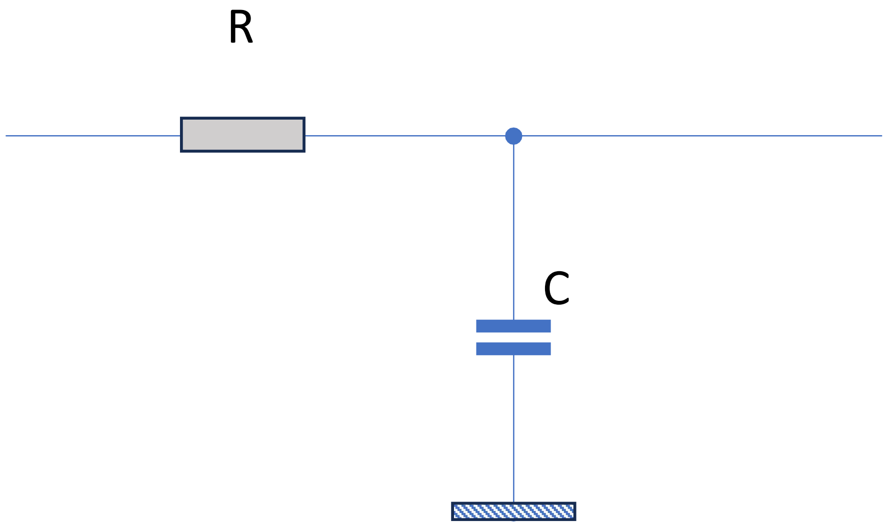
EDM-RC-60V-5A

System for Drilling and Stamping by RC Electroerosion.



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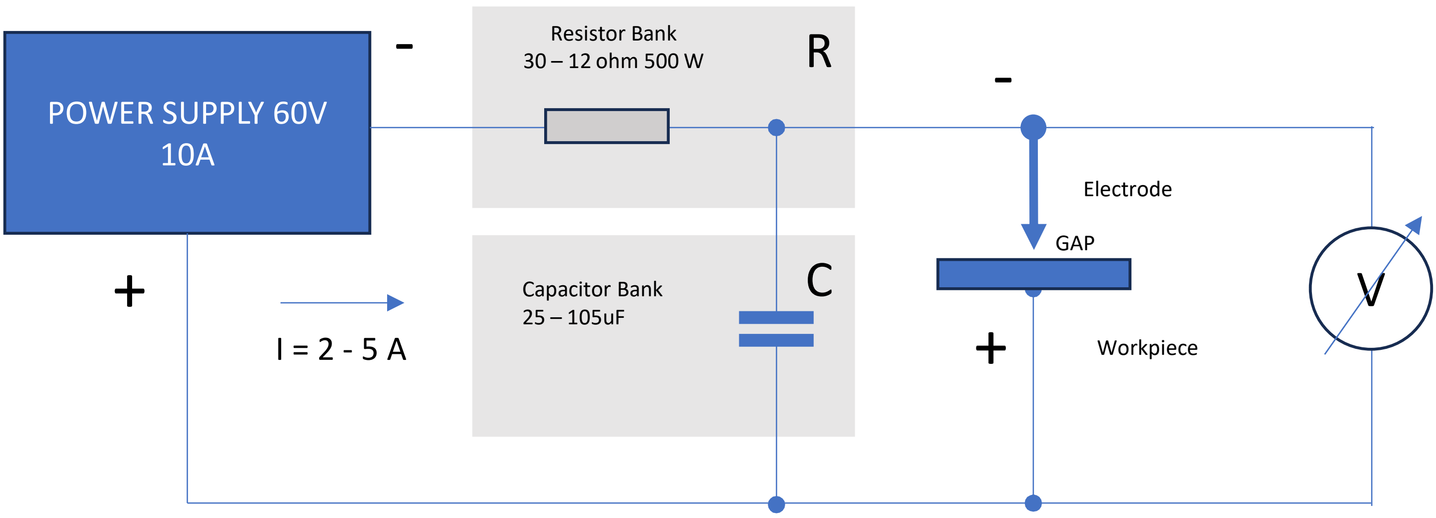
System for Drilling and Stamping by RC Electroerosion.
Date of creation: December 2024 – January 2025. Project and realization by Marcello Caselli

Technical specifications:

- Power supply: 220V AC.
- Maximum power: 600 W.
- Electrode power supply voltage: 60V DC.
- System based on an RC circuit.

Maximum working current (at the RC circuit input): 5A.
The working current can be set across a range of 4 values, corresponding to 4 different working resistance values in the RC circuit:
2A of working current as base (guaranteed by a parallel array of two 60-ohm, 100W power resistors), to which 3 increments can be added, each of 1A, by activating the 3 dedicated switches (SW2–SW4). These allow adding, in parallel to the fixed bank, up to 3 more 60-ohm/100W resistors.
The working capacitance of the RC circuit can be regulated across a range of 9 different values:
25uF; 50uF; 75uF; 100uF; 105uF; 125uF; 155uF; 180uF; 205uF.

25uF is the fixed base, to which 8 increments can be added via the 3 selector switches (SW5–SW7), as shown in the table at the bottom of the page.



SW2 – SW4

SW5 – SW7

Switches	Position	Value										Value	Position	Switches
Fixed 25uF capacitor to be added to selected values by the 3 selector switches														
SW5	1	25 uF	0	1	1	1	0	0	1	1	0	25 uF	1	SW5
	2	50 uF	0	0	0	0	0	1	0	0	1	50 uF	2	
SW6	1	25 uF	0	0	1	1	0	0	1	0	0	25 uF	1	SW6
	2	50 uF	0	0	0	0	0	1	0	1	1	50 uF	2	
SW7	1	25 uF	0	0	0	1	0	0	0	0	0	25 uF	1	SW7
	2	80 uF	0	0	0	0	1	0	1	1	1	80 uF	2	
			25 + 0	25+25	25+25+25	25+25+25+25	25+80	25+50+50	25+25+25+80	25+25+50+80	25+50+50+80			
Total Capacitance			25 uF	50 uF	75 uF	100 uF	105 uF	125 uF	155 uF	180 uF	205 uF	Total Capacitance		

The entire system is made up of two distinct devices: the control box and the motorized head, which hosts the electrode or tool or die; for simplicity, we will call it the "electrode".

Contro Box

Motorized Head

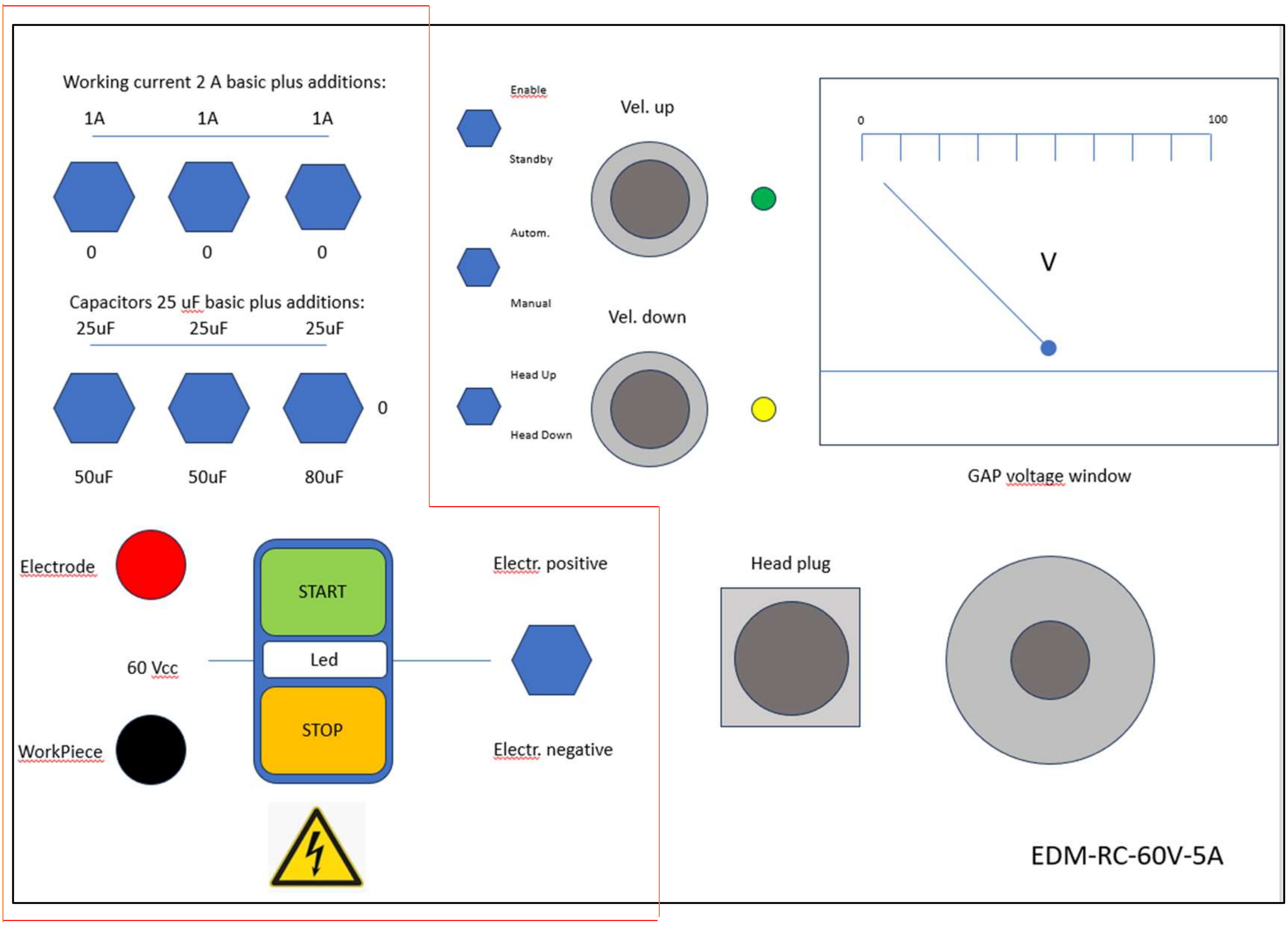
The control box contains most of the components. Inside the box there are three power supplies:

- 220Vac/60Vcc 10 A for the power circuit;
- 220Vac/12Vdc 4 A for powering the control electronics and the motorized head;
- 220Vac/24Vac 0.5 A for the auxiliary circuits (power contactor and auxiliary relay board);

Also we have:

- the capacitor bank;
- the power resistor bank;
- the logic/control board;
- the relay board;
- the stepper motor driver for the motorized head;
- the power contactor and relay group for controlling the 60Vdc power circuit.

On the control box front panel there are the switches and selectors for managing the power circuit, the output connectors, and the commands and controls to move the motorized head, as well as the related 12-pin connector.
The power circuit, through two 2.5 mm² wires, powers the electrode and provides the ground reference to the workpiece.
Note: The red wire indicates the connection to the electrode, while the black wire provides the ground reference to the workpiece;
the color does not indicate polarity according to convention but simply the function. Normally, the electrode is supplied with the negative polarity, and the workpiece receives positive polarity, but a special selector allows the polarity to be inverted.
The control section of the motorized head offers two operating modes: manual and automatic.
It works independently from the power circuit if set to manual mode, and in coordinated mode with the power circuit if set to automatic mode.
Using an analogy (not strictly appropriate, but a poetic license), we can compare it to an arc welder electrode: once the arc starts, you need a clamp to hold the electrode, which must be deftly guided by an experienced user.
In our case, the "clamp" is the spindle in the motorized head, and the expert's task is performed by the control board that manages the logic in combination with the motorized head movement system.
The motorized head can perform all vertical up-and-down movements with respect to the workpiece, essentially functioning as a column press, and, as stated above, can operate in manual or automatic mode.
A specific selector on the control box front panel enables the selection of the desired mode. Manual mode is used to allow precise adjustments of the electrode height before starting the job.
Positioning is controlled via selectors (labeled UP – DOWN); one is located on the control box front panel and another is on the push-button panel on the motorized head.
By setting the manual-automatic selector to automatic mode and starting the process, work begins as soon as the power circuit is activated (60Vdc).
The "Standby" selector allows the advancement of the head to be paused without affecting the power circuit.
The stop button interrupts power to the control circuit and immediately halts the automatic movement of the head.



60 Vdc power control section

Motorized head control section

A graphic representation of the front panel of the control box is shown above.
On the left side is the section for the power controls of the electrode's supply circuit (60VDC).
On the right side is the control section for the motorized head, which manages the up and down movements of the electrode.

Let's start by describing the controls related to the 60VDC electrode power circuit.

At the top left, you see three switches for setting the working current. These are lever switches with on-off function. When switched "on," each one adds the associated resistor (60 ohm) in parallel to the main bank, increasing the working current by 1A.

Below, there are three selector switches (basically three-way toggles with a central zero position) for adjusting the capacitor bank. Just as with the resistor bank, each selection adds the associated capacitor in parallel to the main bank.

There are also two connectors for supplying power to the electrode and ground to the workpiece.
Note: The red wire connects to the electrode; the black wire connects to the ground of the workpiece.
The wire colors indicate function, not polarity. Normally, negative polarity is supplied to the electrode and positive polarity to the workpiece, but a dedicated selector allows you to invert the polarity if required.

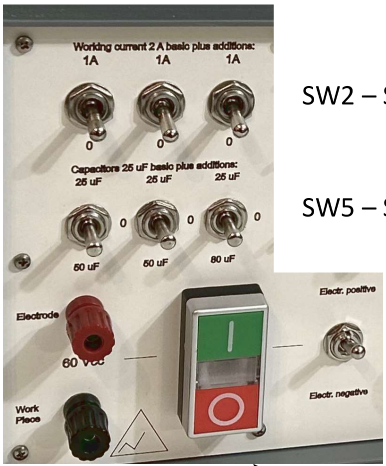
Beside the connectors is the Start–Stop button that controls the power supply to the electrode (60VDC). On the right side of the button is the selector to invert the polarity of the electrode's power supply.
Below, you can see these polarities and the power supply connections for the electrode.

IMPORTANT NOTE ON THE START-STOP CONTROL PANEL

Attention!
Turn on the power supply only after you have completed positioning the workpiece, positioning the electrode, and filling the electrolyte tank.

The electrode power supply voltage is 60 Volts DC – this is a voltage that must be considered dangerous!

It is essential to work with care while the machine is running.
Use dry gloves and rubber-coated protection to minimize risk in case of accidental contact with live parts.



SW2 – SW4: Switches for current control

SW5 – SW7: Selectors for capacitance control

SW8: Selector for electrode polarity reversal

Start-Stop control panel:
Power supply for 60V DC

Connectors:
Power supply output for 60V DC

The control panel, in addition to its obvious function of switching the power supply on and off, also controls the automatic operating mode of the entire system.

- If the electrode power supply is NOT enabled, automatic downward movement of the head is inhibited.
- If the power supply to the electrode is switched OFF, automatic downward movement of the head is also inhibited.
- In automatic mode, nothing moves unless electrode power is ON.

The indicator light between the start and stop buttons signals the presence of voltage at the 60V DC output terminals.

Let's look in detail at the controls related to the motorized head located on the control box panel.

Adjustments of the ascending and descending speed of the motorized head are effective only in automatic mode, while the movement speed in manual mode is controlled separately via the trimmer located directly on the control board.

(In reality, adjusting the speeds does have some effect in manual mode, depending on how the head movement is preset for manual operation, but in practice the trimmer setting is the main and prevailing adjustment in manual mode, unlike in automatic mode, where the potentiometer settings are used.)

In automatic mode, it's important for the descent speed (microns per second) to match the maximum possible erosion rate, since the descent must be slow and allow micrometric control of the distance between the electrode and the workpiece.

In theory, descent would occur at a steady pace as much material as possible is eroded from the workpiece, but in practice these conditions are rarely maintained. The system is designed to act only when the distance between the electrode and the workpiece becomes too small and the discharge ceases (lowering the electrode), or the electrode gets too close and causes a risk of short circuit (raising the electrode enough to avoid a short).

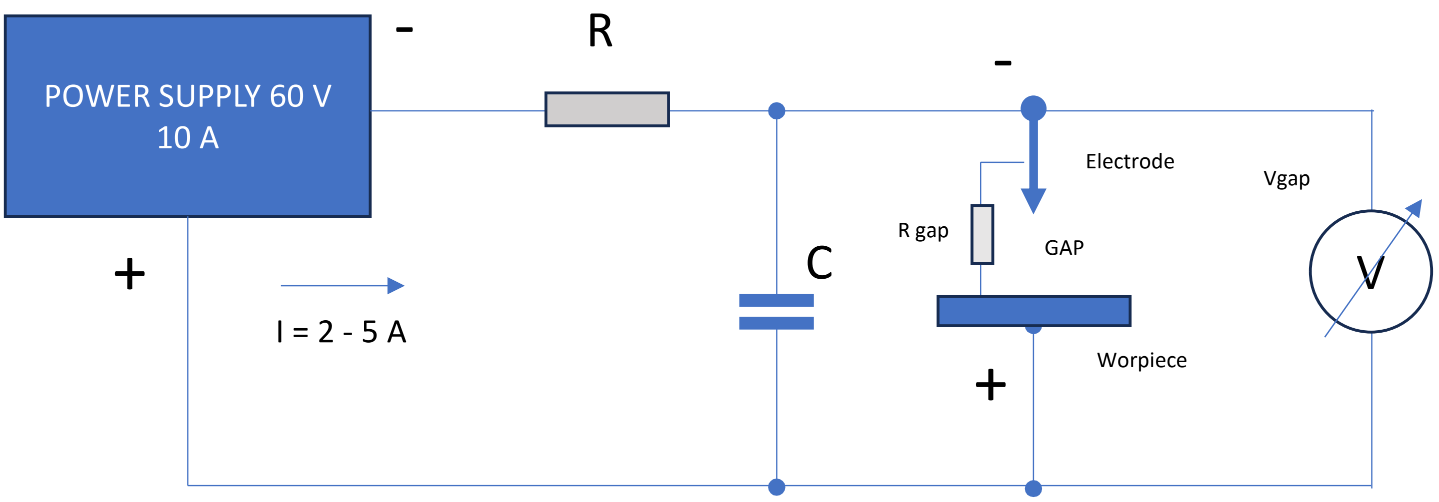
It's clear that upward movement can be slightly faster than downward movement (though not too much).
Since adjustment operations happen at intervals of tenths of a second, this saves fractions of a second during each job, which can last tens of minutes to several hours—ultimately resulting in a significant reduction of the time required to complete machining.

A few key points must be clarified: the electrode must never touch the workpiece (the motorized head prevents this); overheating of the work area is prevented by the movement of the head, while the dielectric liquid (electrolyte) both acts as an insulator and, secondarily, as a coolant.

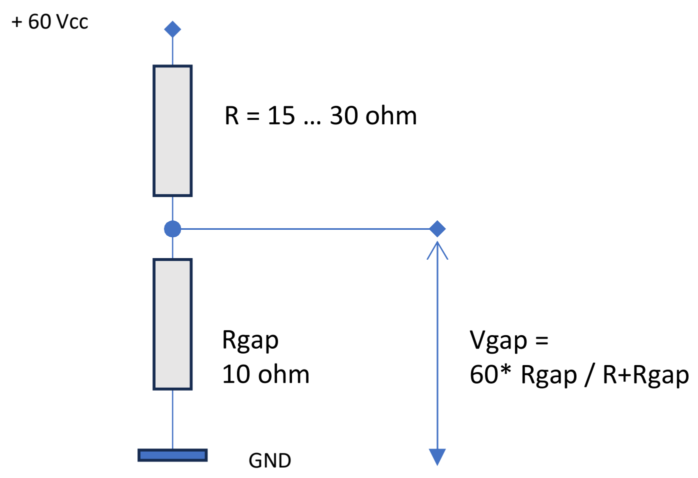
The discharge arc voltage must be constantly interrupted or broken up into short, distinct, powerful bursts.
This function is provided by the RC circuit: a capacitor with suitable value is charged via an appropriate resistor. After a time determined by the values of R and C, the voltage at the capacitor terminals can reach our case's 60 Volt (the power supply voltage). If the gap between electrode and workpiece is small enough, even at 60V (or lower if needed), it will break down the dielectric rigidity of the electrolyte between the electrode and the workpiece, and a discharge arc will form with its own basic resistance, allowing the capacitor to discharge. The arc is extremely hot, thousands of degrees, and when it hits the workpiece, it vaporizes and ejects metal through both physical and electrical effects.

Once the capacitor has discharged and the arc is broken, it is necessary to wait for the next capacitor charge before another arc forms. This happens at hundreds or thousands of cycles per second, depending on the R and C values.

The gap between the electrode and the workpiece (GAP) is especially interesting: among its features, it acts as a variable component in the power circuit—when no arc is present, it behaves as an open circuit; when the arc forms, it can be considered (not exactly, but closely enough) as a variable resistor of around ten ohms, fluctuating a bit above or below that. This resistance, relative to ground, is in series with the resistor R and together they form a voltage divider, as shown in the diagram below.



Schematic representation of the R–Rgap voltage divider:



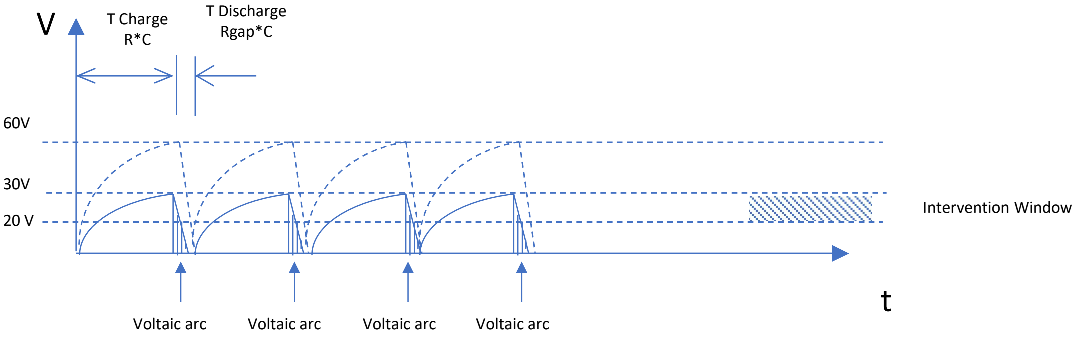
Purely as an example, we can imagine that in regular operation, the voltage across the GAP moves within a window between 20V and 30V, with a midpoint around 25V. Suppose we set the potentiometer so that the window's midpoint aligns with 25V; in that case, the control logic knows that the center of the operating window is at 25V.

This precise adjustment is only needed when the machine is running at steady state, as it is possible to read the amplitude of the work window directly from the voltmeter's scale.

According to how the control logic is built, this work window was designed to have a fixed width of 10V. (It's not exactly by chance…)

At this point, we have a GAP operating between 20V and 30V and a control logic that adapts perfectly to this situation… all set! The control logic knows that if the GAP voltage exceeds 30V, this means no more electrical discharges are happening, so it tells the head to lower the electrode. If the voltage drops below 20V, the logic knows the electrode is too close to the workpiece and instructs the head to raise it slightly—just enough for the voltage to return above 20V.

If we connect an oscilloscope across the GAP, we would see something similar to the schematic shown below.
You can observe how the discharge time of the capacitors is much shorter than the charging time, as this phase happens through the arc, which has much lower resistance compared to the resistance used for charging the capacitors.
When the voltage across the capacitors reaches the breakdown point of the dielectric, the arc fires; once all the energy stored in the capacitors is released, it's transformed into heat, and the GAP behaves as an open switch until a new capacitor charging cycle begins.



By moving the potentiometer for the intervention window to lower values, the whole situation shifts lower; conversely, by setting it to higher values, the entire window goes up. The higher the window is set, the more energy is stored in the capacitors and the more energy is released in each arc discharge.

If you double the voltage across a capacitor, the energy stored quadruples:
$e = 1/2 \times (C \times V^2)/10E\text{-}6$, which is expressed in Joules.
From this, you can see how the position of the intervention window can directly affect machining speed.

Current adjustment defines how fast the capacitors can recharge.
Capacitor bank setting determines how much energy can potentially be used per cycle.
The intervention window potentiometer defines the effective energy actually used in each cycle.
The combination of current (actually, resistance value) and capacitance defines the operating frequency of the RC circuit.

The time constant of an RC circuit is expressed in seconds and is the time it takes a capacitor to charge to 63.2% or discharge to 36.8% of the maximum possible difference (from the charging or discharging phase).
$t = R \times C$, where R is in ohms and C in farads, so t is in seconds.
The frequency in Hz at which charge and discharge cycles occur is Freq. = 1/t.

Example: Suppose we set C = 25uF and R = 12 Ω (for a working current of 5A—note that the current value depends on chosen resistance):
$t = (12 \times 25)/1{,}000{,}000 = 0.0003$ sec; Frequency = 1/t = 1/0.0003 = 3,333 Hz = 3.33 kHz.

The next page contains a table with some useful correspondences.

The control logic essentially interprets what happens in the GAP: it measures the voltage, evaluates its value, and sends the appropriate commands to the motorized head.

It is this last point—accurate, micrometric movements—executed exactly according to logic board commands, that keeps the electrode and workpiece precisely spaced for ongoing stable operation as material is eroded.
As previously stated, in steady-state the GAP behaves as a variable resistor whose value depends on the electrode-workpiece distance. This, in turn, influences the pattern of electrical discharges, which affect the resistance of the GAP, and collectively influence the GAP voltage as read by the controller, which responds to keep the system in the middle of its working window.

The balance point where all these factors meet is where the system finds its correct working condition, which gradually and steadily advances as material is removed from the workpiece.
The set working point is adjusted by the potentiometer that regulates the intervention window; the series resistor determines how quickly this point is reached.

Table of R*C time constants, frequency, and energy

Current Ampere	Capacitance uF	Resistence Ohm	R*C in seconds	Frequency Hz	Energy 1/2 (C *V ²)/10E-6 Joule a 60 V	Energy 1/2 (C *V ²)/10E-6 Joule a 30 V
2	25	30	0,00075	1333	0,05	0,01
2	50	30	0,0015	667	0,09	0,02
2	75	30	0,00225	444	0,14	0,03
2	100	30	0,003	333	0,18	0,05
2	105	30	0,00315	317	0,19	0,05
2	125	30	0,00375	267	0,23	0,06
2	155	30	0,00465	215	0,28	0,07
2	180	30	0,0054	185	0,32	0,08
2	205	30	0,00615	163	0,37	0,09
3	25	20	0,0005	2000	0,05	0,01
3	50	20	0,001	1000	0,09	0,02
3	75	20	0,0015	667	0,14	0,03
3	100	20	0,002	500	0,18	0,05
3	105	20	0,0021	476	0,19	0,05
3	125	20	0,0025	400	0,23	0,06
3	155	20	0,0031	323	0,28	0,07
3	180	20	0,0036	278	0,32	0,08
3	205	20	0,0041	244	0,37	0,09
4	25	15	0,000375	2667	0,05	0,01
4	50	15	0,00075	1333	0,09	0,02
4	75	15	0,001125	889	0,14	0,03
4	100	15	0,0015	667	0,18	0,05
4	105	15	0,001575	635	0,19	0,05
4	125	15	0,001875	533	0,23	0,06
4	155	15	0,002325	430	0,28	0,07
4	180	15	0,0027	370	0,32	0,08
4	205	15	0,003075	325	0,37	0,09
5	25	12	0,0003	3333	0,05	0,01
5	50	12	0,0006	1667	0,09	0,02
5	75	12	0,0009	1111	0,14	0,03
5	100	12	0,0012	833	0,18	0,05
5	105	12	0,00126	794	0,19	0,05
5	125	12	0,0015	667	0,23	0,06
5	155	12	0,00186	538	0,28	0,07
5	180	12	0,00216	463	0,32	0,08
5	205	12	0,00246	407	0,37	0,09

Below is the sequence of setup and starting operations for machining:

1. Position the workpiece inside the containment tank for the electrolyte.
2. Install the electrode in the spindle of the motorized head.
3. Connect the power cables to the electrode and the workpiece.
4. Add the electrolyte to the containment tank.
5. Turn on the control box by flipping the main switch on the rear (do not turn on the 60VDC power yet).
6. Set the motorized head control to manual mode.
7. Move the electrode close to the workpiece, centering it at the desired machining point.
8. Adjust the magnet that activates the limit switch (reed contact) for maximum descent, based on the required machining depth.
9. Turn on and reset the descent depth gauge.
10. Start the 60VDC power supply using the Start button.
11. Switch the head descent to automatic mode.

Regulations

Polarity Choice:
As a rule, the tool is connected to negative and the workpiece to positive. However, certain machining operations may require reversed polarity. For this reason, a selector for polarity inversion is provided on the control box.

Generally, in electrical devices, red indicates the positive pole. In this case, red indicates the terminal connected to the electrode, and black identifies the ground terminal (workpiece).
Most of the erosion occurs to the workpiece, but it is normal for the electrode to also experience some wear—typically between 1% and 5%. For each cubic centimeter of eroded workpiece material, the electrode might lose about 100 cubic millimeters.

Working Current and Capacitor Capacity:
The choice of working current and capacitor value depends on electrode size and the desired finish quality.

A low current and small capacitor value will achieve more precise machining, but will naturally require more time. Higher current and larger capacitance provide more energy per pulse, resulting in faster, rougher machining.

For maximum flexibility, the system allows you to select a wide range of current and capacitance values. The best combination for a specific job is usually determined by on-site experience.

No direct current measurement is provided—the system relies on Ohm's law: At 60VDC, with a fixed 30-ohm resistance bank (two 60-ohm resistors in parallel), the current will be 60/30 = 2A.
Each additional 60-ohm resistor in parallel increases the current by 1A; use this as a reference for estimating pulse energy in the circuit.

The actual operating current at the GAP isn't directly measurable because it depends on the capacitor charging voltage and the real GAP resistance, which affects discharge characteristics as well as the setting for the operating window.

Tool Speed:
Easy: faster is better, but not too fast.

The machine is designed so the descent speed is more precisely adjustable than the ascent speed for maximum versatility. The descent must not be too slow to avoid loss of continuity in erosion, but must not be so fast as to cause repeated corrections or short circuits. Ascending can be slightly faster than descending, but not excessively, or the head could rise too quickly.

The control logic's cadence (visible via the green LED for descent, yellow LED for ascent on the box) should be steady and reflect proper adjustment, which combines mechanical setup and operator experience.

Electrolyte:
Standard jobs can use water—tap water is fine, though demineralized water is preferred for best performance. For more demanding work, you may use vegetable oils (such as canola or sunflower) or kerosene as an excellent dielectric.
Note: Always consider environmental and disposal issues with oils or used fuels.

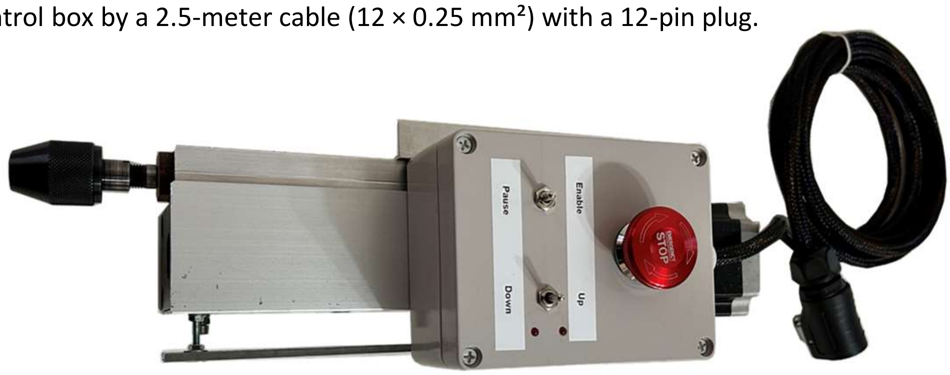
Without going too far into the details of the control board operation, let's simply say that its main function is to continuously monitor the voltage across the GAP.
For example, suppose the working window is 10 volts wide; it is set using the potentiometer to lie between 20V and 30V.
If the control board detects a GAP voltage higher than 30V, it interprets this as a lack of electrical discharges, meaning the GAP is "open." The board then sends a command to the head to move downwards, seeking to re-establish discharges.

If the GAP voltage remains within 20V to 30V, it means that discharges are occurring regularly and the head can stay in its current working position.

If the GAP voltage drops below 20V, it means a short-circuit condition is near (or a short-circuit has occurred). The control board then sends a command to the head to move up.

This process keeps repeating:
If the voltage is too high (GAP open), the head lowers until discharges resume;
If the voltage is too low (possible short), the head rises just enough until the voltage returns to the correct range.

The active element responsible for controlling the GAP is the motorized head.
It is connected to the control box by a 2.5-meter cable (12 × 0.25 mm²) with a 12-pin plug.



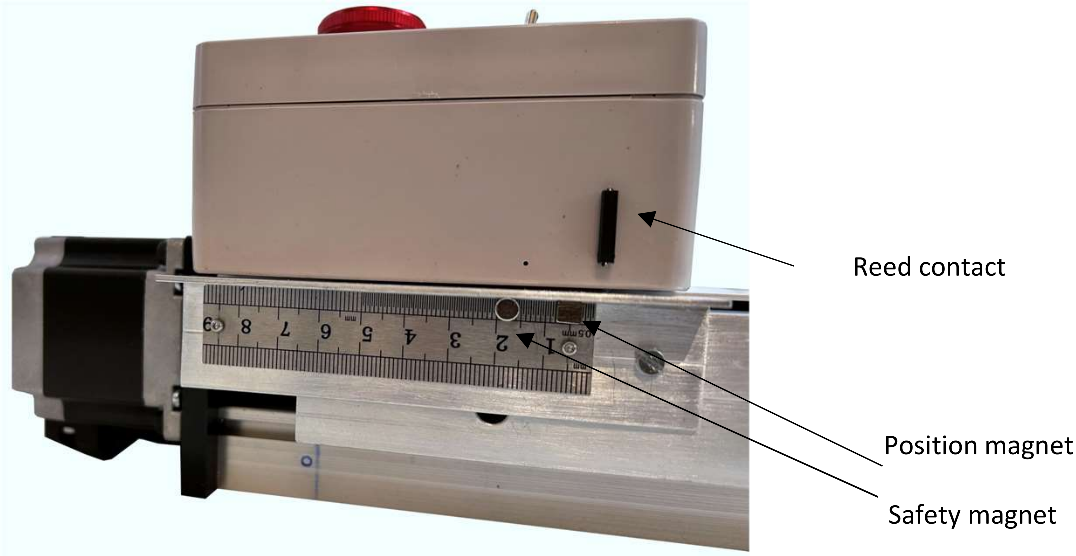
On its front panel, there is a remote control for use apart from the control box.
There you'll find:

- The up/down selector for manual head movement
- The selector to put the head into standby
- The emergency mushroom button to stop automatic mode
- The indicator LED for the home-point limit switch (topmost position)
- The indicator LED for the end-of-travel limit switch (depth stop)
- On the right, the depth gauge for checking the depth reached at any time

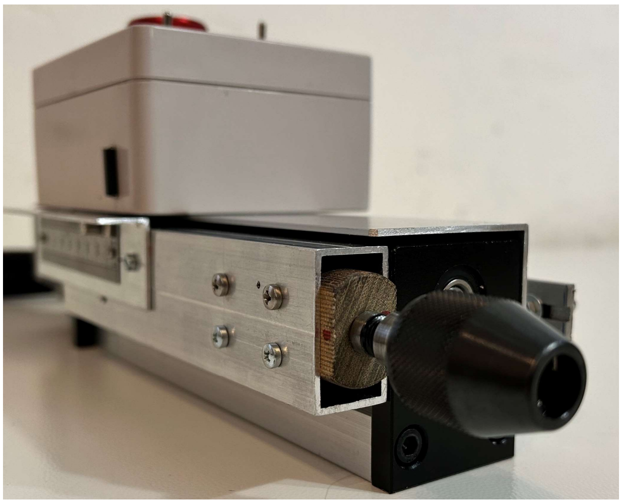
The useful stroke of the head is 80 mm.

On the top left side is the end-of-stroke limit switch adjustment system.
A rectangular-section tube connected to the lead screw carriage serves as support for both the measuring system and the electrode spindle.

A ferromagnetic ruler is positioned with its zero point aligned to the “home” position of the head. Two sliding magnets are attached to the ruler: the smaller magnet is used to precisely determine, within a few millimeters, the end-of-stroke position, while the larger magnet serves as a backup to ensure that, if the reed contact fails to detect the first magnet, the system will still operate safely. This second, larger magnet creates a magnetic field strong enough to trigger the reed contact even if it is only a short distance away, so it must be positioned carefully and close to the correct angle. If not, the emergency magnet may influence the reed switch too early. For correct positioning, the emergency magnet should be set at least 8–10 mm from the position magnet, so it doesn’t affect the reed contact before necessary.



The “home” position is detected by a second reed contact located inside the box; its position is fixed. The magnet that triggers it is on the carriage and also has a fixed position.



Power connection clamp for the electrode

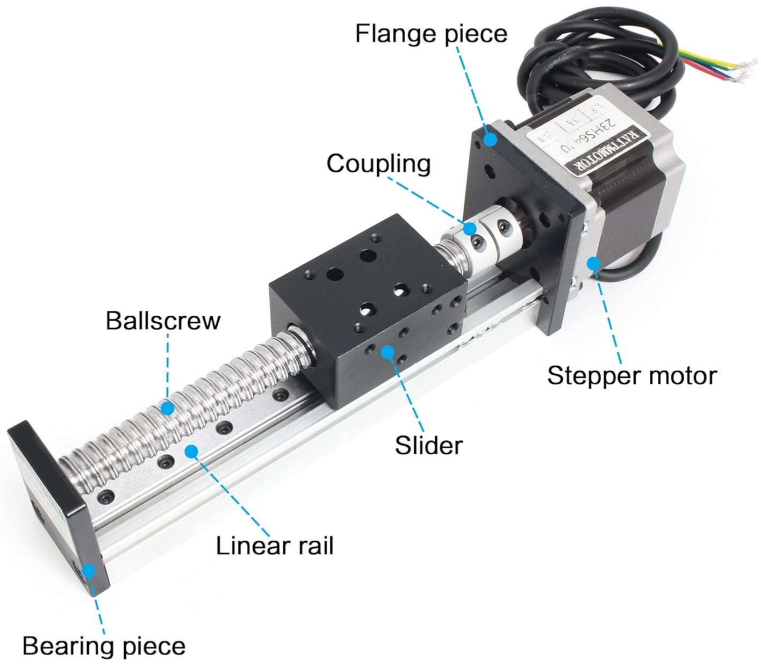
The spindle holder is connected to the tube by an insulating bushing. The electrode cable must be connected directly to the spindle, making sure that the 60VDC supply does not come into contact with the frame or other parts. The cable should end in a well-insulated clamp large enough to connect securely to the spindle body, or directly to the electrode if its size allows.

The servomotor assembly consists of a 12 mm linear rail driven by a ballscrew with CBX1605 recirculating ball nut, paired with a SFU1605 ball nut, 16 mm diameter and 5 mm lead.
The ballscrew is coupled to a NEMA 23 stepper motor, 2 phases, 1.8°, 200 steps/rev, 3 A, 1.2 N·m torque.

The stepper motor driver is a TB6600, set to operate with a current of 1.5 A in 1/16 micro-step mode.

For each pulse sent by the control board to the TB6600 driver, the linear stage moves by 0.00156 mm.

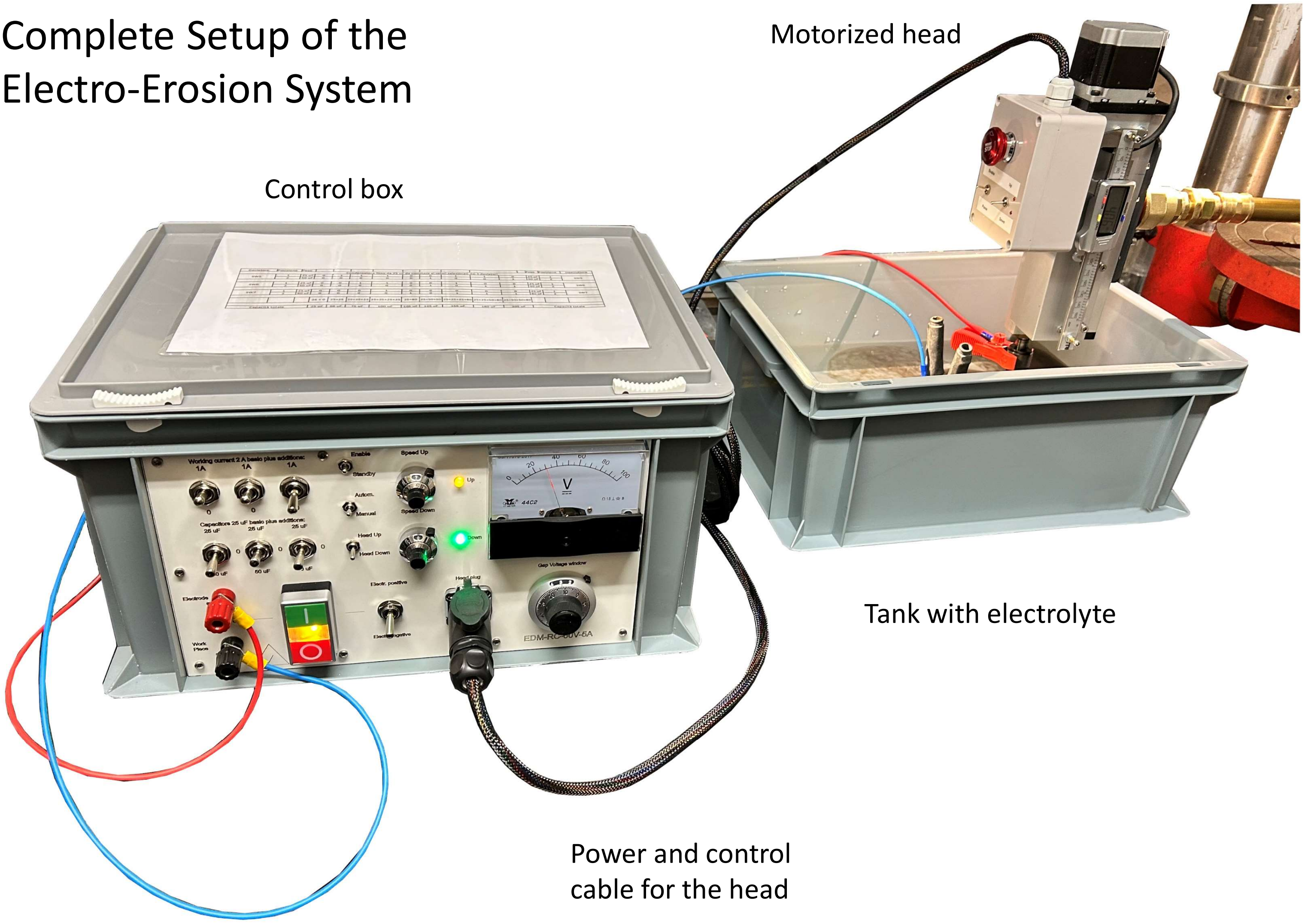
- Stepper motor: 200 steps/rev
- Travel per step: 5 mm / 200 = 0.025 mm
- Driver setting: 1/16 micro-step
- Final resolution: 0.025 / 16 = 0.000156 mm



Complete Setup of the Electro-Erosion System

Motorized head

Control box



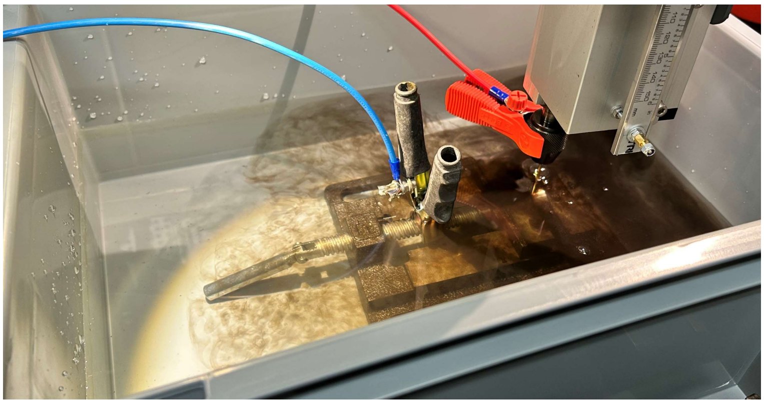
Tank with electrolyte

Power and control cable for the head

Power cables for electrode and workpiece ground

Electrode power connection

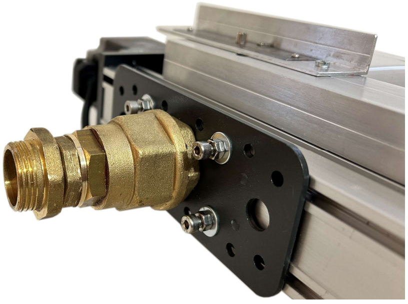
Ground connection



The electrolyte must generously cover the area being machined.
For major operations, it is advisable to equip the system with a circulation pump combined with a filter, in order to keep the electrolyte free of debris and, by passing it through a radiator, allow for cooling. The electrolyte filtration system is not shown in this setup.

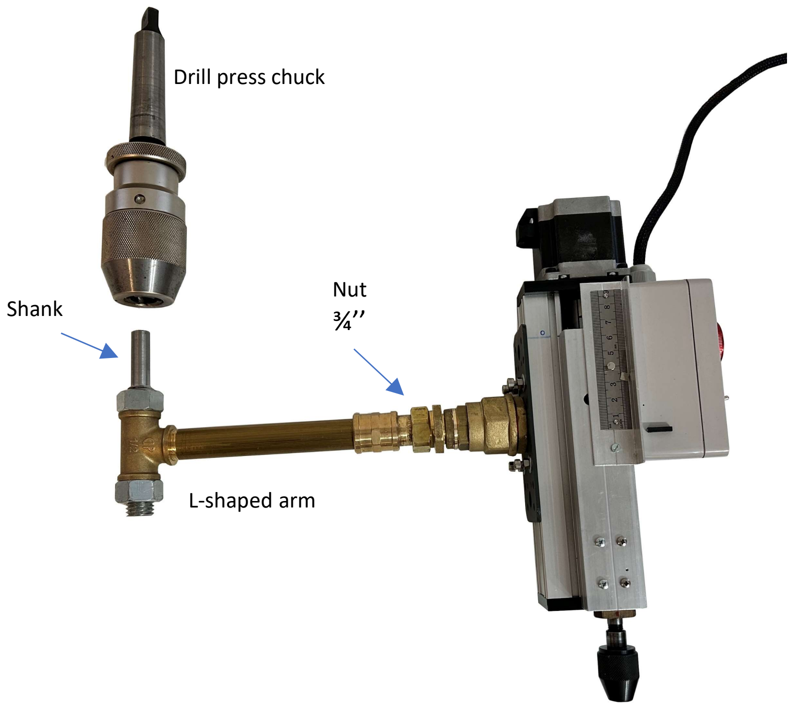
The head must be connected to a support in order to be used. For this purpose, it has been equipped with a flange combined with a threaded fitting, to which various accessories can be attached to meet different needs. For example, if the machining requires a perfectly orthogonal hole relative to the workpiece face, it is convenient to use the workshop's drill press.

¾''
Fitting



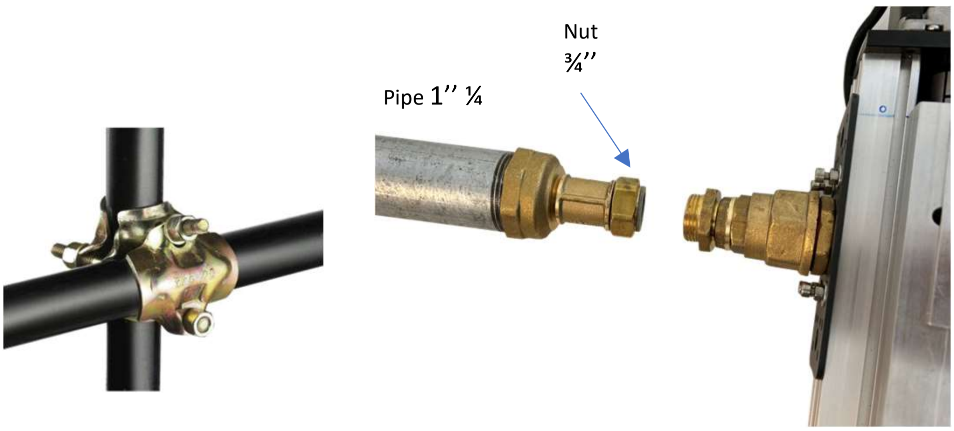
To this end, an L-shaped arm has been designed: the short end has the shank that goes into the drill press chuck, and the opposite end has a locking nut to connect the motorized head.
Thanks to this fitting system—the nut and threaded fitting—the head can rotate on the mounting point, allowing machining at various advance angles.

Drill Press Mounting System



Other requirements may involve a type of support that can be adapted for use outside the workshop, such as directly on agricultural machinery.
To meet most needs, a truly universal adapter has been created: it consists of a joint that screws onto the threaded fitting of the motorized head on one side and ends with a 1¼'' coupling on the other, which can be threaded onto hydraulic pipes of matching diameter. The pipe size fits perfectly with scaffolding clamps, so by combining various pipes and clamps, you can create all sorts of support structures.

Universal Mounting System



Universal Adapter

Nut
¾''

Coupling
1'' ¼

Appendix

Technology based on EDM [excerpt from Wikipedia]

Electroerosion is a machining technology in continuous development, based on the possibility of modifying materials using electrical discharges. It is only usable on highly conductive materials, essentially metals.

Machines built to perform this type of processing are called "electroerosion machines," or in English, **EDM** (Electrical Discharge Machining).

EDM was discovered by accident by the Soviet couple Lazarenko in 1943, during experiments on the wear of electric contacts. By immersing them in oil to reduce wear from sparks, they achieved the opposite effect. Electroerosion really took off only with the development of electronics.

Due to its peculiar features, today it is a commonly used technology in industry and is often essential for manufacturing molds (especially for plastics), where the presence of deep and narrow cavities makes conventional machining difficult or even impossible.

Over time, the processes have divided into die-sinking EDM and wire EDM (WEDM). Both use the same principle, but with different methods: the first uses a negative electrode (usually conductive material) repeatedly brought into contact (at the same spot) with the surface to be machined; the second uses a conductive wire threaded through a hole in the material, then slowly moved to cut through the workpiece using an approach similar to hot wire foam cutting.

Recently, the processes have developed rapidly, with new variants making machining more flexible and efficient. Other critical factors are reactions to imperfections and material density, which can cause breakage, and voltage fluctuations that affect the smoothness of finished surfaces.

The development prospects for EDM lie in its application to machining operations that are difficult or impossible (or costly) to perform with other, less precise methods.

Machining characteristics

The main characteristics of EDM machining are:

Possibility to machine very hard metals (special steels, tool steels, rapid steels, hardened metals, etc.), or metals treated by thermal or chemical processes (tempering, carburizing, etc.).

The hardness of the workpiece slows the erosion rate for a given amount of energy, but unlike conventional techniques, the tool (electrode or wire) does not need to be harder or mechanically stronger than the workpiece.

Possibility to produce cuts and cavities impossible with conventional techniques.

The process is electro-chemical, not mechanical; since the cutting tool doesn't rotate, it doesn't have to be perfectly symmetrical. Sharp corners, ribs, and cavities with complex shapes or profiles are all possible.

Lower machining speeds compared to other chip-removal technologies.

High relative wear of the tool. Typical tool wear may be 1-5%; that is, 1-5 mm^3 of tool for every 100 mm^3 of material removed.

More or less pronounced surface roughness, depending on the required finish; this is caused by the formation of micro-craters from the action of electrical discharges.

Operation.

The process consists of moving the cutting tool (the electrode) close to the material to be machined, all submerged in a dielectric liquid. The tool is supplied with a negative potential relative to the workpiece. When the distance between the tool and the material is small enough to break down the dielectric, current flows through it, and the electrons create a plasma channel—a discharge arc—that melts the surface of the material.

The choice of electrode material, relative to the material being machined, and the process parameters (current, voltage, pulse shapes) are critical for minimizing electrode wear compared to the workpiece. The electrode continuously moves forward as erosion progresses, always keeping enough distance to maintain a layer of dielectric in which the machined particles are suspended. Direct contact between the metals is avoided to prevent welding instead of the desired erosion.

Exceptionally, reverse polarity can be applied, meaning the electrode is given positive polarity and the workpiece negative. This is used in particular applications, such as joining semi-molds—where erosion is balanced between both elements—or when using electroerosion to cut, a process in which the electrode is completely consumed.

No typical machining chips are created; the machining residues (debris) are fine particles that disperse in the dielectric.

The presence of a dielectric liquid is essential for process function and serves several purposes:

Allows for transport and suspension of debris, thus removing material.

Has a high ion content, necessary for arc formation.

Disperses the heat produced by the process.

The process described above cannot be applied without electronic control devices. Applying voltage alone is not enough for continuous material removal and would only fuse the surfaces.

To properly manage energy parameters, control devices consider several factors, such as resistance and capacitance detected between tool and workpiece. They do not apply continuous voltage, but rather pulses (with RC system or pulse system). Arc shutdown periods allow cooling of overheated areas and removal of molten material. Controlled parameters typically include:

Trigger voltage: from a few tens to several hundred volts

Polarity: typically the tool is negative, workpiece positive

Maximum current: range from 1 A to 500 A

Pulse duration (for square wave systems): between 1 microsecond and 2 milliseconds

Pause between pulses (for square wave systems): between 1 and 30 microseconds

Notes

For professional use, computerized systems are employed, where all parameters are managed via software; RC-circuit-based systems are now considered obsolete.

For non-professional use, RC systems are undoubtedly more economical and nonetheless very reliable—whenever high-precision and fine finishing are not needed and for small-scale jobs, they remain fully valid.

Physical Principle

Electroerosion works by using the thermomechanical capacity of electrical discharges to erode materials.

The erosive action of discharges can be divided into phases:

1) **Application of Voltage Between Electrode and Workpiece:**In this phase, a strong electric field is generated, with the highest intensity between two points at minimal electrode/workpiece distance.

2) **Breakdown of Dielectric and Opening of Discharge Channel:**The strong electric field accelerates some electrons through the dielectric, creating an avalanche effect that breaks the insulation of the dielectric precisely where the electric field is strongest. This forms a channel with low resistance that allows electric current to pass.

3) **Expansion of Discharge Channel and Fusion of Material:**

The impact of accelerated electrons with the dielectric molecules generates further electrons and positive ions (charge carriers) that are also accelerated by the electric field. This creates a plasma channel at very high temperatures (thousands of degrees), capable of conducting a lot of electrical current. As discharge current continues, the channel expands around the initial point. Areas of the electrode and workpiece in direct contact with the plasma, bombarded by carriers and exposed to high temperatures, melt and form small craters of molten material.

4) **Interruption of Discharge and Implosion of the Discharge Channel:**

When current stops, the plasma channel, no longer supplied by an external energy source, collapses.

5) **Expulsion of Crater Material:**

Suddenly losing pressure on the crater surface, the molten material is expelled, leaving an empty crater. The expelled material cools into tiny particles (debris).

Applications:

Electroerosion can be subdivided according to its application:

Die-sinking EDM:

In this application, the main goal is to shape the workpiece by giving it a complementary form to the electrode.

The machining cycle is divided into two phases:

| Creating an electrode with a shape “negative” to the desired final machining shape.

|| Electroerosion of the workpiece using the previously created electrode, resulting in a “positive” final form.

Wire EDM:

In this application, a stretched conductive wire is used as an electrode to cut or profile the workpiece.

The wire (stored in a spool) is continually replaced during machining because, exposed to discharge wear and expansion stress, it would constantly break, interrupting the process.

Hole drilling by EDM:

In this application, a small-diameter tube is used as an electrode for drilling the workpiece.

Tubes are generally small in diameter, as dielectric fluid is pumped through them to remove debris from the hole during drilling.

Grinding by electroerosion:

In this application, a wheel made of conductive material erodes the workpiece, similar to standard abrasive grinding.

An example of this technique is sharpening blades with teeth made of sintered carbide (Widia) or diamond, materials which are difficult and expensive to grind by traditional abrasive methods.

Electrodes

One of the main “actors” in electroerosion machining is the electrode. In die-sinking EDM, the machined result is the negative shape of the electrode; in wire EDM, the electrode acts like a saw, cutting the workpiece.

To obtain useful machining, it is necessary to minimize electrode wear. To do this, in addition to controlling electrical parameters, choosing the right electrode material is essential.

EDM Electrode Material

For die-sinking EDM, the material should:

Resist electrical discharges;

Be easy to machine;

Be affordable.

The last two points are especially important in die-sinking operations, when making large or complex electrodes is required—sometimes even for molds weighing hundreds of kilograms.

Experience has shown that two types of material are most widely used: graphite and copper.

Graphite resists discharges well due to its high melting point, is relatively easy to machine, and costs little. However, machining thin graphite parts (fins, ribs, etc.) can cause flaking and rounded edges, since discharges tend to roughen the surface, preventing a fine finish. Machining graphite also generates dust, which, unless properly contained, can enter machine mechanisms, such as guides, shortening their life.

New, low-porosity graphites (fine graphite) have greatly expanded graphite’s use: they are now competitive with copper even for precision and fine-finish jobs, thanks to the ease of electrode making, less thermal deformation during erosion, and higher material removal rates.

Copper also resists discharges well, since its high thermal conductivity helps dissipate heat. It can be machined very easily, allowing for extremely fine features and very smooth surfaces, even polishable in some cases. However, copper does not hold up as well as graphite under the high-current, rough-cutting conditions typical in heavy material removal, and it is a more expensive material.

When possible, it’s advisable to use two electrodes: one graphite electrode for roughing and a copper electrode for finishing.