Operating Manual

KÖCO Stud Welding Equipment

KST 108

KST 110

KÖCO Stud Welding Gun

ESP 1 K

ESP 1 S

ESP 1 ISO

This operating manual has the part-no. 399-0411-000. It is a translation of the original document.

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Original-EG-Konformitätserklärung

Die alleinige Verantwortung für die Ausstellung dieser Konformitätserklärung trägt der

Hersteller: Köster & Co. GmbH
Spreeler Weg 32
D-58256 Ennepetal

Bezeichnung der Maschine: **Bolzenschweißgerät**
Serien- / Typenbezeichnung: KST 108 & KST 110

Der oben beschriebene Gegenstand der Erklärung erfüllt die einschlägigen Harmonisierungsrechtsvorschriften der Union:

2006/42/EG	Maschinenrichtlinie
2014/30/EU	Elektromagnetische Verträglichkeit (EMV-Richtlinie)
2011/65/EU	Beschränkung der Verwendung bestimmter gefährlicher Stoffe (RoHS-Richtlinie)

Harmonisierte Normen, die zugrunde gelegt wurden:
EN 60 204-1 „Elektrische Ausrüstung von Maschinen“
EN 60 974-1 „Sicherheitsanforderungen für Einrichtungen zum Lichtbogenschweißen
EN 60 974-10 „Elektromagnetische Verträglichkeit (EMV), Produktnorm für Lichtbogenschweißeinrichtungen“

Sonstige technische Spezifikationen, die angewendet wurden:
DGUV Vorschrift 1

Diese Konformitätserklärung verliert ihre Gültigkeit, wenn das Produkt ohne Zustimmung umgebaut oder verändert wird.

Bevollmächtigter für die Zusammenstellung der relevanten technischen Unterlagen
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Ennepetal, 01.01.2023 Dr. Torben Schmitz, Geschäftsführer

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UKCA-Declaration of Conformity

This declaration of conformity is issued under the sole responsibility of the

manufacturer: Köster & Co. GmbH
Spreeler Weg 32
58256 Ennepetal
Germany, North Rhine Westphalia

Product Type: **stud welder**
Product Model: KST 108 & KST 110

The object of the declaration described above is in conformity with the essential requirements and other relevant requirements of the:

Supply of Machinery (Safety) Regulations 2008 (S.I. 2008/1597)

Electromagnetic Compatibility Regulations 2016 (S.I. 2016/1091)

Restriction of the Use of Certain Hazardous Substances in Electrical and Electronic Equipment Regulations 2012 (S.I. 2012/3032)

Standards applied:

EN 60204-1 „Safety of machinery - Electrical equipment of machines - Part 1: General requirements”
EN IEC 60974-1 „Arc welding equipment - Part 1: Welding power sources”
EN 60974-10 „Arc welding equipment - Part 10: Electromagnetic compatibility (EMC)“

This declaration of conformity loses its validity if the product is converted or modified without consent.

Authorized person for compiling the relevant technical documentation
Köster & Co. GmbH
Development, Mr. Enno Putzer
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Signed for and on behalf of: Köster & Co. GmbH, 58256 Ennepetal

Ennepetal, 01.01.2023 Dr. Torben Schmitz, Managing Director

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1 Introduction

Dear User,

with the KÖCO KST 108 or KST stud welding system you have purchased an appliance of superior quality. It has been constructed to latest technological standards and complies with all technical requirements and regula-tions in force at the time of delivery. To ensure trouble-free operation at all times, we recommend that you follow the instructions hereunder:

- Before start-up, carefully read through the complete manual and make sure that anyone on your staff han-dling or operating the appliance has also read and understood the instructions.
- The safety instructions must be followed at all times.
- Store this manual in a safe place with easy access for anyone operating the appliance.
- Secure the appliance against use by unauthorized persons.
- The appliance may only be operated by sufficiently qualified and trained personnel.
- Have a trained electrician inspect the mains connection for correct fusing and earthing.
- If any malfunctions occur which you cannot remedy yourself, call our after-sales service.
- In case of accidents, call for medical help and, if necessary, notify accident insurers and/or local trade su-pervision authorities.

1.1 Information for the User

This manual for your KÖCO KST 108 or KST 110 stud welding system and KÖCO ESP 1 K and ESP 1 S stud welding guns contains all necessary information about the equipment, safety instructions for stud welding opera-tions, and assessment of welds. All information supplied is given to the best of our knowledge, but without ac-cepting any liability on our part. In particular, we cannot accept any responsibility for welding suitability of mate-rials, nor for the suitability of the stud welding process for certain applications. In all of these cases, responsibil-ity for welding results rests with the user.

We shall be glad to assist you with any questions you may have concerning particular applications or remedies for malfunctions. Any suggestions on your part towards improving this operating manual will also be welcome.

1.2 Safety Instructions

KÖCO KST 108 and KST 110 stud welding appliance and KÖCO ESP 1 K / ESP 1 S welding guns are de-signed exclusively for capacitor discharge stud welding with tip ignition. They must not be used for any other purpose. In particular, welding under water is strictly prohibited, and using the equipment to thaw up frozen wa-ter pipes is not permissible under any circumstances.

1.1.1 Personal Safety

KÖCO KST 108 and KST 110 stud welding appliance and KÖCO ESP 1 K / ESP 1 S welding guns are ap-proved for welding under increased electrically hazardous conditions according to EN 60974-1. However, for his own safety, the operator must wear appropriate protective clothing during welding, which includes the following:

- Dry, insulating shoes
- Close-fitting, dry and non-flammable (free of inflammable materials) working clothes (leather apron)
- Leather gloves
- Safety goggles with an adequate degree of protection
- A helmet protecting the head and the neck for use during overhead welding

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- No metallic jewellery (rings, chains, etc.) or watches may be worn during welding.
- While welding is in progress, persons wearing heart pace-makers must keep at a safe distance from the appliance and the welding cables, because the strong magnetic fields generated could endanger their lives.
- All normal accident prevention regulations must also be observed.

1.1.2 Operational Safety of the Equipment

- **For the mains connection only a suitable mains plug of the right size or a fixed mains connection may be used.** Fixed mains connections (including fitting of the mains plug) may only be installed by a trained electrician. Servicing and repairs on the opened power source may only be carried out by sufficiently qualified personnel.
- **The insulation of all cables must be in perfect condition.** Cables with defective insulation must not be used. Welding cables may carry high currents. Any points subject to bending, for example the cable entry point at the handle of the welding gun, present a constant risk of the cable cross-section being gradually reduced by breakage of individual wires. When subjected to high pulsed currents, a cable thus weakened may suddenly arc over and burn out. This causes a risk of burns to the operator and ignition of inflammable ob-jects nearby.
- **All parts of the housing must be kept firmly closed.** Operation of the equipment with an open housing is not permissible, because the operator is not protected against touching live parts while the housing is open.
- **All insulating legs must be in perfect condition.** If the legs are removed for fixed installation of the appliance, alternative insulation between the housing of the appliance and the workpiece must be provided. If galvanic currents flow between the housing and the workpiece during welding, this may, in case of a malfunction, destroy the protective earth-line of the equipment.
- **The interior of the appliance must be kept clean.** Especially when working in dusty surroundings, dust will collect on parts of the machine. Therefore, the housing should be opened at regular intervals (only after first disconnecting the mains plug!) to blow out the dust (first call in an electrician to ascertain that the appliance is not under voltage). In particular, it is vital to remove any metallic dust, since it can damage parts of the appliance by short-circuiting. Do not aim a jet of air at PCB's, but remove the dust from these with a vacuum cleaner.
- **Sufficient cooling.** Cooling air is sucked in at the bottom of the appliance and blown out at the rear (version with external ventilation). Provide adequate air circulation! Do not cover any ventilation openings!
- **The welding gun must be in perfect condition.** All connections in the welding circuit must be tight. Therefore, make sure that the chuck is firmly attached by tightening the nut on the adapter screw, and that the stud is firmly seated in the chuck. Otherwise, contact scorching may result. The bellows must always provide an impermeable shield against welding splashes and smoke.
- **Electrical safety.** Before opening the appliance, always pull out the mains plug to disconnect it from the power supply, and make sure it cannot be switched on unintentionally! Keep in mind that, even after the ap-pliance has been switched of, a dangerous level of residual voltage still persists in the capacitors for several seconds. Therefore, before starting work on the interior of the power source, call in an electrician to make sure that the capacitors are free of residual voltage.
  Prevent moisture and foreign substances from entering the power source! If such substances have entered, the appliance must be immediately disconnected from the power supply! The appliance should also be in-spected by specialists at regular intervals and especially following any malfunction. Make sure that all mark-ings remain clearly visible!

1.1.3 Workplace safety

- Do not operate the equipment in areas of fire or explosion danger! Remove all flammable objects from its surroundings!
- Keep in mind that welding splashes are likely to ignite flammable objects, for example cleaning rags con-

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taining oil, grease or solvent or packaging materials, even at several metres' distance.

- In case of doubt, check with the security officer in charge and obtain his release for the welding project before starting work!
- Make sure that the operating site has sufficient ventilation!
- Do not weld without air extraction on any workpiece which may release substances dangerous to health, such as coating materials, zinc, nickel, chromium or cadmium!
- Do not weld on hollow objects which contain, or have contained, flammable liquids or gases, or which are under pressure, or inside which a dangerous level of pressure can be generated by the welding heat! In some cases, the heat generated by welding may also cause the release of gases or vapours which are dangerous to health or even explosive. Specialized knowledge is required for this kind of work. Do not carry out such operations unless you possess the necessary knowledge!
- Keep at a safe distance from any objects which might be affected by magnetic fields, such as EDP installa-tions (computers), cards with magnetic strips or timepieces (wrist-watches).
- Do not weld on the same workpiece (welding potential) simultaneously with other types of welding machines, especially those operating with different poles or frequency (alternating current), or welding systems with high-voltage ignition, since this could adversely affect or damage the control system of the stud welding appliance.
- Ensure that a flawless, safe welding circuit is generated. The earthing cables must be firmly clamped onto the workpiece. If this is not possible or not desirable, make sure that there are no parts in contact with the welding circuit which can be damaged or destroyed by the welding current, such as crane hooks, anti-friction bearings, and clamps with layers of partly insulating material, screws or bolts. Especially dangerous is the destruction of protective conductors in other electric appliances if they come into contact with the welding circuit.
- The noise generated by welding can be in excess of 85 dB (A). Therefore the operator and auxiliary personnel must wear ear protectors, and the welding site may have to be classed as a noise pollution danger area.
- Whenever the appliance must be placed on sloping ground, secure it against tipping over or rolling downhill.
- When transporting the appliance, use the handles provided. However, these handles are not designed for lifting the appliance by crane.

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2 Stud Welding with Tip Ignition

Stud welding with tip ignition is a process for welding mostly cylindrical metallic parts with diameters from about 0.8 to 10 mm onto metallic workpieces from approximately 0.6 mm thickness. This process requires a capacitor plus a mobile device (welding gun).

Prior to welding, the stud is placed above the workpiece (fig.1 - 1). When the gun is triggered and the welding thyristor ignites, the piston of the gun moves the stud towards the workpiece. As soon as the ignition tip of the stud makes contact, a strong current builds up quickly, which causes explosive melting and partial evaporation of the ignition tip. (fig. 1-2). The arc generated by this process melts the tip of the stud and a portion of the workpiece. During welding time, the stud continues its steady movement towards the workpiece until it comes to a halt in the welding pool. (fig. 1 - 3). Then the drawn arc is extinguished by a short-circuit, and the welding pool solidifies (fig. 1 - 4).
Due to the high speed of the stud's movement, the impact made by its plunge causes part of the welding pool to splash out, forming a circle of splashes which can be used as an indicator for assessing the weld. (see chapter 3.7).
Welding time is approximately 1 to 3 milliseconds. Due to the extremely short welding time, burning in is limited to about 0.2 mm; consequently, impairment to the rear surface of the workpiece is minimized.

The length of the ignition tip is the decisive factor determining the length of the welding time, with all other conditions being equal. Therefore, studs with deformed ignition tips must not be used. Nor should centre punch marks be used to mark the position of the stud on the workpiece, since welding time will be shortened by the ignition tip plunging into a recess.

More details are available from the DVS-Technical bulletins 0903 and 0904.

Depending on the layout of the gun and its welding time range, a distinction is made between **gap welding** and **contact welding.** The difference is that, in the first case, welding takes place across a **gap of air** of predetermined width G. In the second case, the stud is in direct electrical **contact** with the workpiece which means G = 0. Chart 1 illustrates the characteristics and recommended fields of application for both processes.

Chart 1: Characteristics and applications of tip ignition stud welding

characteristics	**Gap welding (gun ESP 1 S)**	**contact welding (gun ESP 1 K)**
ISO 4063 number	786	786
stud diameter range (mm)	0.8 to 10 (aluminium up to 6)	0,8 to 10 (aluminium not recommended)
peak current app. (A)	10000	5000
welding time app. (ms)	0,5 to 2	1 to 3
spring force app. (N)	40 to 60	80 to 120, depending on piston dimen-sions
plunge speed app.(m/s)	0,5 to 1, aluminium 1 to 1,5	0.5 to 0.7
ignition	mostly on time, premature ignition possible	always on time
recommended applications	automatic welding, aluminium, brass	manual welding of steel (non-alloy and alloyed), galvanized, zinc-coated or oiled surfaces

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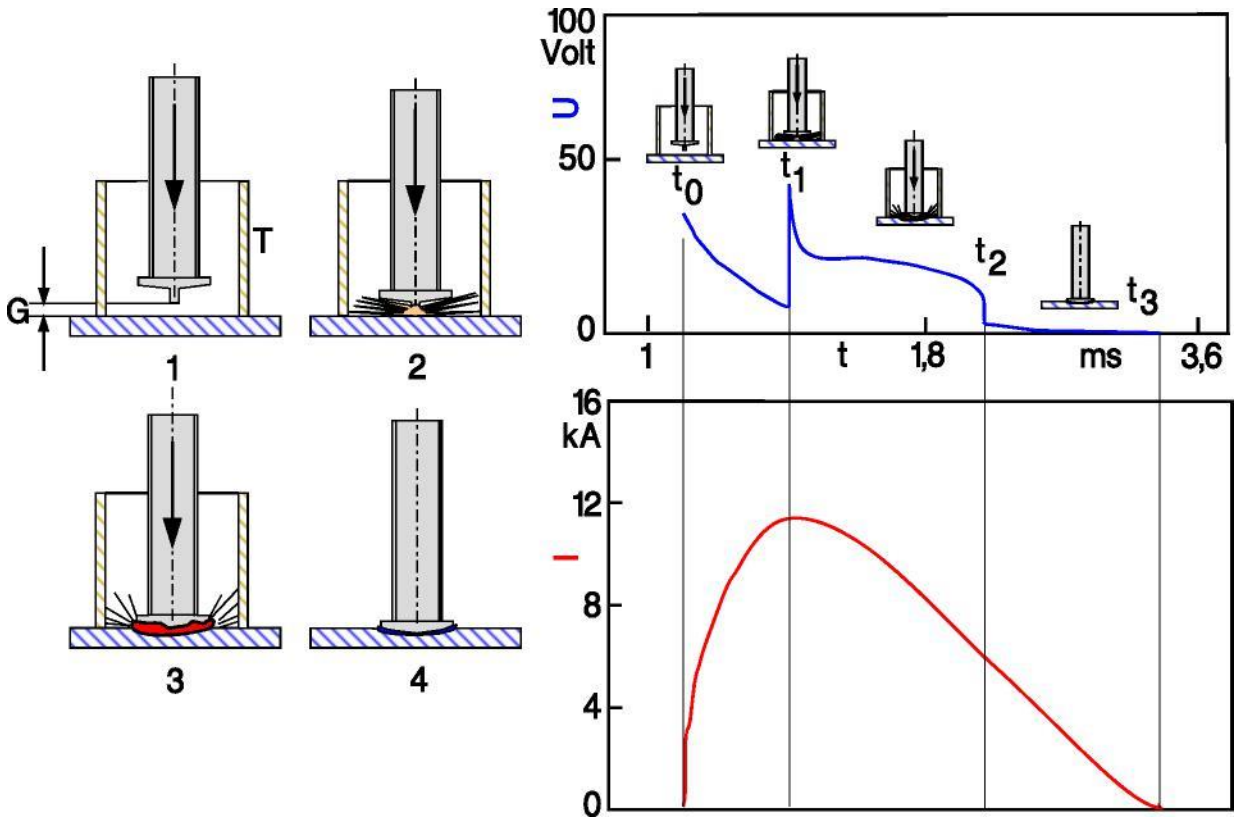

Fig 1: Tip ignition stud welding with voltage and current development curves (gap welding process)

Explanation:

1: Stud welding with an air gap, start of the downward movement.

2: Contact between the ignition tip and the workpiece, explosion of the ignition tip and generation of the arc.

3: Generation of the welding pools while the stud continues its downward movement.

4: The stud touches the workpiece, extinguishing the arc, and the welding pool

solidifies. G: Air gap

T: Supporting legs or supporting tube

t: Time

U: Voltage

I: Current

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2.1 The Power Source

The power source consists of a one-phase transformer, a capacitor accumulator, a welding thyristor, a discharge resistor, a charging connection with a rectifier, and an electronic control system. The standard model is laid out for a 230 V mains input voltage.

2.2 Technical Data of KST 108 and KST 110 Power Sources

Technical data	KST 108	KST 110
tip ignition stud welding (gap or contact welding), welding range Ø (mm)	3 - 8	3 - 10
nominal capacity (mF)	66	99
loading voltage range (infinitely adjustable) app. (V)	50 - 200	50 - 200
max. studs/min. for ... Ø (mm)	10 / 3 4 / 6	10 / 3 4 / 8
mains power supply 50/60 Hz, 1-phase current (V)	115 or 230	115 or 230
mains connection plug for 230 V (A)	16	16
mains connection cable, 3-pole, for 230 V (m/mm^2)	3/1.0	3/1.0
mains time-lag fuse for 230 V (A)	6.3	6.3
mains input at 230 V (W)	700	700
class of protection	IP 23	IP 23
cooling	F	F
operational temperature range (°C)	0 - 50	0 - 50
housing dimensions (L x W x H) mm without handles and legs	330 x 190 x 280	330 x 190 x 280
weight (app. kg)	8.9	9.9

Approved for operation under increased electrically hazardous conditions, CE labelling according to EN 60974-1

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2.3 The Welding Gun

In tip ignition stud welding, the task of the welding gun is to hold the stud in its chuck, to conduct the welding current through the stud, and to unite the two welding pools by means of precisely controlled movements.

When the welding process is triggered, the **ESP 1 S** gun first generates the air gap by activating its lifting magnet. As soon as the piston has been lifted to its set end position, the magnet is switched off, and the piston is moved towards the workpiece by means of spring force. At the same time, the welding thyristor ignites, transferring the charging voltage from the capacitor to the welding clamps. As soon as the stud comes into contact with the workpiece, the welding process begins (see fig 1). Due to the acceleration of the piston in the air gap, the welding time (i.e. the time taken to cover the length of the ignition tip) can be adjusted by changing the width of the air gap. Welding times are longer with a narrow gap than with a large gap.

The **ESP 1 K** gun is a device for contact welding. Therefore, it is only equipped with a pressure spring, without a magnet. When the gun is triggered, the welding thyristor ignites immediately, and consequently the starting velocity is zero. Compared to the ESP 10 S gun, it operates with lower speeds and consequently longer welding times. By changing the spring force the welding time can also be altered here.

During the welding process there is a peak electricity flow of up to 10000 A. It is urgently recommended that only the welding and earthing cables supplied as part of the scope of delivery are used. Welding cable extensions lead to a pronounced drop in voltage, a reduction of the welding current and possibly to an increase in welding time. Damage to the power source due to too high inductivity of the welding circuit cannot be ruled out.

2.4 Technical Data of KÖCO Welding Guns

Technical data	ESP 1 S (gap welding)	ESP 1 K (contact welding)	ESP 1 ISO (for cup head pins)
tip ignition stud welding - welding range Ø (mm)	2 - 8	2 - 10	2 - 4
welding range stud length (mm)	8 to 40, longer studs may also be used with spacer ring or spacer bolts (q.v. 12.1.1)	8 to 40, longer studs may also be used with spacer ring or spacer bolts (q.v. 12.1.1)	Up to app. 100
standard support via ... legs	3	3	n. a.
welding cable (m/mm^2)	4/25	4/25	10/6
welding cable plug (mm^2)	50	50	50
control cable (m/mm^2)	4/4 x 0.75	4/2 x 0.75	4/2 x 0.75
length (excluding chuck) (mm)	165	165	150
body diameter app. (mm)	40	40	50
height (including handle) (mm)	130	130	180
weight without connection cable app. (kg)	0.730	0.635	0.7

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2.5 Requirements placed on materials

Basically, stud welding with tip ignition is possible with all materials suitable for arc welding. Even different materials, such as carbon steel and stainless steel, can be welded together by this method without any problems, since blending between the two welding pools is only minimal, with hardly any brittle transition zones resulting.

Due to the extremely short welding time, a clean, smooth surface is vital for achieving good welding results.

The material combinations listed in chart 2 have been proven in practice. Since a precisely calibrated ignition tip is an absolute necessity, standardized studs that comply with EN ISO 13918 should be used wherever possible.

Chart 2: Material combinations for drawn-arc stud welding

	Parent Metal				
Stud Material	non-alloy steel up to app. 0.35% C, for example S235, S355, C35	stainless Austenite steel, for example 1.4301, 1.4401, 1.4541, 1.4571	non-alloy steel up to app. 0.35% C, for example S235, S355, C35, with zinc or other metal coating, max. 25 µm	copper and copper alloys, for example CuZn37 (lead- free)	aluminium and aluminium alloys
non-alloy steel up to 0.18% C, for example S235	well suited	well suited	suitable to a limited degree	suitable to a limited degree	impossible
stainless austenite steel, for example 1.4301	well suited	well suited	suitable to a limited degree	well suited	impossible
CuZn37 (brass lead free)	suitable to a limited degree	well suited	suitable to a limited degree	well suited	impossible
AlMg3, Al99,5	unsuitable	unsuitable	unsuitable	unsuitable	well suited

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3 Working with the stud welding equipment

3.1 Requirements before start-up

1. The power connection must be earthed according to regulations.
2. The housing of the power source must not have any electrical contact with the workpiece. Make sure that the insulating supporting legs are in perfect condition!
3. Make sure that the power source is standing firm on vibration-free, dry ground.
4. Ensure adequate cooling! The circulation of air must not be restricted in any way.
5. Operating the equipment in a fire or explosion danger area is prohibited. In case of doubt obtain a release for the welding operation from the security officer in charge.
6. Keep a safe distance from any objects which may be affected by strong magnetic fields, such as EDP instal-lations!. Persons wearing heart pace-makers must keep away from the welding cables!

3.2 Start-up of the ESP 1 S Welding Gun

1. **Attention:** Setting of the gun may only be carried out while the power source is switched off!

2. Attach the leg ring with its three legs or the support tube to the gun and tighten the Allen screws around the circumference. When using a support tube, make sure that the protective rubber cap is not wedged in; oth-erwise it may obstruct the movements of the piston. For studs above 40 mm length, a height adjustment ring, part No. 351-0053-000, must be inserted between the body of the gun and the leg ring and the stop screw must be reversed if necessary (half dog point outwards). For studs exceeding a length of 55 mm spacer bolts (see chapter 12.1) need to be mounted between feet and base ring.

Alternatively, for long studs you may use a gun support acc. to chapter 12.1.1. In this case the stud flange should protrude the end of the supporting tube by 1 to 2 mm. The suitable setting shall be determined by trial welds.

For M 10 studs please note: mount spacer bolts (see chapter 12.1) between the legs and the base ring, since the stepped chuck (part No. 351-7010-000) allows only a reduced insertion depth. The minimum length of the stud is 20 mm, for which spacer bolts with a length of 10 mm are required. Longer studs re-quire the use of more or longer distance bolts.

3. Push a stud of the required size into the chuck. Then adjust the stop screw to provide a gap of 51 mm be-tween the end of the stud (not including the ignition tip) and the upper edge of the counter-nut (see fig.2). This extends the chuck's service life by protecting it against splashes. Now tighten the counter-nut to lock the stop screw into position.

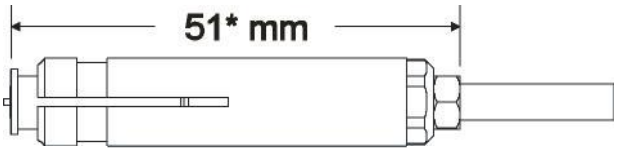

Fig. 2: Set-up of the chuck for gun ESP 1 S for studs with max. length 40 mm
*** 67 mm for studs with length exceeding 40 mm**
*** 57 mm for studs M 10**

Figure 3: setting disk of the pistol ESP 1 S

4. Push the chuck into the gun to the stop, and then lock it into position with a 17 mm gauge spanner.

By turning the setting screw clockwise (see Figure 3) the gap is in each case narrowed by one millimeter for

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each turn of the screw.

A large gap shortens the welding time, a small gap lengthens the welding time.

Now place the gun firmly on the workpiece so that all support legs are resting on the surface. The piston should now be pushed back by app. 1.5 mm (“protrusion”).

3.3 Start-up of the ESP 10 K Welding Gun

1. **Attention:** Setting of the gun may only be carried out while the power source is switched off!
2. Attach the leg ring with its three legs or the support tube to the gun and tighten the Allen screws around the circumference. When using a support tube, make sure that the protective rubber cap is not wedged in, otherwise it may obstruct the movements of the piston. For studs above 40 mm length a height adjustment ring, part No. 351-0053-000, must be inserted between the body of the gun and the leg ring and the stop screw must be reversed if necessary (half dog point outwards). For studs exceeding a length of 55 mm spacer bolts (see chapter 11.1) need to be mounted between feet and base ring.

   Alternatively, for long studs you may use a gun support acc. to chapter 12.1.1. In this case the stud flange should protrude the end of the supporting tube by 3 to 4 mm. The suitable setting shall be determined by trial welds.

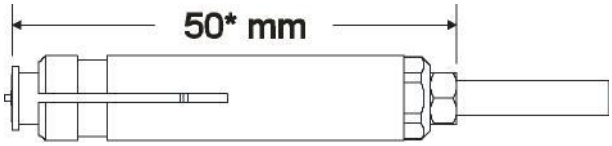

Fig. 4: Set-up of the chuck for gun ESP 1 K for studs with max. length 40 mm
*** 66 mm for studs with length exceeding 40 mm**
*** 57 mm for studs M 10**

Figure 5: setting disk of the pistol ESP 1 K

For M 10 studs please note: mount spacer bolts (see chapter 11.1) between the legs and the base ring, since the stepped chuck (part No. 351-7010-000) allows only a reduced insertion depth. The minimum length of the stud is 20 mm, for which spacer bolts with a length of 10 mm are required. Longer studs re-quire the use of more or longer distance bolts.

3. Push a stud of the required size into the chuck. Then adjust the stop screw to provide a gap of 50 mm be-tween the end of the stud (not including the ignition tip) and the upper edge of the counter-nut (see fig.4). This will protect the chuck against welding splashes, thus extending its service life. Tighten Tighten the counter-nut to lock the stop screw into position.
4. Push the stud back into the gun to the stop, and then lock it into position with a 17 mm gauge spanner.
5. By turning the setting screw clockwise (see Figure 5) the spring force can be respectively increased by approx. 14 N, beginning with a minimum value of approx. 50 N up to a maximum value of 130 N.

   High spring tension shortens the welding time, low spring tension lengthens the welding time.
6. Press the pistol firmly onto the workpiece, so that all its legs are firmly seated. The piston should only be compressed a few millimetres.

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3.4 Start-up of the welding gun ESP 1 ISO

With the ESP 1 ISO welding gun, insulating mats can be fastened to a metallic wall with cup head pins. The pin is pushed through the insulating mat, the mat should be a few millimeters thicker than the length of the pin. Upon initiation of the welding process, the tip of the pin melts and the underlying sheet melts. After complete discharge of the capacitor, the melt cools, it creates a solid connection between disc pin and plate.

1. **Attention:** Perform all adjustment work on the gun only with the power source switched off!
2. Slide the stud holder for the cup head pins (magnetic stud holder) as far as possible into the gun and tighten the clamping nut with a socket wrench SW 17.
3. Place a cup head pin on the stud holder and prick the pin through the insulation.
4. Push the gun far enough in the direction of the sheet that the piston springs in a few millimeters.
5. Press the push button; the capacitor is discharged and the pin is connected to the plate.
6. Pull the gun off the plate.
7. If necessary, clean the copper disc of the stud holder from traces of scorch marks. A clean surface reduces wear.

Note: The welding time depends on the contact pressure; the more the spring is preloaded, the shorter the welding time. Avoid loading the spring as far as it will go, because then the welding time may be too short. The correct contact pressure (welding time) must be determined by tests.

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3.5 Start-up of KST 108 or KST 110 Power Sources

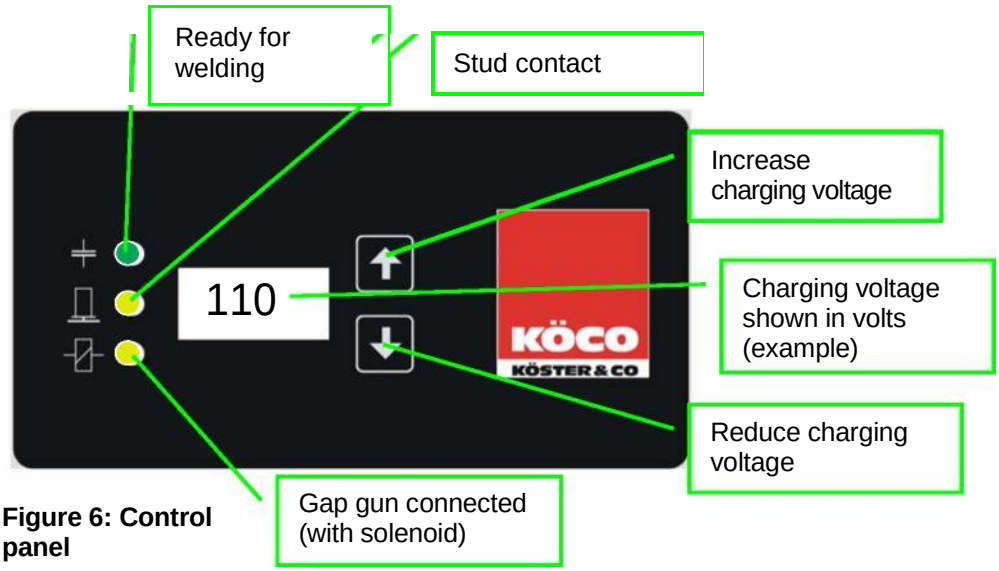

Figure 6: Control panel

1. Make sure that the mains switch is in the „0“ position. Then plug in the mains plug.
2. Connect the ground cables to the ground sockets of the power source and the workpiece. The connection points on the workpiece must be bright metal. Preferably, the earthing clamps should be mounted on opposite sides of the workpiece. Lock the ground cable plugs by turning them clockwise to the stop.
3. Connect the welding and control cables of the gun to the correct sockets of the power source. Lock the welding cable plug by turning it clockwise to the stop.
   Note: as a rule, the stud is connected to the minus pole and the workpiece to the plus pole. In certain cases, especially when welding non-ferrous metals, reversed polarity may improve the welding results. The power source is capable of welding with either polarity.
4. Turn on the mains switch to switch on the power source. The red pilot lamp will light up, and charging of the appliance to the set charging voltage will begin.
5. You can change the charging voltage by pressing the "UP" und "DOWN" buttons. Choose the voltage charging in accordance with the recommendations in 3.5 or according to your experience.
6. As soon as the charging voltage has been reached, the green pilot lamp (READY) will light up to signal that the power source is ready for welding.

3.6 Setting values for stud welding with tip ignition

Explanations:

On the pistol ESP 1 K the spring force is increased by approx. 14 N per turn (Figure 5) by turning the setting screw clockwise. Start with the minimum value (turn the setting screw anticlockwise till it reaches the stop) and set the required spring force from this starting point.

Set the required charging voltage at the power source. Example: a recommended value of "95 / +3" means: 95 V charging voltage and 3 clockwise turns from the minimum value.

On the pistol ESP 1 S the gap is reduced by 1 mm per turn respectively by turning the setting screw clockwise. Start with the minimum value (turn the setting screw anticlockwise till it reaches the stop) and set the required gap from this starting point.

Set the required charging voltage at the power source. Example: a recommended value of "100 / -4" means: 95 V charging voltage and 4 clockwise turns from the minimum value.

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As a matter of principle a higher spring force (ESP 1 K) and a larger gap (ESP 1 S) reduce welding time. With a minimum spring force, respectively a minimum gap (long welding time) the capacitor can already be discharged before the stud reaches the workpiece ("cold plunge"). When subjected to a load the stud will break off without any plastic deformation; spots of bright metal will appear on the fracture surface.
Our experience has shown that spring forces under +1 and gaps under -4 are generally not recommendable.

With a maximum spring force, respectively maximum gap, if there is insufficient voltage the welding time can be shortened so much that the arc no longer covers the entire area of the stud. Here, when subjected to a load the studs would also break off without great plastic deformation, and the fracture area would show incomplete melting.

A longer welding time (reduction of the spring force, respectively reduction of the gap) can improve the quality of the welding on slightly soiled (oily) surfaces.

The following recommended values for charging voltage and spring force, respectively gap, can serve as a guide:

Pistol ESP 1 K	KST 110		KST 108		Pistol ESP 1 S	KST 110		KST 108	
	Steel, non-alloy steel, brass	Alumi-nium	Steel, non-alloy steel, brass	Alumi-nium		Steel, non-alloy steel, brass	Alumi-nium	Steel, non-alloy steel, brass	Alumi-nium
M 3	60 / +3	50 / +3	70 / +3	60 / +3	M 3	60 / -3	70 / -4	75 / -3	70 / -4
M 4	80 / +3	80 / +3	90 / +3	85 / +3	M 4	90 / -3	90 / -3	110 / -3	110 / -3
M 5	95 / +3	95 / +3	100 / +3	100 / +4	M 5	100 / -4	100 / -4	115 / -4	115 / -4
M 6	120 / +4	120 / +4	140 / +4	140 / +4	M 6	120 / -3	120 / -4	135 / -3	135 / -3
M 8	180 / +6	160 / +6	200 / +4	200 / +6	M 8	170 / -3	170 / -3	200 / -4	200 / -4
M 10	200 / +6	-	-	-	M 10	200 / -0	-	-	-

Please note: for M 8 aluminium studs and M 10 steel studs, satisfactory results can only be achieved under particularly favourable conditions, such as clean surfaces, thin sheet metal, faultless ignition tips, firm support, symmetrical ground connection, etc. The sole responsibility for applicability rests with the user.)

3.7 The Welding Process

1. Place the prepared welding gun on the workpiece with all its legs firmly seated. This causes the piston of the gun to be pushed back by the length of the protrusion, and simultaneous tightening of the pressure spring. It is recommended to stabilize the gun from the rear by holding it down with the free hand, to prevent it from moving during the welding process.
   The chuck must not come into contact with the workpiece except through the stud.
   It is vital that the piston movement is not obstructed in any way.
   Ensure that the workpiece is firmly supported; it should under no circumstances rebound when the pistol is applied!
2. Trigger the gun and keep it still until the welding pool has cooled.
3. Lift off the gun from the welded stud, keeping it straight in the axial direction of the stud. If the gun is not lifted off straight, the gripping jaws of the chuck may be bent open, which prevents a sufficiently tight grip on the next stud.
4. Now check the weld (by visual inspection and possibly other tests according to EN ISO 14555) and adjust settings if necessary. Test welds should always be carried out before starting a series of welds.

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3.8 Weld tests

Stud welds can be tested by several different methods:

1. Visual inspection:

A good weld will be surrounded by a closed, even ring of splashes with a diameter exceeding the diameter of the flange by no more than 1.5 mm.

There must not be any visible gap between the flange of the stud and the workpiece surface. It must be impossible to squeeze even the edge of a sheet of paper between the flange and the workpiece.

A frequent defect is the so-called plunge impediment. It happens whenever the plunging movement of the stud is slowed, and consequently the plunge is delayed past the extinction of the arc and remains incomplete. This kind of fault is sometimes hard to detect in the course of a visual inspection, therefore visual tests should never be the only means of assessing a weld. Mechanical tests (bend test and tension test) should be carried out as well.

Fig. 7: Weld with energy supply correctly set and an even ring of splashes

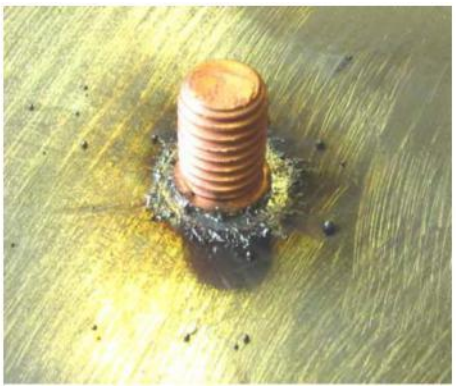

Fig.8: Energy set too high, therefore ring of splashes too wide

Fig. 9: Weld with energy set too low, consequently no visible ring of splashes present

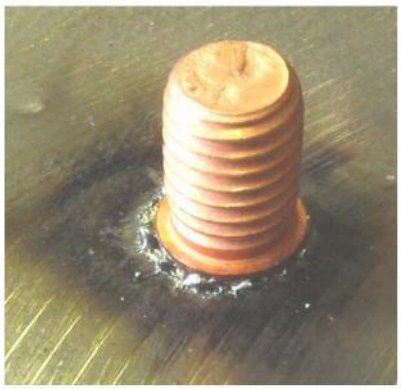

Fig. 10: One-sided ring of splashes, caused by arc blowing

Fig. 11: Defective weld caused by a plunging impediment. A gap is visible between the stud and the workpiece.

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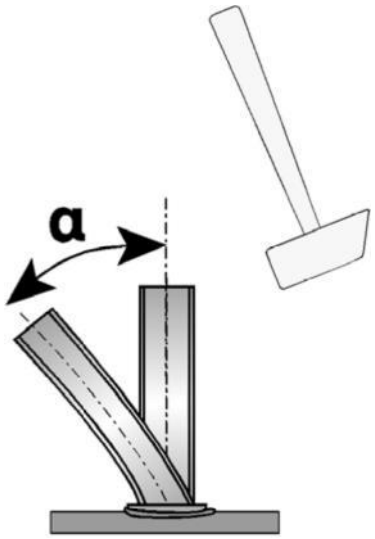
2. Bend Test:

A good weld must reach a bending angle of 30° without developing cracks in the welding zone. The bend test serves to check the selected settings as well as the suitability of the welding conditions and the combination of materials. For short, thick studs, which cannot be bent as described above, for example M 8 x 12, the stability of the weld must be checked by another method. Basically, the weld zone should always be more stress-resistant than either the stud or the workpiece. In any case, the responsibility always rests with the processor, depending on the application and the risks or danger involved in a possible failure of the welding connection.



Bending the stud with a hammer or a leverage tube by c. = 30°. The weld has passed the test if the weld zone or the heat affected zone shows no cracks or fissures following bending.

Fig. 12: Bend test of a stud welding connection

3. Tension test:

Threaded studs can be mounted on a fixed support and then tested with a gripping nut. The test can be either non-destructive, i.e. the nut is tightened up to a certain torque (for actual values see DVS-Technical bulletin 0904), or it can be destructive, i.e. the nut is tightened up to the breakage point. Breakage should always occur outside the weld zone. If breakage occurs in the weld zone, the nominal breakage-resistance value of the stud material should at least have been reached before the connection breaks.

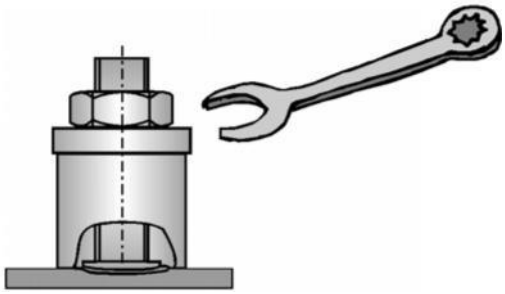


Fig. 13: Tensile test of a **stud welding connection**

3.9 Maintenance of the Power Source

The mains plug must be disconnected prior to any servicing. The housing must not be opened unless the machine is voltage-free. Especially when working in dusty surroundings, dust will collect on parts of the machine. It can impair the performance of the appliance's cooling system, with a consequent risk of overheating. Moreover, it reduces the resistance of insulating materials, and, combined with moisture, it can cause malfunctions in the control system Therefore open the housing at regular intervals to blow out the dust. This is vital in the case of metallic dust,

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which may cause short-circuits and thus damage parts of the machine. Do not aim the jet of air at any PCB's, but remove the dust from these with a vacuum cleaner.

The power source must not be cleaned with water jets (for example high-pressure cleaners). Do not use solvents, because these could damage protective coatings and plastic parts.

There must be no electrical link between the metal housing of the power source and the workpiece. Therefore make sure that the insulating supporting legs are in perfect condition if the site of the power source has an electrical link to the workpiece.

3.10 Maintenance of the Welding Gun

The welding gun is an electrical tool which must be kept perfectly insulated. If its body or cables are damaged, work must be discontinued at once. Do not use water jets or solvents for cleaning the gun. Protect it from moisture. If the gun does get wet, it must be completely dried before being used again.

Chucks and support legs (support tubes) are expendable parts and must be cleaned or replaced in case of heavy scorching or contamination with splashes. The chuck must have sufficient clamping force to ensure trouble-free current transmission. If, in spite of tightening the gripping jaws, its clamping force is no longer sufficient, the chuck must be replaced. Typical signs for insufficient clamping force are scorched threading on threaded studs or scorch marks on the top of studs caused by electric current flowing through the stop screw.

Keep in mind that the stud, the chuck and the clamping nut are all under voltage in relation to the workpiece once the welding process has set in. Therefore keep a safe distance during welding from parts of the workpiece where no welding is intended and from studs already welded.

3.11 Maintenance of Welding and Control Cables

The insulation of all cables, plugs and sockets must be kept in perfect condition. Due to the high currents involved, it is necessary to ensure that all connections within the welding circuit are tight, otherwise scorching will occur. Critical points are where parts of the cables are frequently moved, for instance cable entry points. Here, the cable cross-section is gradually reduced by breakage of individual wires, which involves the risk of sudden breakage and arcing over of the remaining cross-section. Therefore always check the cables and replace defective parts before starting work!

Protect the cables from moisture, especially at the connection points. When cleaning the cables, do not use solvents or water jets.

3.12 Shut-down

After completing the welding work turn off the main switch. When there are longer interruptions to the welding process the equipment should also be disconnected from the mains power supply (for instance by pulling the plug out of the wall socket). Do not use the mains connection plug in lieu of a switch, i.e. the main switch must always be turned off before the plug is pulled out.

3.13 Waste Disposal

Your KÖCO stud welding equipment contains valuable materials and must therefore not be disposed of together with household waste or by any other uncontrolled method.

We are registered with the "Stiftung Elektro-Altgeräte Register ® (EAR)" (Registry of Disused Electrical Appliances Foundation) under the registration number

WEEE-Reg.-Nr. DE 70903619

and will take back any appliance delivered by us from 2005 onwards free of charge for correct disposal in compliance with the relevant legislation, if such appliances are delivered to us carriage free.

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4 Trouble-shooting

In the event of malfunctions which the power source itself recognises, in the display field an "E" followed by a number will be shown. The following table shows the type of error.

4.1 Error Signals from the Power Source

Error No.	Cause	Remedy
E01	Mains power supply too high or too low	Ensure correct mains power supply
E02	Interruption of discharge resistance	Change discharge resistance
E03	Defective thyristor	Replace thyristor.
E04	Temperature too high	Ensure better cooling, allow equipment to cool down while idling.
E05	Capacitors, diode D1 or charging source defective	Repair
E06	Short circuit of lifting solenoid or control cable	Repair
E07	Not used	
E08	Not used	
E09	Short circuit MOSFET discharge circuit	Repair
E10	MOSFET discharge circuit does not switch	Repair

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4.2 Other Malfunctions

In the chart below, a number of malfunctions are described which can be diagnosed and remedied by trained service technicians with relative ease. In case you cannot solve these problems yourself, contact our agent in your neighbourhood or our customer service department. It is important that you give us details of the type and serial number of your appliance, as well as an exact description of the malfunction.

Malfunction	Cause	Remedies and Explanations
The piston of the gun does not respond to triggering (applies for gun ESP 10 S only)	Faulty connection in the control cable of the gun or in the pistol	Test with ohmmeter: Normal resistance of the coil is app. 11 Q. The magnet is connected to points 1 and 2, the trigger to points 3 and 4. Next, check the plug-and-socket connections.
	Fuse Pos. 16 defective	Replace fuse!
	The piston is jammed	Try to move the piston by hand. There must not be any unusual friction. The total piston stroke for the ESP 1 S is approx. 7 mm and for the ESP 10 K approx. 11 mm.
	Magnetic coil under continuous current	Turn off the power source, then switch it back on, watching the piston of the gun (do not trigger the gun). The piston must remain unmoved. If the magnet attracts it immediately, there is a defect in the control. Note: The magnetic coil will burn out if kept under continuous current even for a short time. Therefore turn off the power source again immediately!
Faulty welding results in spite of correct parameter settings	Workpiece surface contaminated with oil, grease, rust, or galvanized, painted, etc. Movement of the piston obstructed	Clean the welding zone and the ground clamping points of the workpiece. Best welding results are achieved on clean bright metal surfaces. Protective rubber cap has been wedged in
Welding results unreliable (sometimes good, sometimes faulty)	Function of the piston irregu- lar	Piston of the gun subjected to an excessive and fluctuating amount of friction. Clamping force of the spring insufficient. In either case, have the gun repaired!
	Arc blowing caused by difficult workpiece geometry	Follow the instructions which can be found in the relevant literature to reduce arc blowing. Make sure that both ground clamps are connected to the workpiece. Do not weld near a ground clamp!
	The workpiece yields on the impact of the stud.	Provide adequate support for the workpiece.
Unusually early power source cut-out because of overheating.	Fan does not function.	Replace fan.
Unusually strong heating at some points of the welding circuit	Cable cross-sections reduced by partial wire breakage Scorching caused by loose connections	Stop welding immediately! Replace cables. Tighten all connections within the welding circuit!

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5 Illustrations of KST Power Sources

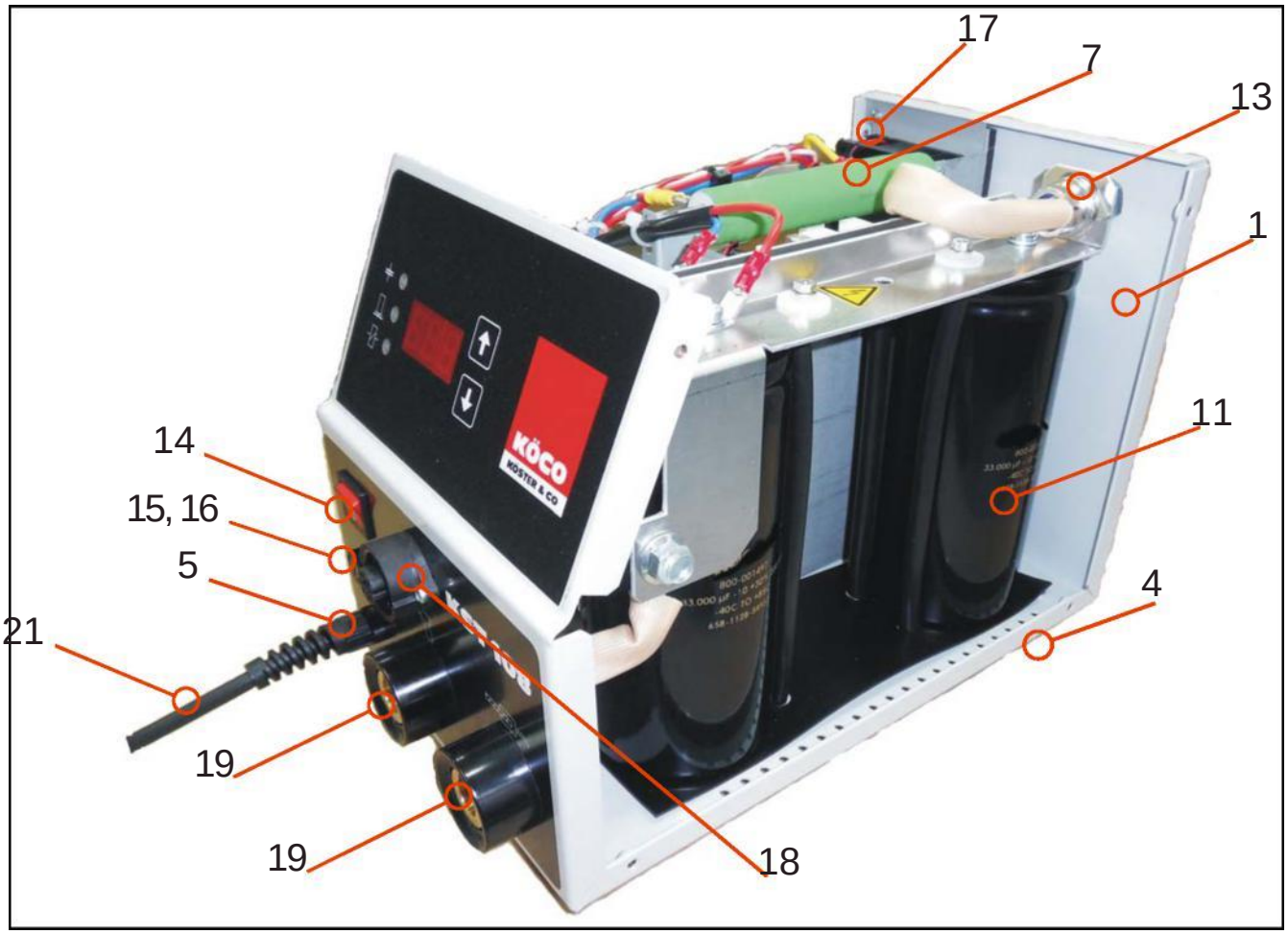

Fig. 14: Right-side view of KST108 with the cover removed

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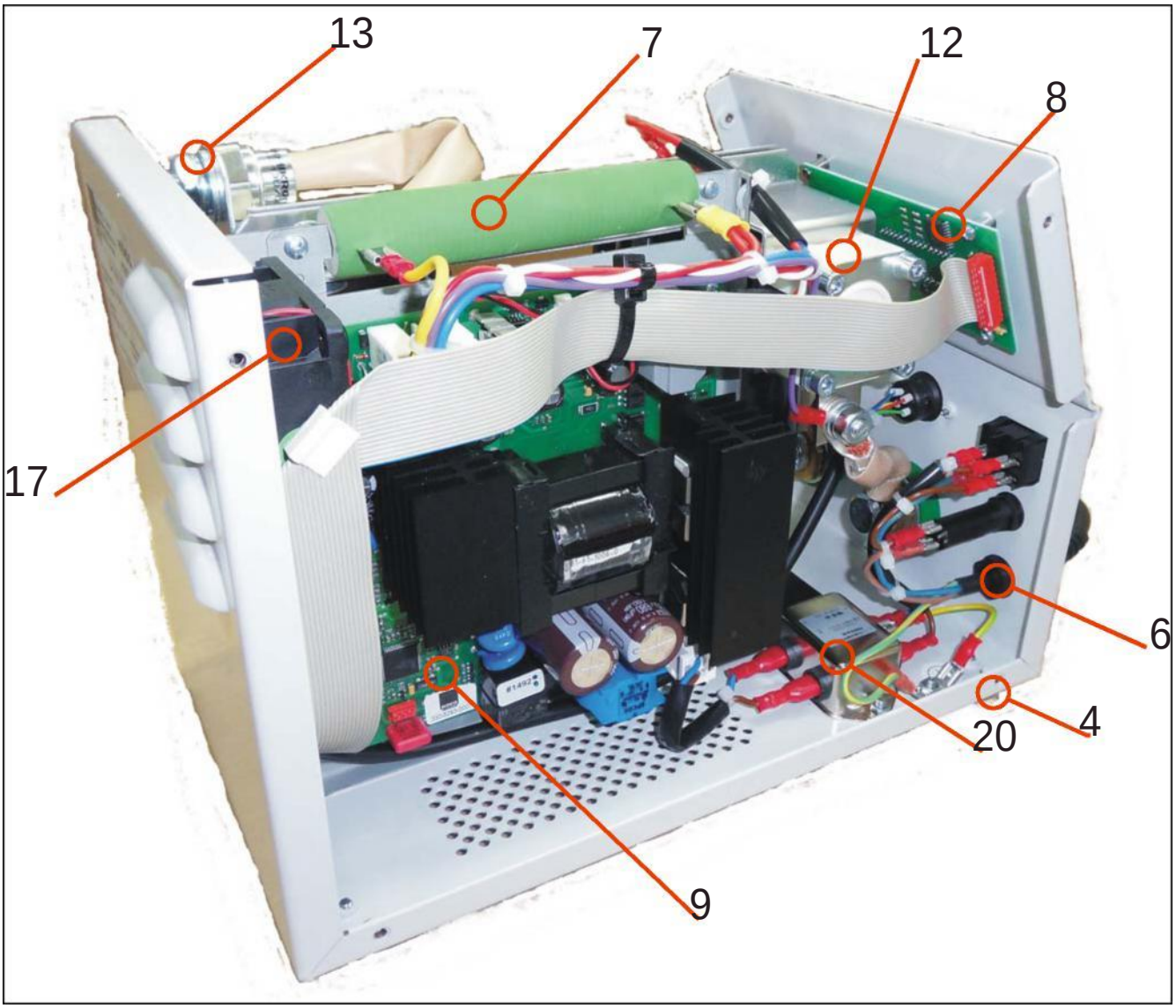

Fig. 15: Left-side view (front) of KST 108 with the cover removed

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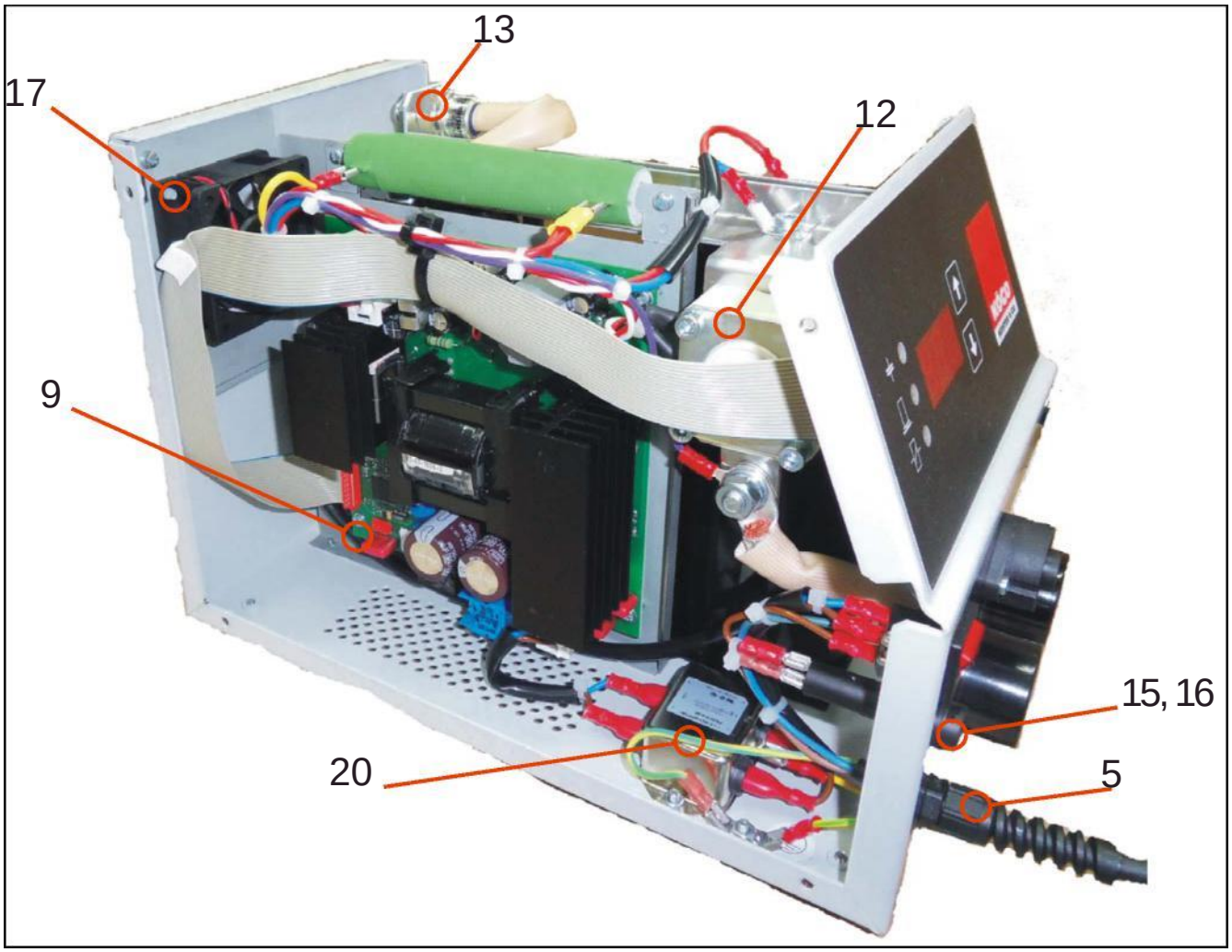

Fig. 16: Left-side view (rear) of KST 108 with the cover removed

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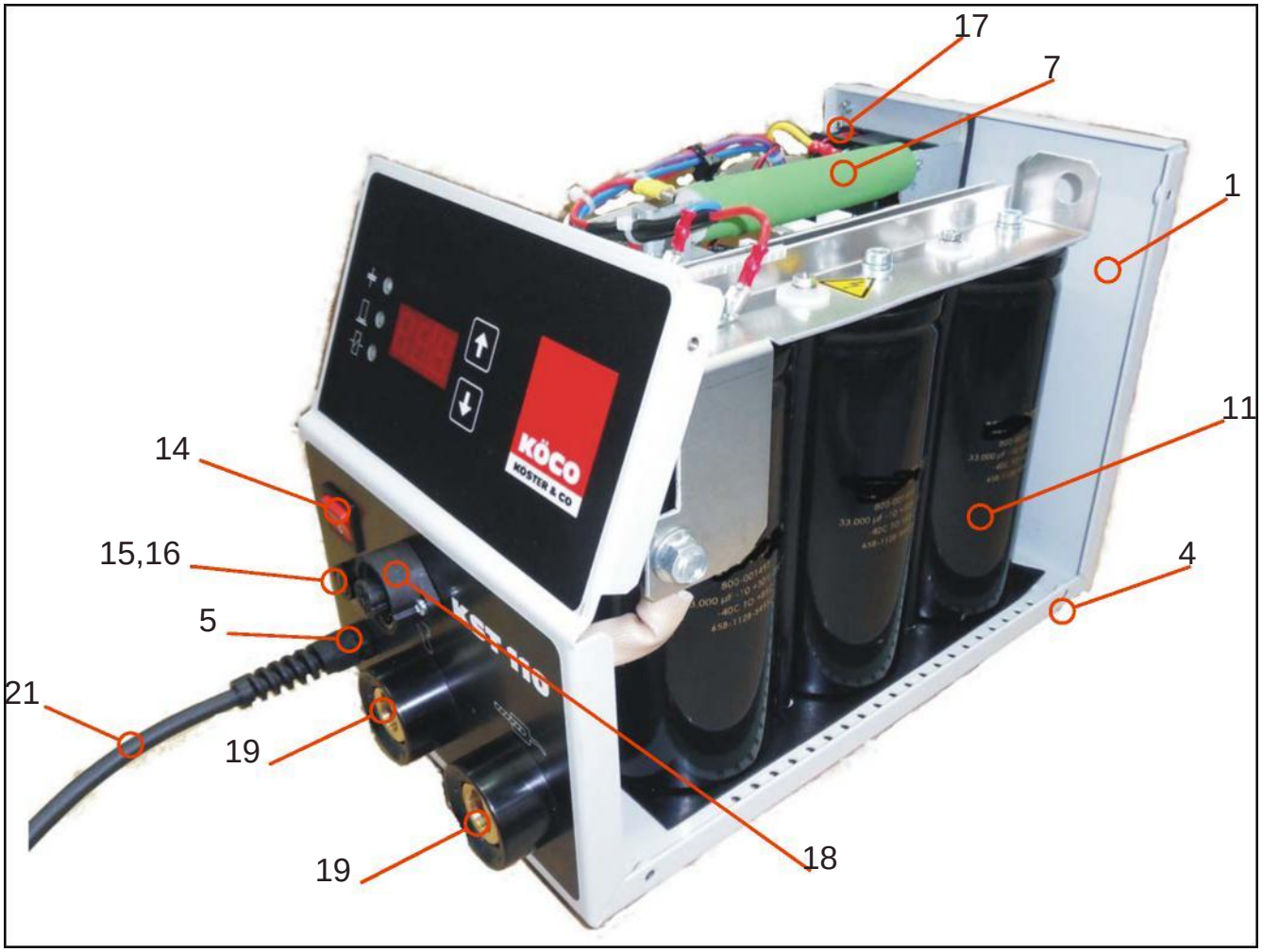

Figure 17: Right-side view (rear) of KST 110 with the cover removed

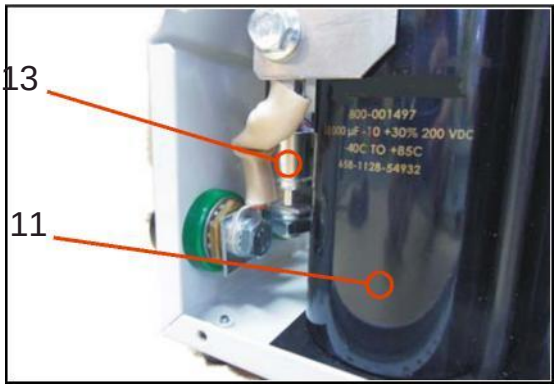

Figure 18: Detail diode KST 110

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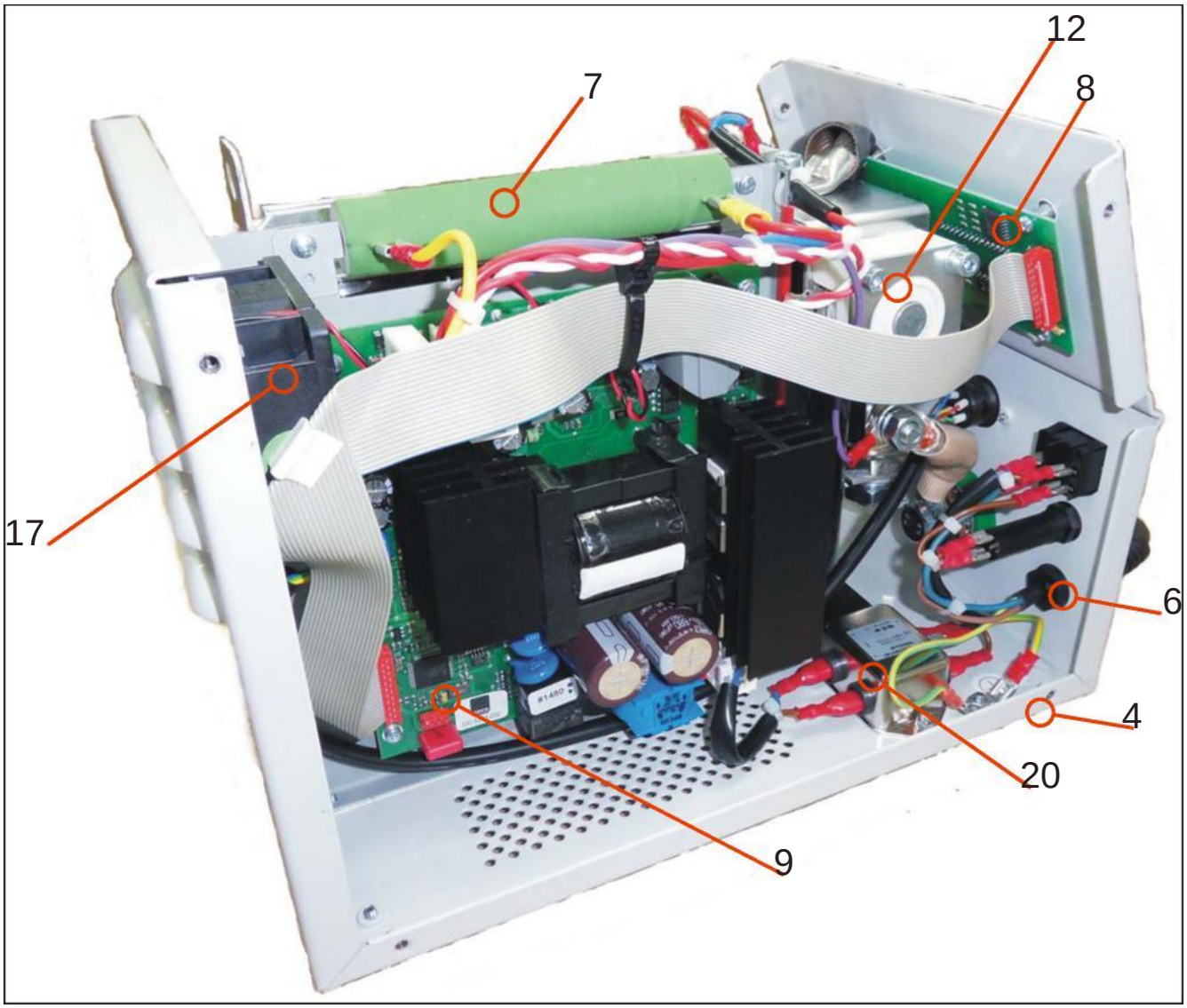

Figure 19: Left-side view front of KST 110 with the cover removed

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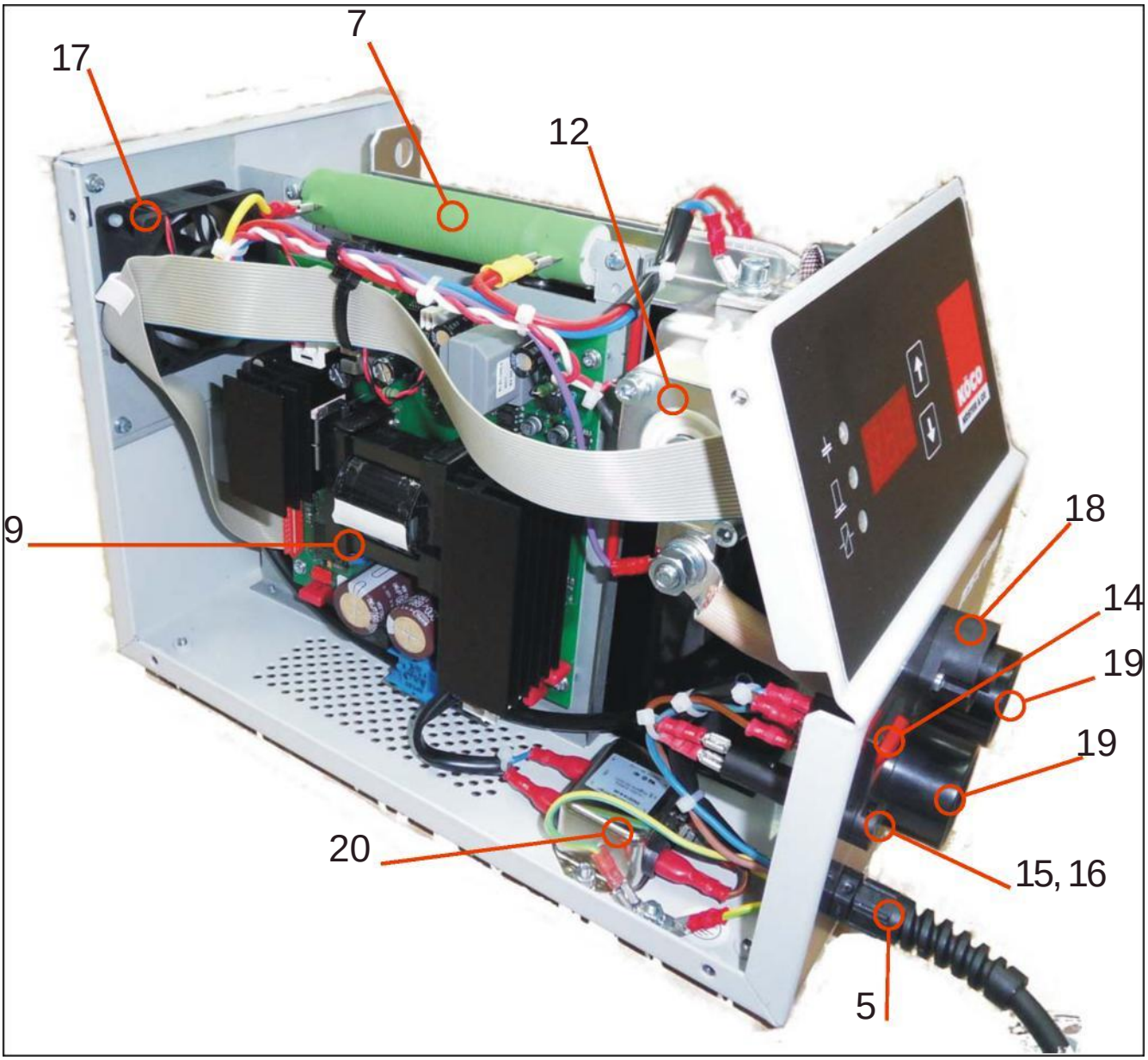

Figure 20: Left-side view rear of KST 110 with the cover removed

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6 Spare Parts List KST 108 and KST 110

Item	Quantity	Description	Part number
1	1	housing	320-6500-000
2	1	cover	320-6501-000
3	1	carrying handle	320-0566-000
4	4	appliance leg	320-0012-000
5	1	cable gland	325-0027-000
6	1	nut for cable gland	325-0028-000
7	1	resistor	330-0148-000
8	1	operating card	330-5294-000
9	1	control card	330-5293-000
10	1	front foil	399-0090-000
11	2	capacitor KST 108	330-0330-000
	3	capacitor KST 110	330-0330-000
12	1	thyristor	325-0678-000
13	1	diode for KST 108	320-0567-000
13	1	diode for KST 110	320-0568-000
14	1	mains switch	325-0026-000
15	1	fuse holder, plug-in type	325-0800-000
15	1	fuse holder cap	325-0801-000
16	1	fine-wire fuse 6.3AT	325-0397-000
17	1	fan	325-0680-000
18	1	flange connector 4-pole	325-0079-000
19	2	welding connector	325-0017-000
20	1	line filter	325-0671-000
21	1	3 m mains connection cable with plug	317-0006-000

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7 Illustration of the ESP 1 K Welding Gun

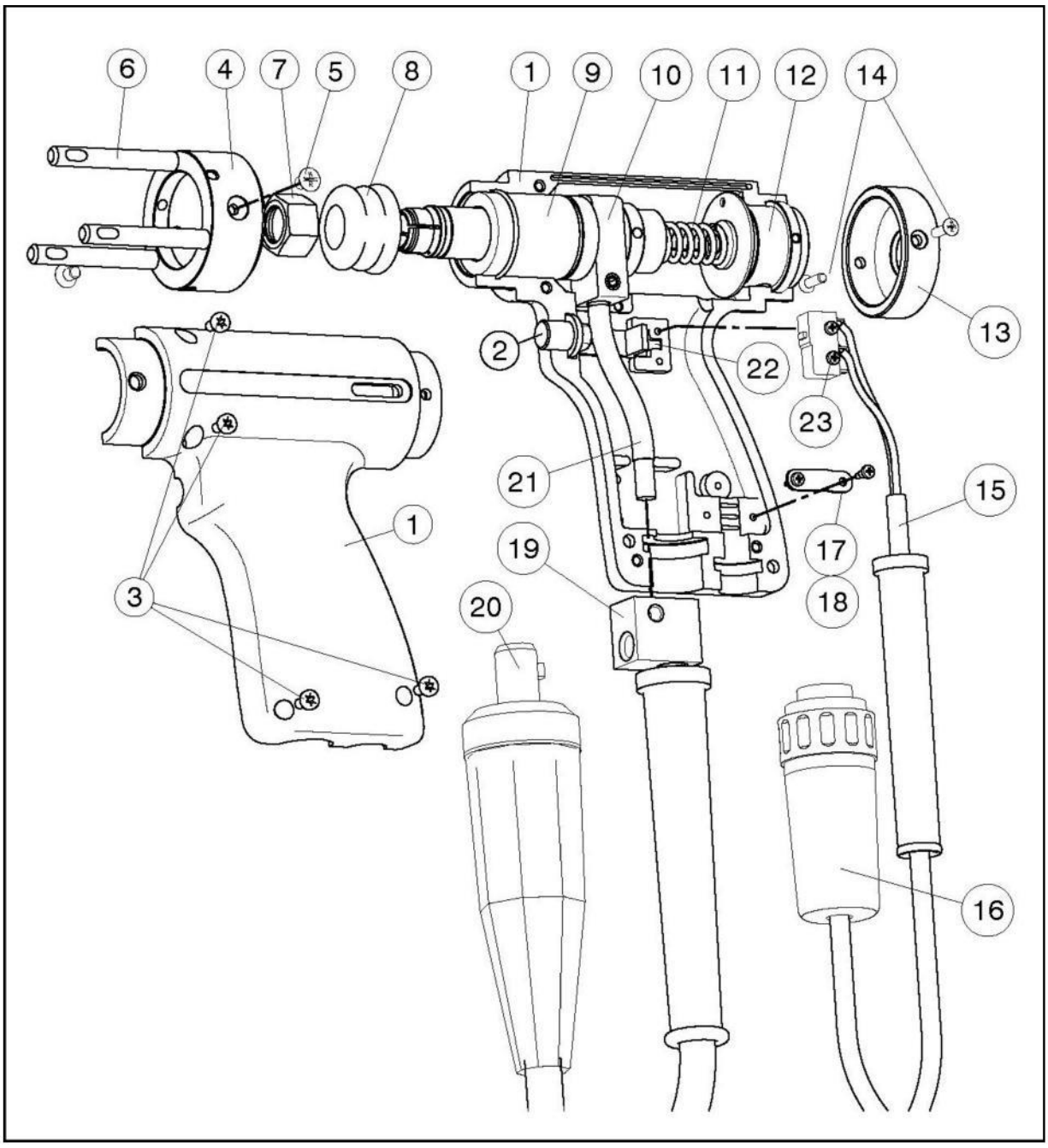

Fig. 21: Detailed view of the ESP 1 K welding gun (contact welding)

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8 Illustration of the ESP 1 S Welding Gun

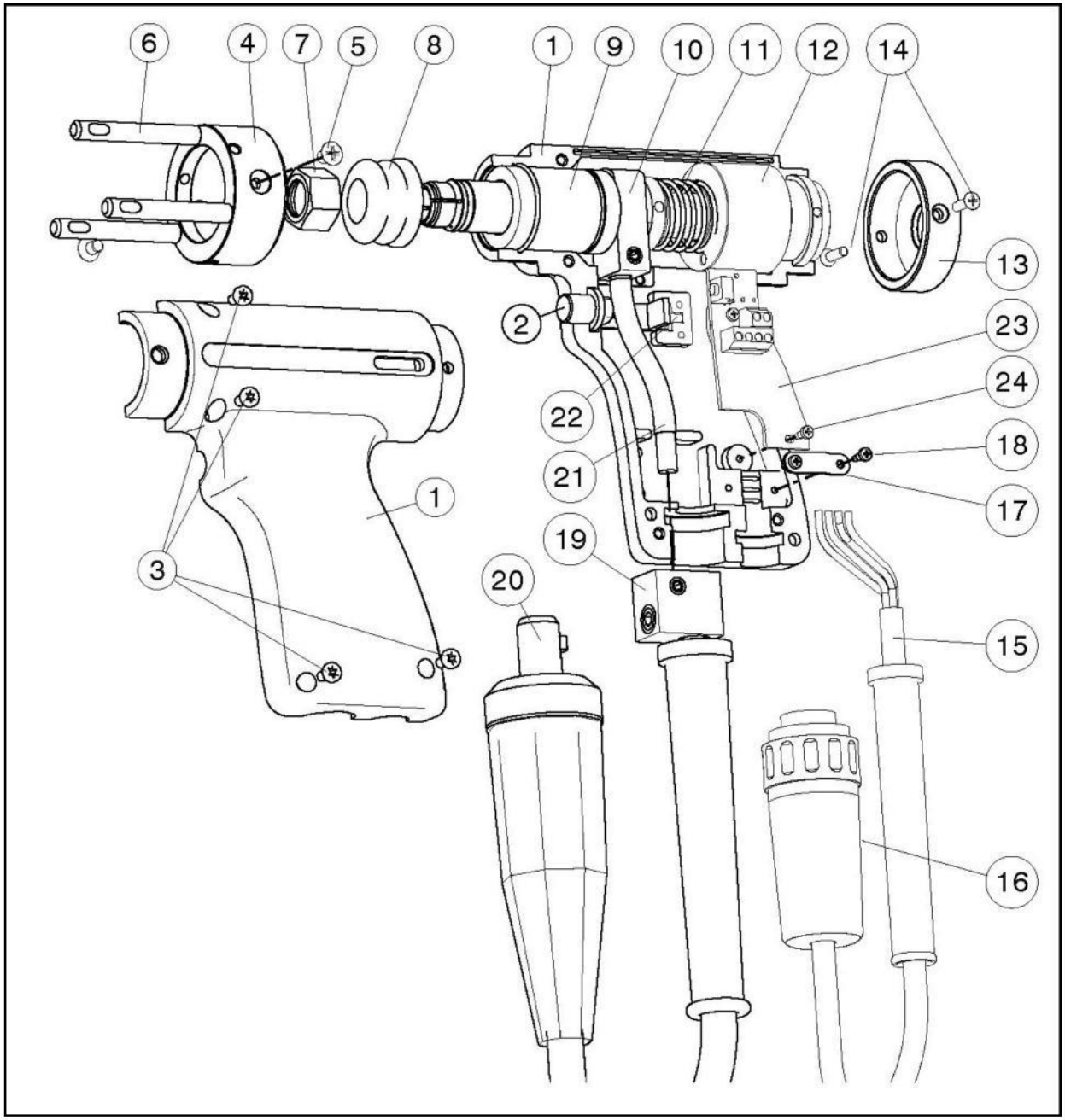

Fig. 22: Detailed view of the ESP 1 S welding gun (gap welding)

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9 Illustration of ESP 1 ISO welding gun

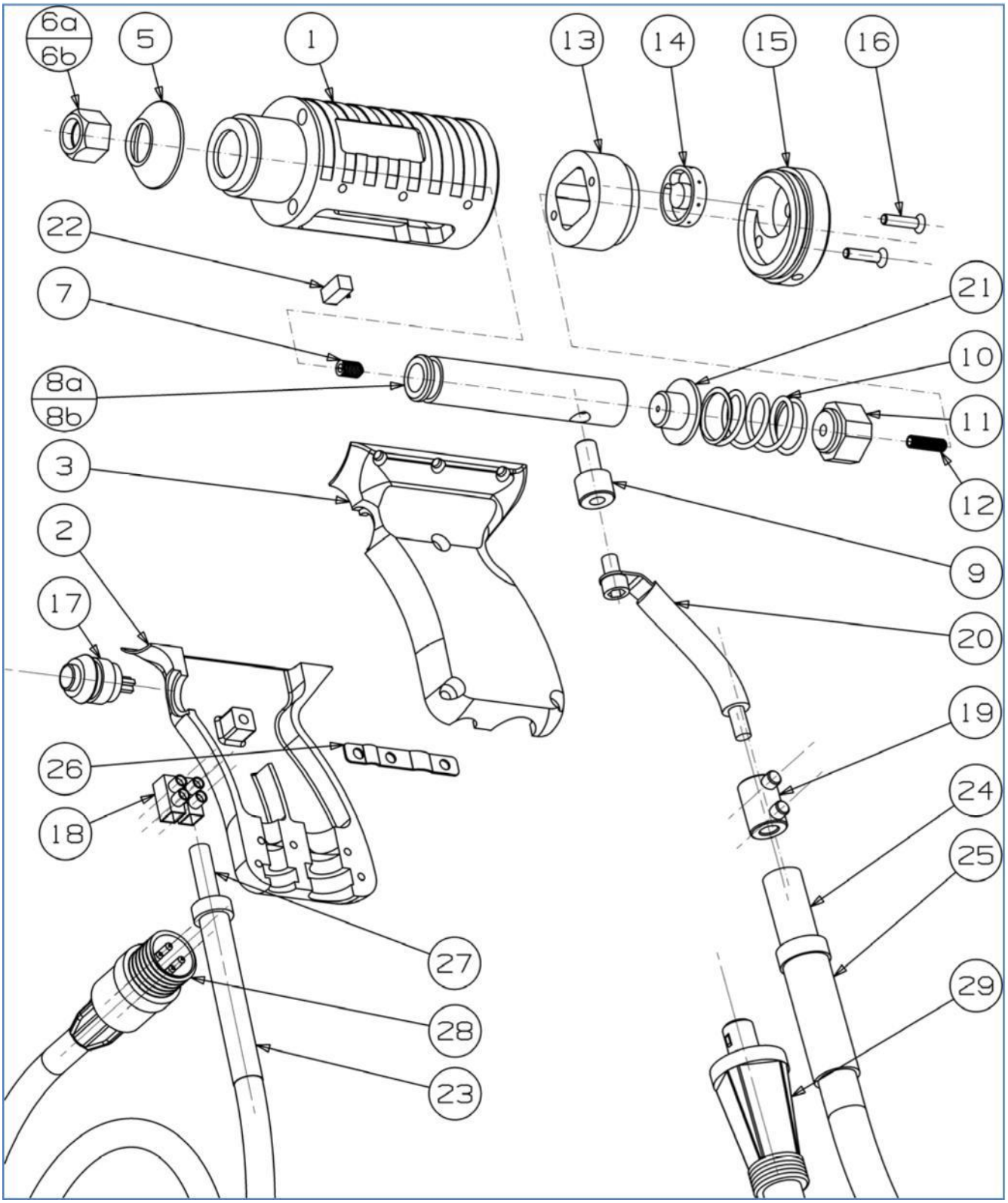

Fig. 23: Detailed view of the ESP 1 ISO welding gun (welding of cup head pins)

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10 Spare Parts List for the ESP 1 K Welding Gun

Item	Description	Part No.	Note
1	gun handle set	326-0001-000	Only available as set
2	push button	326-0002-000	
4	leg ring	326-0003-000	
6	support leg	326-0004-000	
7	lock ring	326-0005-000	
8	bellows	326-0006-000	
9	ball lining	326-0007-000	
10	piston unit	326-0020-000	Not available as individual parts
11	compression spring	326-0008-000	
12	pretensioning system	326-0009-000	Not available as individual parts
13	end cap	326-0010-000	
15	control cable (4 m 2 × 0.75 mm^2) with plug	326-0016-000	Not available as individual parts
17	cable clip	326-0011-000	
16	control cable plug 4-pole	325-0240-000	
19	welding cable (4 m × 25 mm^2) with plug	326-0015-000	Not available as individual parts
20	welding cable plug	325-0234-000	
21	welding cord	326-0012-000	
22	pusher spring	326-0014-000	
23	micro switch	329-0065-000	

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11 Spare Parts List for ESP 1 S Welding Gun

Item	Description	Part No.	Note
1	gun handle set	326-0001-000	Only available as set
2	push button	326-0002-000	
4	leg ring	326-0003-000	
6	support leg	326-0004-000	
7	lock ring	326-0005-000	
8	bellows	326-0006-000	
9	ball lining	326-0007-000	
10	piston unit	326-0021-000	Not available as individual parts
11	compression spring	326-0019-000	
12	lifting solenoid	326-0018-000	
13	end cap	326-0010-000	
15	control cable (4 m 4 × 0.75 mm^2) with plug	326-0017-000	Not available as individual parts
16	control cable plug 4-pole	325-0240-000	
17	cable clip	326-0011-000	
19	welding cable (4 m × 25 mm^2) with plug	326-0015-000	Not available as individual parts
20	welding cable plug	325-0234-000	
21	welding cord	326-0012-000	
22	pusher spring	326-0014-000	
23	control panel	326-0022-000	

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12 Spare Parts List for ESP 1 ISO

Pos.	Description	Part No.	Note
1	welding gun body	322-0575-000	
2	bottom gun handle [1]	322-0597-000	
3	top gun handle [1]	322-0596-000	
5	bellows	322-0589-000	
6a	clamping nut SW 17	322-0582-000	
7	threaded pin M 6 x 8	322-0220-000	
8a	piston for cylindrical chuck	322-0577-000	
9	connection chuck	329-0050-000	
10	compression spring	322-0585-000	
11	pretensioning device	322-0581-000	
12	M 5 threaded pin with ball	322-0591-000	
13	guide bushing	322-0586-000	
14	pretensioning disc	322-0580-000	
15	lift adjustment box	322-0592-000	
16	oval, slotted counter-sink screw M 4 x 20 DIN EN ISO 2010		
17	pushbutton	329-0031-000	
18	luster terminal	325-0655-000	
19	cable connector	329-0025-000	
20	welding cord	317-5113-000	
21	threaded flange	322-0097-000	
22	micro switch	329-0063-000	
23	hose connection gland for control cable	325-0261-000	
25	hose connection gland for welding cable	325-0567-000	
26	double clamp	325-0681-000	
28	control cable plug, 4-pole	325-0240-000	
29	welding cable plug, 35 mm^2	325-0236-000	
23 - 29	cable connection set 10 m, 6 mm^2	329-5255-000	Not available in separate parts

[1] viewed from the assembly / disassembly position

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13 Circuit Diagram

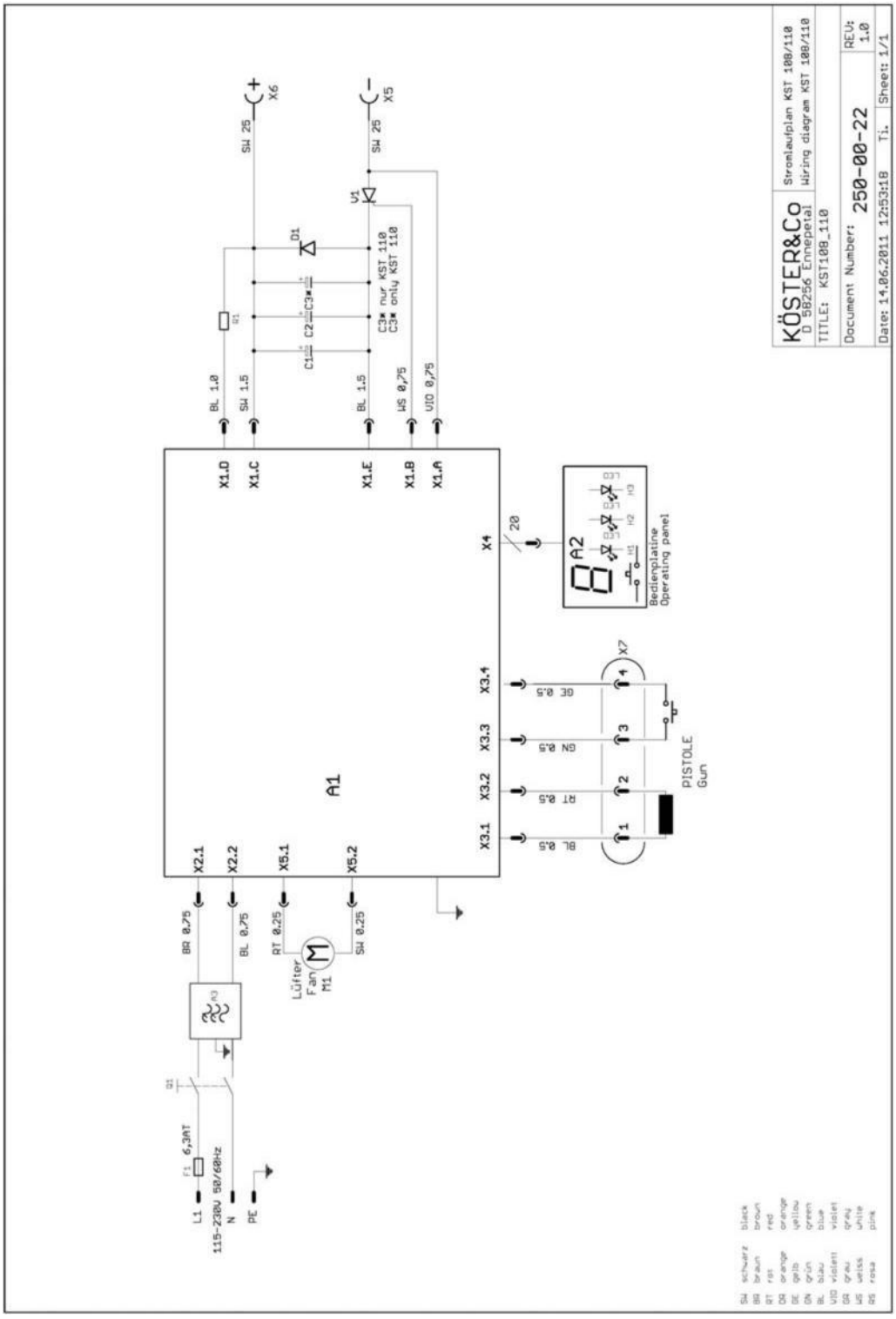

Fig. 23: Circuit diagram KST 108 and KST 110

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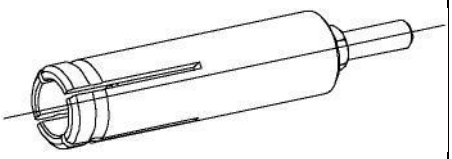
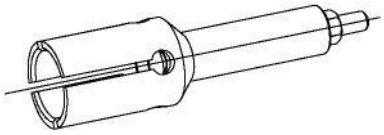
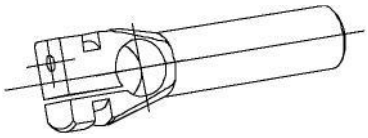
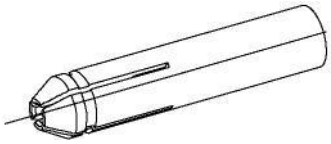
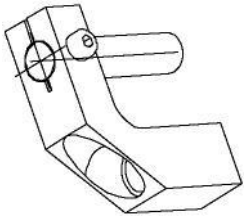
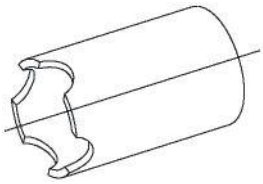
14 Accessories

14.1 Accessories for ESP 1 S and ESP 1 K welding guns

Designation / Application	Part No.	Illustration
10 mm Ø chuck for threaded studs, smooth pins, tapped studs (D = external diameter of the stud)	D = 3 mm: 351-7003-000 D = 4 mm: 351-7004-000 D = 5 mm: 351-7005-000 D = 6 mm: 351-7006-000 D = 7,1 mm: 351-7053-000 D = 8 mm: 351-7008-000	
Ø 12/10 mm chuck for M 10 threaded studs	D = 10 mm: 351-7010-000	
chuck for 6.3 mm blade terminal	351-7050-000	
chuck for insulating pins (D = diameter of the insulating pin)	D = 2 mm: 351-7002-000 D = 3 mm: 351-7001-000	
angle cantilever for welding at restricted places, near to edges, shaft Ø 10 mm, for 10 mm Ø chucks	351-0044-000	
positioning tube (Ø = 30 mm)	370-0335-000	
Supporting tube (D = 30 mm)	326-0034-000	
spacer ring (height = 16 mm)	351-0051-000	

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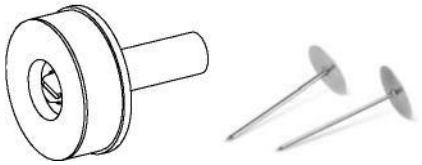
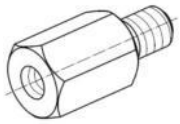
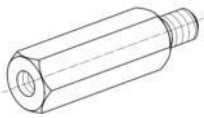
chuck for 38 mm Ø pin, with copper plate part-no. 351-0048-000	351-6162-000	
Set of spacer bolts 10 mm long (3 pieces)	326-0026-000	
Set of spacer bolts 20 mm long (3 pieces)	326-0024-000	

14.2 Special centring device

For welding with stencils, we offer the positioning tube No. 370-0335-000 or the support tube No. 326-0034-000. With these, a slight eccentricity of the gun's axis cannot be excluded due to unavoidable tolerances in the gun's plastic body. Where high-precision centring of the gun's axis is necessary, we recommend using the special centring device No. 326-0037-000.
It consists of the following parts:

Position	Number of units	Designation
1	1	centring tube adapter
2	3	screw M 4 x 12 DIN 912
3	3	washer M 4 DIN 933
4	1	centring tube D 30
5	2	sealing disc P5x
6	1	lock ring, rounded
7	1	cylindrical pin 10 x 60 DIN 6325
8	1	centring gauge D 30

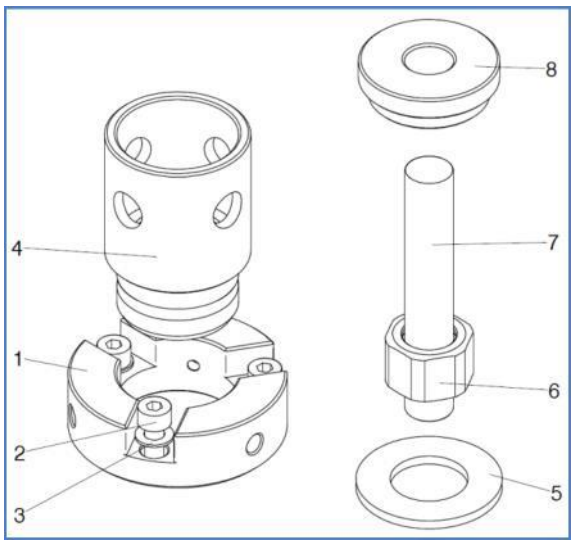


Fig. 25: Special centering device

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For setup, proceed as follows.

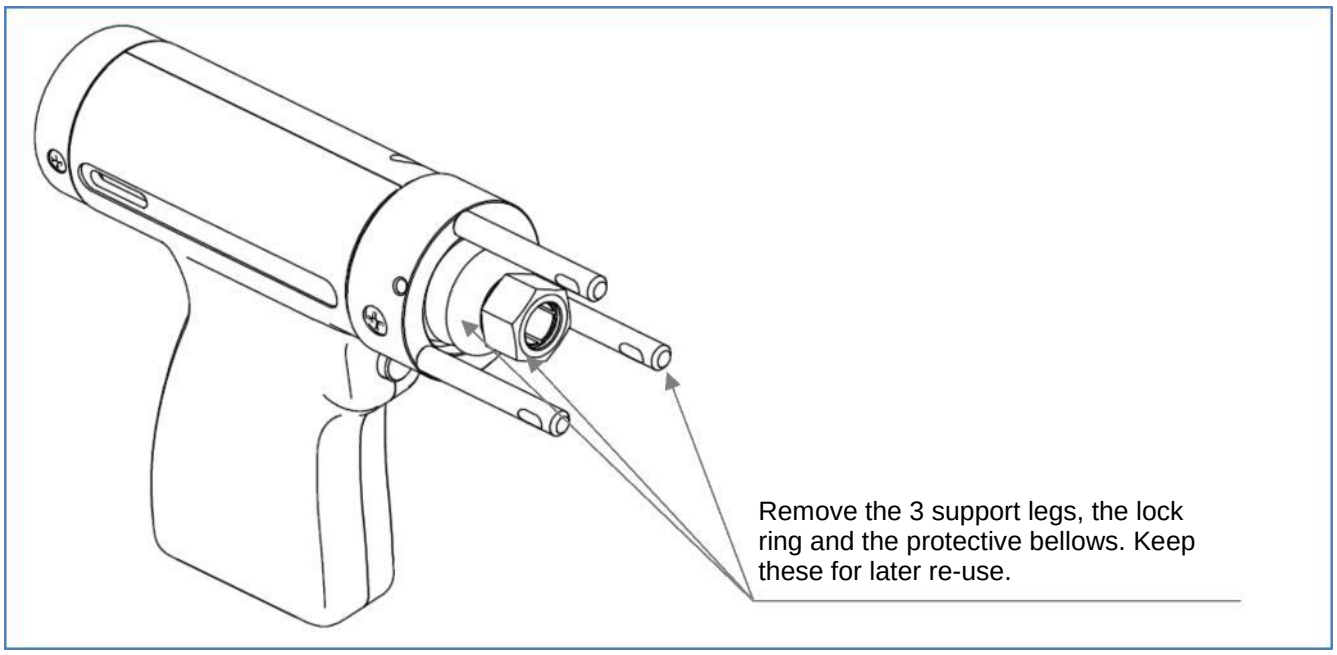

Fig. 26: Setup, step 1

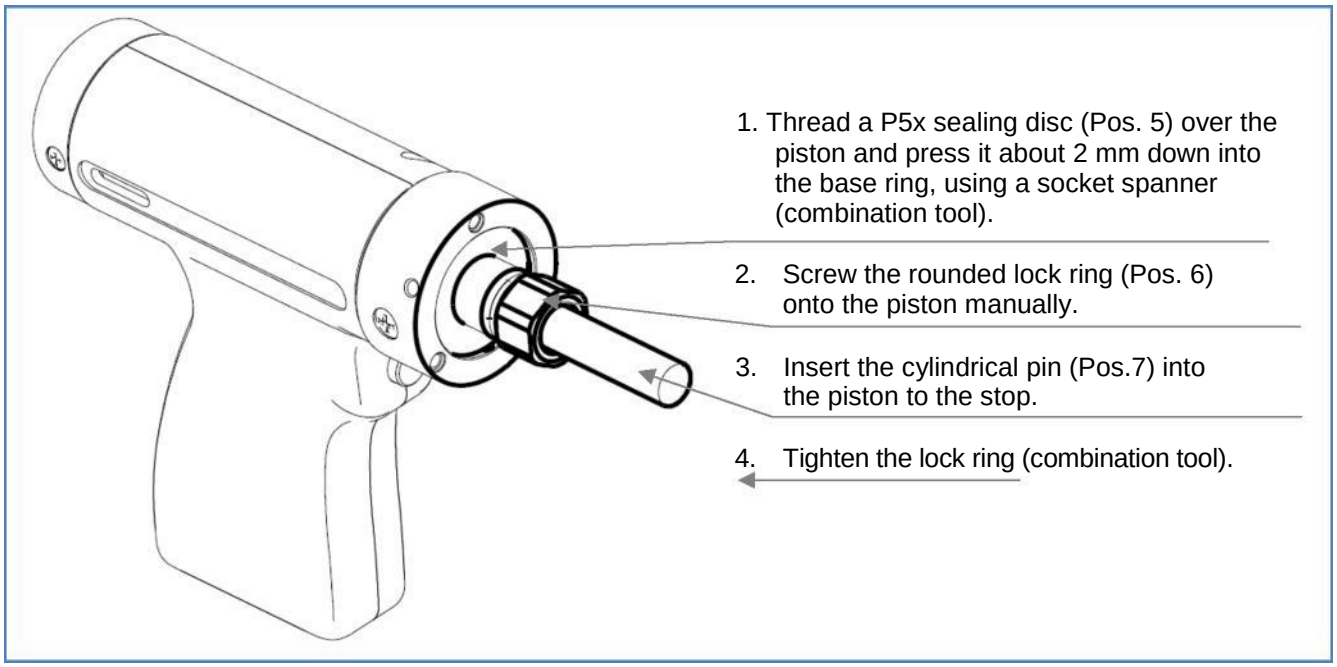

Fig. 27: Setup, step 2

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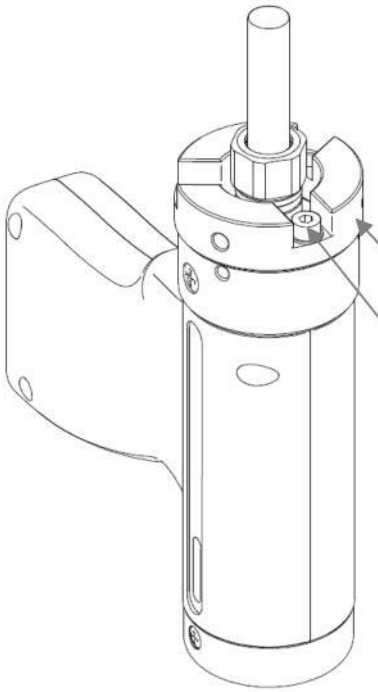
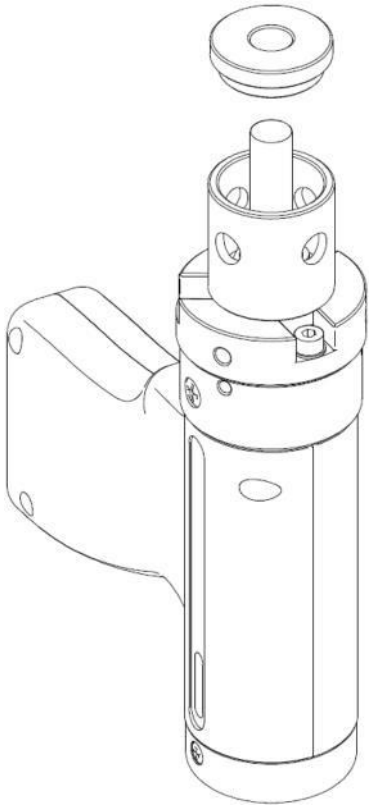


1. Place the rear end of the gun on a horizontal surface.
2. Put the centring tube adapter (Pos. 1) on the base ring and place the three fastening holes above the three screw-in threads for the support legs.
3. Fasten the centring tube adapter lightly to the base ring with the 3 M4x12 screws (Pos. 2) and the washers (Pos.3).

Tip: use a TX15 screwdriver.

Fig. 28: Setup, step 3



1. Insert centring tube (Pos. 4) into the centring pipe adapter and lock it in place.
2. Thread the centring gauge (Pos.8) onto the cylindrical pin and let it fall onto the centring tube.
3. Loosen the three fastening screws carefully until the centring tube adapter can be moved.
   Now shift the centring pipe adapter on the front surface of the base ring until the centring gauge falls into the centring tube.
4. Tighten the three fastening screws alternately in several steps and check each time whether the centring gauge is still easily rotatable.
   If necessary, loosen the screws slightly again and readjust the centring tube adapter.
5. Remove the centring gauge and centring tube.
   Remove the cylindrical pin from the piston and insert a chuck.
   Re-insert centring tube and lock it in place.

Please note:
Thanks to high-precision manufacturing of the centring pipes, the centring pipe adapter does NOT need to be readjusted when the centring pipe is exchanged or replaced.

Fig. 29: Setup step 4

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14.3 Alternative gun support for studs exceeding 50 mm length (in particular insulation pins)

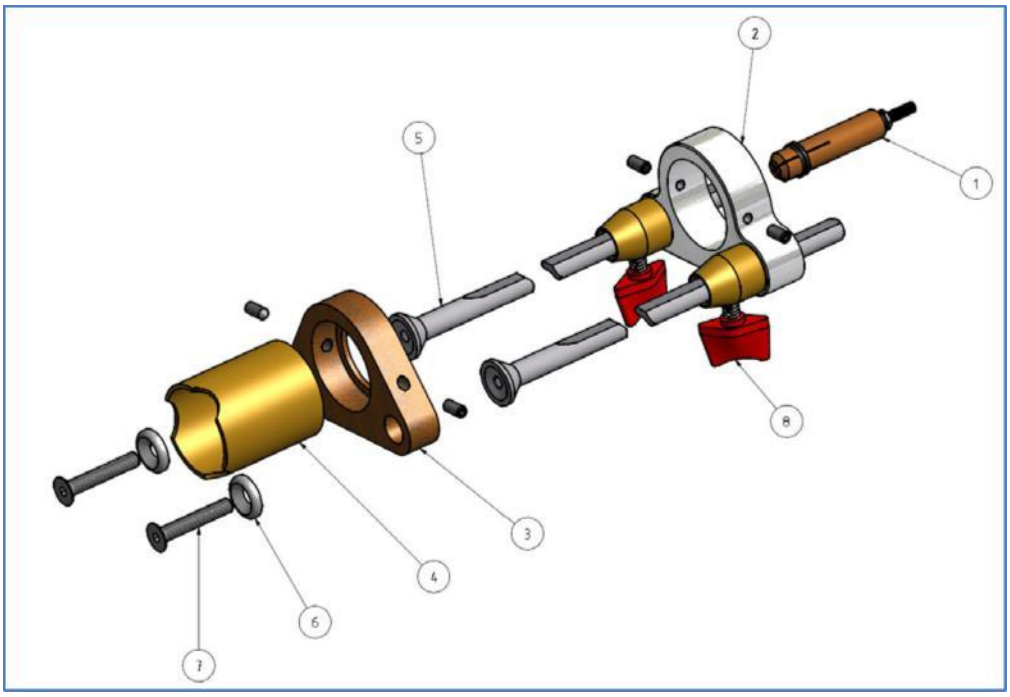

Fig. 30: Gun support for studs exceeding 50 mm length

Stud diameter	Chuck pos. 1	Mounting flange pos. 2	Foot plate pos. 3	Supporting tube pos. 4	Leg pos. 5
Ø 2 x > 50	351-7002-000	326-0027-000	360-0012-000	360-0335-000	370-0240-000
Ø 3 x > 50	351-7001-000				
Ø 4 x > 50	351-7004-000				
Ø 5 x > 50	351-7005-000				
Ø 6 x > 50	351-7006-000				
Ø 8 x > 50	351-7008-000				
Ø 10 x > 50	351-7010-000				
Washer pos. 6		370-0055-000			
Screw with hexagon socket pos. 7		322-0372-000			
Wing screw pos. 8		322-0631-000			

The complete gun accessories for insulation pins 3 mm Ø is available with part-no. 326-0028-000.

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15 Literature

EN ISO 14555 “Arc Stud Welding of Metallic Materials”

EN ISO 13918 “Studs and Ceramic Ferrules for Arc Stud Welding”

DVS Technical bulletin 0901 “Stud Welding Processes for Metals – Overview”

DVS Technical bulletin 0902 “Drawn Arc Stud Welding”

DVS Technical bulletin 0903 “Stud Welding with Tip Ignition”

DVS Technical bulletin 0904 “Drawn Arc Stud Welding - Practical Hints”

TRILLMICH, R. AND WELZ, W.: Stud Welding - Principles and Applications DVS-Media Düsseldorf 2014 english edition vol. 12

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