + Ac

	E' Graphite + Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

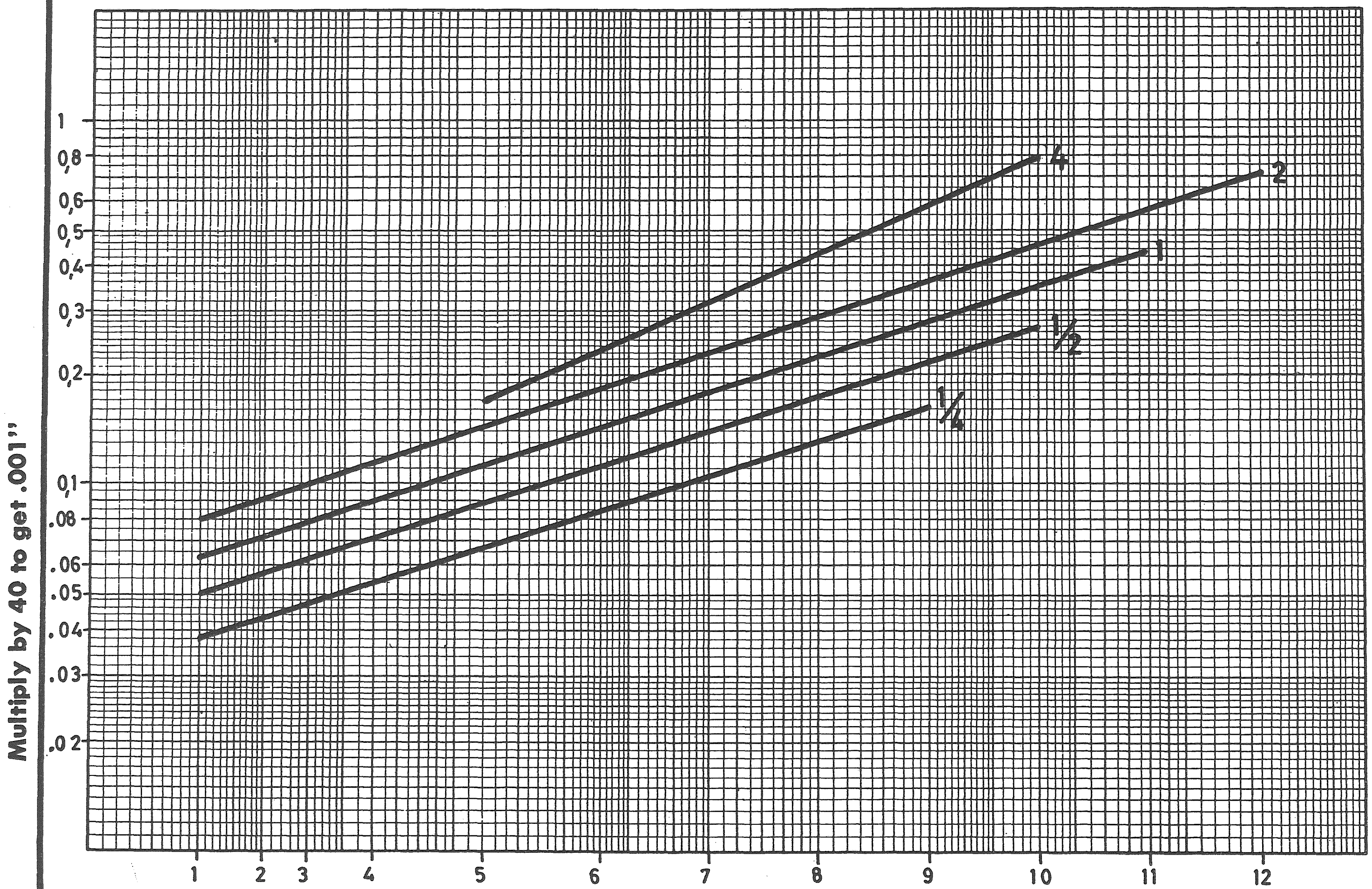
INJECTION

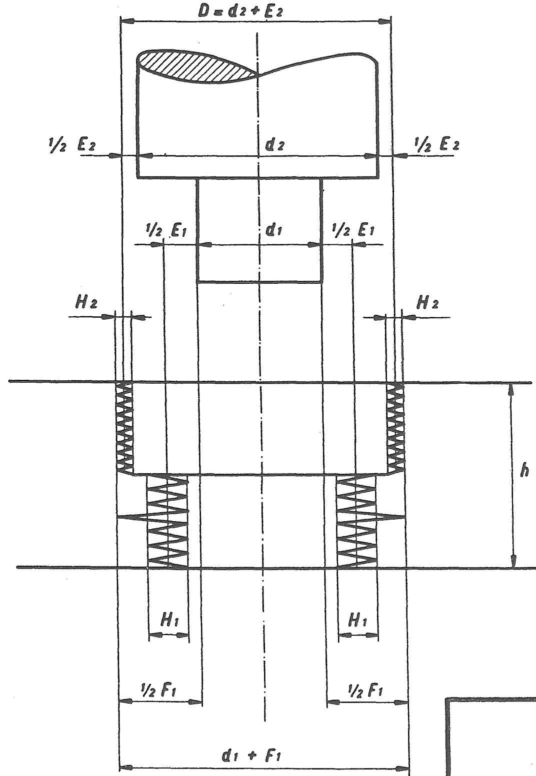
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection: 200 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E'
Graphite +
Steel

E' Gr + Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

F
Graphite -
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

SUCTION

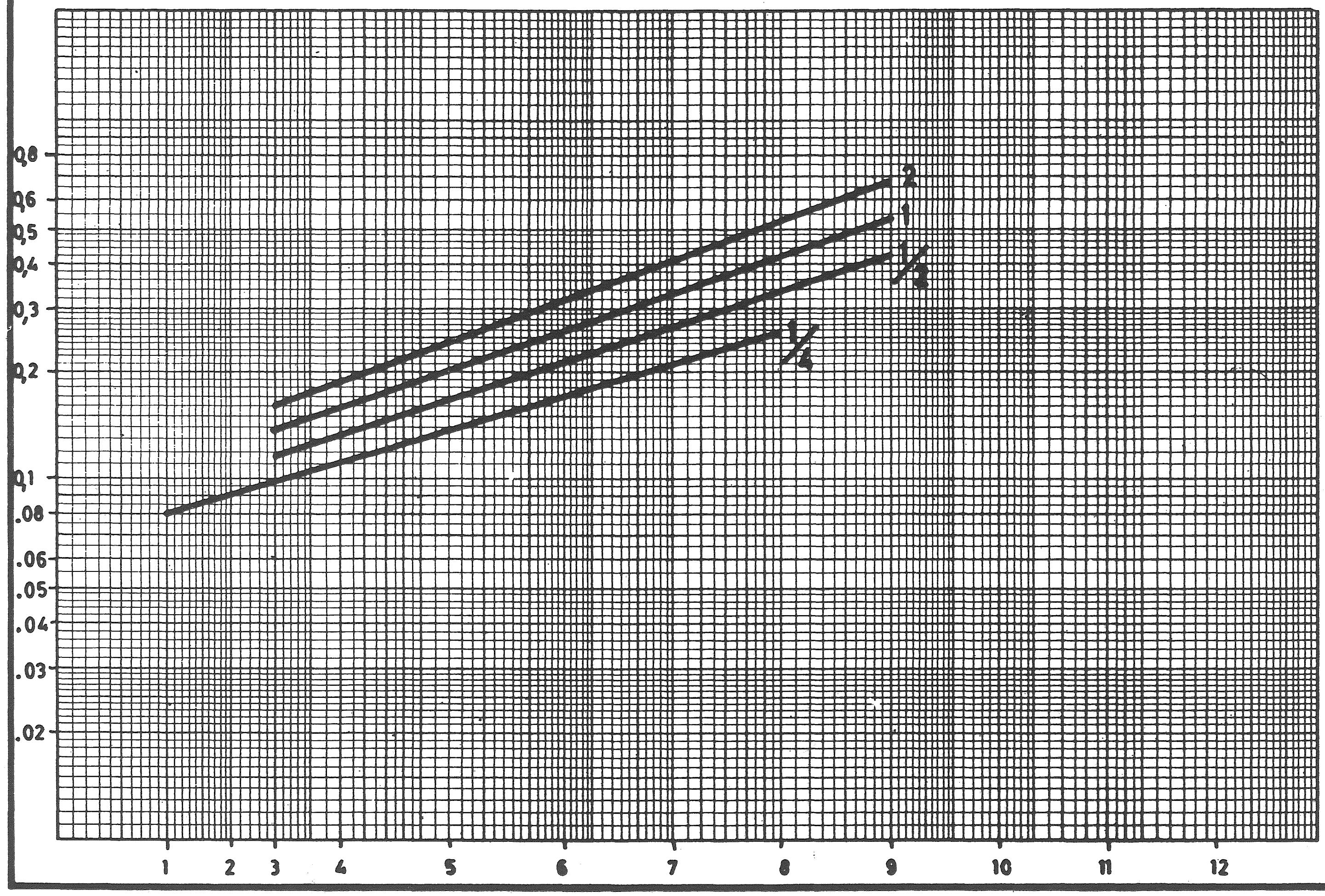
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

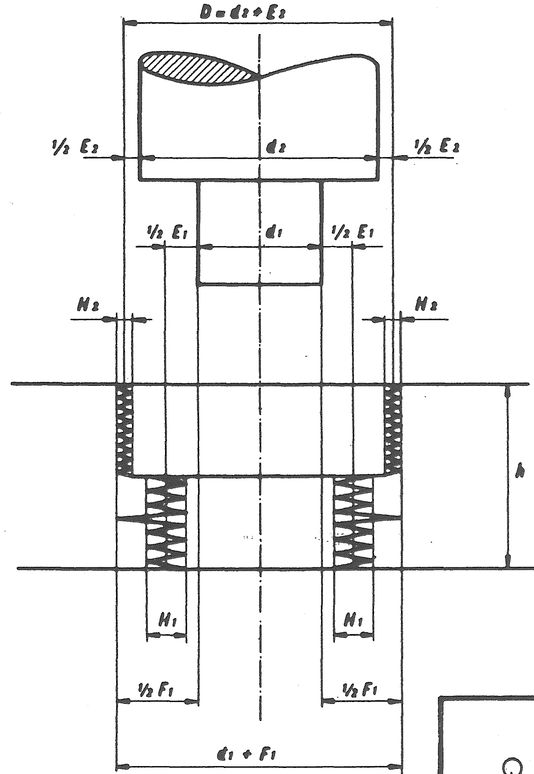
Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Suction: 200 to 400 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)

Multiply by 40 to get .001"





F
Graphite -
Steel

F Gr. - Ac.

CHARMILLES - TECHNOLOGIE ISOPULSE

F
Graphite +
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

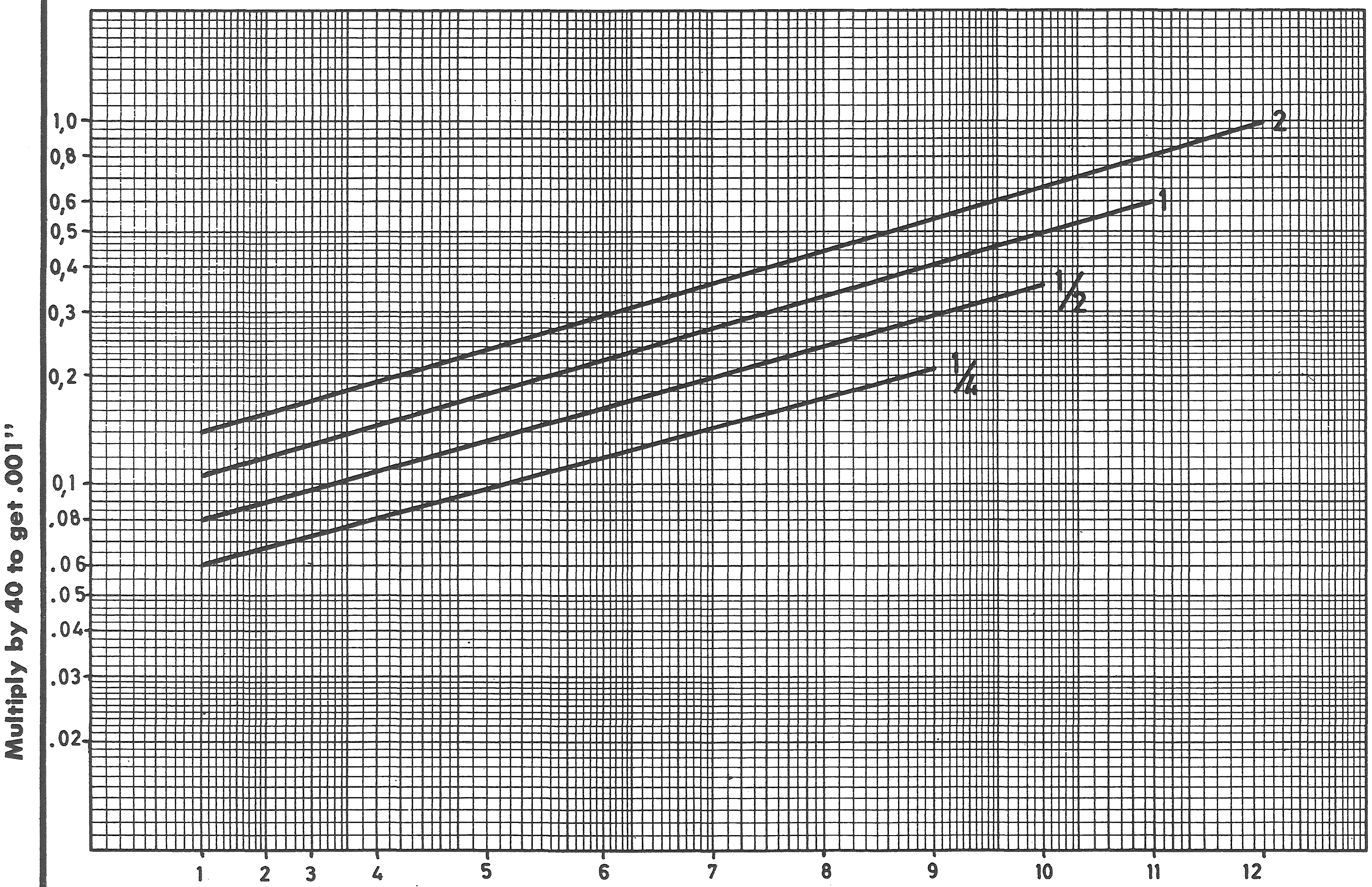
SUCTION

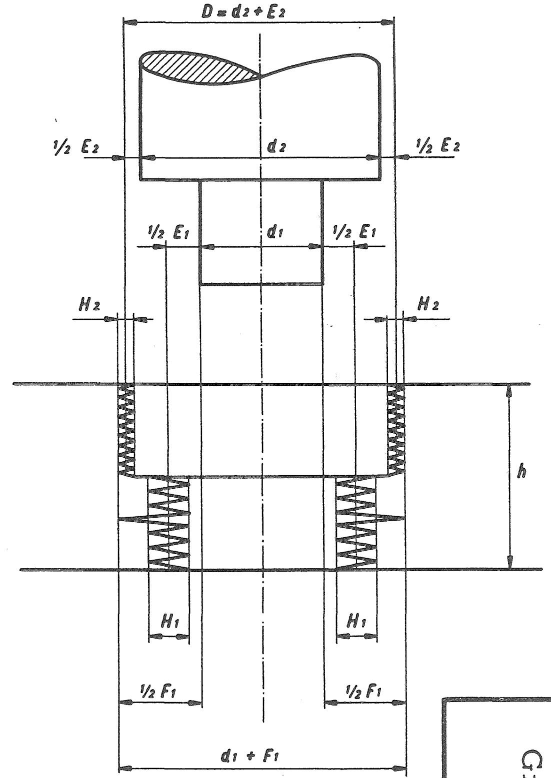
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Suction: 200 to 400 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





F
Graphite +
Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

F'
Graphite +
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

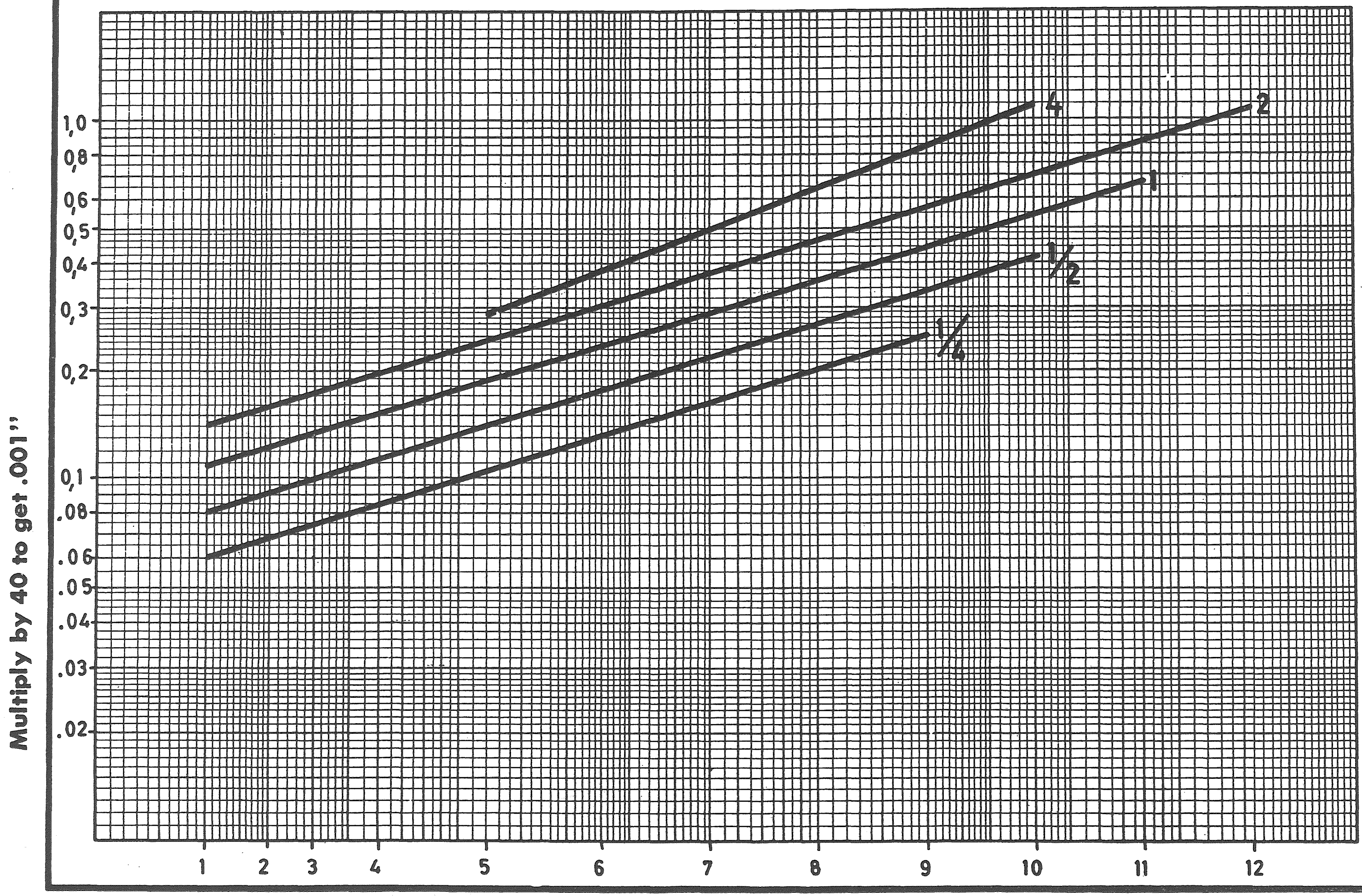
INJECTION

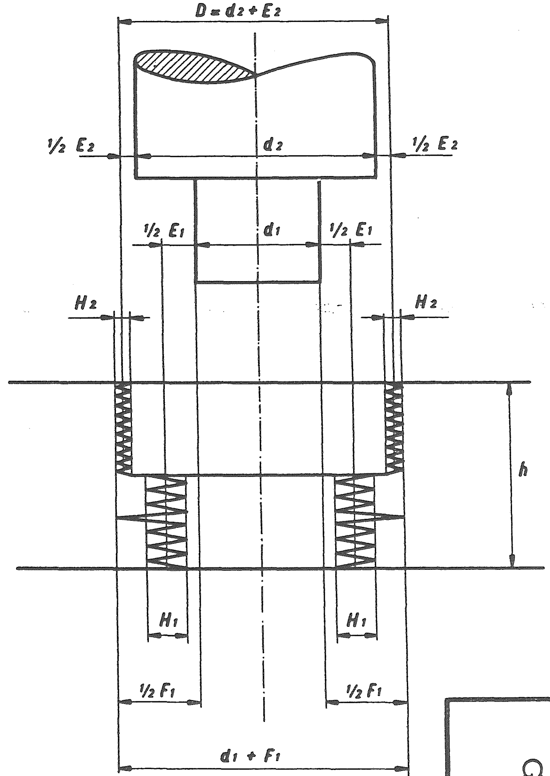
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection: 200 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





F'
Graphite +
Steel

F' Gr + Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

R
Graphite +
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: +

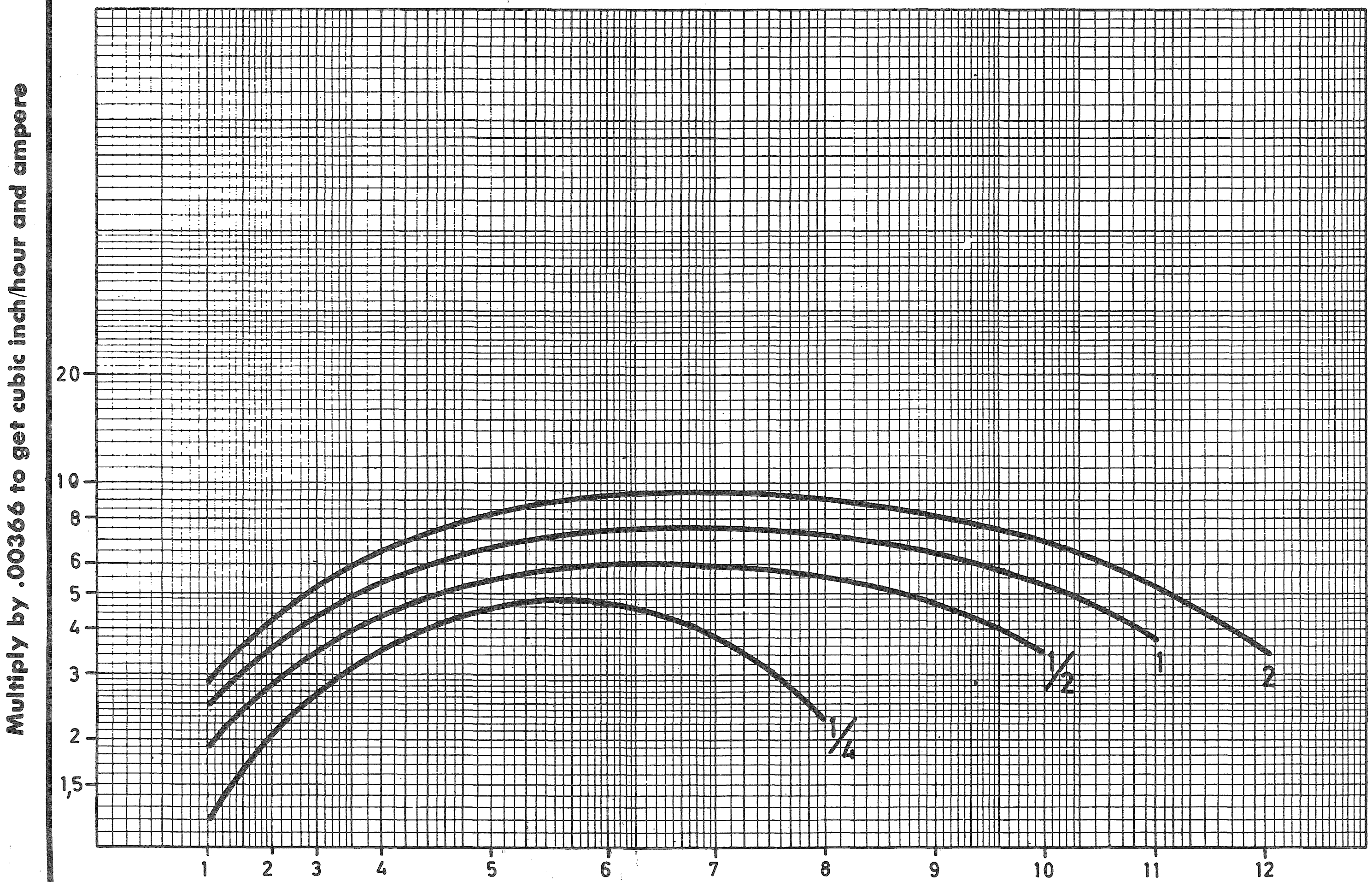
WORKPIECE: Steel MST 65 RC

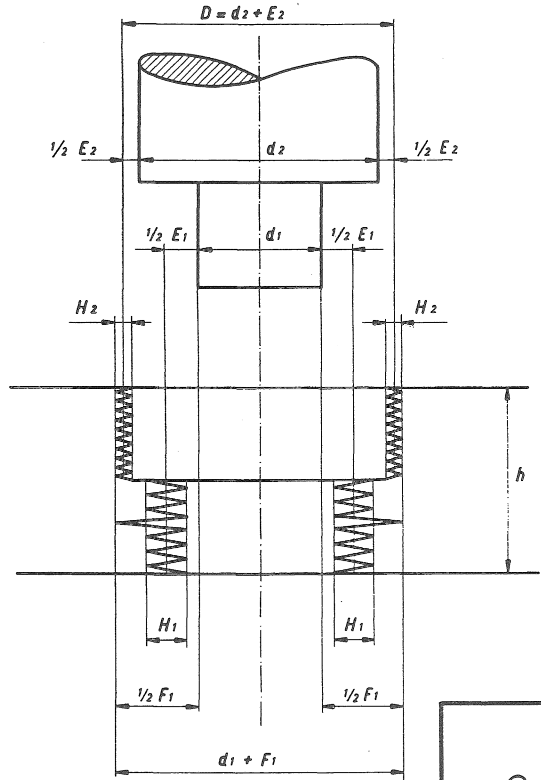
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 15 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection or suction: 200 gr/cm^2

SPECIFIC METAL REMOVAL RATE IN MM^3 PER MINUTE AND PER AMPERE - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





R
Graphite +
Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

GRAPHITE +
STEEL
1/4 - 80 V

ELECTRODE : Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1/4 - 80 V

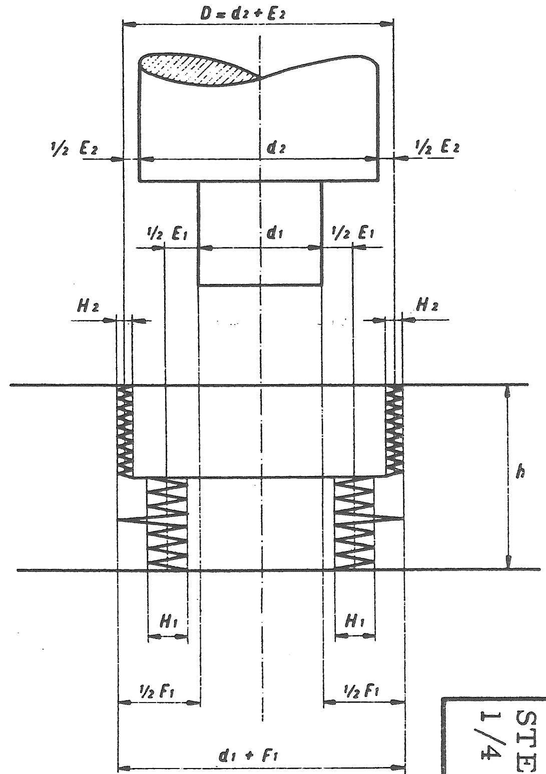
TEST CONDITIONS: D = 20 mm   h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard)   ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	2,3	0,038	0,060	0,038	0,06	22		25		2,4	41	1,2
2	1	1,8	0,042	0,067	0,043	0,068	23		25		5,2	25	2,0
3	1	1,5	0,046	0,072	0,047	0,074	24		26		8,2	18	2,7
4	2	1,3	0,050	0,080	0,054	0,084	26		28		14	13	3,5
5	2	0,9	0,058	0,096	0,067	0,104	28		29		22	7,5	4,6
6	3	0,6	0,075	0,12	0,085	0,13	30		31		23	4	4,6
7	4	0,3	0,090	0,142	0,105	0,16	32		33		19	2	3,8
8	5	0,2	0,11	0,171	0,13	0,20	34		35		12	0,9	2,2
9	6	0,2	0,13	0,21	0,16	0,25	36		37		4	-	0,8
10													
11													
12													



GRAPHITE +
STEEL
1/4 - 80 V

GRAPHITE +
STEEL
1/2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1/2 - 80 V

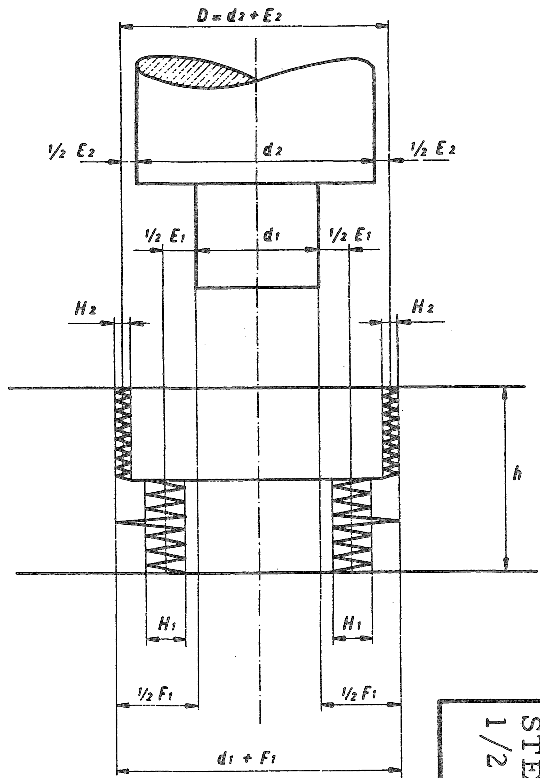
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (... X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (μm)	CH No.	R_t (μm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	3,0	0,048	0,08	0,05	0,08	25		28		12	28	1,9
2	1	2,1	0,054	0,09	0,056	0,09	26		29		20	19	2,8
3	1	1.7	0,059	0,095	0,062	0,10	27		30		28	14	3,5
4	2	1,3	0,066	0,11	0,070	0,11	28		30		42	10	4,3
5	3	0,9	0,080	0,13	0,090	0,14	30		32		55	6,5	5,5
6	4	0,6	0,10	0,16	0,11	0,175	32		33		64	3,8	6,0
7	4	0,4	0,12	0,20	0,14	0,22	34		35		65	2	6,0
8	5	0,3	0,15	0,24	0,17	0,27	36		37		61	0,9	5,5
9	6	0,3	0,18	0,29	0,215	0,33	38		39		51	-	4,7
10	7	0,2	0,22	0,35	0,270	0,41	40		42		40	-	3,4
11													
12													



GRAPHITE +
STEEL
1/2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

GRAPHITE +
STEEL
1 - 80 V

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 1 - 80 V

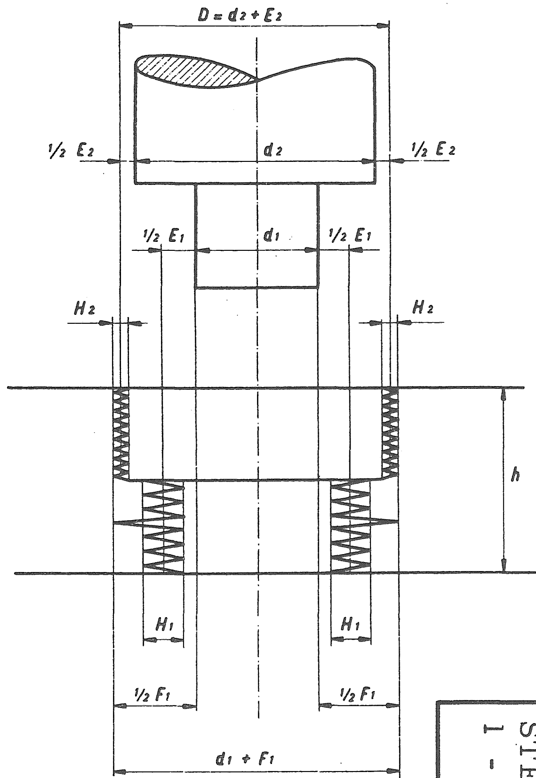
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : Ellor 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (. . . X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	2,6	0,062	0,105	0,063	0,11	27		30		26	22	2,5
2	1	2,0	0,070	0,12	0,071	0,12	28		31		46	15	3,6
3	2	1,7	0,076	0,13	0,079	0,13	29		32		70	11	4,3
4	2	1,3	0,086	0,145	0,090	0,15	31		33		110	8	5,4
5	3	0,9	0,107	0,18	0,11	0,19	32		34		140	5	6,6
6	4	0,6	0,132	0,22	0,14	0,23	34		35		160	3	7,4
7	4	0,5	0,162	0,27	0,18	0,29	36		37		170	1,5	7,5
8	5	0,4	0,20	0,33	0,22	0,36	38		39		165	-	7,2
9	6	0,3	0,25	0,40	0,28	0,44	40		42		150	-	6,4
10	7	0,3	0,31	0,50	0,35	0,55	42		44		130	-	5,3
11	8	0,2	0,38	0,60	0,43	0,66	44		46		90	-	3,8
12													



GRAPHITE +
STEEL
1 - 80 V

GRAPHITE +
STEEL
2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELECTRODE: +

WORKPIECE: Steel MST 65 RC

POWER: 2 - 80 V

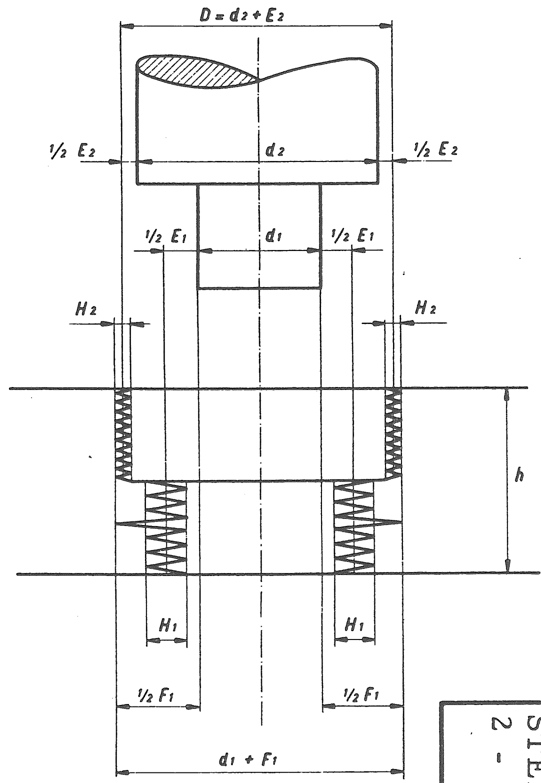
TEST CONDITIONS: D = 20 mm   h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard)   ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (μm)	CH No.	R_t (μm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	2	2,3	0,079	0,14	0,080	0,14	30		32		40	20	2,8
2	2	1,7	0,090	0,158	0,090	0,16	31		33		70	12	4,2
3	2	1,5	0,096	0,17	0,100	0,17	32		33		110	8	5,2
4	2	1,1	0,110	0,19	0,113	0,20	33		34		170	6,2	6,5
5	3	0,8	0,14	0,23	0,14	0,24	35		35		270	3,8	8,2
6	4	0,6	0,17	0,29	0,18	0,30	37		37		340	2	9,2
7	5	0,5	0,215	0,36	0,23	0,37	39		39		380	1	9,5
8	6	0,4	0,27	0,44	0,29	0,46	40		41		390	0,5	9,0
9	7	0,4	0,34	0,54	0,36	0,57	42		43		360	-	8,0
10	7	0,3	0,42	0,65	0,45	0,70	44		46		310	-	7,0
11	8	0,3	0,52	0,80	0,57	0,87	46		49		235	-	5,2
12	9	0,2	0,63	1,0	0,71	1,05	48		52		150	-	3,4



GRAPHITE +
STEEL
2 - 80 V

CHARMILLES

TECHNOLOGIE ISOPULSE

AGMO
Gra-phite -
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: Negative

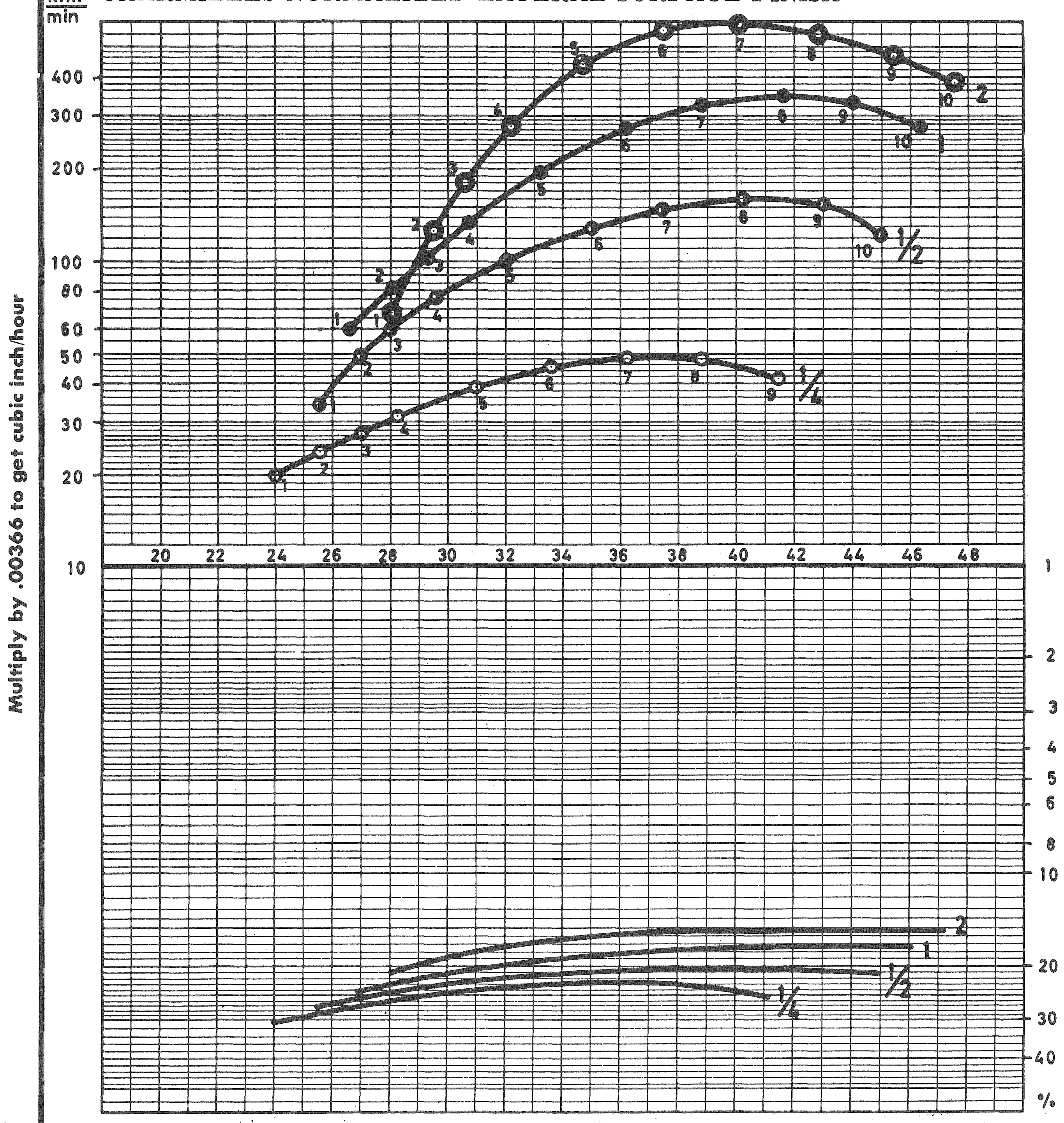
WORKPIECE: Steel MST 65 RC

TEST CONDITIONS: D = 20 mm Diameter pre-hole: 15 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection or suction: 200 to 400 gr/cm^2

METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



Gr. - Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

E
Graphite -
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

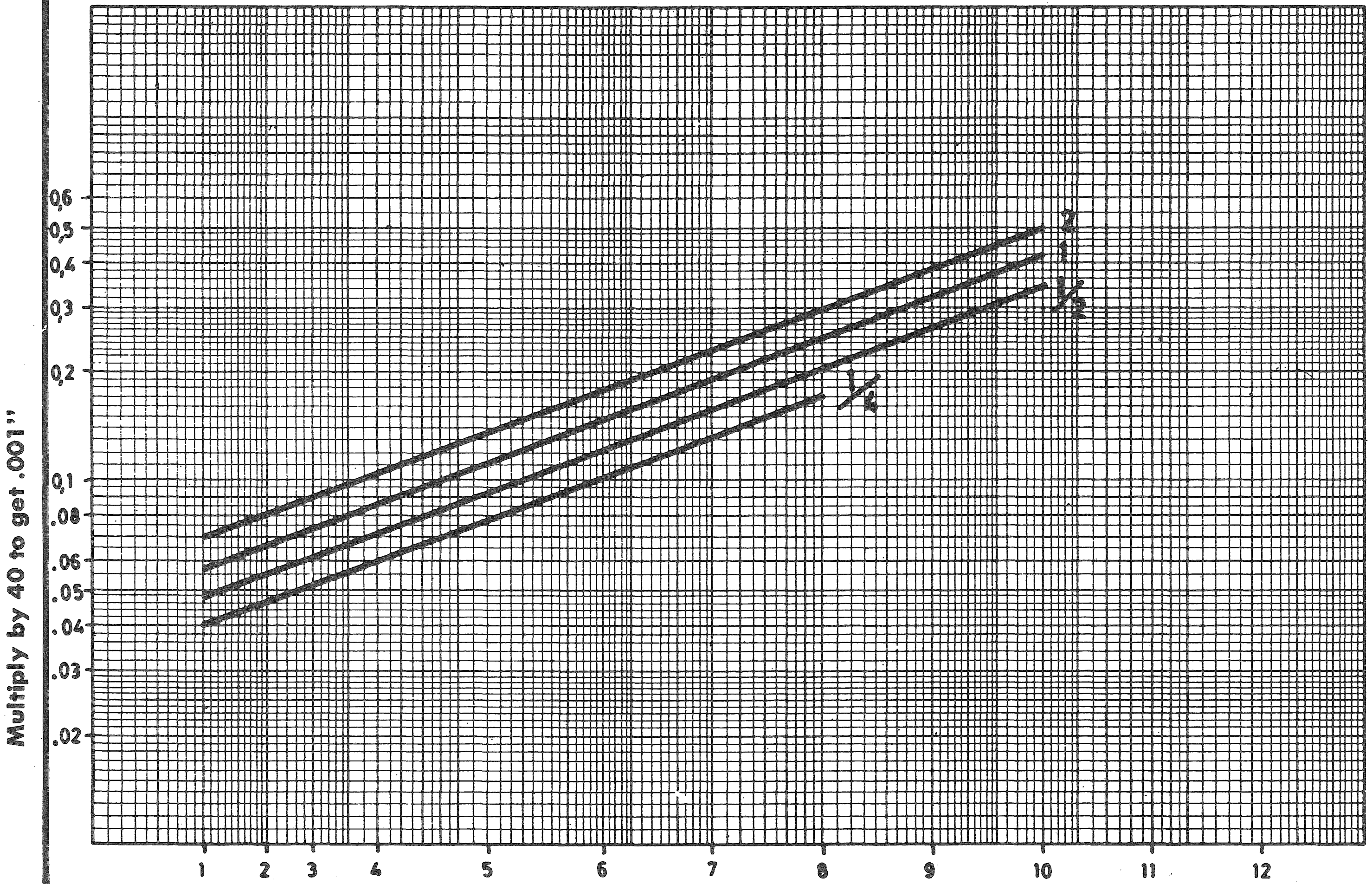
SUCTION

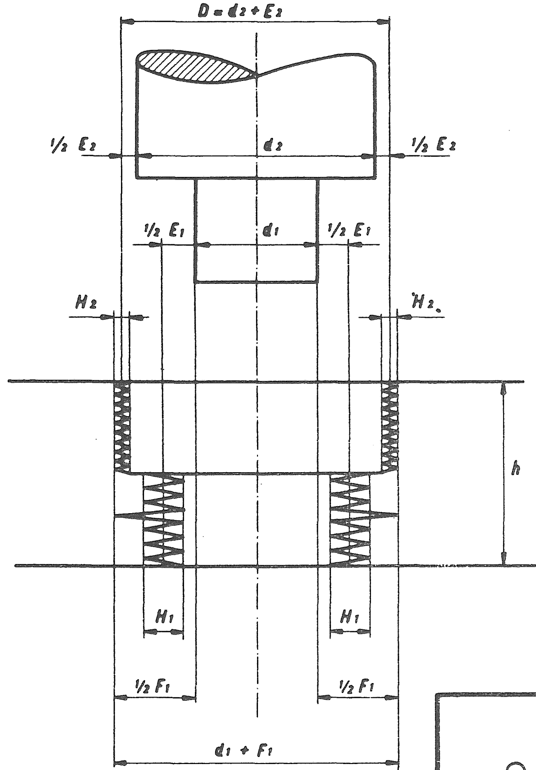
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Suction: 200 to 400 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E
Graphite -
Steel

E Gr. - Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

E'
Graphite -
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

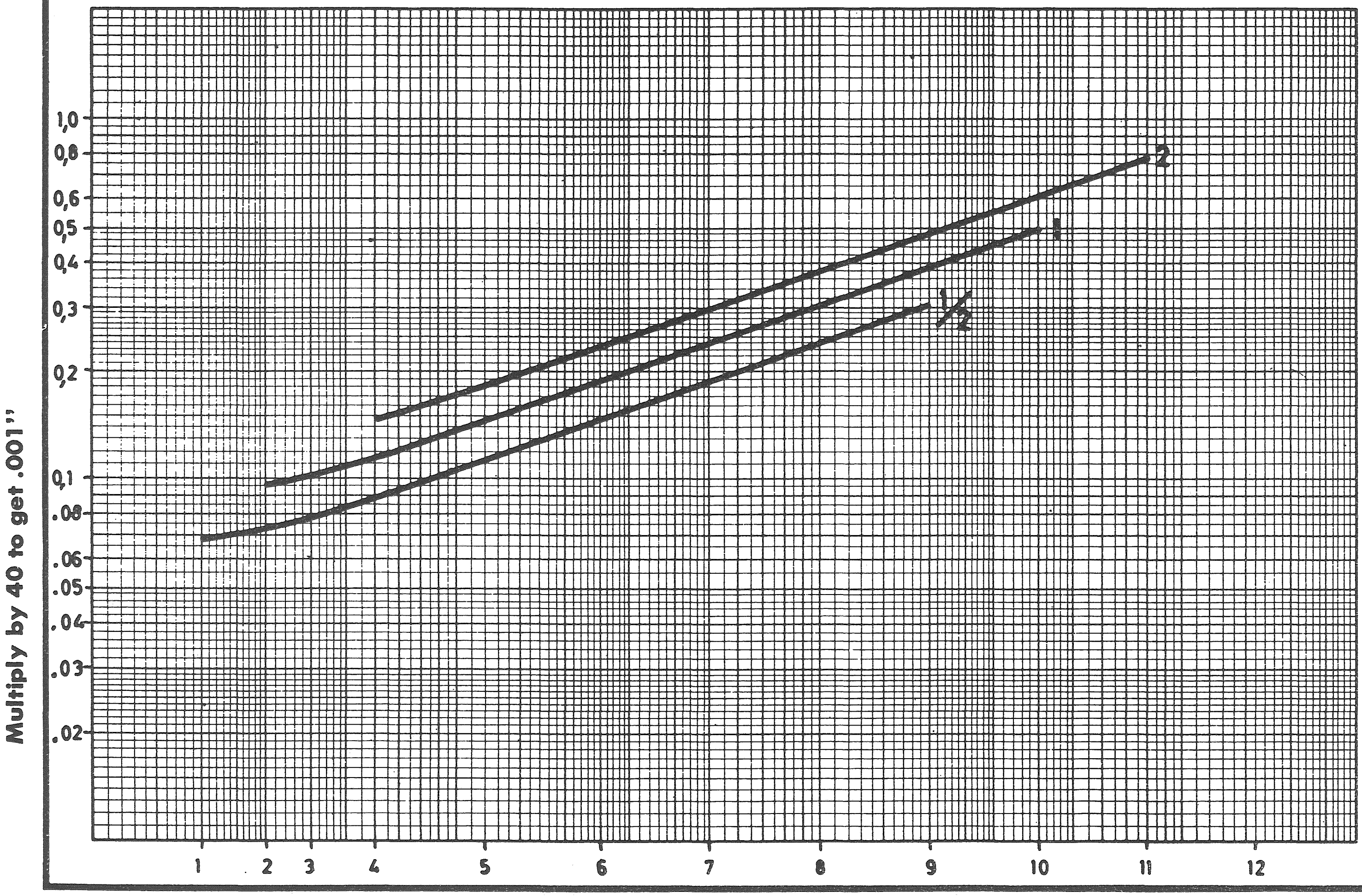
INJECTION

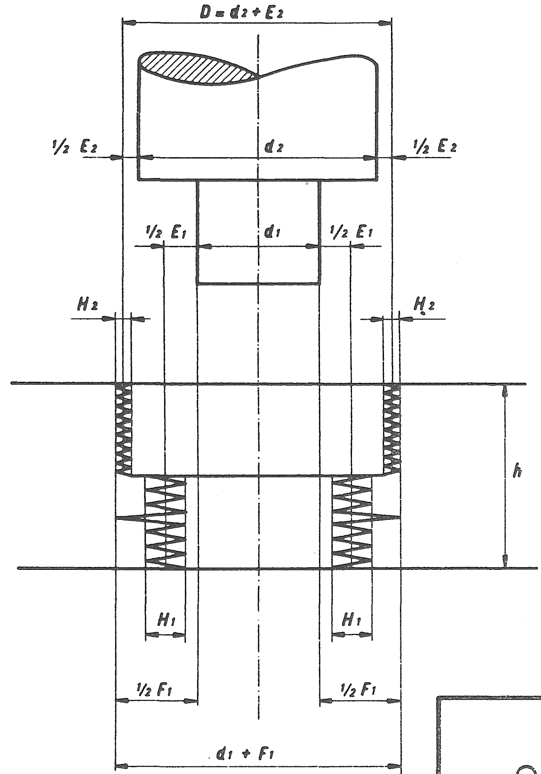
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection: 200 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E'
Graphite -
Steel

E' Gr - Ac

CHARMILLES - TECHNOLOGIE ISOPULSE

F'
Graphite - Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

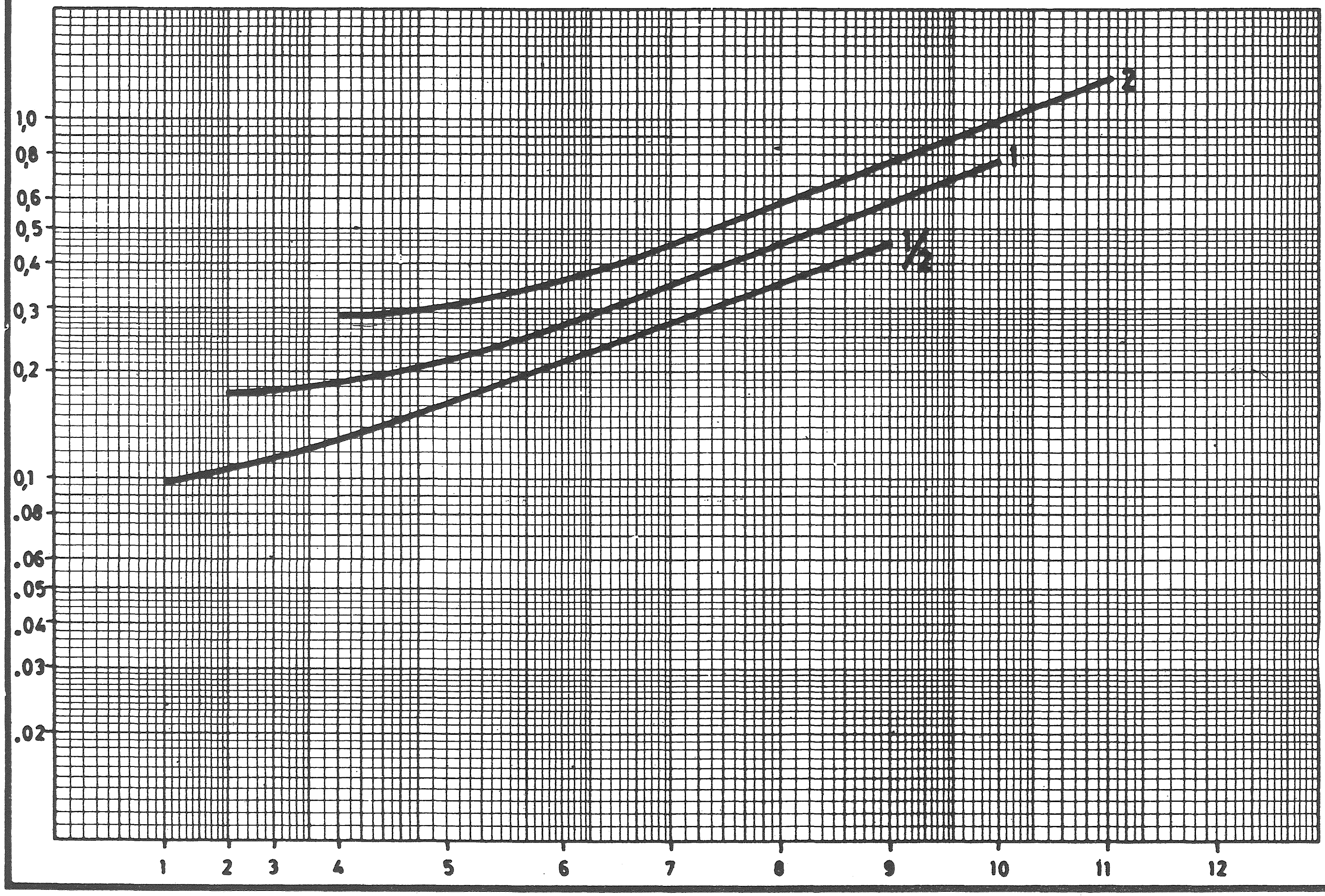
INJECTION

TEST CONDITIONS: D = 20 mm Diameter pre-hole: 18 mm

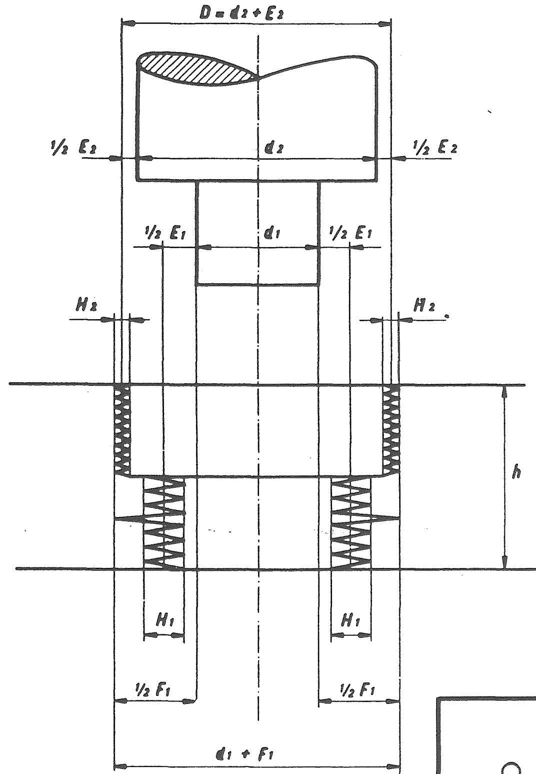
Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection: 200 gr/cm^2

DIAMETRAL INFLUENCE LIMIT IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)



Multiply by 40 to get .001"



F'
Graphite - Steel

CHARMILLES - TECHNOLOGIE ISOPULSE

R
Graphite -
Steel

ELECTRODE: Graphite

POLARITY ELECTRODE: -

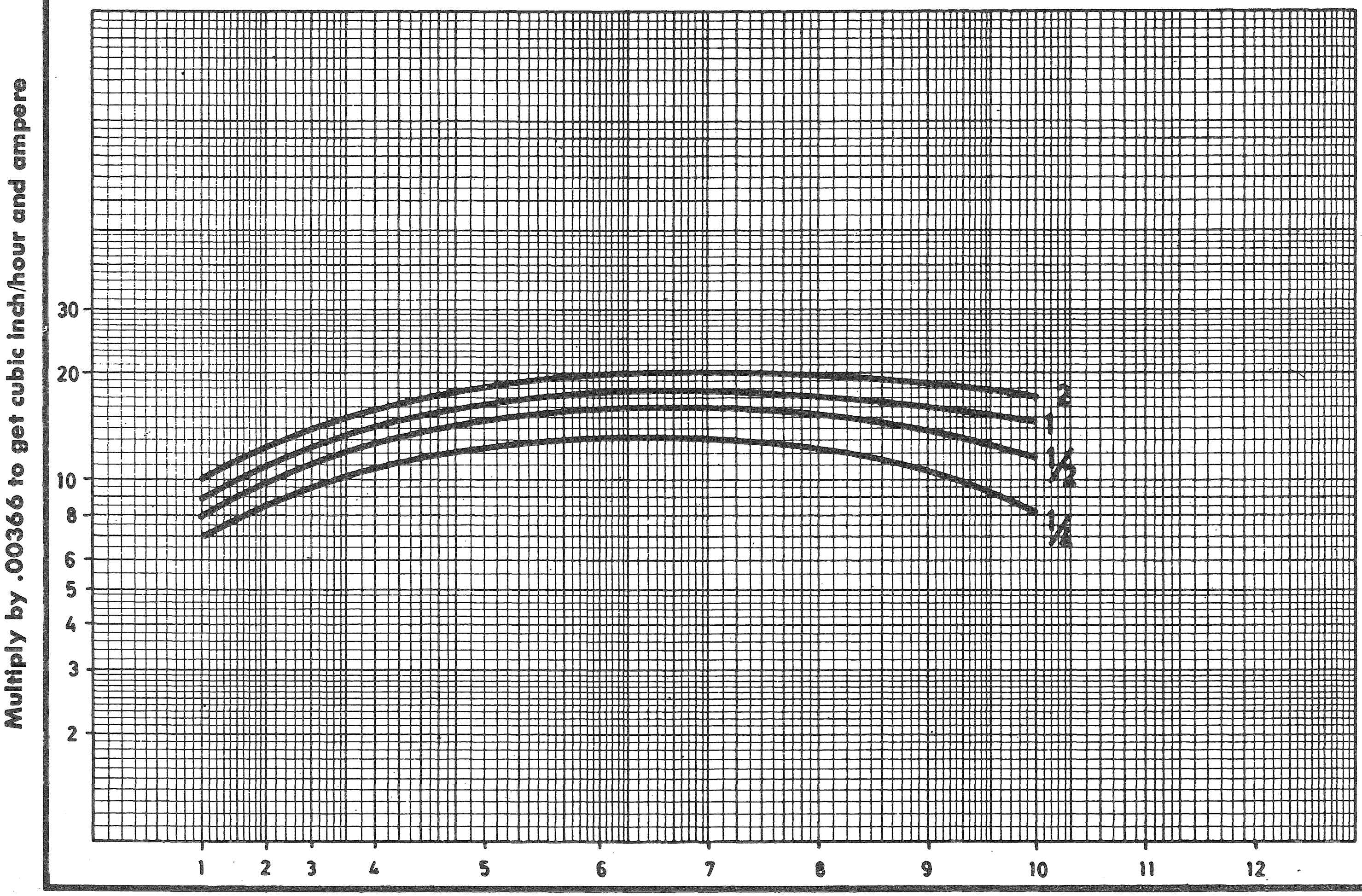
WORKPIECE: Steel MST 65 RC

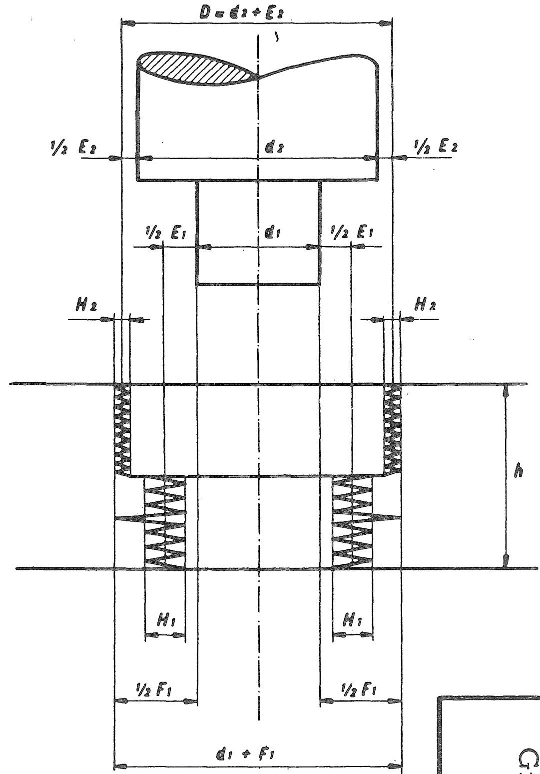
TEST CONDITIONS: D = 20 mm Diameter pre-hole: 15 mm

Dielectric: Mentor 28 (Esso - Standard) Graphite type: Ellor 9

Injection or suction: 200 gr/cm^2

SPECIFIC METAL REMOVAL RATE IN MM^3 PER MINUTE AND PER AMPERE - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





R
Graphite -
Steel

R Gr - Ac

GRAPHITE - STEEL 1/4 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1/4 - 80 V

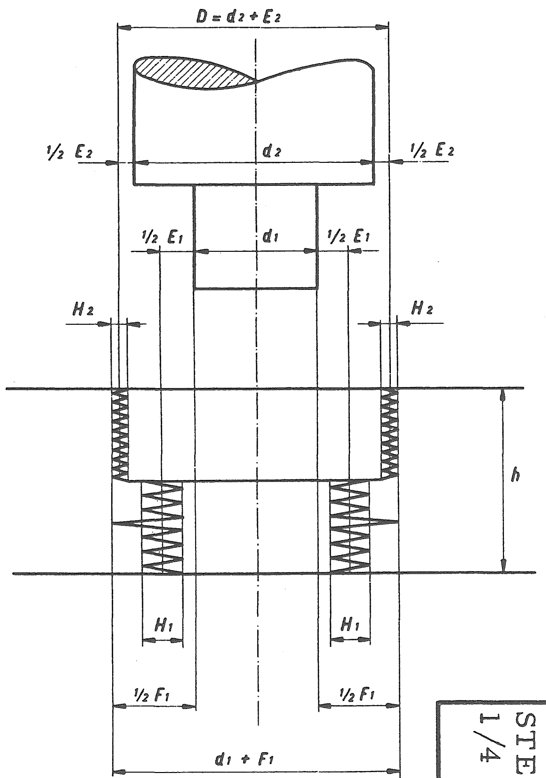
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : Ellor 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	1	1,3	0,040	0,08			24				20	31	7
2	1	1,2	0,046	0,09			26				24	29	8,5
3	2	1,1	0,052	0,098			27				28	27	9,5
4	3	1,1	0,060	0,11			28				31	26	11
5	4	1,0	0,077	0,14			31				39	24	12
6	5	1,0	0,10	0,17			34				45	23	13
7	6	0,9	0,13	0,21			36				49	23	13
8	7	0,9	0,17	0,26			39				48	24	12
9	8	0,9	0,22	0,32			41				41	25	11
10													
11													
12													



GRAPHITE - STEEL 1/4 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

GRAPHITE - STEEL 1/2 - 80 V

ELELCTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1/2 - 80 V

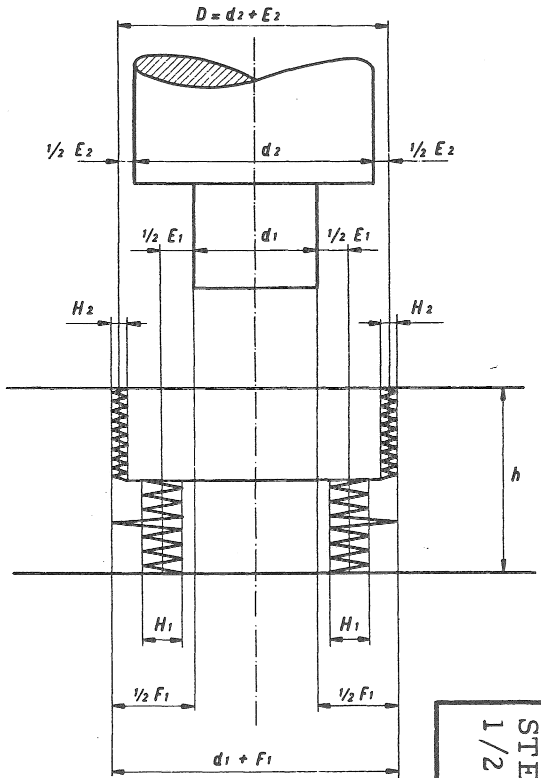
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	2	1,4	0,048	-	0,068	0,10	26				34	27	8
2	2	1,3	0,055	-	0,073	0,108	27				49	26	10
3	2	1,2	0,062	0,117	0,078	0,115	28				59	25	11
4	3	1,1	0,072	0,132	0,088	0,13	30				76	24	13
5	4	1,0	0,092	0,17	0,112	0,16	32				100	22	15
6	5	0,9	0,12	0,21	0,145	0,21	35				130	21	16
7	6	0,9	0,16	0,27	0,185	0,27	37				150	20	16
8	7	0,9	0,20	0,34	0,24	0,35	40				160	20	15
9	8	0,9	0,26	0,42	0,30	0,45	43				155	21	14
10													
11													
12													



GRAPHITE - STEEL 1/2 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

GRAPHITE - STEEL 1 - 80 V

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 1 - 80 V

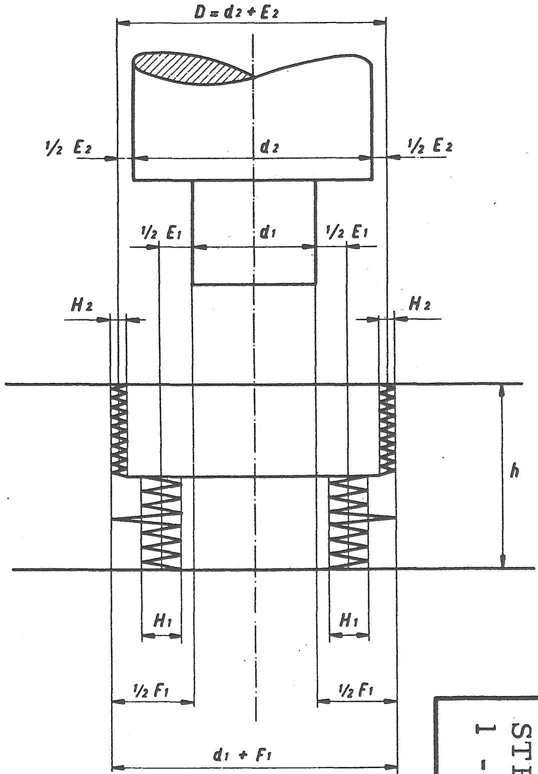
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (...X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (μm)	CH No.	R_t (μm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	3	1,3	0,057				26				60	24	9
2	3	1,1	0,066		0,095	0,17	28				80	23	11
3	3	1,0	0,073	0,14	0,10	0,18	29				105	22	12
4	3	1,0	0,085	0,16	0,115	0,19	31				135	20	14
5	4	1,0	0,11	0,20	0,145	0,215	33				195	19	16
6	5	0,9	0,15	0,26	0,185	0,27	36				280	18	18
7	6	0,8	0,19	0,33	0,24	0,35	39				330	17,5	18
8	7	0,8	0,25	0,42	0,30	0,45	42				350	17	17
9	8	0,8	0,32	0,53	0,39	0,58	44				320	17	16
10	9	0,8	0,42		0,50	0,75	46				270	17	15
11													
12													



GRAPHITE - STEEL 1 - 80 V

CHARMILLES - TECHNOLOGIE ISOPULSE

GRAPHITE - STEEL
2 - 80 V

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Steel MST 65 RC

POWER: 2 - 80 V

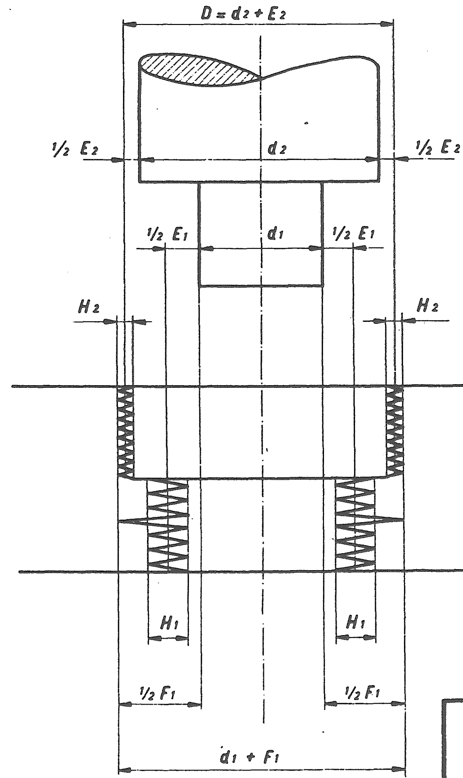
TEST CONDITIONS: D = 20 mm h = 12 mm

DIELECTRIC: Mentor 28 (Esso - Standard) ELECTRODE : E11or 9.

DESIGN FORMULA FOR DIAMETRAL DIMENSIONS OF THE ELECTRODES

Rough and semi-finish electrode: $d_1 = D - F_1$ Finish electrode: $d_2 = D - E_2$

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
			suction		injection		surface finish						
							lateral		frontal				
POS. A	POS. B mini	active electrode length (... X h)	mean diam. sparking gap (mm)	diametral influence limit (mm)	mean diam. sparking gap (mm)	diametral influence limit (mm)	CH No.	R_t (µm)	CH No.	R_t (µm)	metal removal rate (mm^3/min.)	relative volumetric electrode wear (%)	specific metal removal rate (mm^3/min./A)
1	3	1,0	0,070	-	-	-	28				68	21	10
2	3	1,0	0,080	-	-	-	30				125	19	12,5
3	3	1,0	0,090	0,16	-	-	31				180	18	14
4	4	1,0	0,105	0,185	0,15	0,28	32				275	17	16
5	5	1,0	0,137	0,24	0,18	0,30	35				430	16	18
6	5	1,0	0,178	0,32	0,23	0,36	37				550	15	20
7	6	0,9	0,23	0,41	0,30	0,45	40				600	15	20
8	7	0,9	0,30	0,53	0,38	0,58	43				550	15	20
9	8	0,9	0,38	0,67	0,48	0,75	45				470	15	18,5
10	9	0,9	0,50	0,88	0,60	1,0	48				380	15	17
11													
12													



GRAPHITE - STEEL
2 - 80 V

E Graphite- Copper

CHARMILLES - TECHNOLOGIE ISOPULSE

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Electrolytic copper

SUCTION

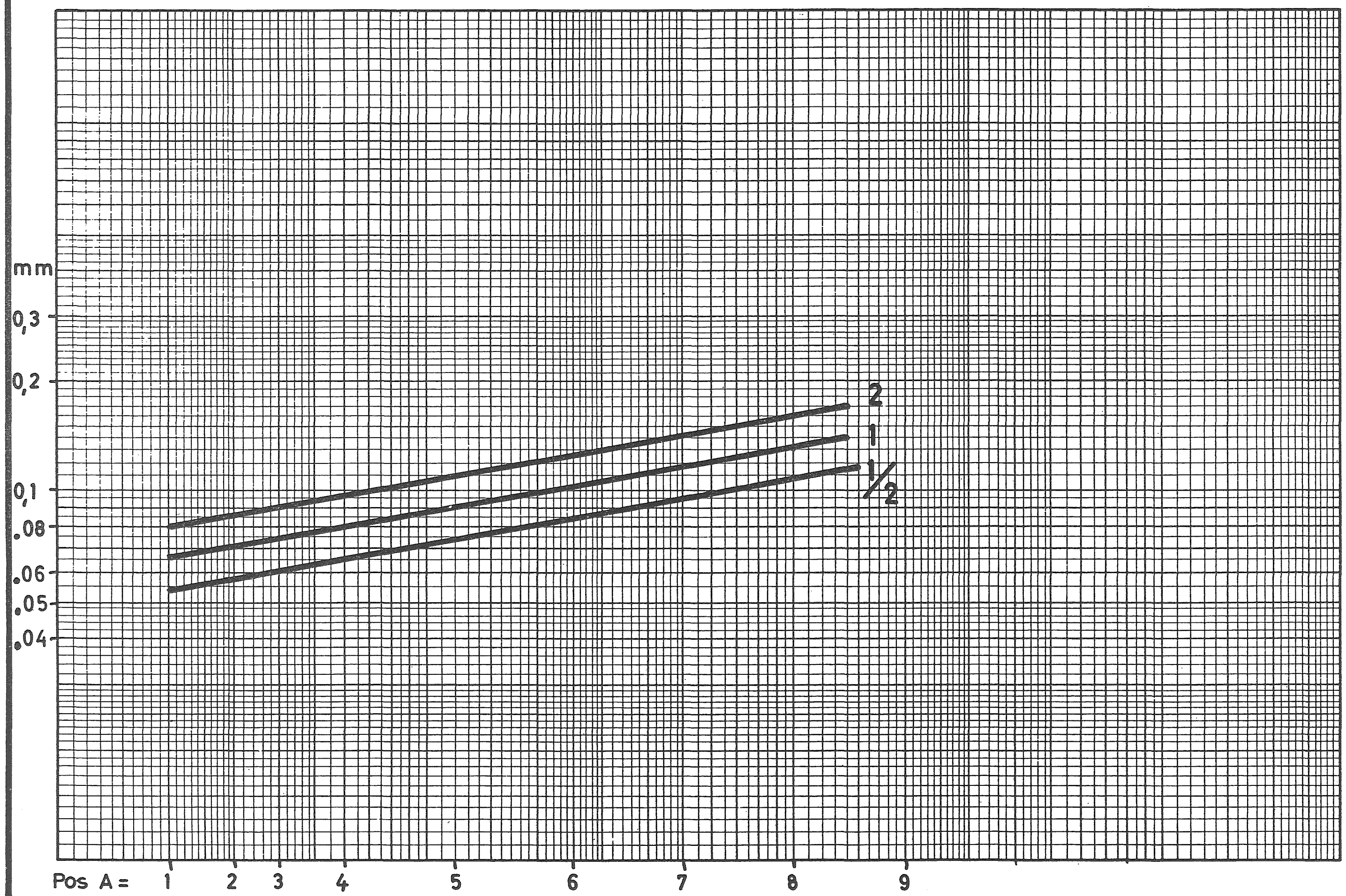
TEST CONDITIONS: D = 22 mm Diameter pre-hole: 20 mm

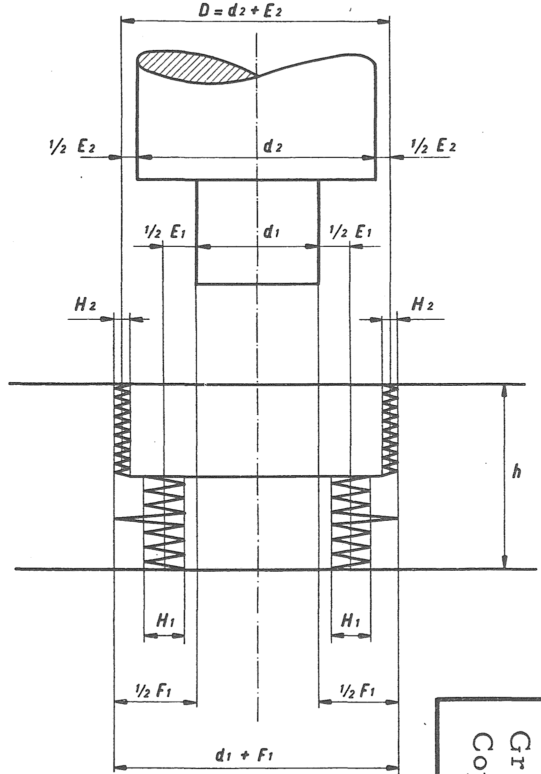
Dielectric: Mentor 28 (ESSO Standard) Graphite type: ELLOR 9

SUCTION: 400 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)

Multiply by 40 to get .001





E Graphite- Copper

E Gr - Cu

CHARMILLES - TECHNOLOGIE ISOPULSE

E'
Graphite-
Copper

ELECTRODE: Graphite

POLARITY ELECTRODE: -

WORKPIECE: Electrolytic copper

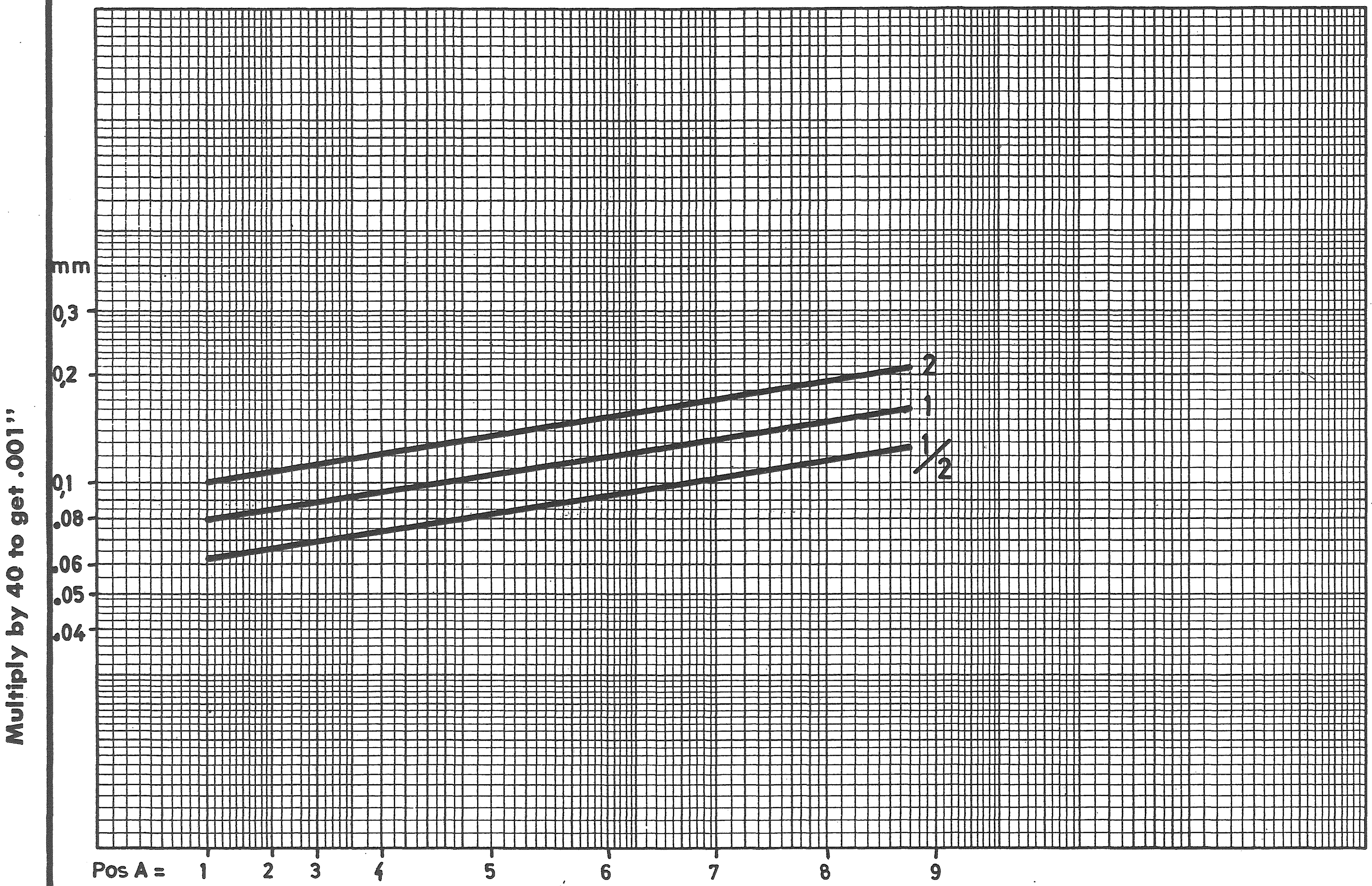
INJECTION

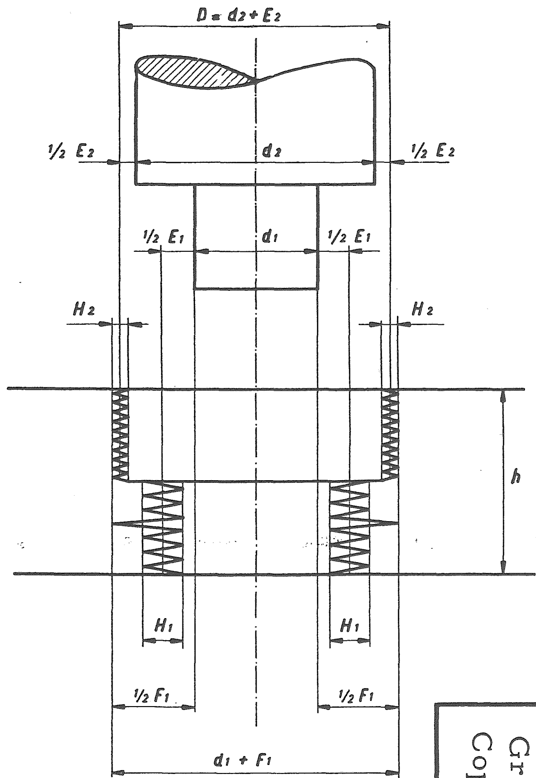
REST CONDITIONS: D = 22 mm Diameter pre-hole: 20 mm

Dielectric: Mentor 28 (ESSO-Standard) Graphite type: ELLOR 9

Injection: 200 gr/cm^2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





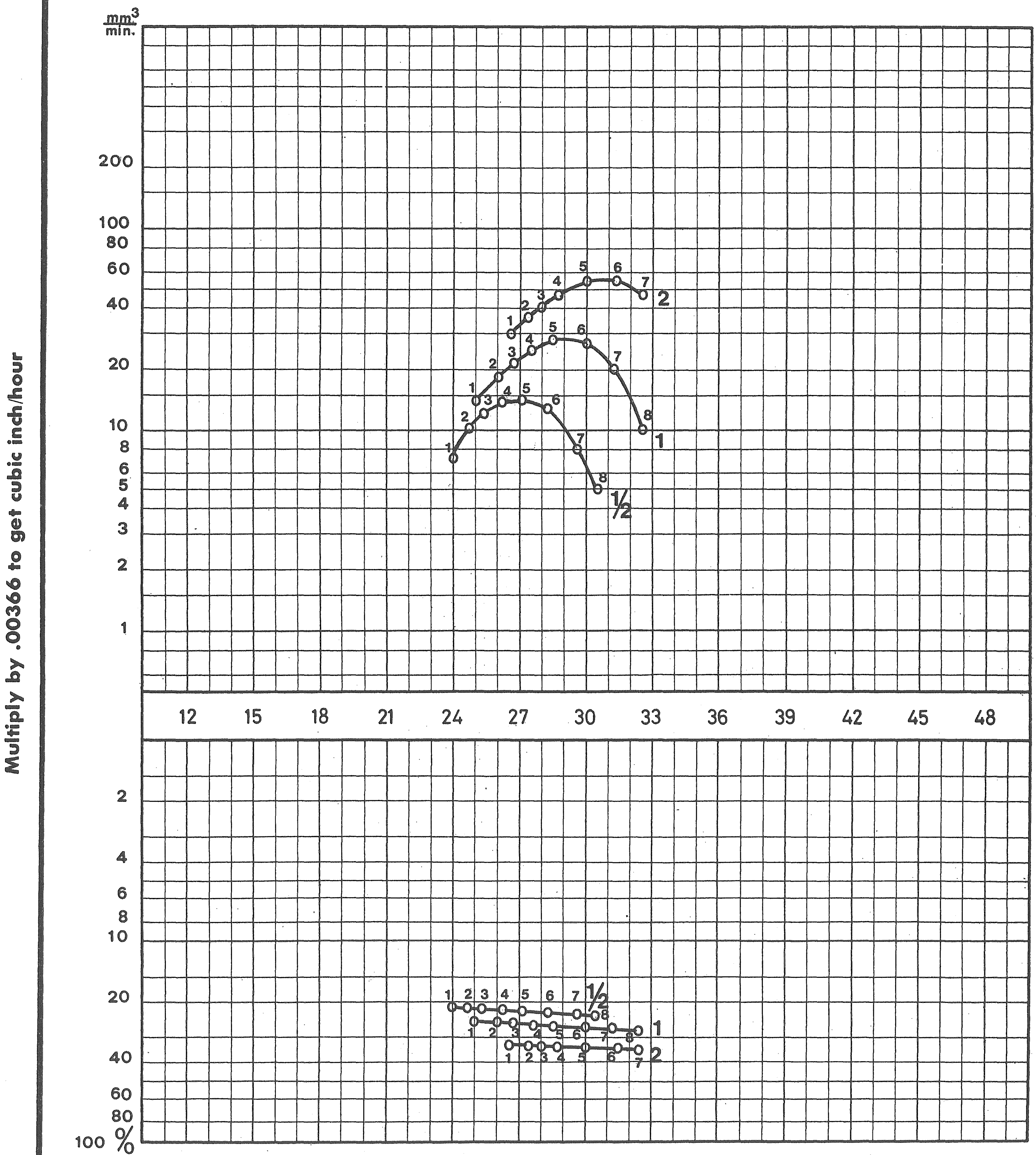
E'
Graphite-
Copper

CHARMILLES
TECHNOLOGIE ISOPULSE

AGMO
Sparkal X -
Carbide G 1

ELECTRODE	:	Sparkal X
POLARITY ELECTRODE	:	negative
WORKPIECE	:	Tungsten-Carbide Stellram G1
TEST CONDITIONS	:	D = 6mm. Diameter pre-hole: 5mm
DIELECTRIC	:	Chevron EDM Fluid 71
INJECTION	:	0,2 kg/cm^2

METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



E

Sparkal X -
tungsten
Carbide G 1

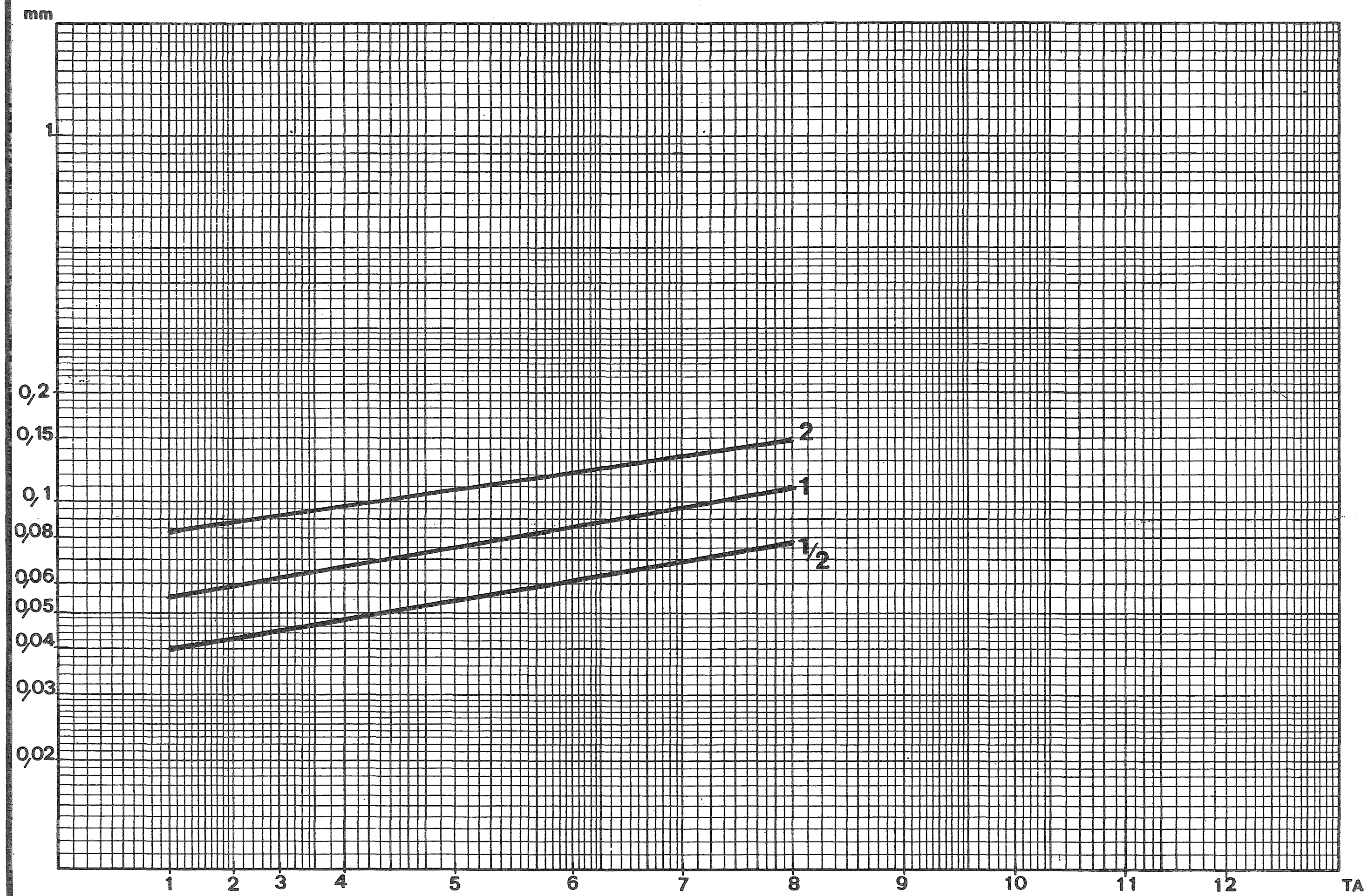
CHARMILLES - TECHNOLOGIE ISOPULSE

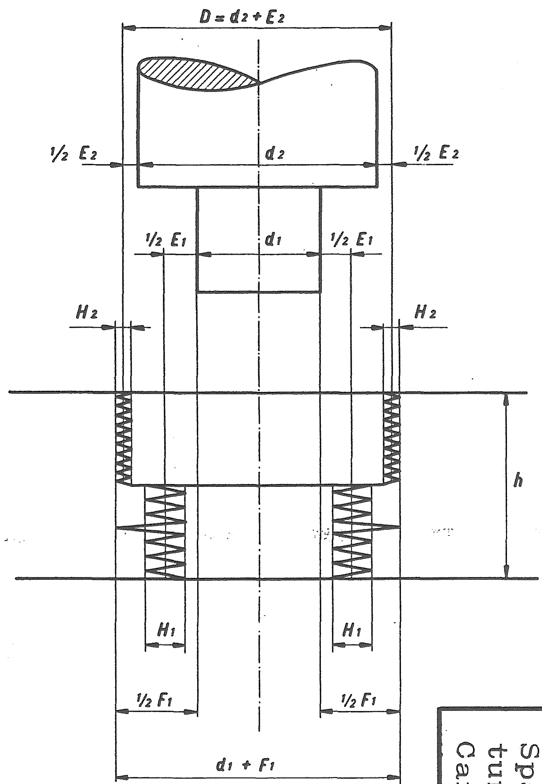
ELECTRODE : Sparkal X
POLARITY ELECTRODE : negative
WORKPIECE : Tungsten-Carbide Stellram G1
SUCTION

TEST CONDITIONS : D = 10mm/ h = 10mm
Dielectric : Chevron EDM Fluid 71
Suction : 0,2 kg/cm2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)

Multiply by 40 to get .001





E
Sparkal X -
tungsten
Carbide G1

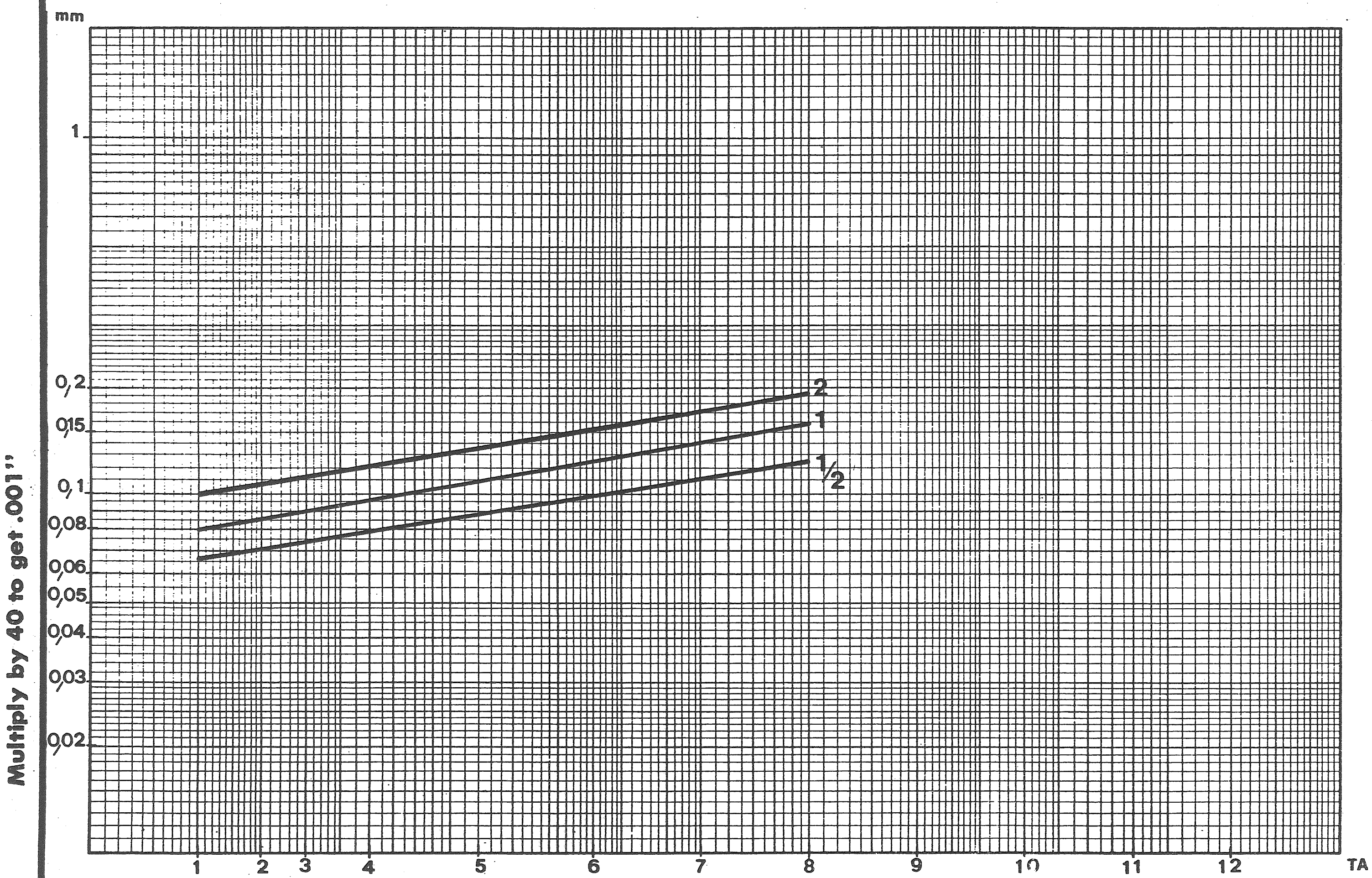
CHARMILLES - TECHNOLOGIE ISOPULSE

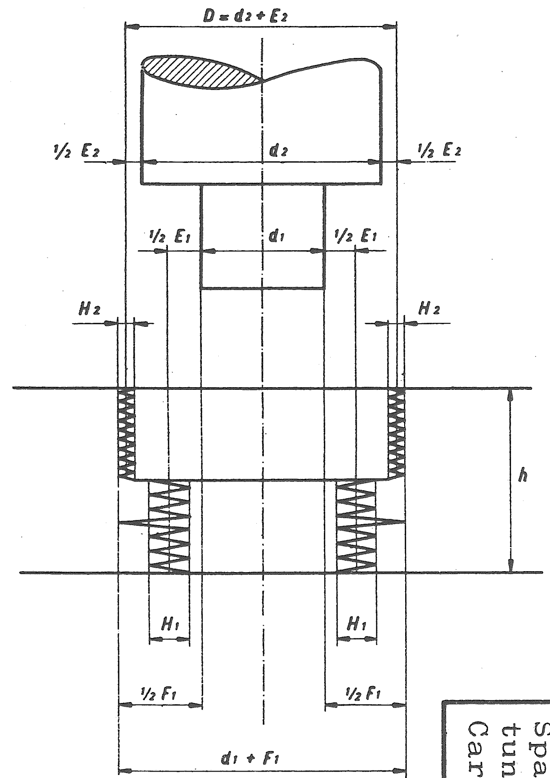
E'
Sparkal X - tungsten Carbide G1

ELECTRODE : Sparkal X
POLARITY ELECTRODE : negative
WORKPIECE : Tungsten-Carbide Stellram G1
INJECTION

TEST CONDITIONS : D = 10mm/ h = 10mm
Dielectric : Chevron EDM Fluid 71
Injection : 0,2 kg/cm2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE DISCHARGE ON-TIME (BUTTON A)





E'
Sparkal X - tungsten Carbide G1

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol. El.	I	mm³/min	%
Acier Steel Stahl	Cuivre Copper Kupfer	Voir technologie See detailed technology Siehe Technologie					
	Graphite Graphit	Voir technologie See detailed technology Siehe Technologie					
	Bronze	1/2	2/1	+	8	7.4	134
		1	11/8	+	20	47.5	50
		2	11/7	+	44	97	41
		1/2	2/1	-	6	8	86
		1	9/8	-	18	31.7	75
	Laiton Brass Messing	1/2	2/1	+	8	8.7	430
		1	11/8	+	20	61	38
		1/2	2/1	-	8	11	50
		1	9/7	-	20	97	35
		2	9/7	-	40	248	28.5
	Sparkal A	1/2	2/1	+	8	37	47
		1	11/6	+	24	230	0
		2	12/6	+	48	420	0
		1/2	2/1	-	6	12	25
		1	8/6	-	20	60	0
	Sparkal X	1/2	2/1	+	8	25	18
		1	11/9	+	20	99	0
		2	11/8	+	44	190	0
	Fonte Cast Iron Gusseisen	1/2	2/1	+	6	21	33
		1	8/7	+	18	103	17
		2	8/7	+	26	212	20
		1/2	2/1	-	5	10	75
		1	7/8	-	14	16	200
	Aluminium	1/2	2/1	+	8	4	400
		1	11/8	+	20	168	5.3
		2	11/7	+	46	383	13
		1	11/8	-	20	0	∞
	Zamac	1/2	2/1	+	8	0	∞
		1/2	2/1	-	8	3.2	67
		1	8/6	-	22	145	47
		2	8/8	-	24	206	29
	Acier Steel Stahl	1/2	2/7	+	1	1	32
		1/2	7/9	+	1.5	3	20
		1	6/8	+	4	20	6.5
		2	5/7	+	7	44	9.5

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol	I	mm³/min	%
Aluminium	Cuivre Copper Kupfer	1 2 1/2	9/6 9/5 2/1	+ + -	20 47 10	515 1270 65	0 0 4.3
	Graphite Graphit	1 2 1/2	9/7 9/5 2/2	+ + -	20 45 5	508 1015 156	0 0 12
	Bronze	1 2 1/2	9/7 9/5 2/1	+ + -	20 46 10	470 1450 166	9.8 4.8 18
	Laiton Brass Messing	1/2 1 2	2/1 9/6 9/5	- - -	10 20 46	152 860 1800	11 5.4 7.7
	Sparkal A	1 2 1/2	9/6 9/5 2/1	+ + -	20 44 8	625 1340 101	0 0 5.5
	Sparkal X	1 2 1/2	9/7 9/6 2/1	+ + -	20 46 10	512 1160 40.5	0 0 3.3
	Fonte grise Cast Iron Gusseisen	1/2 1 2	2/1 9/7 9/6	+ + +	10 20 40	31 630 1310	9 4 3.5
	Aluminium	1/2 1 2 1/2	2/1 8/6 8/6 2/1	+ + + -	6 20 40 6	4.6 535 965 4.6	70 8.7 7.2 100

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	arc.	A/B	Pol	I	mm^3/min	%
Bronze	Cuivre Copper Kupfer	1/2	2/1	+	8	20	87
		1	9/7	+	20	138	6.7
		2	9/7	+	46	460	18
		1/2	2/1	-	8	31	9.1
		1	9/7	-	20	166	5.5
		2	9/6	-	48	625	1.5
	Graphite Graphit	1/2	2/2	+	6	8.4	66
		1	9/7	+	20	92	0
		2	9/8	+	30	147	3.1
		1/2	2/4	-	4	33.6	66
		1	9/7	-	20	480	7.7
		2	9/6	-	44	765	3.6
	Bronze	1/2	2/1	+	8	14	140
		1	9/6	+	20	105	200
		2	9/6	+	46	295	166
		1/2	2/1	-	8	23	56
		1	9/6	-	20	212	50
		2	9/6	-	46	432	64
	Laiton Brass Messing	1/2	2/1	+	8	25	122
		1	11/8	+	20	147	50
		1/2	2/1	-	8	39	36
		1	11/8	-	20	355	18
		2	11/8	-	46	1030	22
	Sparkal A	1/2	2/1	+	8	40	46
		1	9/7	+	20	308	3.6
		2	9/6	+	46	870	3.9
		1/2	2/1	-	10	62	14
		1	9/7	-	20	268	4.2
	Sparkal X	1/2	2/1	+	8	36	7
		1	8/6	+	20	140	1.8
		2	8/5	+	49	445	4.5
		1/2	2/1	-	8	31	0
		1	8/6	-	20	125	1.2
		2	8/6	-	32	195	2.6
	Fonte Cast Iron Gusseisen	1/2	2/1	+	8	28	50
		1	9/7	+	20	101	91
		2	10/7	+	48	230	180
		1/2	2/1	-	8	32	32
		1	9/7	-	20	65	240
		2	10/7	-	46	120	346
	Aluminium	1/2	2/1	+	8	28	440
		1	9/7	+	20	74	740
		2	9/6	+	48	184	900
		1/2	2/1	-	8	17	500
		1	9/7	-	20	37	∞

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol.	I	mm³/min	%
Cuivre Copper Kupfer	Cuivre Copper Kupfer	1/2	2/1	+	8	2.8	400
		1	7/5	+	20	18.6	90
		2	9/6	+	45	50	100
		1/2	2/1	-	8	10	21
		1	7/5	-	20	17	107
		2	9/6	-	45	50	100
	Graphite Graphit	1/2	1/4	-	4	14	80
		1	6/7	-	6	50	60
		2	9/9	-	25	120	42
	Bronze	1/2	2/1	+	8	5.6	550
		1/2	2/1	-	8	18	120
		1	5/3	-	20	46	220
		2	9/7	-	46	83	550
	Laiton Brass Messing	1/2	2/1	+	10	4.6	∞
		1/2	2/1	-	10	27.6	64
	Sparkal A	1/2	2/1	+	8	10	250
		1	7/4	+	20	41	100
		2	7/4	+	44	130	130
		1/2	2/1	-	8	18	15
		1	11/8	-	20	0	∞
	Sparkal X	1/2	2/1	+	8	5.5	100
		1	7/4	+	20	15	56
		2	8/5	+	46	58	23.5
		1/2	2/1	-	8	20	12.5
		1	11/8	-	20	1.7	150
	Fonte Cast Iron Gusseisen	1/2	2/1	+	8	8.4	67
		1	7/7	+	10	23	100
		2	7/8	+	14	55	100
		1/2	2/1	-	8	10	21
		1	7/5	-	20	17	107

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol	I	mm^3/min	%
Fonte Cast Iron Gusseisen	Cuivre Copper Kupfer	1/2 1 2 1/2	2/1 11/8 11/8 2/1	+ + + -	8 20 40 8	14 180 368 8.4	100 0 0 50
	Graphite Graphit	1/2 1 1/2 1 2	2/4 8/8 2/2 8/8 8/8	+ + - - -	3 12 5 12 12	5.6 110 7.5 222 248	75 0 37 15 15
	Bronze	1/2 1 2 1/2 1	2/1 9/7 10/7 2/1 11/8	+ + + - -	8 20 46 8 16	14 152 460 17 78	280 64.5 28 150 106
	Laiton Brass Messing	1/2 1 1/2 1 2	2/1 11/8 2/1 11/8 11/8	+ + - - -	8 20 8 20 50	11.2 179 5.6 225 535	200 20 150 32 40
	Sparkal A	1/2 1 2 1/2 1	2/1 11/8 11/8 2/1 11/8	+ + + - -	8 20 32 5 20	11.2 176 390 5.6 136	100 0 0 50 6.5
	Sparkal X	1/2 1 2 1/2	2/2 8/8 11/7 2/3	+ + + -	5 13 30 5	8.2 100 225 4.1	25 0 0 25
	Fonte Cast Iron Gusseisen	1/2 1 2 1/2	2/4 7/9 7/9 2/4	+ + + -	5 3 6 5	4.2 27.5 46 1.4	130 50 40
	Aluminium	1/2 1 1/2 1	2/1 8/7 2/1 11/7	+ + - -	8 14 5 20	17 87.5 11 0	500 90 580 ∞
	Zamac	1 1	11/8 11/8	+ -	20 20	120 100	220 600

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ	A/B	Pol	I	mm^3/min	%
Graphite Graphit	Cuivre Copper Kupfer	1/2	4/5	+	4	7	145
		1	9/9	+	10	30	70
		2	10/9	+	30	46	200
		1/2	4/4	-	6	8	20
		1	6/5	-	14	19	30
		2	6/6	-	18	30	28
	Graphite Graphit	1/2	2/5	+	2	4.2	100
		1	6/8	+	4	14	33
		2	6/8	+	6	37	75
		1/2	2/5	-	3	3	150
		1	6/8	-	4	4.6	300
		2	6/8	-	6	28	135
	Bronze	1/2	2/1	+	8	11.2	950
		1	9/7	+	20	28	∞
		2	9/9	+	20	64	∞
		1/2	2/1	-	8	8.4	66
		1	9/7	-	20	18	∞
	Laiton Brass Messing	1/2	2/4	+	5	13.8	335
		1	9/7	+	20	46	∞
		2	9/9	+	22	57	900
		1/2	2/1	-	8	4.2	133
		1	9/7	-	20	0	∞
	Sparkal A	1/2	2/5	+	3	8.4	166
		1	7/7	+	10	31	145
		2	8/9	+	14	55	316
		1/2	2/5	-	2.5	8.4	66
		1	7/6	-	12	10	80
		2	7/6	-	20	18.5	70
	Sparkal X	1/2	2/4	+	4	8	100
		1	7/8	+	7	17	60
		2	7/8	+	12	38	82
		1/2	2/2	-	7	8.1	0
		1	7/8	-	7	3.4	50
	Fonte Cast Iron Gusseisen	1/2	2/4	+	4	4.2	166
		1	8/9	+	12	37	625
		2	8/8	+	16	46	660
		1/2	2/4	-	3	4.2	133
		1	8/8	-	12	4.6	∞
	Aluminium	1/2	2/3	+	5	11.2	∞
		1	9/8	+	16	64.5	∞
		2	8/8	+	21	83	∞
		1/2	2/2	-	6	4.2	935
		1	9/7	-	20	0	∞

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol	I	mm^3/min	%
Laiton Brass Messing	Cuivre Copper Kupfer	1/2	2/1	-	10	55	8.3
		1	9/6	-	20	165	0
		2	9/6	-	45	438	5.3
	Graphite Graphit	1/2	2/1	+	8	14	17
		1/2	2/4	-	5	46	30
		1	9/7	-	20	508	4.5
		2	10/8	-	24	600	2
	Bronze	1/2	2/1	-	8	37	62
		1	9/7	-	20	110	167
		2	9/6	-	46	230	210
	Laiton Brass Messing	1/2	2/1	-	10	92	30
		1	9/7	-	20	230	24
		2	9/6	-	46	508	41
	Sparkal A	1/2	2/1	-	10	67	12.5
		1	9/7	-	20	202	0
		2	9/7	-	40	505	4
	Sparkal X	1/2	2/1	-	10	42	5.9
		1	6/4	-	20	142	1.2
		2	6/3	-	36	267	0
	Fonte grise Cast Iron Gusseisen	1/2	2/1	-	10	73.5	28
		1	1/1	-	16	138	30
		2	1/2	-	22	202	35
	Aluminium	1/2	2/1	-	10	27.5	335
		1	1/1	-	16	46	340
		2	1/2	-	22	92	400

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ	A/B	Pol	I	mm^3/min	%
Sparkal A	Cuivre Copper Kupfer	1/2 1 2	2/1 2/1 1/1	- - -	10 18 22	25 67.5 101	17 25 21
	Graphite Graphit	1/2 1 2	2/4 6/7 6/8	- - -	4 8 8	15 42 50.5	57 60 50
	Bronze	1/2 1 2	2/1 1/1 1/2	- - -	10 15 22	20 42 75.5	186 180 200
	Laiton Brass Messing	1/2 1 2	2/1 7/5 7/5	- - -	10 20 40	29.5 47 126	100 280 200
	Sparkal A	1/2 1 2	2/1 5/3 6/2	- - -	10 20 45	38 101 272	22 17 23
	Sparkal X	1/2 1 2	2/1 3/1 5/2	- - -	10 20 40	27 60 135	10 9 8
	Fonte grise Cast Iron Gusseisen	1/2 1 2	2/1 1/1 1/2	- - -	9 15 20	37 42 92.5	90 120 80
	Aluminium	1/2 1 2	2/1 1/1 1/2	- - -	8 16 20	17 21 42	500 480 850

CHARMILLES - TECHNOLOGIE

Pièce Werkstück	Electrode	Circ.	A/B	Pol	I	mm³/min	%
Sparkal X	Cuivre Copper Kupfer	1/2 1 2	1/1 1/1 1/2	- - -	9.5 15 22	4.5 12.2 16.2	100 100 100
	Graphite Graphit	1/2 1 2	2/4 1/5 1/6	- - -	4 5 5	8 11 11	100 112 100
	Sparkal A	1/2 1 2	2/1 5/3 5/3	- - -	10 20 34	5.4 16 22	100 134 213
	Sparkal X	1/2 1 2	2/1 5/3 5/3	- - -	7 17 28	2.9 10 20	40 42 42
	Fonte grise Cast Iron Gusseisen	1/2 1 2	2/4 1/6 1/6	+ + +	3.5 4 6	1.7 3.4 5.1	250 300 300

TECHNOLOGIE ISOPULSE POUR LE CARBURE DE TUNGSTENE

1. Généralités

Le métal dur est un matériau fritté dont la teneur en carbure de tungstène est dominante. Ses additifs tels que TiC, Ta Nb C, le liant, en général du Co, la pression et la température de frittage lui confèrent les caractéristiques mécaniques spécifiques. Le nombre de nuances obtenues par variation des additifs et des conditions de frittage est presque illimité.

Pour effectuer nos recherches portant sur l'usinage par étincelage de ces carbures, nous en avons choisi quatre dont les compositions sont très différentes les unes des autres. Les quatre nuances ont été usinées avec des électrodes en cuivre, graphite et cupro-tungstène (Sparkal X) dans les deux polarités.

L'enlèvement de matière en mm^3/min., l'usure de l'électrode en % et l'enlèvement spécifique en mm^3/min. A sont représentés sous forme de courbes en fonction de la durée des décharges (bouton A du générateur Isopulse). La puissance utilisée (2 x 1/2 ou 4 x 1/2) correspond à la puissance maximale des générateurs Isopulse de 25 resp. 50 A.

2. Composition et caractéristiques des carbures examinés

IMPULSE - TECHNOLOGIE FÜR WOLFRAMKARBID

1. Allgemeines

Das Hartmetall ist ein gesintertes Material, bei dem der Gehalt an Wolframkarbid vorherrscht. Die Zusätze wie TiC, Ta Nb C, das Bindemittel, meistens Co, Sintertemperatur und -druck geben diesem Material die spezifischen mechanischen Eigenschaften. Die Zahl der Qualitäten, die durch Kombination der Zusätze und der Konditionen für das Sintern erhalten werden können, ist fast unendlich gross.

Für unsere Bearbeitungsversuche mittels Funkenerosion haben wir 4 Qualitäten ausgewählt, die voneinander sehr verschieden sind. Diese wurden mit Elektroden aus Kupfer, Graphit und Wolframkupfer (Sparkal X) in beiden Polaritäten bearbeitet.

Die Abtragsleistung in mm^3/min., der Elektrodenverschleiss in % und die spezifische Abtragsleistung in mm^3/min. A sind in den graphischen Darstellungen in Funktion der Entladungsdauer (Knopf A des Isopulse-Generators) aufgezeichnet. Die verwendete Leistung (2 x 1/2 oder 4 x 1/2) entspricht der maximalen Leistung des Isopulse-Generators von 25 resp. 50 A.

2. Zusammenstellung und Eigenschaften der untersuchten Karbide

ISOPULSE TECHNOLOGY FOR TUNGSTEN-CARBIDE

1. Generalities

Hard metal is a sintered material having a predominating tungsten carbide content. Its specific mechanical characteristics results from additives such as TiC, Ta Nb C and the usual binding agent Co, as also from the temperature and the pressure under which sintering takes place. The number of qualities that may be obtained by variation of the additives and of the sintering conditions is nearly unlimited.
Our investigations in connection with the machinability of tungsten carbides by electro-erosion methods were undertaken with four widely differing qualities. All four qualities were successively machined using electrodes made of copper, graphite and tungsten-copper (Sparkal X), both under direct and reversed polarity conditions.
The removal rate, expressed in mm^3 per minute, the electrode wear in % and the specific removal rate in mm^3 per minute and per ampere are indicated by curves traced in function of the discharge on-time (knob "A" of the Isopulse Generator). The power applied (2 x 1/2 or 4 x 1/2) corresponds to the maximum power of, respectively, the 25 Amp. and the 50 Amp. Isopulse generators.

2. Composition and characteristics of the carbides investigated

	No	Composition / Zusammensetzung / Composition			Dureté / Härte / Hardness	Ténacité / Festigkeit / Tenacity	Densité / Dichte / Density
		TiC %	Ta Nb C %	Co %	RC	kg/mm^2	g/cm^3
S 0	1526	18	5	7	83	135	10,9
H 3	1822	1	2	3	82	145	15,1
G 5	1474	0	1	20	69	320	13,7
G 1	285	0	1	6	79	200	14,8

3. Conditions d'essai

Electrode cylindrique ∅ 20 mm.
Avant-trou dans la pièce ∅ 5 mm.
Liquide diélectrique: Mentor 28 (Esso-Standard)
Arrosage par injection au travers de la pièce.

3. Versuchsbedingungen

Zylindrische Elektrode ∅ 20 mm.
Vorgebohrtes Loch im Werkstück ∅ 5 mm.
Dielektrische Flüssigkeit: Mentor 28 (Esso-Standard)
Dielektrikumzufuhr durch Einspritzen durch das Werkstück.

3. Conditions of test

Cylindrical electrode, ∅ = 20 mm.
Forebore in the piece ∅ = 5 mm.
Dielectric liquid - Mentor 28 (Esso-Standard)
Flushing by injection through the piece.

CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
S0	+

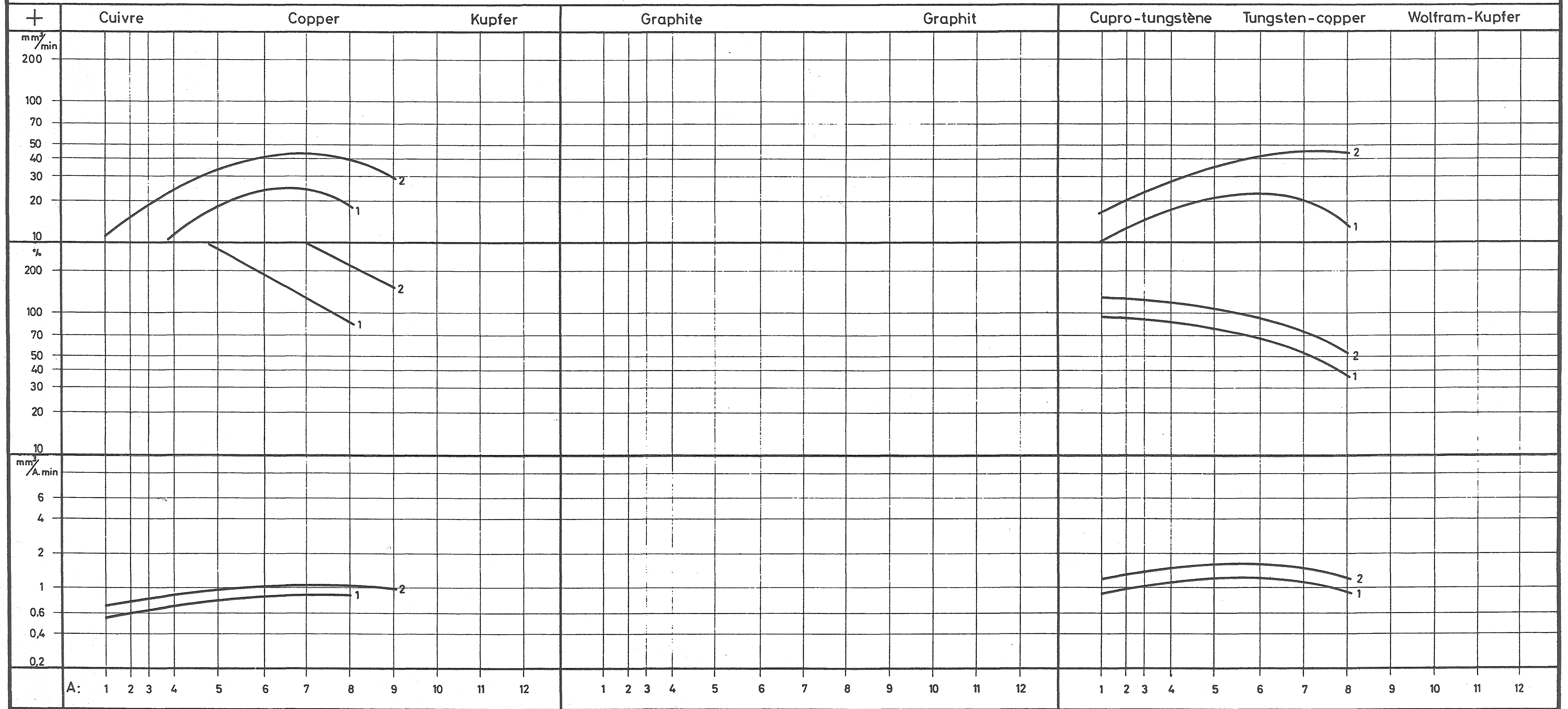
PIECE: Carbure de Tungstène
STELLRAM S 0
POLARITE ELECTRODE: positive
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM S 0
POLARITY ELECTRODE: positive
Removal rate, electrode wear, specific removal rate - in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM S 0
POLARITÄT ELEKTRODE: positiv
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)

Multiply by .00366 to get cubic inch/hour

Multiply by .00366 to get cubic inch/hour and ampere



CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
S0	—

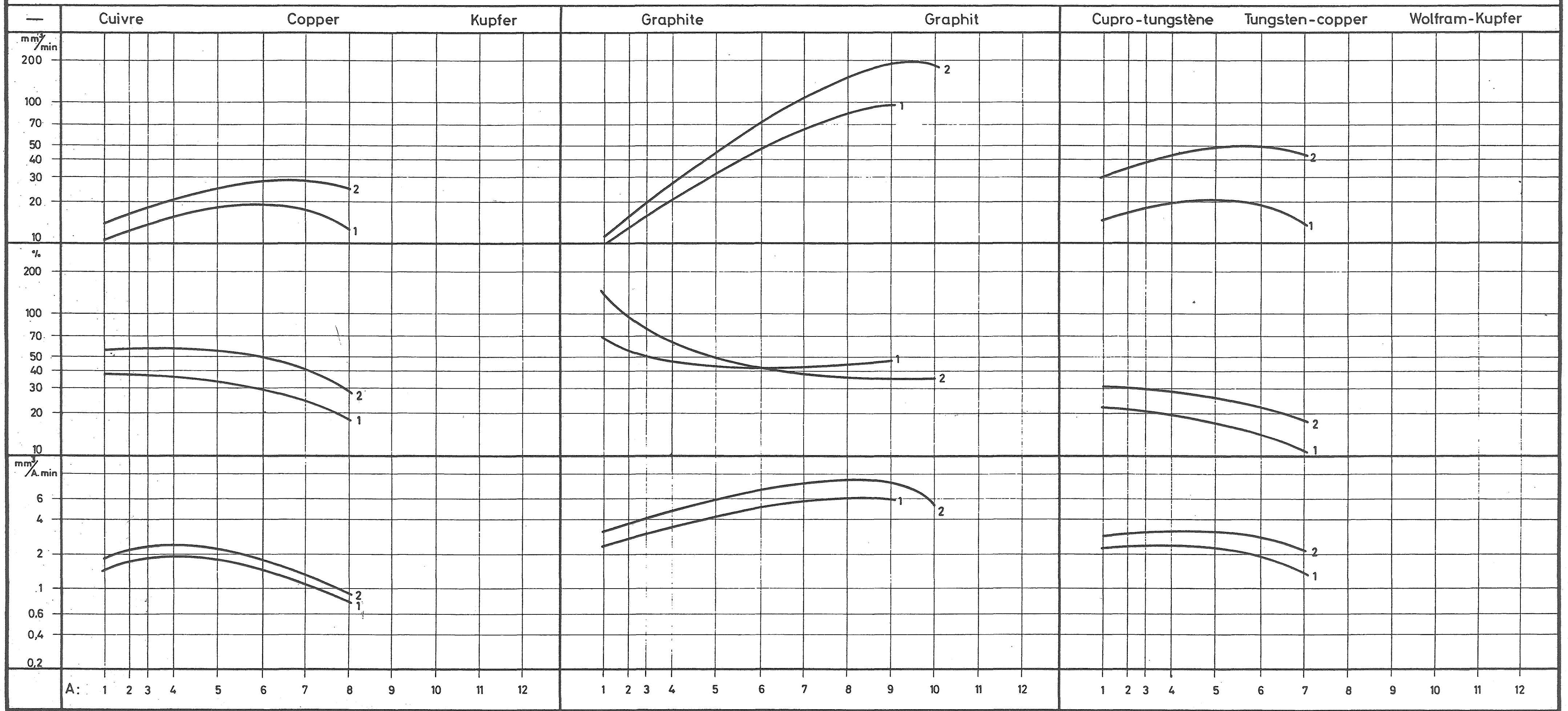
PIECE: Carbure de Tungstène
STELLRAM S 0
POLARITE ELECTRODE: négative
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM S 0
POLARITY ELECTRODE: negative
Removal rate, electrode wear, specific removal rate-in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM S 0
POLARITÄT ELEKTRODE: negativ
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)

Multiply by .00366 to get cubic inch/hour

Multiply by .00366 to get cubic inch/hour and ampere



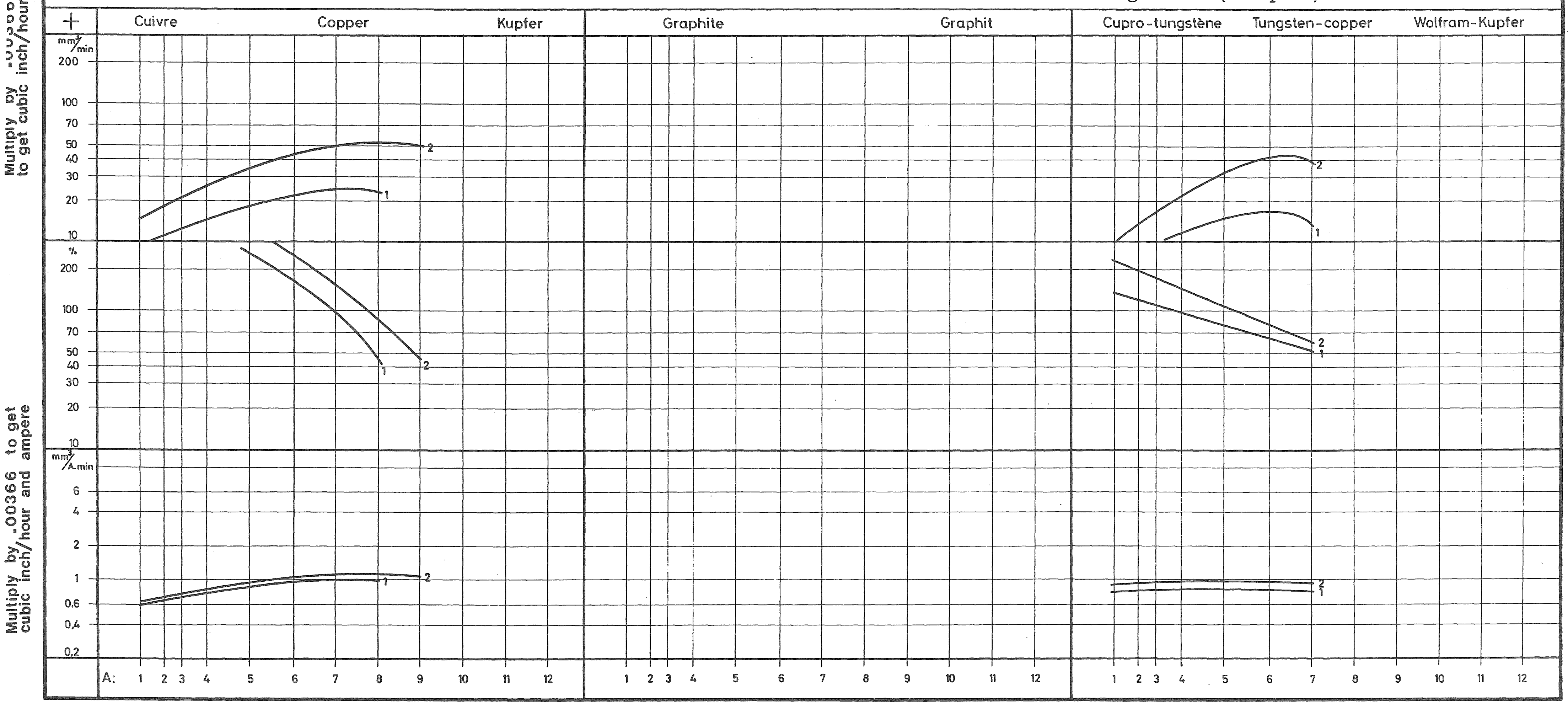
CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM H3 | ELECTRODE +

PIECE: Carbure de Tungstène
STELLRAM H 3
POLARITE ELECTRODE: positive
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM H 3
POLARITY ELECTRODE: positive
Removal rate, electrode wear, specific removal rate- in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM H 3
POLARITÄT ELEKTRODE: positiv
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)



CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
H3	—

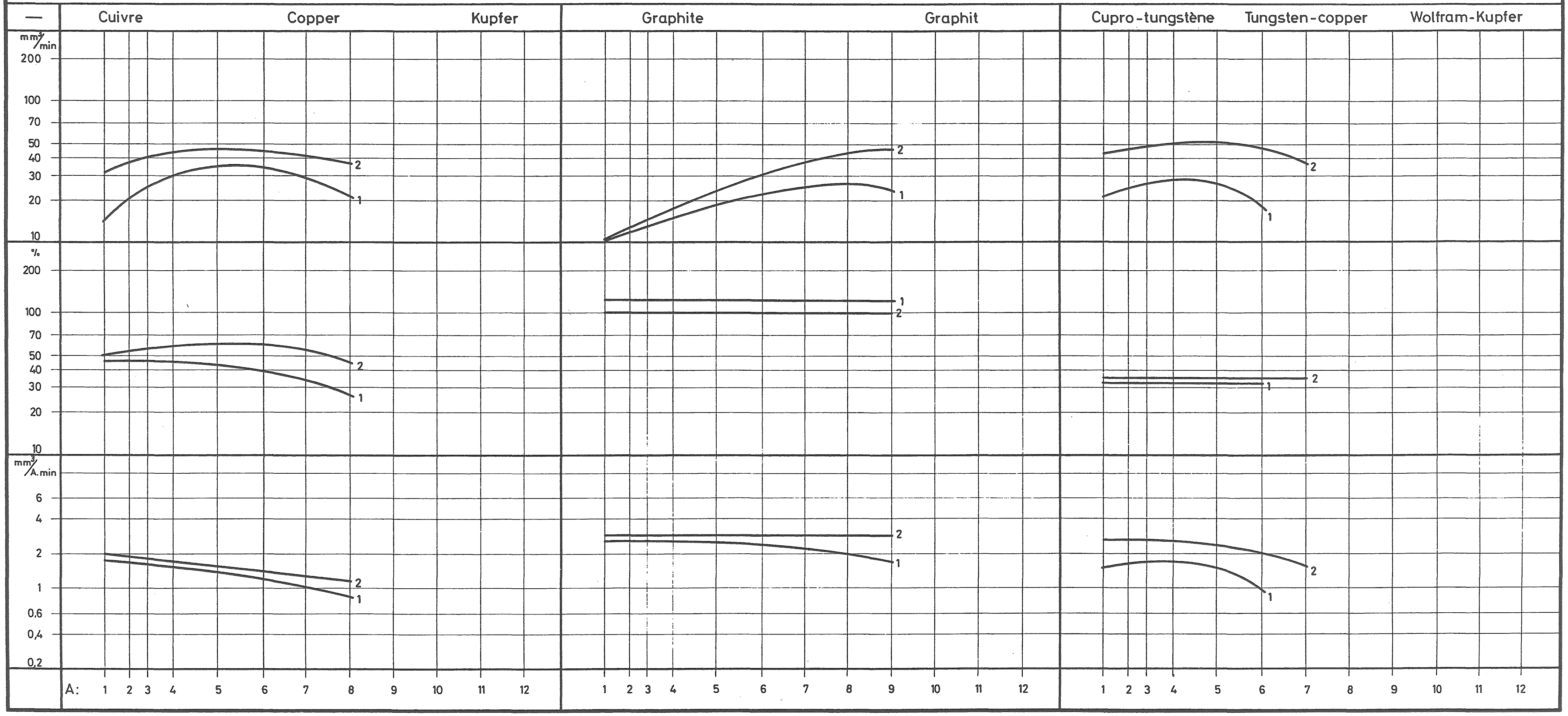
PIECE: Carbure de Tungstène
STELLRAM H 3
POLARITE ELECTRODE: négative
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten Carbide
STELLRAM H 3
POLARITY ELECTRODE: negative
Removal rate, electrode wear, specific removal rate-in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM H 3
POLARITÄT ELEKTRODE: negativ
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)

Multiply by -.00366 to get cubic inch/hour

Multiply by -.00366 to get cubic inch/hour and ampere



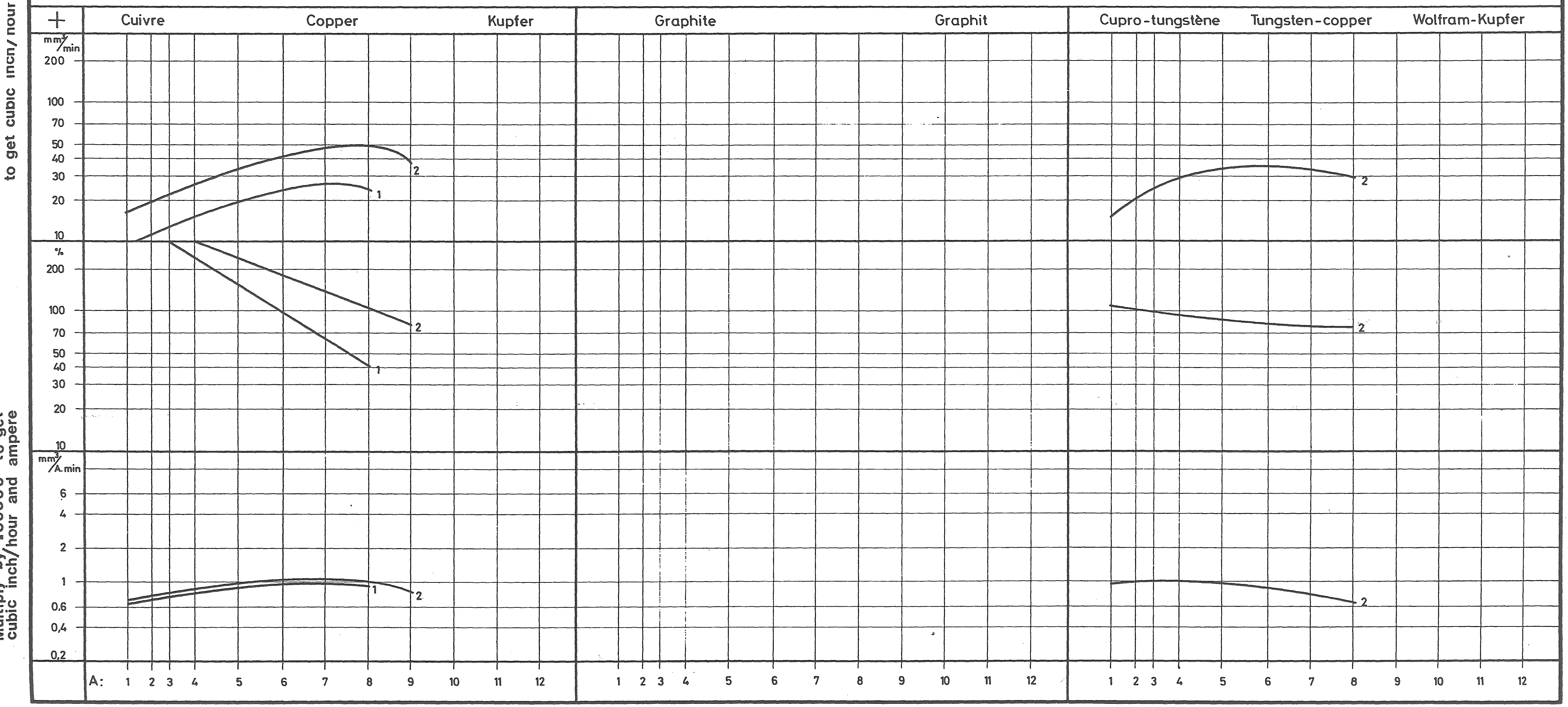
CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
G1	+

PIECE: Carbure de Tungstène
STELLRAM G 1
POLARITE ELECTRODE: positive
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM G 1
POLARITY ELECTRODE: positive
Removal rate, electrode wear, specific removal rate-in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM G 1
POLARITÄT ELEKTRODE: positiv
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)



CHARMILLES - TECHNOLOGIE ISOPULSE

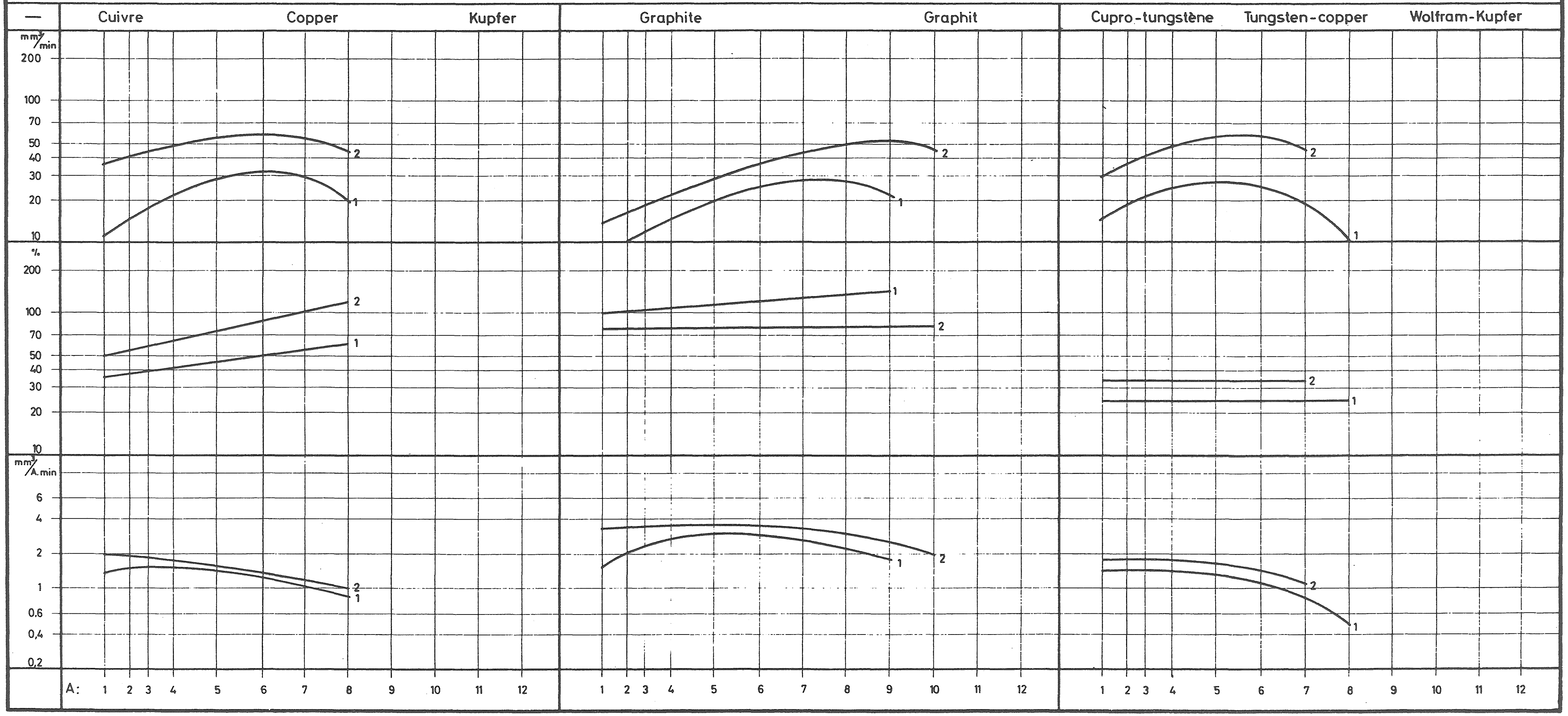
STELLRAM	ELECTRODE
G1	—

PIECE: Carbure de Tungstène
STELLRAM G 1
POLARITE ELECTRODE: négative
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM G 1
POLARITY ELECTRODE: negative
Removal rate, electrode wear, specific removal rate-in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM G 1
POLARITÄT ELEKTRODE: negativ
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)

Multiply by .00366 to get cubic inch/hour



Multiply by .00366 to get cubic inch/hour and ampere

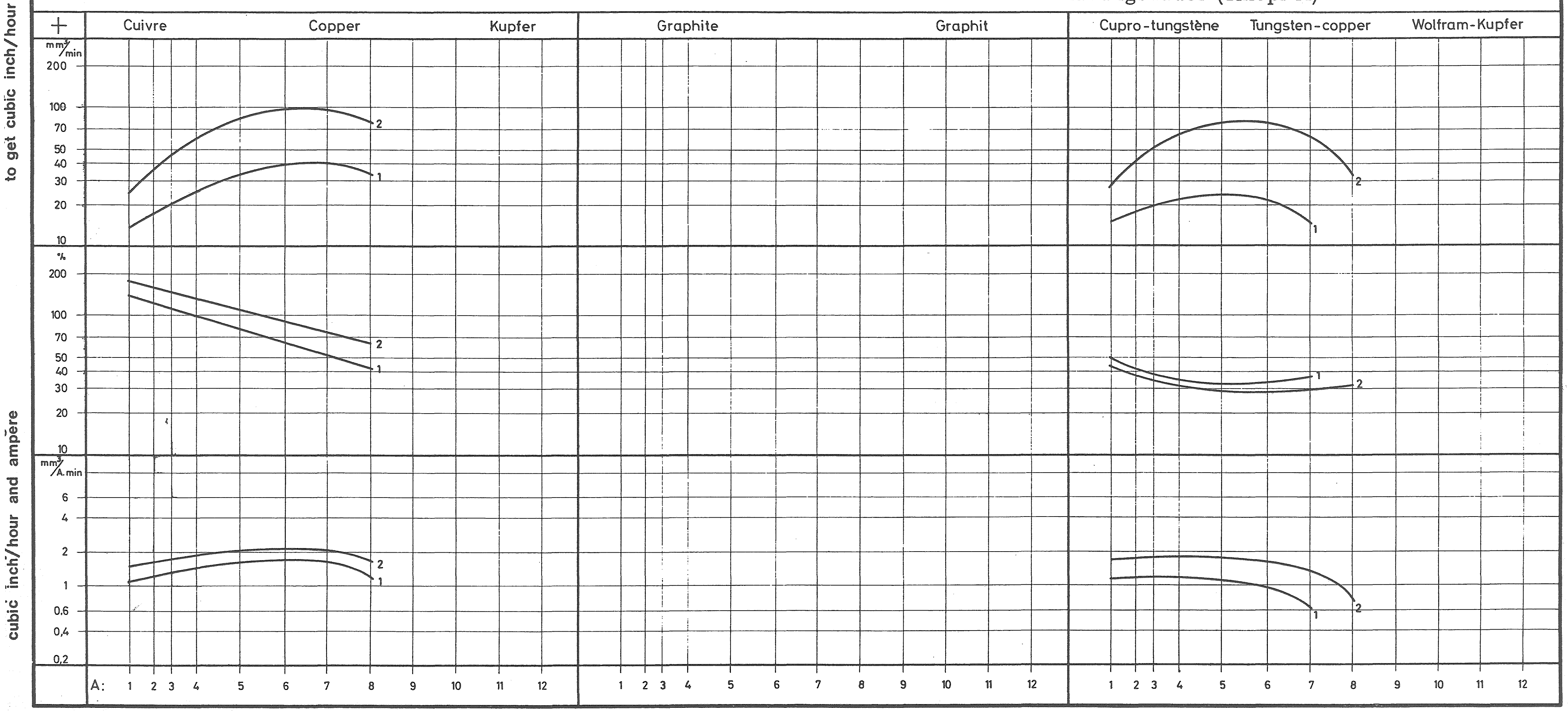
CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
G5	+

PIECE: Carbure de Tungstène
STELLRAM G 5
POLARITE ELECTRODE: positive
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM G 5
POLARITY ELECTRODE: positive
Removal rate, electrode wear, specific removal rate - in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM G 5
POLARITÄT ELEKTRODE: positiv
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)



CHARMILLES - TECHNOLOGIE ISOPULSE

STELLRAM	ELECTRODE
G5	—

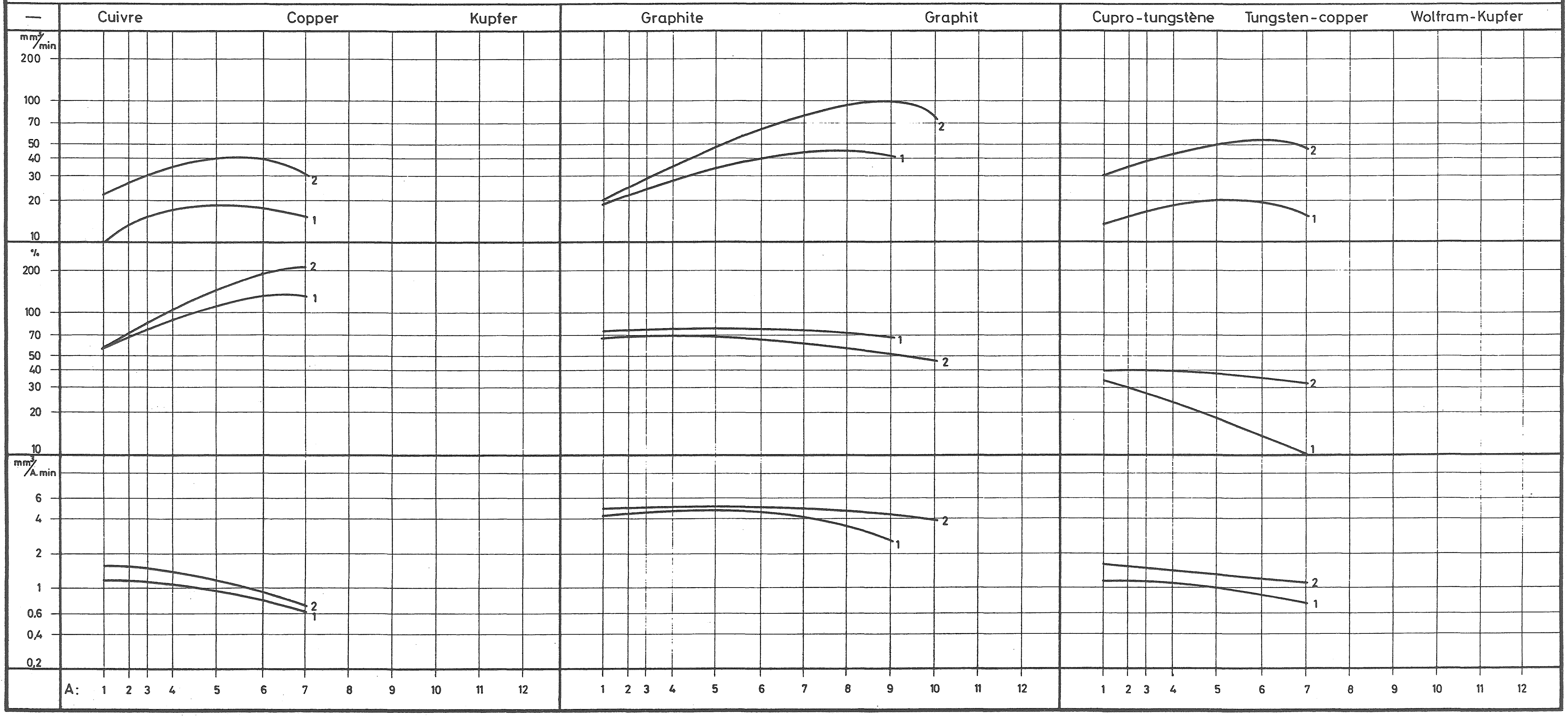
PIECE: Carbure de Tungstène
STELLRAM G 5
POLARITE ELECTRODE: négative
Enlèvement, usure, enlèvement spécifique - en fonction de la durée des décharges (Bouton A)

PIECE: Tungsten-Carbide
STELLRAM G 5
POLARITY ELECTRODE: negative
Removal rate, electrode wear, specific removal rate-in function of the discharge on time (Button A)

WERKSTÜCK: Hartmetall
STELLRAM G 5
POLARITÄT ELEKTRODE: negativ
Abtragsleistung, Elektrodenverschleiss, spezifische Abtragsleistung - in Funktion der Entladungsdauer (Knopf A)

Multiply by .00366 to get cubic inch/hour

Multiply by .00366 to get cubic inch/hour and ampere



TECHNOLOGY

MICROFIN POWER SUPPLY

Test conditions

Electrodes	: Copper
Dielectric	: Kerozene
Flushing	: Suction 500 Gr.
Work piece	: MST Steel 65 RC Pre-hole diam. 14 mm thickness 10 mm

Pulsation of electrode : none

Capacity C	Power I	Diam. gap undercut of finishing electrode	Diam. undercut of roughing electrode mm.	Surface finishes in micrometers RT	CLA
1	3	0,025 mm	0,030	2,8	0,34
2	4	0,028 mm	0,035	3,4	0,44
3	5	0,032 mm	0,045	5,0	0,62
4	6	0,036 mm	0,055	7,0	0,90
5	7	0,040 mm	0,065	9,5	1,20
6	8	0,044 mm	0,075	12	1,60
7	9	0,047 mm	0,090	16	2.00
8	10	0,050 mm	0,100	19	2,50

REMARK : We recommend to use Kerozene as dielectric while working with MICROFIN Power Supply

CHARMILLES

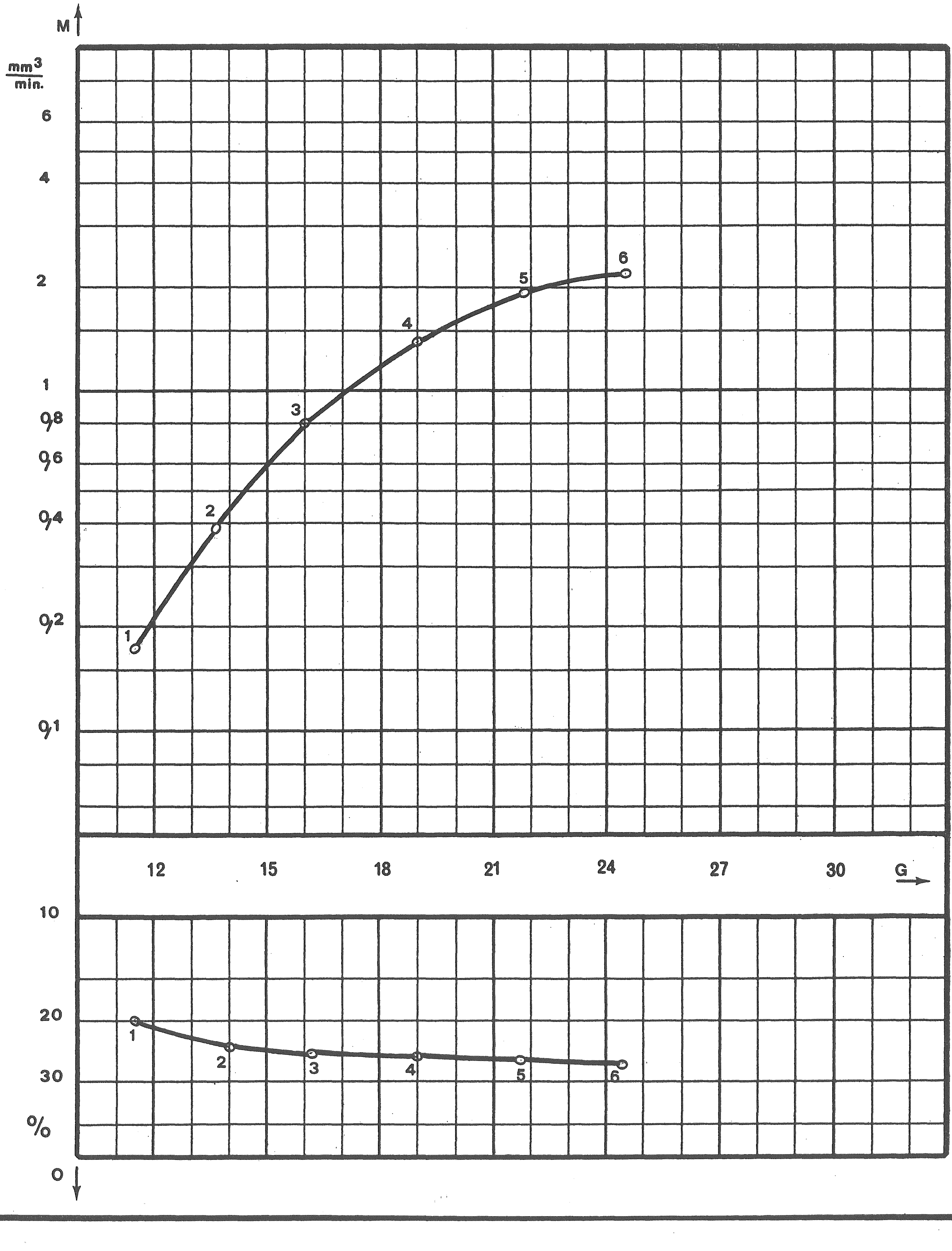
TECHNOLOGIE MICROFIN P12 P25

AGMO | Copper-Steel

ELECTRODE : Copper
POLARITY ELECTRODE : negative
WORKPIECE : Steel

TEST CONDITIONS : D = 6mm / Diameter pre-hole: 5mm
DIELECTRIC : Chevron Fluid EDM 71

METAL REMOVAL RATE IN MM^3 PER MINUTE AND RELATIVE VOLUMETRIC ELECTRODE WEAR IN % - IN FUNCTION OF THE CHARMILLES NORMALIZED LATERAL SURFACE FINISH



CHARMILLES - TECHNOLOGIE MICROFIN P12 - P25

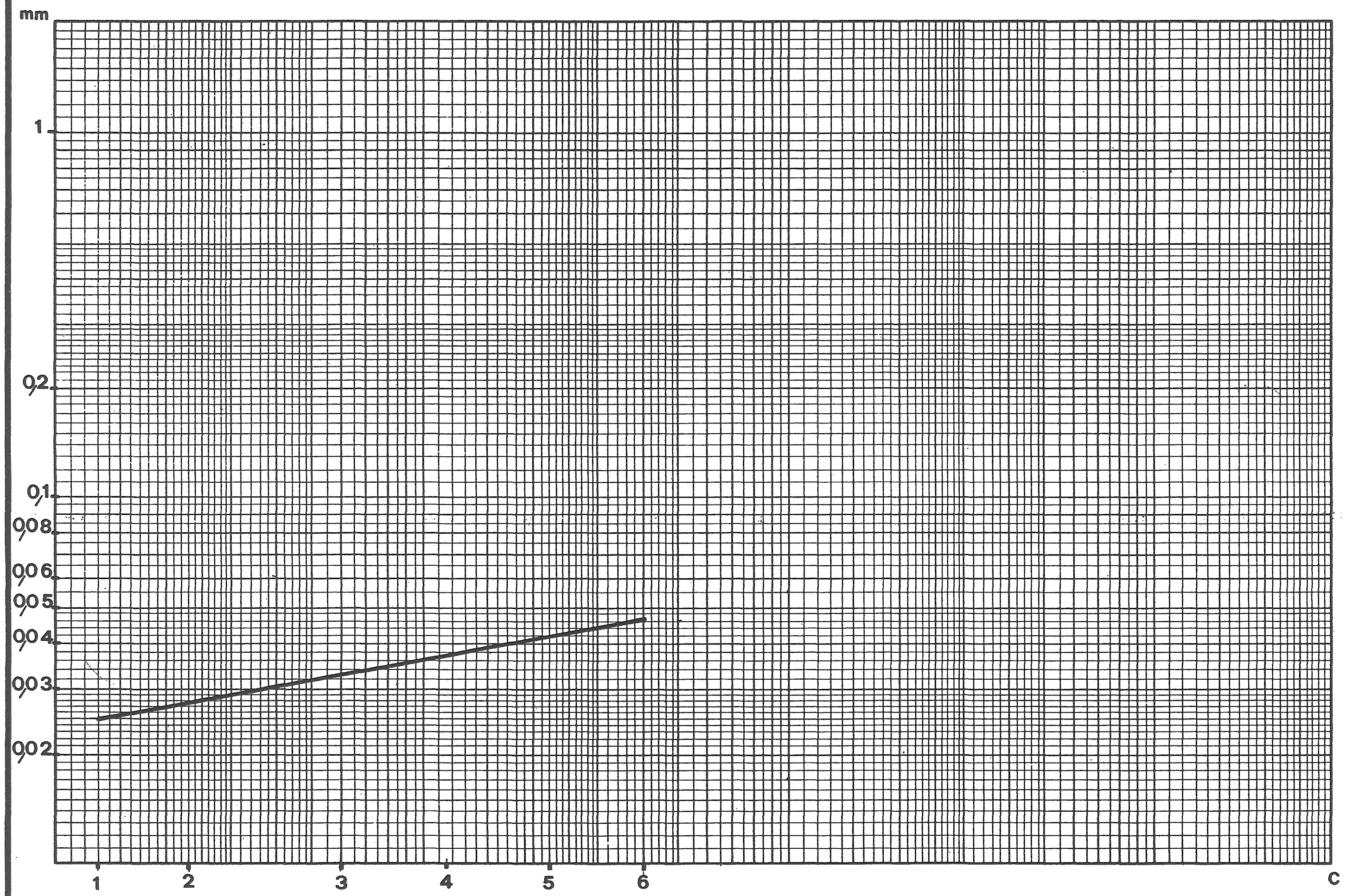
E
MICROFIN
Copper -
Steel

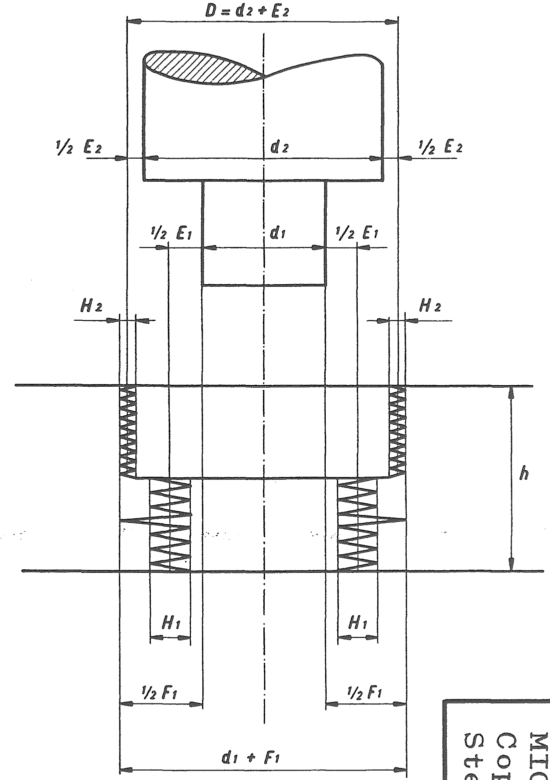
ELECTRODE : Copper
POLARITY ELECTRODE : negative
WORKPIECE : Steel MST 65RC

TEST CONDITIONS : D = 6mm
Diameter pre-hole: 5mm
Dielectric : Chevron EDM Fluid 71
Suction : 0,2 kg/cm2

MEAN DIAMETRAL SPARKING GAP IN MM - IN FUNCTION OF THE POSITION OF THE SWITCH OF THE CAPACITY "C"

Multiply by 40 to get .001"





E
MICROFIN
Copper -
Steel

CHARMILLES - TECHNOLOGIE MICROFIN P12 P25

MICROFIN
Copper -
Steel

ELECTRODE : Copper
POLARITY ELECTRODE : negative
WORKPIECE : Steel MST 65 RC

TEST CONDITIONS : D= 6 mm
Diameter pre-hole: 5mm
Dielectric : Chevron EDM Fluid 71

A	B	C	E	F	E'	F'	G	H	K	L	M	O	R
Pos. Cap. "C"	Position "I"	active electrode length (...Xh)	mean diam. sparking gap (mm)	diametral influence limit (mm)			surface finish lateral CH		surface finish frontal CH		metal removal rate (mm³/min.)	relative volumetric electrode wear (%)	
1	7	0,5	0,025	0,030			12		12		0,2	20	
2	8	0,5	0,028	0,035			14		14		0,35	23	
3	10	0,5	0,033	0,045			16		16		0,8	25	
4	10	0,5	0,037	0,055			19		19		1,4	25	
5	10	0,5	0,042	0,065			22		22		1,9	26	
6	10	0,5	0,047	0,075			24		24		2,1	26	
7													
8													
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10													
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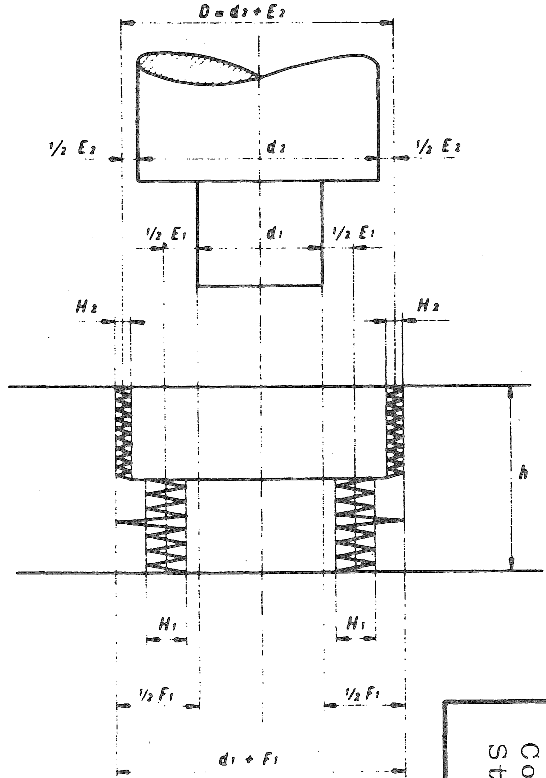
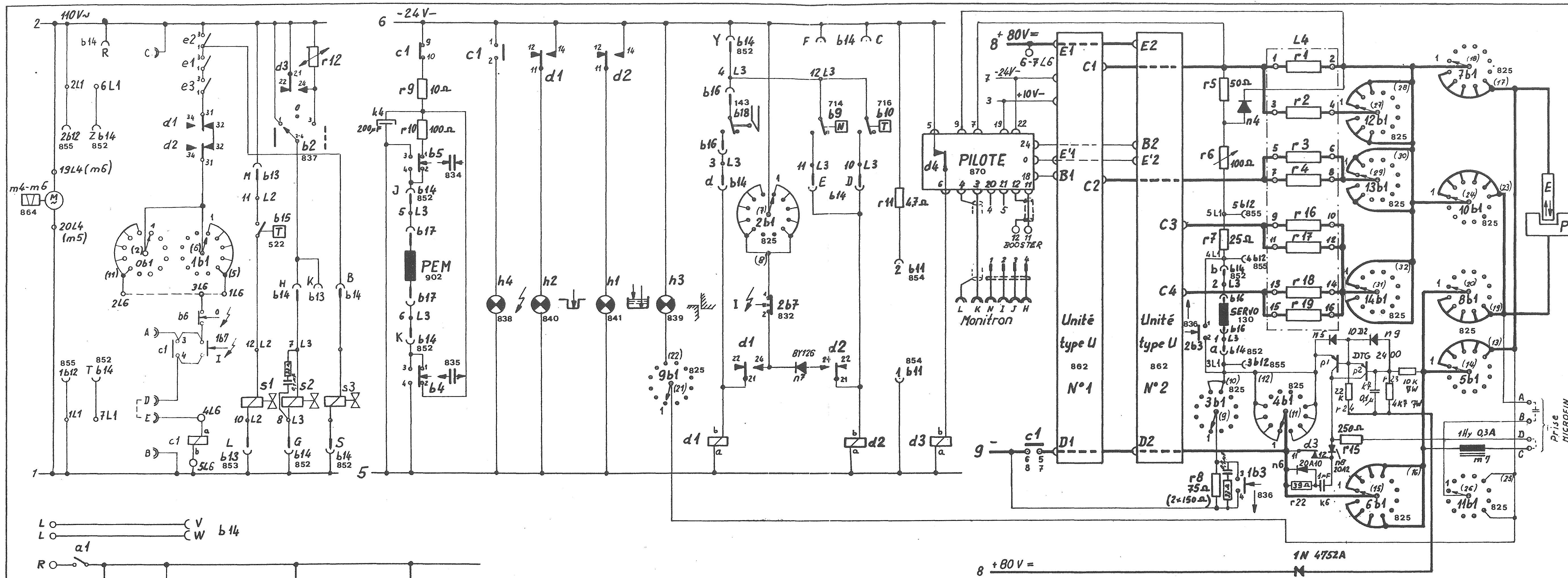
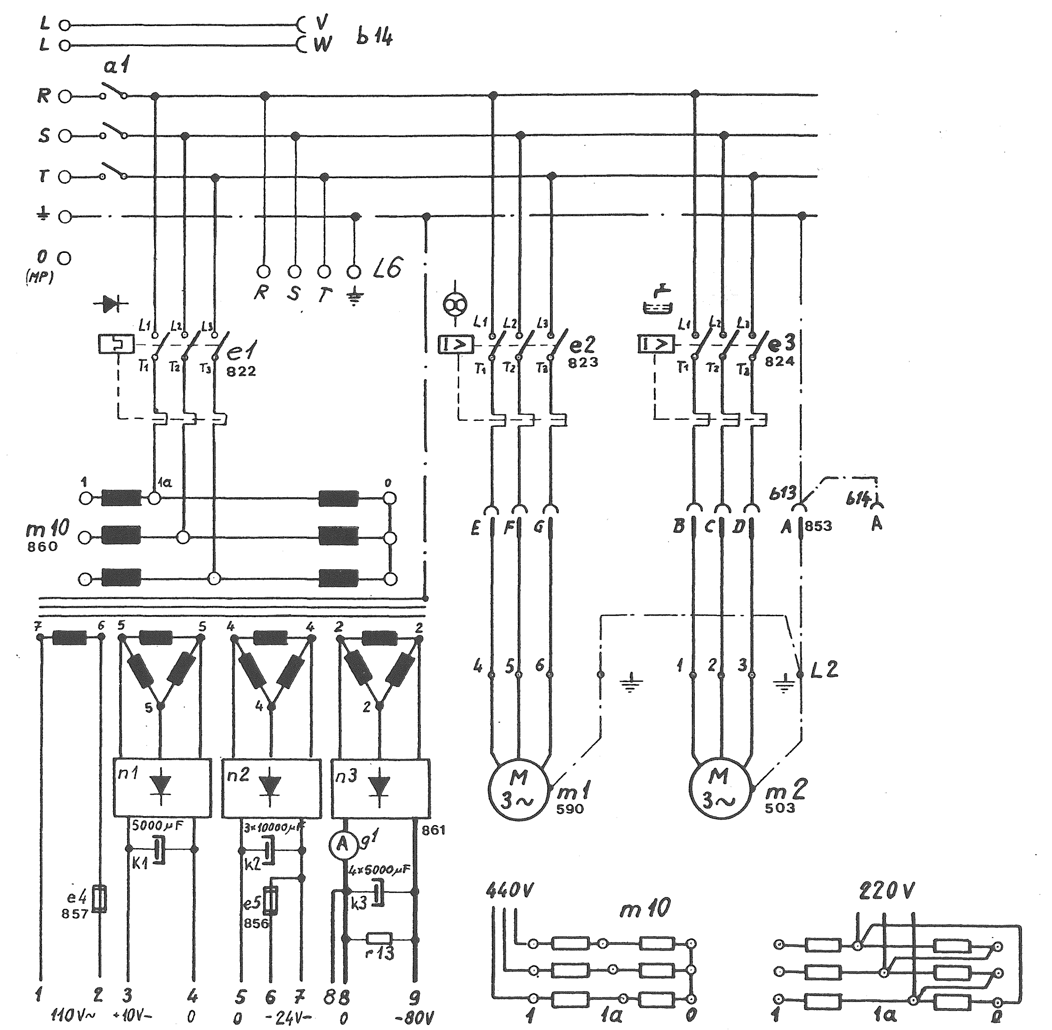
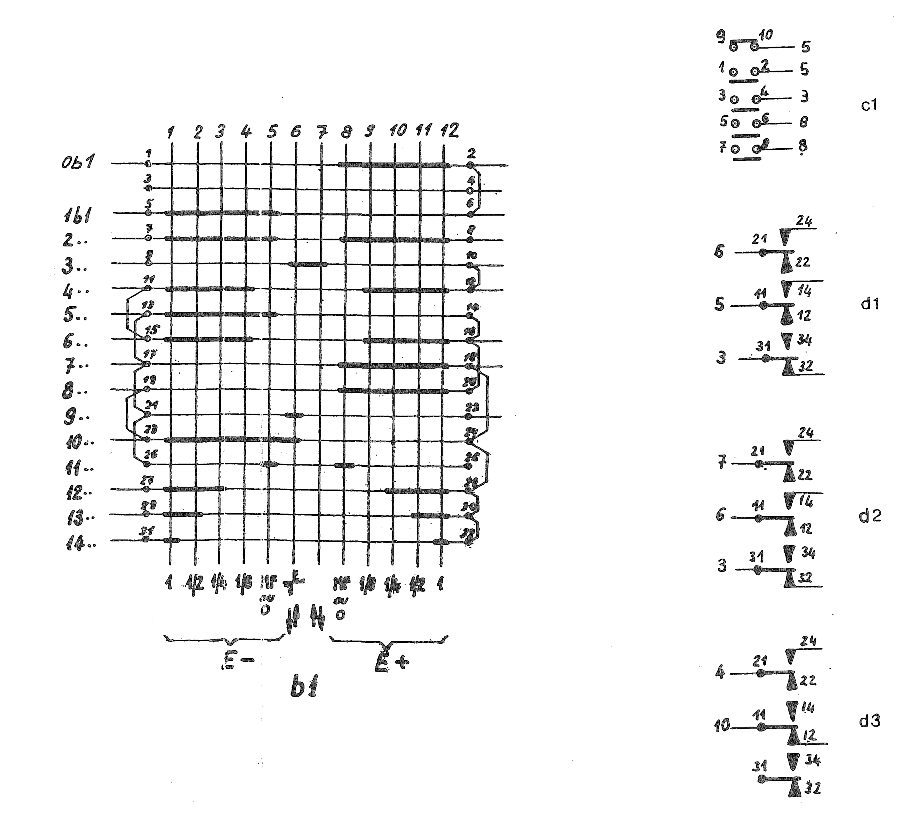


MICROFIN
Copper -
Steel





Contacts



Légende

m1	Pompe hydraulique Hydraulic Pump Hydraulische Pumpe	c1	Générateur Generator
m2	Pompe diélectrique Dielectric Pump Dielectrik Pumpe	s1	Réfrigérateur Refrigerator Wärmeaustauscher
d1	Arrêt profondeur Depth stop Tiefeneinstellung	s2	Injection Spülung
d2	Niveau-Thermostat Diélectric fluid level and Thermostat Dielektrikumstand und Thermostat	s3	Décharge Discharge Entladung
d3	Pulsateur Pulsator	—)—	Prise 14 pôles

P 25 avec / with / mit **Microfin**

SCHEMA GENERAL

GENERAL DIAGRAM

HAUPTSCHEMA

CHARMILLES

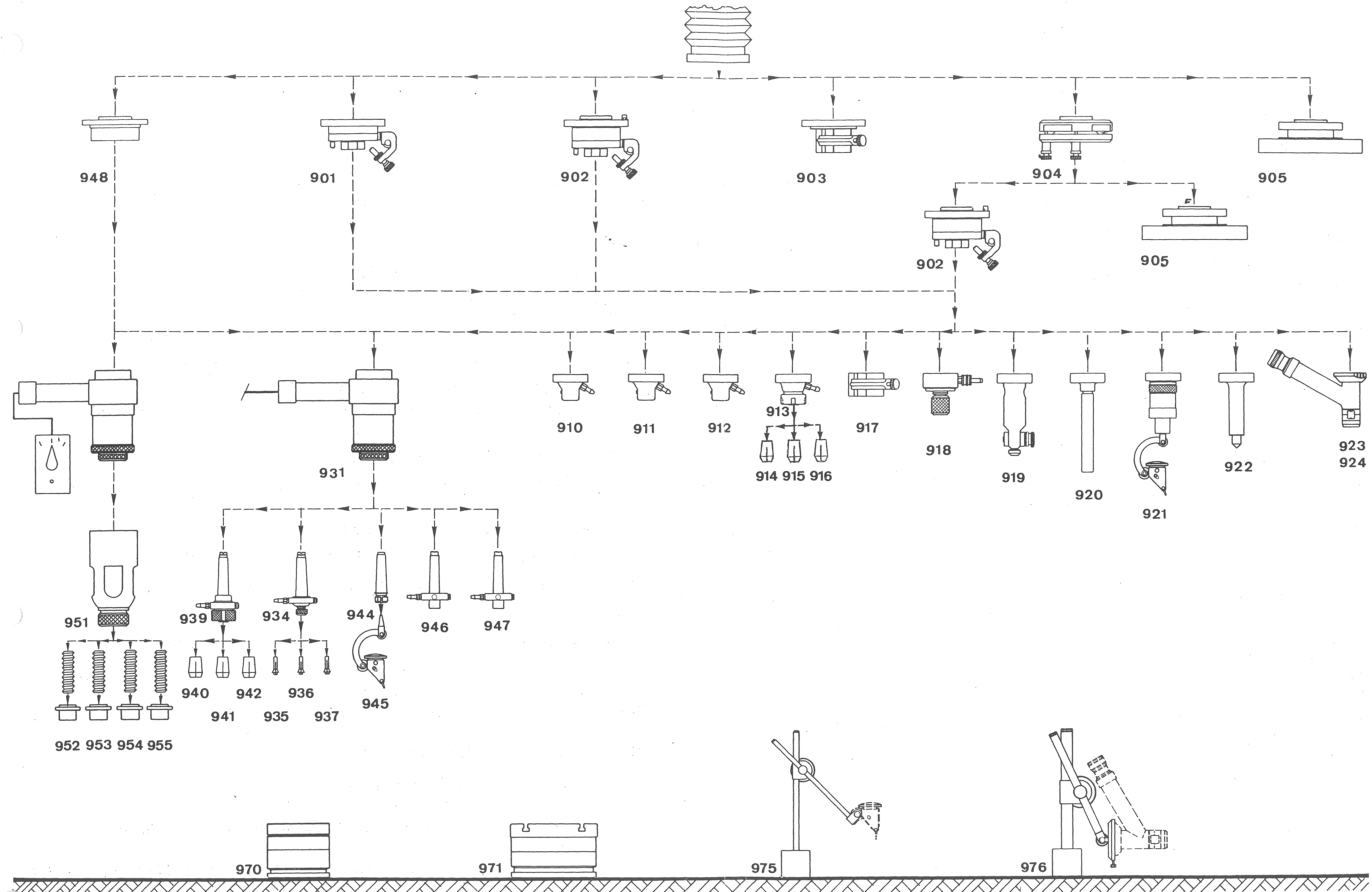

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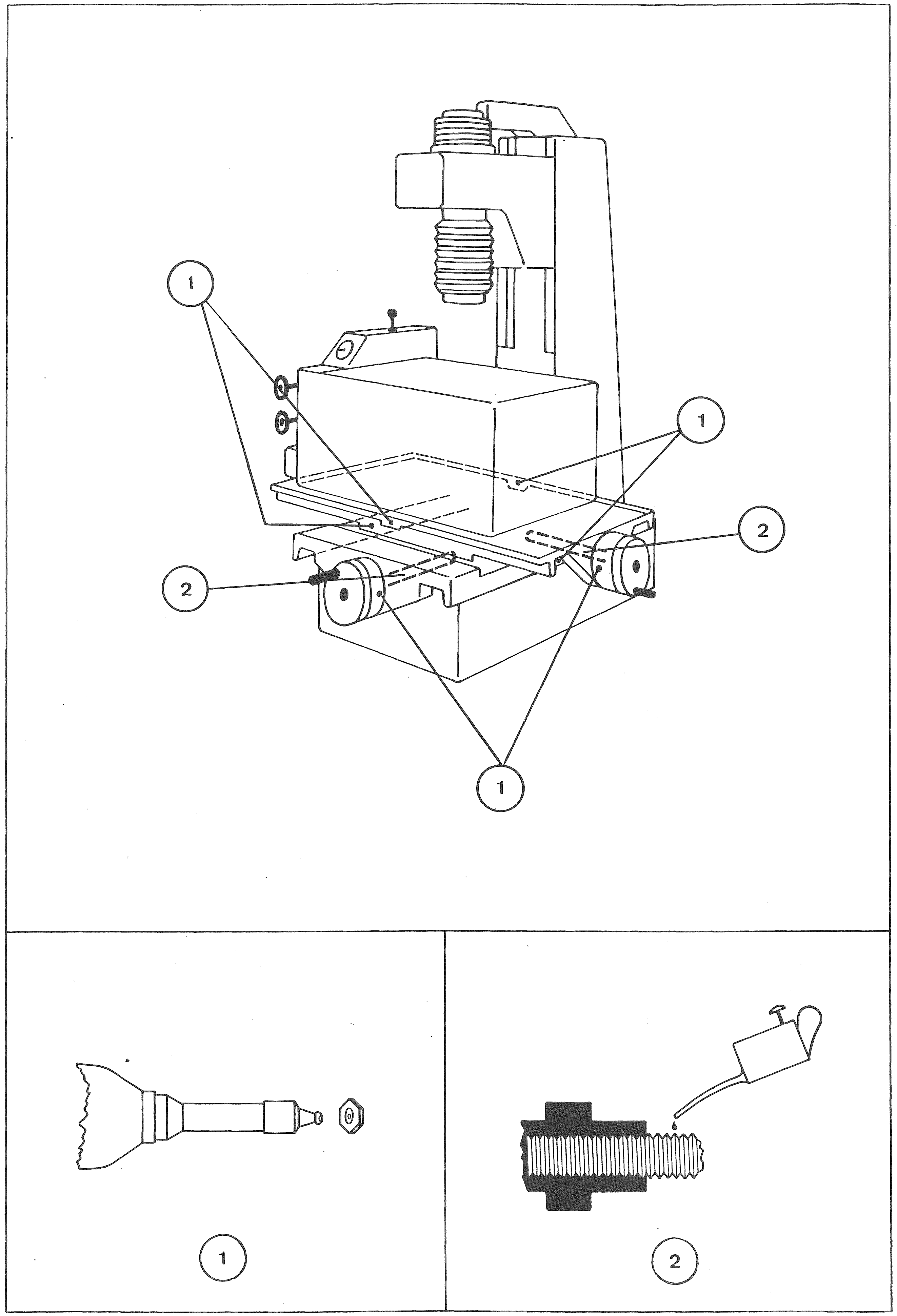
Fig 1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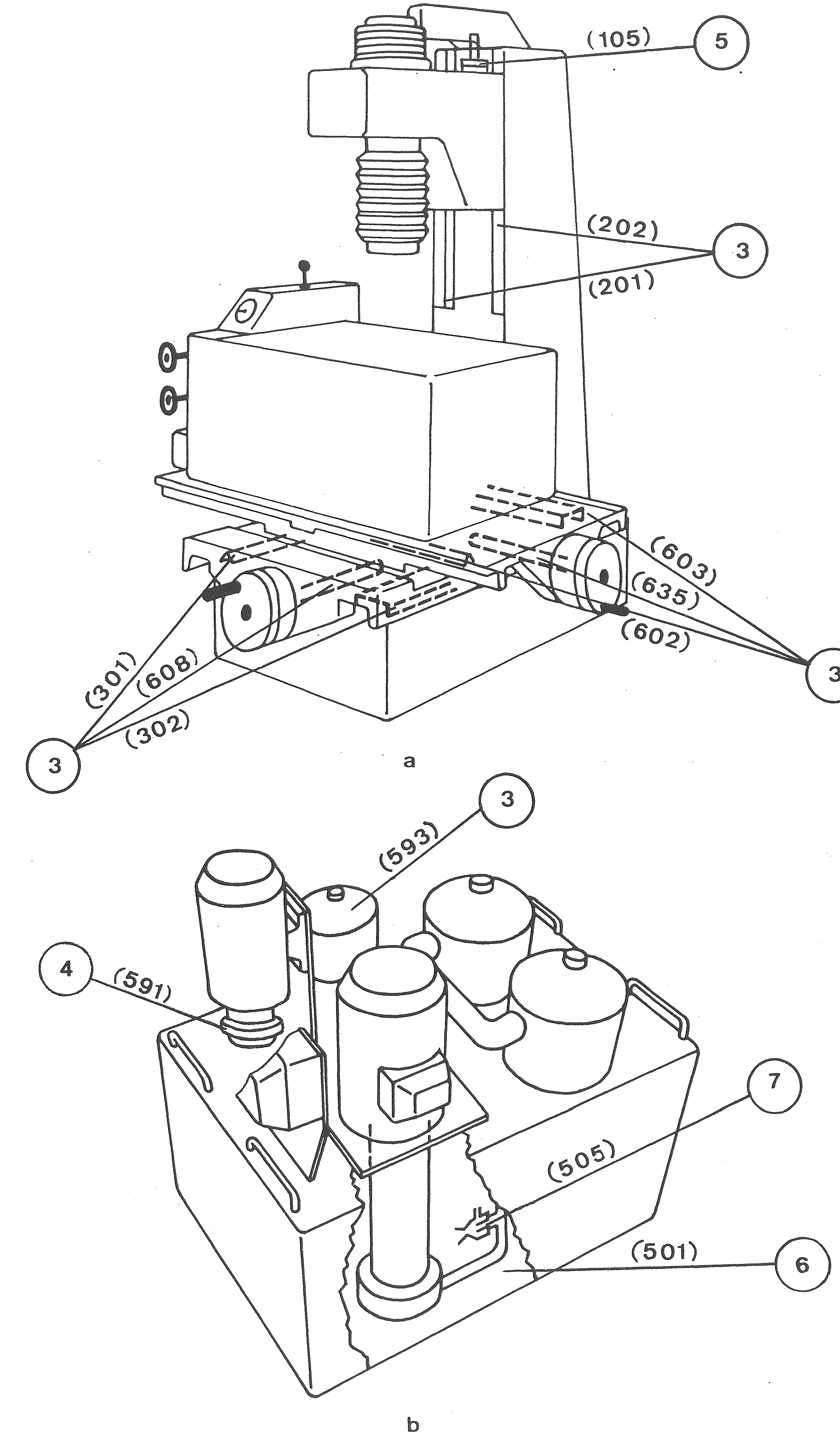
2
2
1
1
2

Fig 1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(591)
7
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(501)
6
b

Fig 2