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**How to Act After Accidents Caused by Electrical Current – Course:
Basic Skills and Knowledge of Electrical Engineering. Methodical
Guide for Instructors**

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How to Act After Accidents Caused by Electrical Current – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

Institut für berufliche Entwicklung e.V.
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Original title:

Methodische Anleitung für den Lehrenden
"Verhalten nach elektrischen Unfällen"

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1. Aims and Contents of Practical Vocational Training in the Field of "How to Act After Accidents Caused by Electric Current"

At the end of the training, the trainees should have achieved the following aims:

- The trainees have acquired the necessary knowledge and skills for acting correctly after accidents caused by electric current.
- The trainees know how to use instructions on first aid.
- The trainees are able to render first aid quickly, safely and carefully after accidents caused by electric current.
- The trainees observe the labour safety regulations.

In order to achieve the above mentioned aims, the following contents have to be imparted by the instructor:

Knowledge

- Effects of electric currents on the human organism.
- Rules of conduct and hints on labour safety concerning the safety of the rescuer.
- First aid measures after accidents caused by electric current.

Skills

- Finding and rescuing of the injured person.
- Rendering first aid.
- Artificial respiration of the injured person.
- Carrying out of the cardiac massage.
- Preparing the injured person for transportation.

2. Organizational Preparation

In order to guarantee a smooth course of instructions and exercises, it is necessary to organize and prepare the lessons well.

This includes the following steps:

2.1. Preparation of the Labour Safety Instructions

Before beginning the exercises, a brief instruction has to be given as to the expert use of the working means and to working free of accidents.

It is recommendable to start a book on labour safety instructions, in which all instructions on safe working and proper use of the working means are entered in brief outlines. The trainees confirm by their signatures that they have participated in the respective instruction.

The following instructions should be included:

- Protection of the rescuer while rescuing the injured person out of the fault–current circuit.
- Name and workshop place of an educated first–aid attendant.
- Working hours and telephone number of the next first–aid post.
- Name, address and telephone number of the department or office of the enterprise disposing of a car for the transportation of injured people.
- Address and telephone number of the office in charge of ambulance service.
- Address and telephone number of the next clinic or outpatient's department.
- Practical exercise at a person must not be detrimental to the health of that person. (Artificial respiration and cardiac massage are only indicated!)

Possible further hints on labour safety are given to the respective local conditions.

2.2. Preparation of the Teaching Aids

For theoretical instructions the trainees need a place where they can take notes. Recommendable is a room with blackboard, desks and electric connection.

If the instructions are given in the workshop or at the working place, clean pads should be on the working tables, so that the trainees can make notes.

For practical demonstration during the instructions, an exercising place with the following equipment should be available:

- Equipment required for rescuing an injured person out of the fault–current circuit or auxiliary means that may be used for this purpose.
- Fire–fighting equipment suited for extinguishing fire in electric plants.
- Materials required for the preparation of an alkalization solution.
- Dummy or anatomical model.
- Materials required for first–aid measures with injured people.

- Mouth opener.
- Mouth respiration apparatus, mouth masks.
- Stretcher.
- Blankets, safety belts.

The "Trainees' Handbook of Lessons – How to Act After Accidents Caused by Electric Current" is distributed among the trainees. Diagrams are prepared before the lesson in the form of blackboard drawings.

2.3. Preparation of the Working Means

As a theoretical basis for the practical exercises, distribute the "Instruction Examples for Practical Vocational Training–How to Act After Accidents Caused by Electric Current" among the trainees according to their number.

The materials required for the exercises are to be prepared on the basis of the "Instruction Examples..." in sufficient quantity. Each trainee must have a place for exercise.

2.4. Time Planning

Starting from the total number of teaching hours, the time for each respective section of this lesson should be planned individually. Time planning is recommended for the following sections:

- Introduction into the respective working technique in the form of an instruction.
- Required demonstration.
- Task–related instructions in preparation of the exercises.
- Carrying out of the exercises.
- Recapitulations and tests.

For time planning take into consideration the following factors:

- The level of education of the trainees.
- The training conditions.
- The future field of working of the trainees.
- The degree of difficulty of the respective section.

The main stress of each section is on the acquisition of abilities and skills by exercises.

If, despite a good planning, it should come to waiting times for the trainees, these should be filled by small corresponding tasks such as the preparation of materials for the exercises.

3. Recommendations for Practical Vocational Training in the Working Techniques Required for "Acting After Accidents Caused by Electric Current"

The following sections contain suggestions as to how the instructions, demonstrations as well as exercises and tests can be arranged.

3.1. Introductory Instructions, Demonstrations and Exercises

The introductory instructions on each respective working technique can be held with the trainees in a classroom. During the instructions, make sure that the trainees write down necessary supplements and

answers into the "Trainees' Handbook of Lessons".

The "Trainees' Handbook of Lessons", in its structure, is adapted to the introductory instruction. The main points have to be imparted. A precondition for learning the techniques of "Acting After Accidents

Caused by Electric Current" is that the trainees master the techniques for first aid.

Therefore, refer to these techniques in the form of repetition. The main points of "Rescue of Injured

People out of Electric Plants under 1 kV and Immediate Measures After an Accident Caused by Electric

Current" should be imparted making intensive use of all teaching aids that are available.

Effects of electric current on the human organism

In order to make the trainees aware of the danger of electric current, especially point to the irritating and heat effects of electric current.

Irritating effect

- Explain to the trainees that the intensity of current and the time of the current flow through the body are decisive for the degree of its detrimental effects.
- Starting from Ohm's law, the current intensity is determined by voltage and resistance.
- In this context, repeat the importance of protecting oneself against hazardous contact voltage.
- Especially point to the most dangerous effect of electric current, that of ventricular fibrillation as well as to the incurable cerebral defects due to missing blood circulation.

Heat effects

- Explain to the trainees that the heat effect of electric current can cause burns of the skin as well as fire by an electric arc.
- Put special emphasis on the fact that fire caused by electric current must never be extinguished by water.

After this section the trainees must have realized that first aid must be rendered promptly and carefully.

Rescue of injured people out of electric plants under 1 kV

- Give detailed practical demonstration of the possibilities to break an electric circuit. However, do only explain how to create a short circuit.
- Especially deal with the possibilities of the rescuer to protect himself, if it should be impossible to break the fault-current circuit.

Here, the trainees must learn that the rescuer has to protect himself against the dangers of electric current when trying to rescue injured people.

Immediate measures after an accident caused by electric current

Explain to the trainees that the degree of health defects and the life of the injured person to a far extent depend on the correct measures of help.

Explanations and demonstration in this field should be concentrated on the following techniques:

- Rescuing and bedding of the injured person.
- Emergency respiration in the case of respiratory arrest.
- Measures with cardiac arrest – cardiac massage.

- Alkalinization.
- First treatment of wounds.
- Calling medical help.

Here, the survey of "Measure in the Case of Unconsciousness" from the "Trainees' Handbook of Lessons" may be used as a blackboard diagram or projected illustration.

Measures to be taken when the injured person is conscious

- Bedding.
- Protection against hypothermia.
- Examination of respiration and pulse.
- Calling another person for help.
- Calling medical help.
- Transportation and further medical treatment – preparation.

The demonstration of the activities to be carried out must be carefully prepared. Groups of 6 to 8 trainees should be formed to enable each trainee to watch the demonstration well. Only then start the demonstration of the required measures.

In doing so, pay attention

- that during the demonstration the aim and purpose of the demonstrated actions are explained;
- that the correct sequence of operations is emphasized;
- that it is pointed out that it is important to taste the alkalinization solution.

It is also important to point to the fact that every person who had an accident caused by electric current has to be considered as a seriously injured person and must not be left alone!

After demonstration, one or two trainees should repeat the required operations. Here, the correct order of actions has to be observed and faults have to be corrected immediately.

In order to develop the practical skills of the trainees, they should practise the measures repeatedly.

Measures taken if the injured person is unconscious but respiration is regular

With demonstration and relevant explanations it is assumed that the injured person has just been rescued.

In the order: explanation – demonstration – exercise all required measures are carried out in logical order at a person for practice. The examination of the injured person should be demonstrated in such a way that statements of the extent of injuries can be made. Make sure that such examination takes only little time!

The examination should be concentrated on

- heart action
- respiration
- further signs of life
- further injuries.

Then, the correct coma position has to be demonstrated and the importance of this measure be explained. This measure, too, should be demonstrated at a person for practice by single steps each of which has to be repeated by the trainees after demonstration. Only then, the entire coma position should be practised by the trainees. In doing so, all actions from understanding the accident situation to coma position have to be carried out. Mistakes have to be corrected immediately and assessed together with the trainees.

This should be followed by further measures such as

- Treatment of arterial bleedings
- Calling of medical help
- Preparation of the transportation of the injured person for further medical help.

Measures taken when the injured person is unconscious and has stopped to breathe

Make clear that respiratory arrest means acute danger of life! Together with the trainees repeat the consequences of an interruption of oxygen supply to the brain. In doing so, show the correlation between blood circulation, respiration and blood supply to the brain. Since 5 minutes at the latest after respiration has stopped it comes to incurable cerebral damages, make clear that the rescuer must start artificial respiration as quickly as possible.

Artificial respiration must be started immediately after the rescue of the injured person.

Explain to the trainees how and why artificial respiration has to be prepared.

Preparatory measures are:

- opening of the mouth of the injured person
- cleaning the oral cavity
- bending the head backwards.

Cleaning of the oral cavity is only explained theoretically. Point out that with unconscious people there is the danger of suffocation.

In order to prevent this, the upper respiratory tract must be made free by overstretching the head backwards. After demonstration and explanation, the trainees must practise the preparatory measures for artificial respiration.

Wrong movements have to be corrected permanently.

Always bear in mind, that the trainees acquire safe skills only, if they practise the measures again and again. Therefore, the main points of the immediate measures should now be repeated in their entirety.

This includes:

- rescue of injured people
- examination of the injured person
- alkalization
- bedding
- preparation for artificial respiration
- calling of medical help
- preparation for transportation.

Artificial respiration of injured people

For showing the different methods of artificial respiration, the survey of "Measures in the case of unconsciousness" may be used.

Again it is important to emphasize that every second is precious and that prompt and effective help decides about life or death of the injured person.

Giving artificial respiration takes priority over any other measure.

Explain the principle of giving artificial respiration.

- By blowing the breath of the rescuer into the lungs of the injured person the required oxygen is supplied. Process of breathing in!
- The injured person breathes out by the natural elasticity of his chest. Process of breathing out!

Artificial respiration is always begun with breathing in.
Respiration is continued until the injured person starts to breathe independently or till a physician orders to stop artificial respiration.

In your explanations on artificial respiration also deal with the oxygen content of the breathing-out air of the rescuer and with the advantages of giving artificial respiration compared with other methods.

Especially point to possible mistakes with artificial respiration. These should be mentioned, explained and together with the trainees it should be found out how such mistakes can be avoided.

All the methods of giving artificial respiration must not be practised at people for exercise. For this purpose, dummies have to be used.

It results from the importance of the various techniques of artificial respiration that the instructor must prepare himself thoroughly for the demonstration of artificial respiration.

Mouth-to-nose respiration

With the preparation for and giving of the demonstration the following should be taken into consideration:

- The trainees must be told to follow each demonstration very attentively.
- The working place has to be carefully prepared for the demonstration and exercises that follow.
- All required auxiliary means have to be kept ready before the demonstration starts.
- The dummy and breathing apparatus have to be cleaned before and after every exercise. This prevents aesthetical and hygienical objections on the part of the trainees.
- Make sure that each trainee is in a position to exactly follow each demonstrated movement and operation.
- During the demonstration, each individual phase has to be explained and the correct sequence of operation be pointed out.
- Mention the possible mistakes with artificial respiration as well as the way to avoid them.
- Make sure that the trainees recognize the signs of returning life.

When the trainees exercise the giving of artificial respiration, especially see to the following:

- The breaths must be regular.
- The position of the head of the injured person (dummy) must remain unchanged.
- The trainees must watch how the chest of the dummy goes down with breathing out.
- The trainees must keep the mouth of the injured person (dummy) closed.

Mouth-to-mouth respiration

Point out that this technique should be used only if the respiratory tract of the nose is blocked.

This method is very similar to the mouth-to-nose respiration. Explanations and demonstration are given in the same way as those of mouth-to-nose respiration at the dummy.

With the exercises of the trainees that follow the explanations make absolutely sure that the correct order is observed.

It is important to point out that with this technique of artificial respiration the nose of the injured person must be kept closed.

Artificial respiration with the help of apparatus Explain to the trainees, that there are different auxiliary means for artificial respiration such as:

- mouth respirators and
- mouth masks.

These are shown to the trainees and their application is demonstrated.

Point out that also here the success of respiration should be watched after each breath.

At this point, repeat the sign of returning life together with the trainees.

Make clear that, in case of emergency, one must not search for auxiliary equipment but start with artificial respiration immediately!

Mouth respirators or other apparatus are universally applicable and can also be used while the injured person is moved.

Explain to the trainees that the oral tube is allowed to be used only by a physician, because a layman could easily injure a person's respiratory tracts by intubating.

Manual methods of artificial respiration

Explain to the trainees that the manual techniques – especially with respect to the breathing volume – are inferior to the methods of giving artificial respiration.

The manual methods should only be used, if extensive wounds in the face of the injured person make the respiration from mouth to mouth impossible.

Also here, make the principle of the manual methods clear:

– Breathing out

By pressing the chest down and thus the lungs, the air is forced out of the lungs and a low pressure is created.

– Breathing in

With relieving the external pressure, the chest – due to its flexibility – returns to its original position, the lungs expand and air is taken in. It must be made clear that the manual methods of respiration must be started by breathing out.

In preparing and giving the demonstration, consider the following:

- Start from the fact that the injured person has just been rescued.
- It is recommendable to repeat or let the trainees repeat why the immediate measures must be taken without delay, to have some chance of succeeding at all.
- The trainees should repeat the required examination of the injured person as well as the measures for preparing the artificial respiration of the injured person.
- It would be best if the demonstration was given on the floor. For this purpose, a blanket or tarpaulin should be kept ready.
- Demonstration can be given at a person for exercise.
- Make sure that all trainees can follow the sequence of operations.
- During the demonstration make the trainees constantly aware that it is a moral duty of each of them to put his personal interest after the rescue of human life.
- The movements are accompanied by explanations during the demonstration.
- The demonstration should be repeated by one or two trainees in order to check whether the actions shown have been understood.
- With the then following exercise pay attention that the trainees observe the measures which were demonstrated and repeated as well as the explanations.

- During the exercises, the trainee should be given assistance. Mistakes are corrected immediately.

In order to avoid fractures of the ribs and the breast bone, only moderate pressure has to be exercised on the chest of the injured person.

The first manual method of artificial respiration that is taught should be the one in prone position. Only if the trainees master the above method, the technique in dorsal position can be dealt with. Before starting the demonstration of the technique of artificial respiration in dorsal position, emphasize that this method should only be used if the rescuer masters no other technique. The method in dorsal position is the most inconvenient and least effective one.

In the course of the exercise pay attention that

- the trainees apply the methods correctly;
- the respiration phases are deep enough;
- the respiration rhythm is observed;
- the movements of the arms are made in the anatomically correct way;
- the respiratory movements are carried out evenly.

Measures taken with circulatory arrest

At the beginning of explanations and demonstration, again make the trainees aware that by all means human life must be saved unselfishly.

The trainees must realize that circulatory arrest is a sign of utmost danger to life.

Here, let the trainees repeat what is understood by ventricular fibrillation and how dangerous it is.

Demonstration and exercises of first aid in the case of circulatory arrest must not be carried out at people. The respective measures are only taken in the case of emergency.

It is recommended just to indicate the required measures at a person for exercise, to demonstrate them with the help of a dummy or to explain them by illustrations. Again it is important that the trainees can see all details well and concentrate upon the demonstration. Explain to the trainees why the feet of an injured person should be elevated if the pulse beat of the person is weak.

If the injured person is unconscious, has no pulse and does not breathe and if his pupils are wide and show no reaction, cardiac massage has to be given in addition to respiration – if possible simultaneously by a second person.

Before giving demonstration, explain to the trainees the principle of cardiac massage.

Point out that before beginning the cardiac massage, 10 breaths must be given in breathing rhythm.

After that, cardiac massage is combined with artificial respiration in the ratio of 4:1. That is to say that 12 strokes of cardiac massage have to be followed by 3 breaths.

It is recommendable at this point to repeat the methods of artificial respiration together with the trainees.

With the then following exercise special attention has to be paid that the trainees carry out the individual operations accurately.

Special value has to be attached to the control and correction of the following actions:

- correct application of the hands to the breast bone;
- correct order of giving respiration and cardiac massage;
- correct ratio of giving respiration and cardiac massage;
- correct pressure on the breast bone.

Too much pressure on the breast bone involves the risk of fractures of the ribs and the breast bone.

Emphasize that the cardiac massage must be continued until the heart of the injured person starts to beat or till a physician orders to stop the massage.

Other measures for stimulating the heart action are allowed to be taken only by a physician.

As soon as the trainees master the cardiac massage, it should be combined with giving respiration. The trainees should realize that cardiac massage is hard work and that, therefore, the rescuer should call for help, so that another person can come to his assistance. During the exercises, mistakes should be corrected immediately and analyzed with the trainees.

Hints for the transportation of injured people

In this context, it is important to point out to the trainees that

- injured people have to be transported very carefully;
- the condition of health of the person concerned can be decisively influenced by a perfect transportation;
- the most important rules of the transportation of injured people must be known.

The demonstration must show the trainees what they must pay special attention to in moving injured people and how exactly transportation has to be carried out.

After the demonstration, the trainees should practise how to move injured people.

During these exercises, special value is attached to

- the bedding of the injured person on the stretcher;
- the even lifting up and putting down of the stretcher;
- the cautious transportation and
- the surmounting of obstacles with the stretcher.

Show the trainees where near their working place stretchers and auxiliary means for moving injured people are to be found.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

In the instruction examples, the sequence of actions is described including a sketch of rendering first aid to people who had an accident caused by electric current. Moreover, a list of materials and the required basic knowledge is attached to each instruction example. To the sequence of actions, corresponding remarks are given, so that the trainees get all necessary information to render first aid systematically.

When working with the instruction examples, consider the following:

- The trainees shall put the instruction examples into practice on their own. This enables the instructor to assess the performances of each trainee individually and to correct them.

3.3. Examples for Recapitulation and Tests

For consolidating and testing the knowledge and skills acquired, questions are raised in this section.

To each question the corresponding answer is given.

Questions which are contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What voltages have to be considered as hazardous contact voltages?

(a.c. voltages of more than 50 V; d.c. voltages of more than 120 V)

2. What are the effects of electric current on the human organism?

(Irritating effect; heat effect)

3. What is the intensity of a current flowing through a person, if the current path goes from hand to feet and the applied voltage is 220 V?

"A" (220 mA)

4. What conclusion is to be drawn from this current intensity?

"A" (The current intensity is lethal.)

5. Why is every single minute of first aid measures decisive in the case of an accident caused by electric current?

"A" The most dangerous irritating effect – ventricular fibrillation – may occur. Due to failure of blood circulation, no oxygenic blood reaches the brain of injured person, so that it comes to incurable damage to the brain.)

6. What measures have to be taken for rescuing an injured person?

(Breaking of the fault–current circuit; rescuing the injured person; rendering first aid.)

7. Why must the rescuer never touch the injured person with bare hands?

"A" (He exposes himself to utmost danger of death.)

8. What information should an information board of first aid give?

"A" (Name and working place of a trained first–aid attendant; service hours and telephone number of the station of an ambulance address and telephone number of the department/office of the enterprise disposing of a car for the transportation of injured persons; address and telephone number of the ambulance service concerned; address and telephone number of the next clinic or outpatient's department.)

9. Why must unconscious people not be given anything to drink?

(Danger of suffocation.)

10. What must be kept in mind when treating wounds and secondary injuries?

"A" (Immediate measures take priority. Open wounds must not be touched with hand. Do not try to remove foreign bodies that have penetrated the injured person's body. Measures are restricted to first aid.)

11. Why is an alkalization necessary with people who had an accident caused by electric current?

(In order to achieve a neutralization of the acids created in the body by the electric current.)

12. Why are unconscious people exposed to the danger of suffocation?

"A" (Whit unconscious people, the lower jaw falls back and the tongue blocks the upper respiratory tracts. There is the danger of suffocation.)

13. Why are injured people placed in coma position?

(The coma position prevents the squeezing of the respiratory tracts and guarantees that blood, mucus and vomit can flow out of the mouth.)

14. What methods are used for giving artificial respiration?

(Mouth–to–nose respiration with the help of auxiliary equipment such as mouth breathing apparatus and masks.)

15. Why must aesthetic and hygienic objections be suppressed with giving artificial respiration?

(Because otherwise the injured person cannot be saved.)

16. Why must the head of the injured person be overstretched backwards?

"A" (Because this makes the upper respiratory tracts accessible for artificial respiration.)

17. When must the manual methods of artificial respiration be used?

(When extensive injuries of the face make the giving of respiration from mouth to nose or mouth to mouth impossible.)

18. Why should manual methods of artificial respiration be applied only in exceptional cases?

"A" (Because the manual methods are clearly inferior to the giving of respiration from mouth to nose or mouth to mouth, respectively.)

19. Why must measures of resuscitation not be broken up by the rescuer on his own?

"A" (Because only a physician is able to determine whether or not an injured person is dead.)

20. Why must an injured person be carried by at least two people?

"A" (Because a person who had an accident caused by electric current must be moved in lying position and must be constantly observed during transportation.)

21. Why must the medical staff be informed about the first aid measures taken?

"A" (To enable them to assess the condition of the injured person and to take further measures.)

**How to Act After Accidents Caused by Electrical Current – Course:
Basic Skills and Knowledge of Electrical Engineering. Instruction
Examples for Practical Vocational Training**

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How to Act After Accidents Caused by Electrical Current – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Introduction

The present material comprises 3 selected instruction examples on the basis of which essential skills may be practised as to how to act after accidents caused by electric current.

Since the necessary measures that have to be taken after accidents caused by electric current are mastered only after much practice, the instruction examples have to be constantly repeated.

In order to facilitate the preparation for and carrying out of the exercises, for each instruction example the required materials as well as basic knowledge are mentioned which must be available for accomplishing the tasks.

In addition to the sequence of actions sketches are enclosed showing how the exercises have to be carried out.

Instruction Example 1.1. Putting an Injured Person in Coma Position

It shall be practised how to put an injured person in coma position on the left or right side, respectively.

Material

Anatomical model
Dummy
Demonstration person

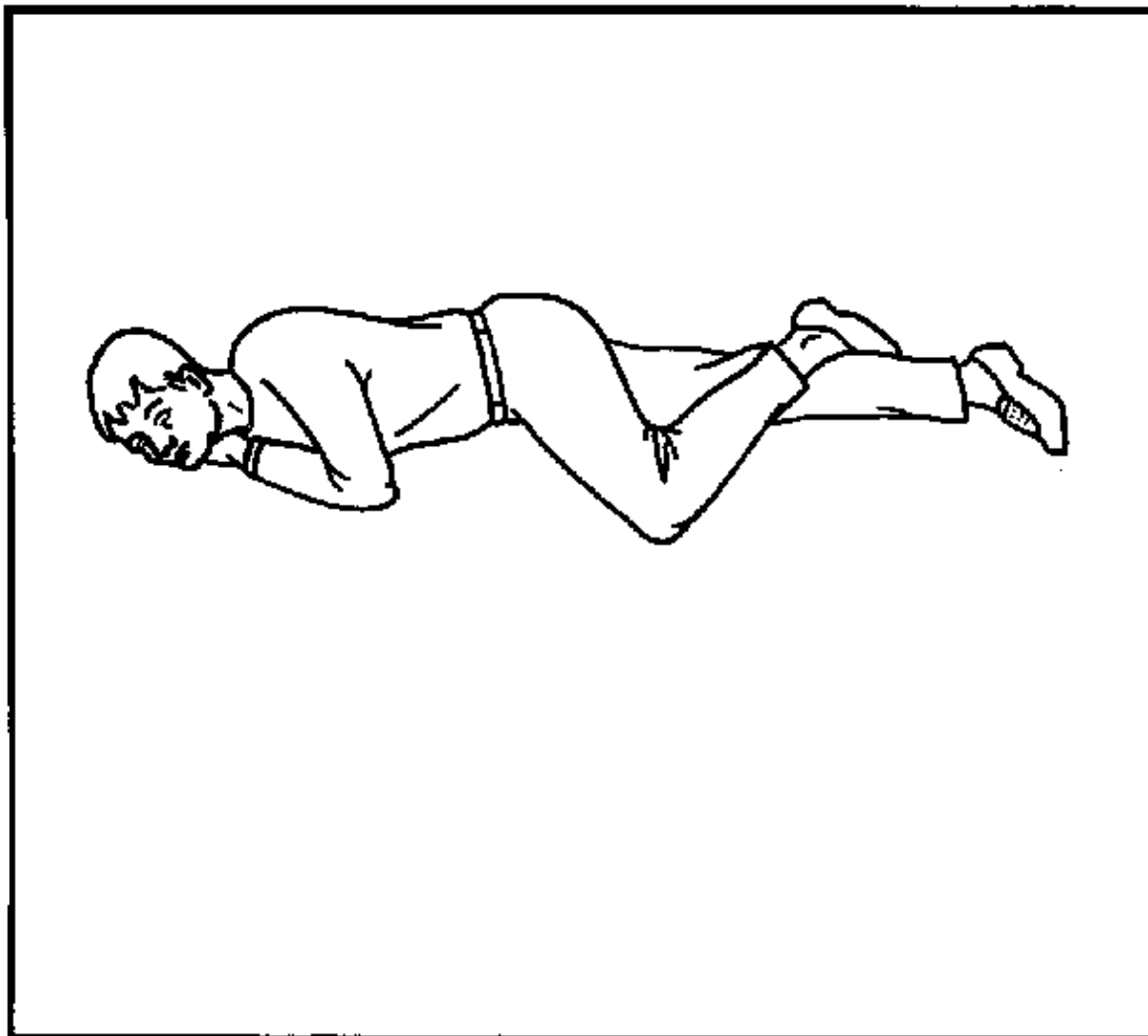
Required basic knowledge

Effects of electric current on human organism.

Rescuing of injured person out of electric plants below 1 kV, urgent measures after an accident caused by electric current.

Sequence of actions	Comments
<u>Coma position, right side</u>	

	If there are injuries on the right side of the body, the injured person has to be put in coma position on the left side!
1. The injured person is in dorsal position.	
2. Kneel down by the right side of the injured person.	Kneel down on the left side!
3. Carefully pull the injured person by his left arm and leg on his right side.	Use the right arm and right leg!
4. Pull the right arm of the injured person backwards underneath his body.	Left arm!
5. Bend his left arm and put his left hand under his head the back of the hand being placed under the face.	Right arm and right hand!
6. Bend his left leg by the knee and put the foot on the calf of the right leg which remains elongated.	Put the right leg on the calf of the left leg!



				1.1.
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Putting an injured person in coma position

Instruction Example 1.2. Immediate Measures after an Accident Caused by Electric Current

Practising of the immediate measures in order to be able to render prompt and safe help after an accident caused by electric current.

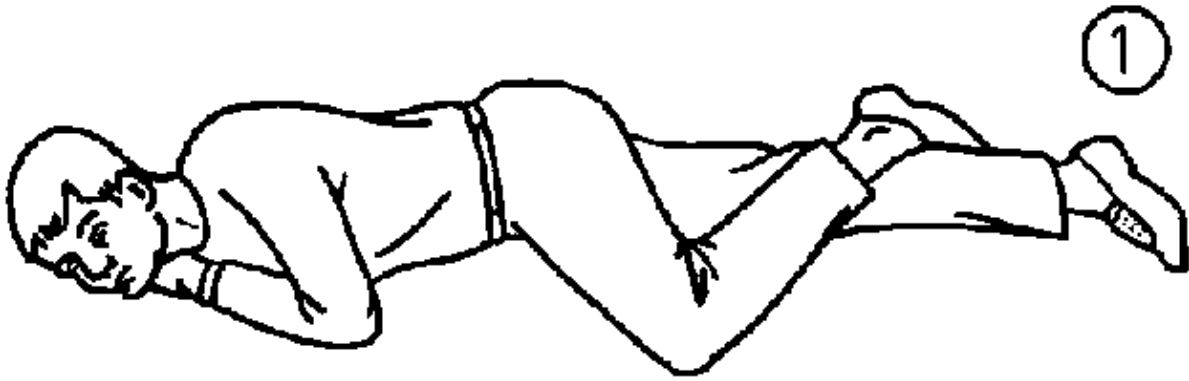
Material

Drinking water
Bicarbonate of soda
Receptacle holding 1 l
Tablespoon or measuring jug of equal volume

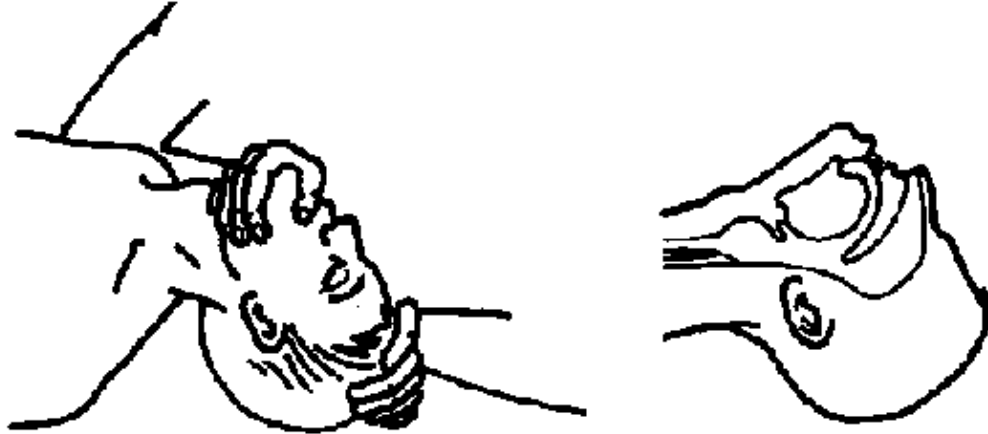
Required basic knowledge

Effects of electric current on human organism.
Knowledge of the measures which have to be taken.

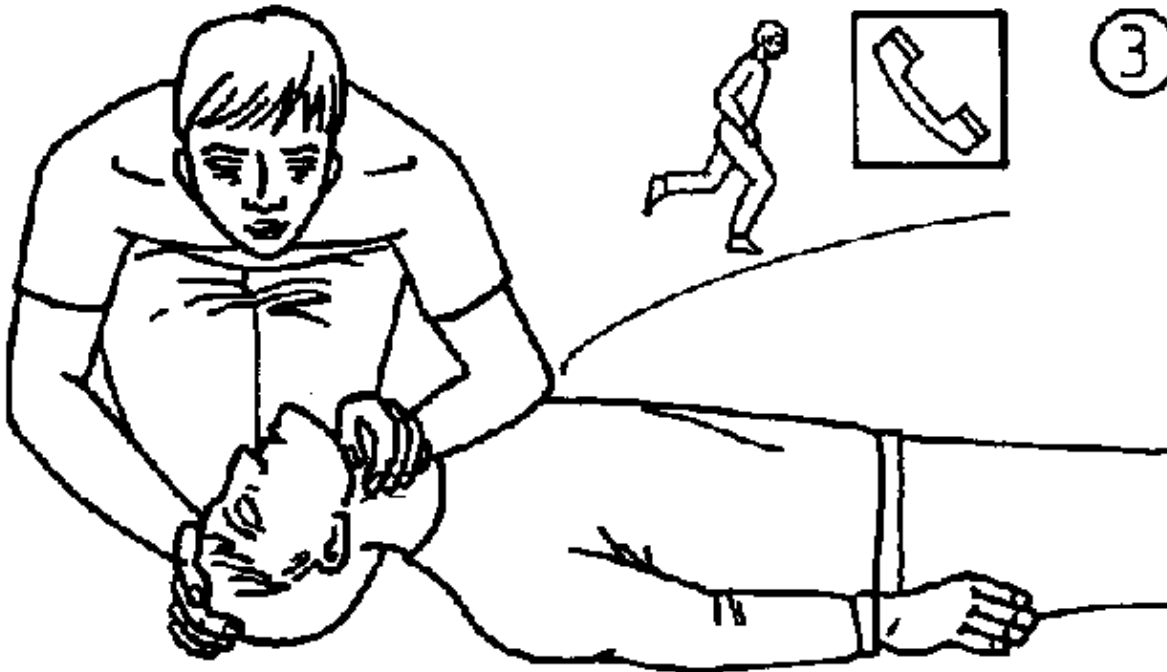
Sequence of actions	Comments
1. Rescuing of the injured person.	Disconnect the fault–current circuit! Protect yourself!
2. Examine the injured person.	Heart activity! Respiration! Further signs of life! Further injuries!
3. Alkalinization.	Prepare an alkalinization solution.
4. Put the injured person in coma position.	Coma position on right side! In the case of injuries on the right side of the body, use left coma position!
5. Prepare for mouth–to–mouth respiration.	Open the mouth of the injured person. Clean the oral cavity (only suggest). Bend the head of the injured person backwards.
6. Carry out mouth–to–mouth respiration.	Only mention briefly.
7. Call medical help.	Inform the medical staff about: The kind of accident, the first aid measures that have already been taken.
8. Preparation of the transportation of the injured person for further medical treatment.	The injured person must be able to be transported: Blood circulation functions, respiration functions, no critical injuries!
9. Securing of the place of accident.	The place of accident must be secured in such a way that no further accidents may happen.



1



2



3

				1.2.
IBE	Immediate measures after an accident caused by electric current			3101

Immediate measures after an accident caused by electric current

Instruction example 1.3. Transportation of an Injured Person

Practising how an injured person has to be transported.

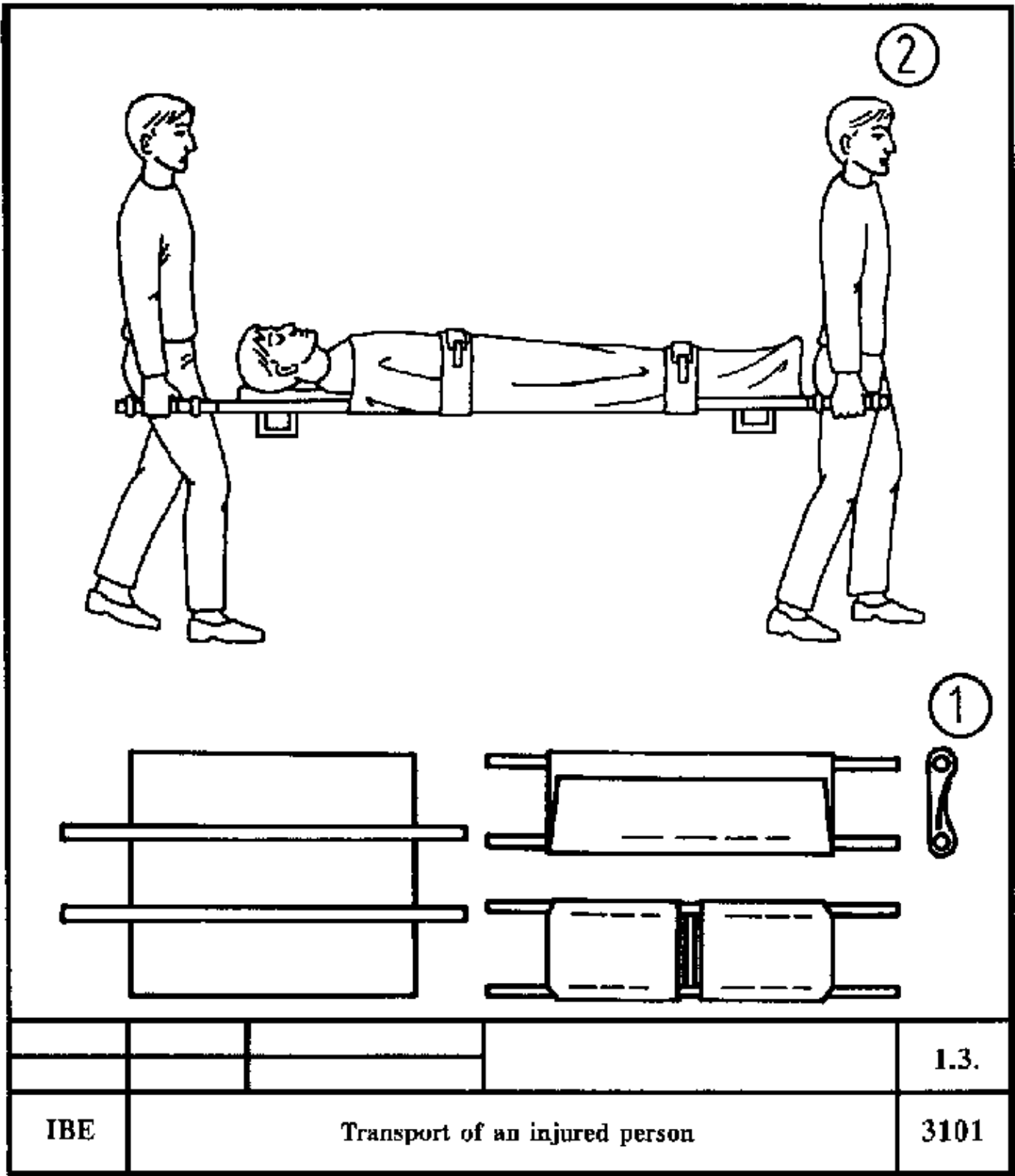
Material

Stretcher Wooden bars Blankets Belt

Required basic knowledge

Deciding whether an injured person is able to be transported

Sequence of actions	Comments
1. Deciding whether the injured person is able to be transported.	Blood circulation!
	Respiration!
	No critical injuries!
2. Placing at disposal of the stretcher.	If required, make a makeshift stretcher from wooden bars and blankets.
3. Putting the injured person on the stretcher.	If it is cold, cover the injured person with blankets. Make sure that the injured person cannot fall down.
4. Transportation of the injured person.	Lift and put down the stretcher simultaneously on the command.
	Hold the stretcher securely.
	Do not march in step!
	Draw each other's attention to obstacles.
	Make sure that the injured person's line of vision is in transport direction.
	Watch the injured person constantly during transportation.
5. Handing the injured person to the medical personnel.	Inform the medical staff about the kind of accident that had happened and about the first aid measures taken.



Transport of an injured person

**How to Act After Accidents Caused by Electrical Current – Course:
Basic Skills and Knowledge of Electrical Engineering. Trainees'
Handbook of Lessons**

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How to Act After Accidents Caused by Electrical Current – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Berlin

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Arbeitsmaterial für den Lernenden
"Verhalten nach elektrischen Unfällen"

Author: Gerhard Klix
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Introduction

The present material is meant for the training for jobs in the field of electric engineering.

It comprises the description of activities and auxiliary means required after accidents caused by electric current.

The required methods are described in self-contained sections. The required knowledge and skills are explained in each section in the order of the necessary sequence of activities. Illustrations are included to support the text of the individual sections.

In order to intensify the process of learning, questions are included for the trainee to check his knowledge.

1. Effects of Electric Current on Human Organism

Irritating effect

– If an electric current flows through the human body, the entire sensitive muscular system becomes cramped.

– For the degree of injury caused by electric current two factors are decisive:

- The intensity of current
- The duration of current flow through the body.

– From the equation $I = U/R$ it is to be seen that the current intensity depends on the following values:

- Intensity of the voltage affecting a person;
- Resistance of the parts of the human body through which the current flows.

Influence of the current intensity on the sensations with alternating current with 50 Hz supposing a current path hand–body–feet.

Current	Sensations
---------	------------

intensity I in mA	
3.5	Current just perceptible on the palms (absolute threshold).
5	Prickling sensation in the whole hand as if it went to sleep.
8	Pressure in the forearm.
10	First sensations at the soles of the feet.
11.5	Slight cramping of the wrist, moving of the hand is difficult, pressure on the heels.
12.5	Prickling in the upper arm, severe cramping of the entire arm, especially of the wrist.
14.5	Strong prickling along the arm to the armpit, forearm almost numb up to the elbow, letting loose "still" possible.
15.8	Pressure in ankles and heels, thumb of the hand completely cramped.
18	Letting loose only possible "with greatest effort".
20	Shooting pain in the wrist-joint and elbow.
	"Letting loose no more possible!"
	"Danger of life!"
more than 40	"Absolute danger of life! Death may occur."

– For the protection of man, the highest permissible contact voltage is:

- for alternating current voltage 50 V,
- for direct current voltage 120 V.

– The body resistance is varying and different with each person.

– The resistance of the body is, to a far extent, determined by the resistance of the skin.

- Dry skin offers a resistance of some kilohms.
- Sweaty skin has a resistance of a few ohms only.

Approximate figures of the body resistance

Current path	Resistance
Hand–body–hand	approx. 1300 ohms
Hand–body–feet	approx. 1000 ohms
Hands–body–feet	approx. 650 ohms
Foot–foot	approx. 1300 ohms

What is the intensity of a current flowing through a person, if the current path is hand–feet and the applied voltage 220 V?

What conclusions have to be drawn from this current intensity?

- The most dangerous irritating effect of the three–phase current is the "ventricular fibrillation". This can occur if the current flows during the T–spike of the electrocardiogram.

The frequency of the three–phase current disturbs the heart rhythm so that it comes to the ventricular fibrillation. This means that the heart works at 400 to 1000 contractions per minute and no blood is pumped through the body.

Why is each minute of first aid decisive in the case of an accident caused by electric current?

Thermal effect

- By the electric arc, i.e. the thermal effect of the electric current, clothes may catch fire and the skin be burned.

Fire with burning people must only be smothered with the help of insulating material, such as 'blankets or clothes. Do never extinguish the fire by water!

2. Rescue of Injured People out of Electric Plants below 1 kV

Rescue measures

- Breaking of the fault–current circuit by
 - switching off the light or machine switch
 - pulling the plug out of the socket
 - removing the fuses
 - creating a short circuit, for example with the help of tools which have an insulated handle
- Rescue of the injured person
 - rendering of first aid

Measures to protect the rescuer

- Insulating his position by
 - wood chairs, wood tables, wood ladders
 - repeatedly folded newspapers, books
 - rubber or plastic mats
 - glass panes
- Insulating the position of the injured person by putting underneath
 - rubber or plastic mats
 - dry wooden plates
 - fabric reinforced laminate plates
- Removing the injured person out of the fault circuit by the rescuer by
 - his insulated hands (working gloves, dry clothes)
 - a dry plank or wooden bar
 - insulated cables or plastic ropes

Why must the rescuer never touch the injured person with bare hands?

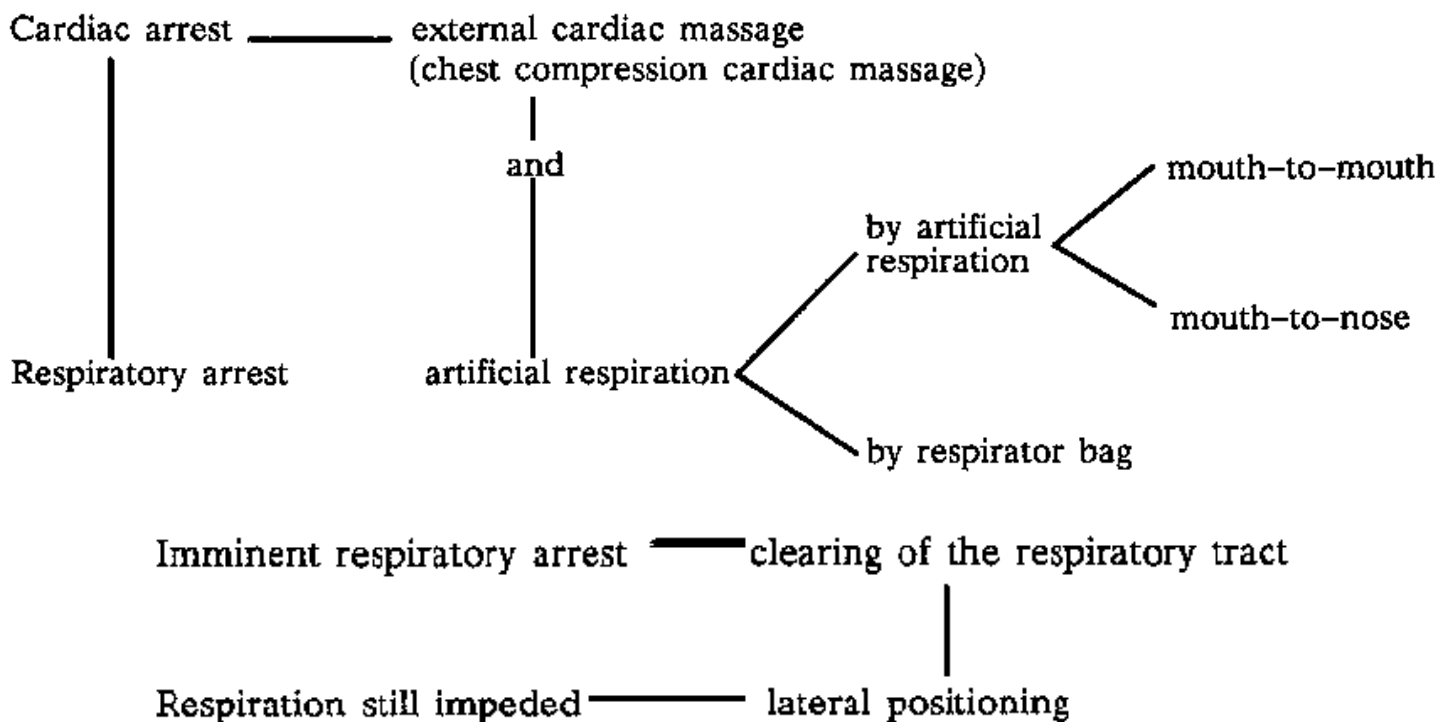
3. Immediate Measures after an Accident Caused by Electric Current

The health defect and the life of the injured person depend to a high degree on the correct rescue work.

First aid measures – Rescue and bedding of the injured person

- Artificial respiration in the case of respiratory paralysis
- Cardiac massage in the case of cardiac arrest
- Alkalinization
- First wound treatment
- Calling medical help

Measures in the case of unconsciousness (survey)



Measures in a state of consciousness

- Let the injured person drink an alkalinized solution.
(Sodium hydrogencarbonate drinking ampoule or two table-spoonfuls of bicarbonate of soda in 1 l water.)
- Only then treatment of secondary wounds, such as immobilization of fractures etc..

Do not

- give the injured person any medicine!
- Do not pour any fluids down an injured person's throat! (Danger of suffocation).
- Do not touch open wounds with hands.
- Do not remove foreign bodies that have penetrated the body.

Reanimation must be continued until clear signs of returning life are visible or a medical doctor orders to stop the measures.

What information should an information board of first aid give?

Every person who had an accident caused by electric current has to be considered as seriously injured. Such person must not be left alone!

3.1. Measures Taken if the Injured Person is Conscious

It has to be supposed that the injured person has just been rescued.

- Prevent hypothermia by putting blankets underneath and on the person.
- Administration of an alkalinized solution.

(Before giving the injured person the alkalinized solution, the rescuer must try it in order to avoid that the injured person gets a cauterization. Inform the medical staff about the alkalinization.)

- Treatment of wounds and secondary injuries. (Only first aid.)
- Examination of the pulse and respiration, especially during the first 30 minutes.
- Calling a second rescuer.
- Calling medical help.
- Preparation of transportation of the injured person to further medical treatment.

What has to be considered with the treatment of wounds and secondary injuries?

3.2. Measures Taken if the Injured Person is Unconscious but Respiration is Regular

Also here it is supposed that the injured person has just been rescued.

Brief examination of the injured person to find out the extent of the injuries.

- Examination of heart action
- Examination of the pulse
- Opening of too tight clothes which might obstruct the respiration
- Recognition of further signs of life

- Rosy skin
- Pupillary light reflex
- Mucosa visibly blood-supplied

- Stating of further injuries

- Burns of the skins
- Arterial bleedings
- Bone fractures

Bedding the injured person in coma position

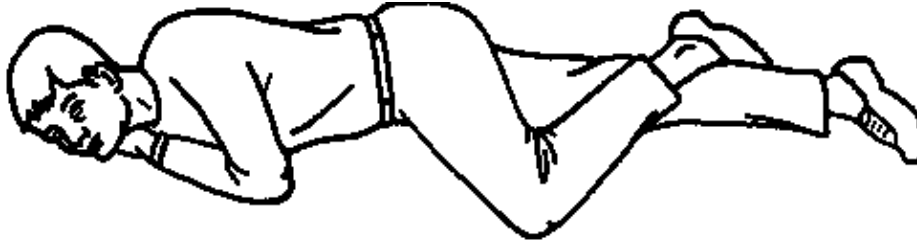


Figure 1 – Coma position (right side)

If the injured person is wounded on the right side of his body, he is put in coma position on his left side.

The coma position prevents the squeezing of the respiratory tract and enables the flowing off of blood, phlegm and vomit through the mouth.

Further measures

- Constant examination of respiration and heart action
- Supply of fresh air
- Treatment of arterial bleedings
- Calling of medical help
- Preparation of the transportation of the injured person to further medical treatment

3.3. Measures Taken if the Injured Person is Unconscious and Has Stopped Breathing

If the respiration stops, there is acute danger of life!

(5 minutes after the respiration has stopped, at the latest, it comes to incurable cerebral damages.)

Artificial respiration must be started immediately after the injured person is rescued.

Preparatory measures

- Open the mouth of the injured person by hands.
 - Kneel down above the head of the injured person.
 - Put both your thumbs on the lower jaw of the injured person, left and right thumbs pointing to the tip of the chin.
 - Get hold of the lower jaw with the fingers of both hands.
 - Press the lower jaw downwards thumbs and fingers acting as a lever.
- Opening the mouth of the injured person with the mouth opener.
 - Kneel down on the right side of the injured person.
 - Press the thumb of your left hand between the lips of the injured person thus exposing the row of teeth.
 - Open the clenched jaws with the help of the mouth opener.
- Cleaning of the oral cavity.
- Overstretching the head in order to make the upper respirator tract accessible.
 - Put one hand on the forehead of the injured person and – without force – pull his head back.
 - By the other hand raise the lower jaw.

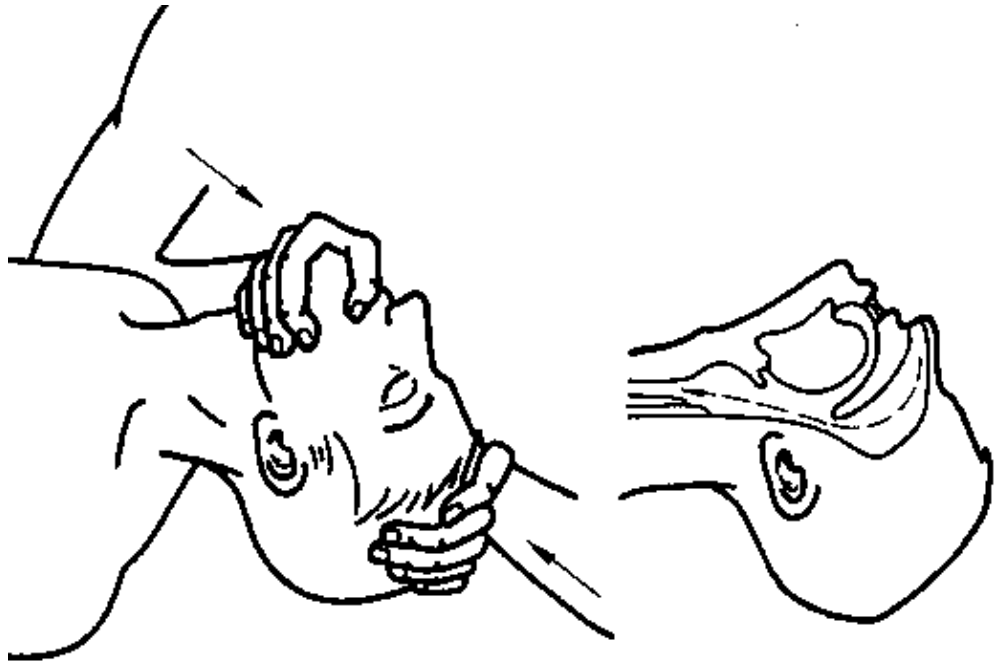


Figure 2 – Overstretching of the head

If after the overstretching of the head respiration does not start visibly and audibly, artificial respiration must be started immediately!

Carrying out of the artificial respiration

Why is a person who has lost consciousness in danger of suffocation?

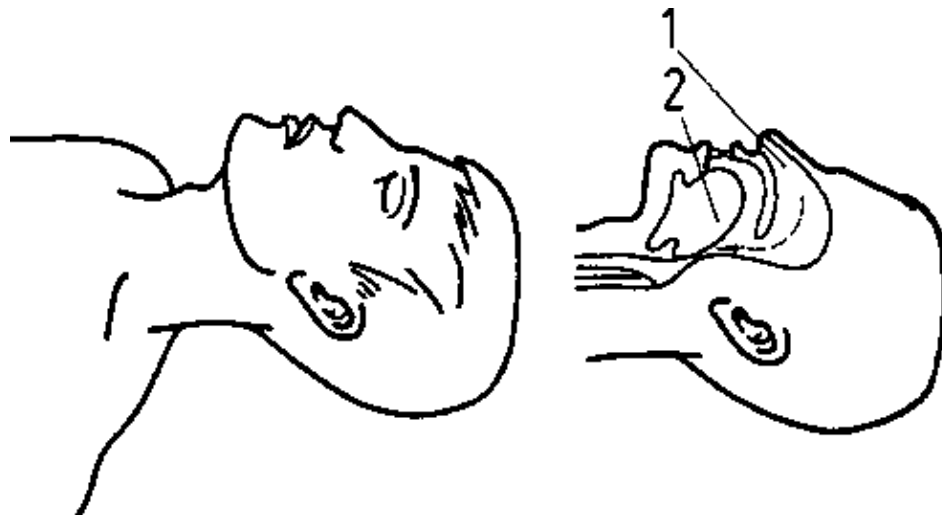


Figure 3 – Danger of suffocation in a state of unconsciousness – 1 Respiration tract, 2 Tongue

4. Giving Artificial Respiration to Injured People

The chance of surviving of an injured person decreases with passing time. Approximately 5 minutes after breathing has stopped, there is only a chance of 15 %.

Each second is valuable and fast and efficient help decides about life and death of the injured person. Artificial respiration has priority over any other measure!

4.1. Artificial Respiration

Principle of artificial respiration

- Breathing in

By breathing the rescuer's breath into the lungs of the injured person, this person is supplied with the required oxygen.

- Breathing out The injured person breathes out spontaneously due to the natural flexibility of the chest.

On principle, artificial respiration is started by breathing in.

- The breath of the rescuer which is breathed into the injured person contains still 16 to 17 percentage by volume of oxygen.

- For sufficient respiration, 15 to 20 moderate breaths per minute given by the rescuer are required.

- Artificial respiration has to be continued until the injured person starts breathing or a medical doctor orders to stop the measure.

Advantages of artificial respiration compared with other methods:

- In order to give artificial respiration, the rescuer must keep the respiratory tracts of the injured person free.
- The success of the artificial respiration can be seen from the movements of the chest of the injured person and can be observed by the rescuer.
- Only little energy is required for giving artificial respiration, so that this measure can be continued by one rescuer for a long time.

No method of artificial respiration is allowed to be practised at a person for the purpose of exercise. Her, a dummy has to be used.

Signs of returning life

- Twitching of the corners of the injured person's mouth
- Movement of the throat or fingers
- Returning of the normal colour of the skin
- Spontaneous independent breathing

Mistakes with artificial respiration

- The head of the injured person is not enough overstretched or the rescuer breathes his breath too violently into the lungs of the injured person.

By this the introitus of the oesophagus is pushed open, the stomach of the injured person is pumped up by the rescuer's breath, whereas too little breath reaches the lungs. (This situation is recognized by the fact that the chest of the injured person does not expand and rise.)

- The rescuer himself, during artificial respiration, feels dizzy or everything goes "black" before his eyes. (In this case, stop breathing for a moment and then breathe calmly for a few seconds.)

- The rescuer has aesthetic or hygienic objections.

Clean the face of the injured person.

Cover the face of the injured person with a clean handkerchief or cellulose wadding.

Mouth-to-nose respiration

- Kneel down by the side of the injured person.
- Bend the head of the person back.

(Most important precondition of successful respiration!)

– Breathe in deeply, firmly enclose the nose of the injured person by your mouth and breathe out into his lungs.

(In doing so, keep the mouth of the injured person closed.)



Figure 4 – Mouth-to-mouth respiration (breathing in)

– After this, the rescuer turns his face towards the body of the injured person in order to watch if the chest of the injured person slumps as a sign of breathing out. In doing so, the rescuer again breathes in deeply.

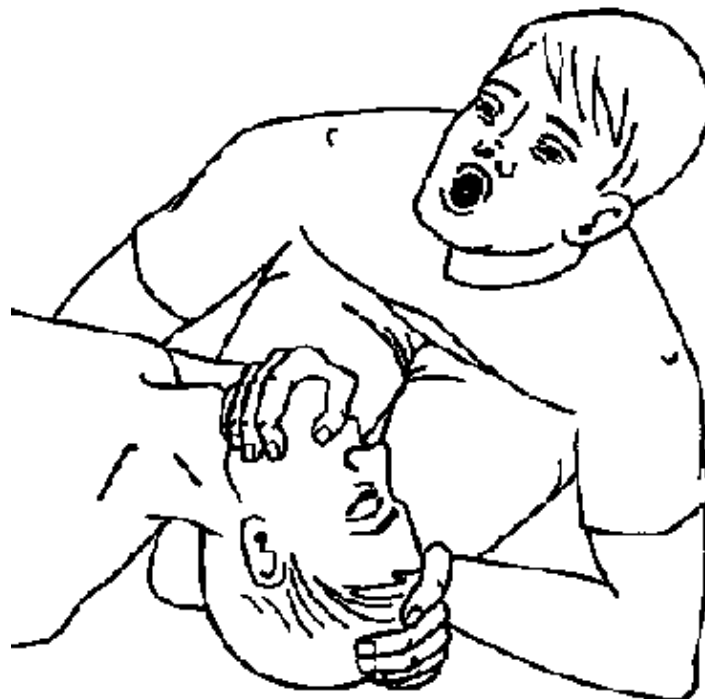


Figure 5 – Mouth-to-nose respiration (breathing out)

– This action is repeated according to the rhythm of the rescuer's own respiration 15 to 20 times per minute

Mouth-to-mouth respiration

This method should be used only if the respiratory tract of the nose is blocked.

- Kneel down by the side of the injured person.
- Put the head of the injured person in the most favourable position for artificial breathing by bending it back.
- Get hold of the chin of the injured person and move the lower jaw till the mouth opens.
- By the other hand get hold of the forehead of the person in such a way, that the nose of the injured person can be held by thumb and fingers.
- Breathe into the lungs of the injured person with your lips wide open. Pay attention to the rising of the injured person's chest.
- Remove from the injured person and watch his breathing out. Pay attention to the noise of breathing out.
- Repeat the action according to the rhythm of your own respiration 15 to 20 times per minute.

Why must the head of the injured person be overstretched backwards?

Artificial respiration by breathing apparatus

For this purpose,

- mouth breathing apparatus and
- mouth masks

are used.

They are universally applicable and can also be used during transportation of the injured person.

- Put the apparatus on the injured person's face.
- Operate the apparatus.
- Watch respiration after each breath.
- Stop artificial respiration when the injured person begins to breathe independently.

In case of emergency, do not search for a breathing apparatus but start mouth-to-nose or mouth-to-mouth respiration immediately.

4.2. Manual Methods of Respiration

Manual methods are applied only if artificial respiration of mouth-to-nose or mouth-to-mouth ' respiration is impossible due to extensive injuries of the face.

Principle of manual respiration methods

- Breathing out

By squeezing the chest and thus the lungs, the respiratory air is forced out of the lungs and a negative pressure is created.

- Breathing in

With relieving external pressure, the chest, as a result of its flexibility, returns to its original position, the lungs expand and surrounding air is aspirated.

With the manual methods, begin with breathing out.
In order to avoid rib and breastbone fractures, the chest must be pressed down only moderately!

Mistakes with the manual methods

- The breathing phases are not deep enough.
- The breathing rhythm is not observed.
- The movements of the arms are anatomically wrong.
- The respiration movements are not carried out evenly.

Method in prone position

- Put the injured person in prone position.
- Bend the arms of the injured person and put them down on the floor.
- Turn the head of the injured person carefully to the side and put it on his bent arms.
- Make the respiratory tracts of the injured person accessible.
- Kneel down on one knee by the head of the injured person.
- Put your hands flat on the back of the injured person just above the waist your thumbs paralleling the injured person's spinal column.

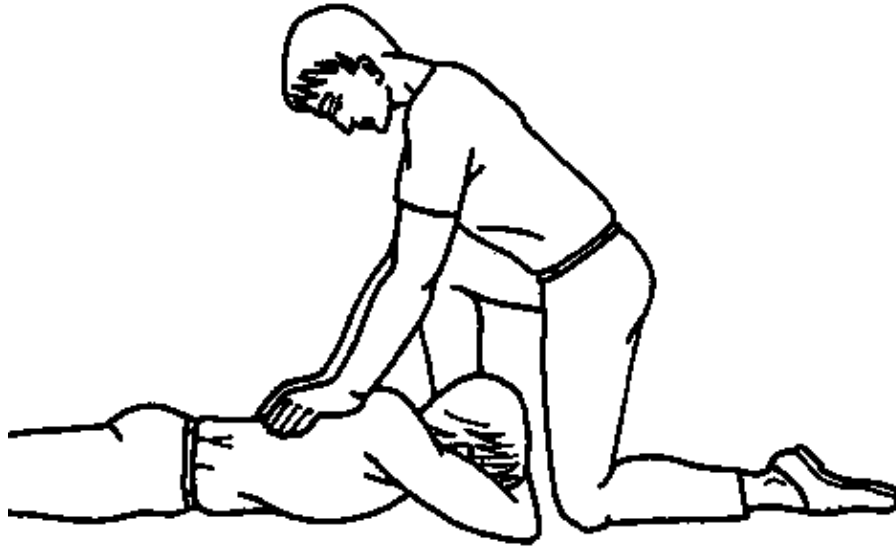


Figure 6 – Correct position before manual respiration

- Begin with breathing out your body shifting slightly forward and thus exercising a moderate pressure. (This way, the chest of the injured person is pressed against the floor and the lungs are squeezed together with the chest. The breathing air can escape through the respiratory tracts of the injured person.)

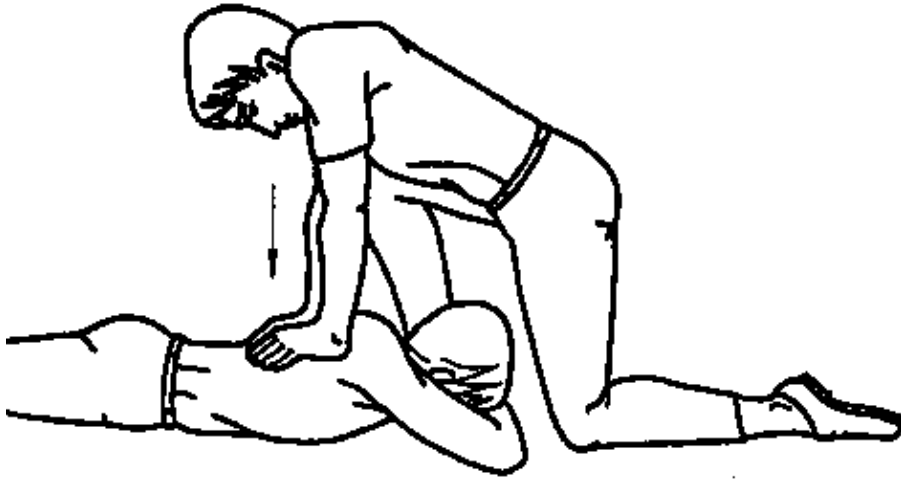


Figure 7 – Manual respiration (breathing out)

- For breathing in, pressure must be relieved suddenly by taking the hands of the injured person's back.
- Get hold of the upper arms of the injured person and lift them slightly. (This enables that the lungs and chest of the injured person expand and the surrounding air flows into the lungs.)

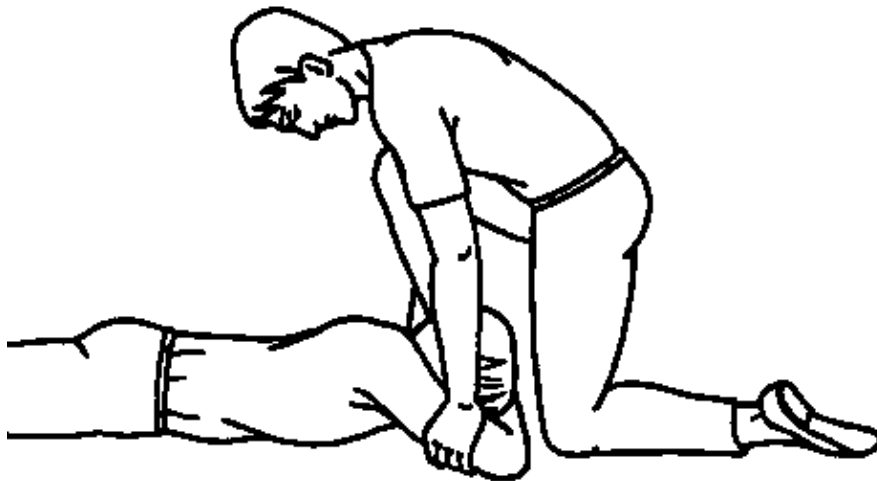


Bild 8 – Letting go of the chest

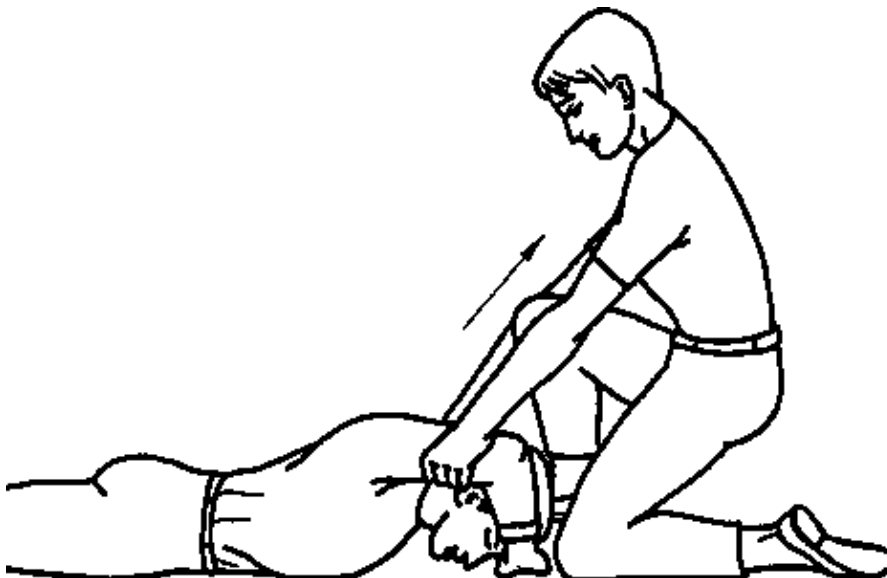


Bild 9 – Manual respiration (breathing in)

- This action must be repeated 12 to 16 times a minute.

Method in dorsal position

The method in dorsal position should be used only if no other respiration method is mastered.

It is the most awkward and least effective of all methods of artificial respiration.

- Put the injured person in flat dorsal position.
- Place a bundle of rolled up clothings or a folded blanket under the shoulder blades of the injured person.
- Clean the external air ways from foreign bodies.
- With the help of a handkerchief or a mull bandage, pull the tongue of the injured person out of his mouth and tie it up on the chin.
- Carefully turn the head of the injured person to the side.
- Kneel down behind the head of the injured person. (Your face towards the injured person.)
- Hold the arms of the injured person right above the elbows and put his arms next to each other on his chest.
- For breathing out, the rescuer shifts his body forward, this way exercising pressure on the chest of the injured person. (By this, the chest of the injured person is squeezed and the air pressed out of his lungs.)
- For breathing in, both arms of the injured person are moved in the widest possible circular movement sideways over his head to the floor. (The chest and the lungs of the injured person expand and air can be drawn in.)
- Then hold the forearms of the injured person right below his elbows and move his chest. In doing so, press the chest down.
- Repeat this action 12 to 16 times per minute.

Why should manual respiration be applied only in exceptional cases?

5. Measures Taken in the Case of Circulatory Arrest

In the case of circulatory arrest there is utmost danger of life!

In any circumstances, even if one rescuer is alone with the injured person, rescue measures have to be started! Call for help!

With unconsciousness, missing pulse beat, respiratory arrest, wide pupils that show no reaction carry out cardiac massage in addition to artificial respiration – if possible simultaneously by a second person.

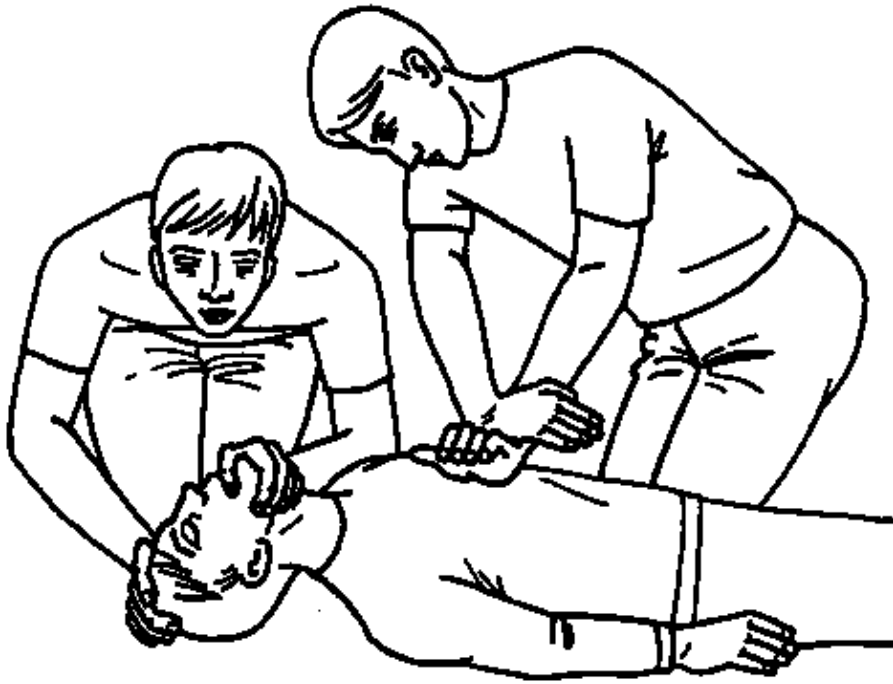


Figure 10 – Cardiac massage with simultaneous mouth-to-nose respiration

Do not practise first aid for circulatory arrest by a person for exercising purpose. It must be applied only in case of emergency. Exercises are made with the help of a dummy. (On living people all required measures are only indicated.)

Principle of cardiac massage

– Using the weight of the body of the rescuer, the heart sac of the injured person is pressed together and his blood forced into the main artery. A pumping effect is created.

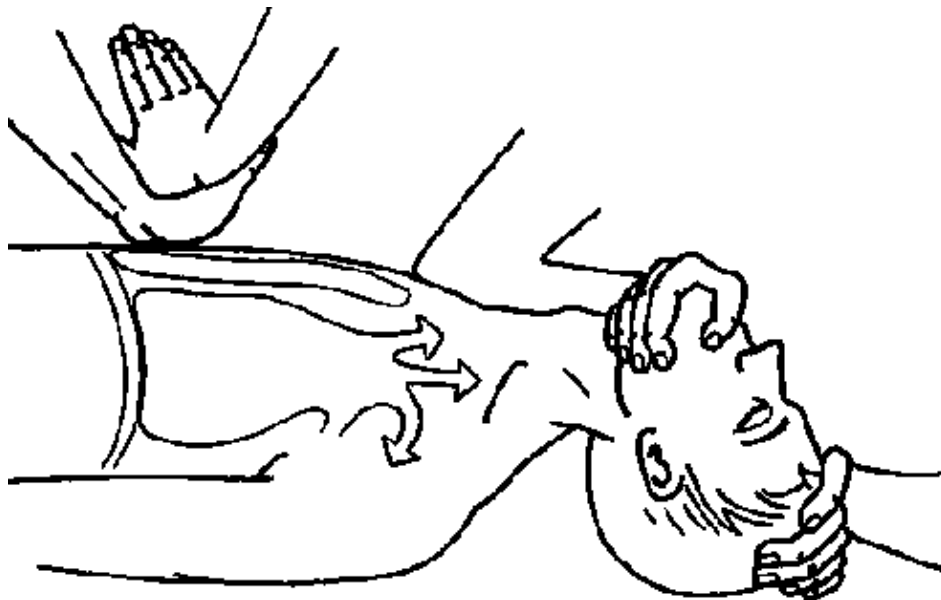


Figure 11 – Principle of cardiac massage

– By relieving the pressure suddenly, chest and heart can reexpand.

A suction effect at the heart is created and the blood can flow towards the heart.

– By rhythmical squeezing and letting go (approximately 60 strokes a minute) blood circulation is forced. (If this is carried out correctly, a blood pressure of up to 40 % of the normal blood pressure is achieved.)

Carrying out of the cardiac massage

Before beginning with the cardiac massage, 10 artificial breaths have to be given in natural breathing rhythm. If after 10 artificial breaths no pulse beat is to be noted, cardiac massage has to be started.

- Bed the injured person on a hard pad.
- Kneel down by the side of the injured person.
- Put your left hand on the chest of the injured person. The wrist should lie on the lower end of the injured person's breast bone.
- Put your right hand on your left wrist.
- Press the breast bone of the injured person 3 to 4 cm towards his spinal column rhythmically approximately 60 to 80 times per minute.

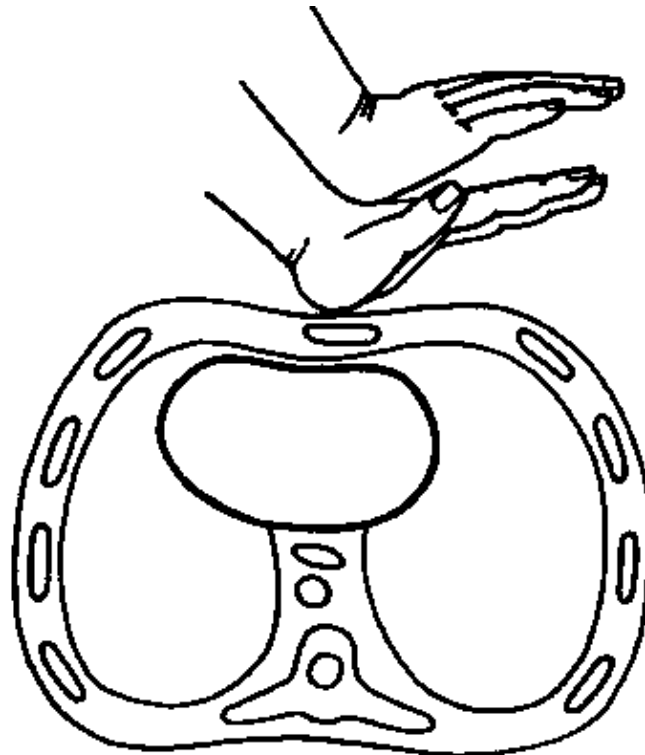


Figure 12 – Cardiac massage

Attention!

With too strong pressure, there is the risk of rib and breast bone fractures.

Cardiac massage has to be combined with artificial respiration at the ratio 4:1. This means that 12 strokes of cardiac massage are followed by 3 artificial breaths.

Continue the cardiac massage till independent heart action starts or if the doctor orders to stop the measure.

Further measure to stimulate heart beating are allowed to be taken only by the medical doctor.

Mistakes with cardiac massage

- Hands are not put in the correct place on the breast bone.
- The ratio of cardiac massage and artificial respiration is wrong.
- Pressure on the breast bone is too strong.

Why must the rescuer never stop resuscitation measures on his own?

6. Hints for the Transportation of Injured People

The health condition of the injured person is perhaps essentially influenced by the right transportation.

- People who had an accident caused by electric current must be transported in lying position.
- The injured person must be able to be transported. (Blood circulation and respiration must be functioning.) There must be not signs of critical injuries.
- If medical staff is present, the question of transportation is decided by them.
- The hospital to which the injured person is going to be transported has to be informed of the kind of accident, kind of injuries and the first aid measures taken so far.
- With low temperature, the injured person must be covered with blankets.
- Make sure that the injured person cannot fall down during transportation.

Why must injured people be carried by at least two rescuers?

Why must the medical staff be informed of the first aid measures that have been taken?

**Handling and Connection of Cables and Lines for Fixed Laying –
Course: Basic Skills and Knowledge of Electrical Engineering.
Methodical Guide for Instructors**

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Handling and Connection of Cables and Lines for Fixed Laying – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

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13187 Berlin

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1. Aims and Contents of Practical Vocational Training in “Handling and Connection of Cables and Lines for Fixed Laying”

After having finished their training based on this lesson, the trainees shall have achieved the following aims:

- They have the necessary knowledge and skills for handling and connection of cables and lines for fixed laying.
- They can carry out the operations involved in handling and connection of cables and lines for fixed laying.
- They are able to check the work done.
- They meet the safety requirements.

In order to achieve the above aims, the following knowledge and skills must be taught by the instructor:

Knowledge

- Selection of the right working technique in accordance with the relevant connection and material to be used.
- Criteria for clamped joints in electrical installations.

Skills

- Correct handling of the lines.
- Proper connection of the conductors.
- Checking the work done.

2. Organizational Preparation

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared. This includes:

2.1. Preparation of Labour Safety Instructions

Prior to the exercises the trainees must be instructed in brief on how to properly handle the working tools and prevent accident.

It is recommended to prepare a book in evidence of the labour safety instructions given to note down in brief outlines all instructions given for preventing accidents and for handling the working tools properly. The trainees should then confirm by their signature that they have been instructed accordingly.

The instructions should include the following:

- For any work in and on electrical installations the installation must be in dead condition.
- The dead condition is to be checked by means of testers.
- The installation is to be secured against re-connection by other persons.
- Proper tools are to be used only. (Defective tools are to be replaced or repaired!)
- When removing insulations with the cable stripper (knife), the knife blades must be sharp. (Sharp blades minimize the risk that the knife might slip off and cause injuries!)
- Cutting with the knife must **always** be directed away from the body.
- Any flash produced with pressed joints is to be removed.
- Soldering iron used for soldered joints
 - must not be unattended in operating condition,
 - are to be deposited only on the stands or supports intended for this purpose,
 - are to be disconnected immediately on completion of the work.

Other labour safety instructions can be given for special local conditions.

2.2. Preparation of Teaching Aids

The theoretical instructions should be given at a place where the trainees are able to make notes, preferably in a room with blackboard, desks and mains supply.

When the instructions are given in the workshop or at the workplace, the tables should be provided with clean supports for the papers etc. to be deposited.

For the demonstrations during the instructions one workplace should be equipped as follows:

- Material and equipment for exercises (cables, lines and electrical equipment).
- Folding rule or steel rule.
- Combination plier, side cutting plier, round nose plier.
- Screwdrivers, hexagon-head wrenches.
- Cable stripper (knife).
- Insulation stripping plier.
- Sheath stripper.
- Pressing tool with accessories.
- Cable eyes.
- Pressing plier.
- Press-sleeves and insulation sleeves.
- Wire wrapping tool.
- Soldering iron and soldering accessories.

- Anti–corrosion grease.

Sufficient copies of the “Trainees’ Handbook of Lessons – Handling and Connection of Cables and Lines for Fixed Laying” are to be made available to provide one copy to each trainee.

Tables etc. are to be written on the blackboard prior to the instructions.

2.3. Preparation of Working Tools and Materials

- Sufficient copies of the “Instruction Examples for Practical Vocational Training – Handling and Connection of Cables and Lines for Fixed Laying” are to be distributed to provide one copy to each trainee as theoretical basis for the exercises to be done.
- The material necessary for the exercises as specified in the “Instruction Examples...” are to be prepared and kept ready in sufficient quantity.
- Each trainee must have a place for carrying out the exercises.

2.4. Time Planning

Based on the total hours available, the times for the individual training sections of this lesson should be planned individually. Time planning is recommended for the following sections:

- Introduction into the relevant working technique in the form of instructions.
- Necessary demonstrations.
- Job–related instructions to prepare the exercises.
- Exercises/practising.
- Recapitulations and tests.

In such time planning the following factors should also be taken into consideration:

- Level of training reached by the trainees,
- training conditions,
- future assignment of the trainees,
- level of difficulty of the relevant training section.

The emphasis in each training section should be on the acquisition of practical skills and abilities by practising. Any waiting times occurring for the trainees in spite of good planning should be bridged by suitable preparatory work, such as preparation of materials to be used for exercises.

3. Recommendation for the Implementation of the Practical Vocational Training in the Working Techniques of “Handling and Connection of Cables and Lines for Fixed Laying”

The following sections contain recommendations on how to organize and implement the instructions, demonstrations, exercises and tests.

3.1. The Introductory Instructions, Demonstrations and Exercises

The introductory instructions for each working technique can be given in a class–room. During the instructions the trainees should be advised to note down necessary additions or answers into the “Trainees’ Handbook of Lessons”.

The arrangement of the contents of the "Trainees' Handbook of Lessons" is adapted to the introductory instructions and the main points therein contained should be taught. The knowledge of the working techniques of making permanent joints and fastening joints should be repeated and referred to since a good command of those working techniques is a precondition for acquiring the working techniques of "handling and connection of cables and lines for fixed laying".

The subject of "Connection of Cables and Lines for Fixed Laying to Electrical Equipment", in particular the criteria for clamped joints in electrical installations, should be taught intensively using all teaching aids available.

Fundamentals for handling and connection of cables and lines for fixed laying

At the beginning the trainees should be informed on the aim to be achieved.

This can be done by showing the trainees finished products and pointing to the many applications of lines for fixed laying in industry, agriculture, public life and, last not least, in households.

Before the demonstrations and exercises the trainees must be made familiar with installation engineering terms not yet known. For this purpose the tables, lists etc. contained in the "Trainees' Handbook of Lessons" may also be written on the blackboard or be used as transparency.

When explaining the new terms, some typical representatives of lines to be handled or connected should be shown and, if possible, also locations where they are installed.

The criteria for the selection and use of lines for fixed laying should also be dealt with in detail.

Usual working techniques to be applied prior to the connection of lines are to be repeated.

Handling of lines

It is to be made sure that all trainees can watch the demonstrations.

After the demonstrations the trainees should start with the exercises at their workplace.

Attention is to be paid to the fact that all trainees have to keep their workplace always in order and that

- tools are to be deposited in cleaned condition,
- tools are to be deposited so that they cannot be damaged,
- tools and materials are to be supported so that they do not protrude and cannot fall down,
- electrical tools are to be switched off after use with the mains plug to be disconnected.

Before the exercises the necessary material is to be handed out to the trainees.

The demonstration parts should be available to the trainees for comparison.

Any mistakes made in the exercises should be corrected immediately and be evaluated together with the trainees. The instructor should point out again and again that wrong operation of tools may cause waste material or re-working.

Stripping of the insulation

First the instructor should explain how to proceed with stripping of the insulation and what tools are to be used for stripping. The stripping length of the insulation sheath and conductor insulation is to be specified.

- Stripping of the insulation sheath by means of the cable stripper (knife) and by means of the sheath stripper

Here it is important that the cable stripper is applied at the correct angle and moved away from the body. (To avoid damage to the conductor insulation and to prevent accidents!)

- Removal of the filler
- Removal of the conductor insulation

When stripping the conductor insulation, special attention is to be paid to guiding the knife correctly since otherwise faults may be produced which cannot be repaired, such as:

- notching of the conductor
- cutting of the conductor sheathing (conductor insulation)
- injury of the trainee (stabs or cuts).

Vertical guidance of the knife on the conductor is a typical example of wrong guidance!

The use of insulation stripping pliers should also be dealt with since they remove the conductor insulation more quickly and more cleanly.

Insulation stripping pliers normally have several ground-in cutting edges, arranged side by side, and are suitable for cross sections of conductors from 0.75 to 6 mm².

Only use the cutting edge intended and marked for the relevant cross section of the conductor to ensure clean removal of the conductor insulation and to avoid damage to the conductor! To avoid damage to the conductor, the pliers should cut into the conductor insulation no more than 2/3 up to 3/4! The rest is to be torn off.

Conductors with cross sections exceeding 6 mm² are to be stripped by means of the cable stripper!

During the exercises the instructor should repeat again and again

- that the insulation layers are to be separated and removed cleanly and completely from the conductor beneath,
- that the conductor must never be cut.

The trainees must be strongly warned of the risk connected with a cut conductor.

- Reduction of the cross-sectional area at the joint may result in
 - lower capacity,
 - excessive heating,
 - possible destruction of the connection and of the connected equipment.
- Risk of breakage of the stripped conductor (particularly of Al conductors)

This may have the following effects:

- Breakdown of the connected equipment.
- Loss of the protective function of the faulty conductor (short circuit, electrical accident by existing shock-hazard voltage).
- Bending of wire lugs
- Pressing-on of cable eyelets

Since these working techniques are already known to the trainees, it is recommended to repeat the knowledge already acquired based on the “Trainees’ Handbook of Lessons” for the lessons of “Making Fastening Joints” and “Making Permanent Joints”.

Connection of cables and lines for fixed laying to electrical equipment

At the beginning it should be made clear to the trainees that the rules elaborated hereinafter apply to all electrical appliances, devices, machines and other equipment and must be strictly observed. But it should also be pointed out that special installations, such as emergency lighting and explosion-proof installations are subject to special rules which are additionally to be observed. The relevant technological regulations are to be made known to the trainees. The demonstrations and subsequent exercises should start with “simple electrical connections”, such as switches, branch boxes etc.

It is not before the trainees have a good command of these working techniques that more intricate clamped joints can be dealt with, such as terminal boxes, distribution installations, machine and contactor connections.

Colour codes of cores are to be specifically discussed.

Making screw joints

The making of screw joints should be demonstrated to the trainees as vividly as possible.

This can be done by showing practical examples, such as screw joints in sockets, on individual terminals or other electrical equipment.

But it is also possible to prepare and show suitable examples on the blackboard or on transparencies.

When explaining the connection of conductors, the following points should be emphasized:

- The conductor insulation must end 1 mm before the point of clamping.
- One conductor only is to be connected to terminals of installation switches, sockets and lamps.
- The conductor must be put under the clamping screw in the direction of rotation only.
- The conductor must be supported by the whole contact area of the point of connection or joint.
- Cu and Al conductors are to be clamped so that they are not in direct contact.
- Al conductors are to be greased with anti-corrosive grease.
- If several conductors are connected to one connection bolt, it is to be made sure that a washer is inserted between the conductors and a lock washer after every third conductor.
- For connections of protective conductors or middle conductors one conductor per point of connection is admissible only.

(Series connection of the protective conductor is admissible only as “uncut” conductor loop within one unit!)

- When a cable eye and a lug are jointly connected to a connection bolt, they are to be separated.
- When connecting conductors to cap screws without clamping saddle or distributor plate, no more than three conductors, which may differ by up to two cross-sectional steps, must be connected with washers to be inserted between the conductors.
- When connecting conductors to cap screws with clamping saddle, one conductor only must be connected per saddle side and the conductors may differ by one cross-sectional step.
- When connecting conductors to cap screws with distributor plate, one conductor only must be connected per distributor plate and the conductors must have the same cross section.
- Washers used for connection to screws or bolts must cover at least two thirds of the conductor.

Criteria for clamped joints in electrical installations

Clamped joints in electrical installations are subject to special rules which must be quoted and explained to the trainees.

This refers in particular to the following rules:

- The switch–lamp–wire is to be connected to the floor contact and the neutral conductor is to be connected to the ring contact.
- Disconnection through switches is allowed for phase conductors only.
- Connection marks on switches are to be observed.
- For connection of sockets the phase conductor is to be clamped at the left–hand side and the neutral conductor with protective function (PEN) or the neutral conductor and protective conductor at the right–hand side.
- The phase conductor sequence is to be observed when connecting power sockets.

The points of clamping are to be firmly tightened!

Points of clamping of Al conductors, in particular, should be re–tightened after a few days since they might get loose because of “flowing” of the material!

The trainees are also to be made familiar with the TRR rule (TOP, REAR, RIGHT–HAND).

The necessity of having a consistent system of clamped connections is also to be underlined.

During the exercises the trainees should be constantly supervised.

Defective or poor–quality connections should be immediately reworked or repaired.

If certain faults are repeatedly found, the trainees should be called together at one working place and be advised on the causes and effects.

The aim should be to make clear to the trainees the proper relationship between expenditure of work and technology on the one hand and esthetics and effects of the faults on the other hand.

Pressed joints

Here it is essential to point out that pressed joints are “permanent” joints.

Moreover it is necessary to discuss the criteria for connection by means of press–sleeves.

Press–sleeves must be fixed only by means of the pressing pliers intended for this purpose! Perfect pressing is to be ensured!

To avoid short circuit or body contact, perfect fit and vertical position of the insulation sleeves are to be ensured!

During the exercises the trainees should also be controlled and corrected, if necessary.

- Making wire–wrap joints
- Making soldered joints

These two working techniques should be dealt with in the form of a repetition since the trainees should already be familiar with these working techniques.

Here, too, “Trainees’ Handbook of Lessons – Making Permanent Joints” should be used.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

The “Instruction Examples” describe the sequence of operations and contain a working drawing for carrying out the respective operations.

Moreover, the recommended materials, a list of the necessary working, measuring, testing tools and

accessories as well as the necessary previous knowledge are included for each example. The sequence of operations is supplemented by comments so as to provide the trainees with any information required for carrying out the work properly and in line with the safety regulations.

The following should be considered in the organization of the work:

- The trainees should do themselves any work involved in the instruction example.

This will enable the instructor to watch, correct and justly judge the achievement of each trainee.

3.3. Examples for Recapitulation and Tests

This section contains questions to strengthen and test the knowledge and skills acquired. The answers to the questions are also given. Questions, which are also contained in the “Trainees’ Handbook of Lessons”, are marked with the letter “A”.

1. What is the difference of lines and cables for fixed laying compared to those for connection of non-stationary (mobile) equipment?

“A” (Cables and lines for fixed laying are permanently installed and intended for single bending considering a bending radius. Their location remains unchanged. Lines for non-stationary laying are intended for portable electrical equipment. They are flexible and have fine or finest wires.)

2. What are the criteria for the selection and application of cables and lines for fixed laying?

“A” (Rated voltage, type of mechanical stress, temperature range, location)

3. How is a plastic-sheathed cable constructed?

(From inside to outside: Cu, Al or AlCu conductor, conductor insulation, filler, insulation sheath)

4. What are the risks involved in a conductor which has been damaged when stripping the conductor insulation?

“A” (Reduction of cross-sectional area at the joint: lower capacity, heating of conductor, destruction of the connection and/or connected equipment; breakage of stripped conductor: breakdown of the equipment, loss of the protective function with risk of short circuit or accident by existing shock-hazard voltage)

5. What is to be considered for bending of wire lugs?

“A” (Round-nose plier to be used only. Conductor must not be damaged. Lug must be adapted to the diameter of the thread or bolt.)

6. What is to be considered for making a joint with wire lugs?

“A” (Lug must be placed so that lug end is in direction of rotation when connection screw is tightened.)

7. What is to be considered for pressing-on cable eyelets?

“A” (Cable eye must be in accordance with cross section of conductor. Pressing inserts must comply with cable eye. V-grooves are applied on Cu conductors only. Change in length is to be considered for

hexagonal pressing. Contact faces of cable eye and conductor must be cleaned to remove dirt and oxide layers. If necessary, wire ring is to be applied for feeding-in segmental, multi-wire conductors. Flash produced at cable eye with hexagonal pressing is to be removed.)

8. What do the rules for the connection of cables and lines for fixed laying apply to?

(To all electrical appliances, devices, machines, clamped joints and other equipment.)

9. When are lugs to be bent for clamped connections?

“A” (When connection is made to stay bolts or cap screw terminals without clamping saddle or distributor plate.)

10. Why must neutral or protective conductors be looped at the point of the connection?

(To avoid loss of the protective function when the preceding point of connection is detached or disconnected.)

11. What are the advantages of a consistent system of clamped connections in electrical installations?

“A” (Facilitates fault finding, repairs, extension and connection of equipment depending on the direction of rotation.)

12. What are the advantages of pressed joints over clamped joints?

“A” (Shorter assembly time, no clamping inserts required, longer lasting contact, no risk of short circuit or body contact since points of connection are insulated.)

13. What operations are required for making wire-wrap joints?

“A” (Preparing the wrapping tool, stripping the conductor, inserting the conductor into the wrapping tool, putting the wrapping tool onto the connection lug, carrying out the wrapping process, removing the wrapping tool and switching off, inspection of the wire-wrap joint.)

14. What operations are required for making soldered joints?

“A” (Making the soldering iron ready for operation, stripping the conductor, cleaning the conductor and connection lug to remove dirt and oxide layers, inserting the conductor into or attaching it to the point of connection, treating the point to be soldered with acidless flux, carrying out the soldering process adding soldering tin, inspection of the soldered joint.)

**Handling and Connection of Cables and Lines for Fixed Laying –
Course: Basic Skills and Knowledge of Electrical Engineering.
Instruction Examples for Practical Vocational Training**

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Handling and Connection of Cables and Lines for Fixed Laying – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Introduction

The present boklet contains 3 selected instruction examples to practise the main skills in “Handling and Connection of Cables and Lines for Fixed Laying”.

Since the skills in handling and connection of cables and lines for fixed laying can be acquired only by practising as much as possible, the instruction examples should be repeated many times.

In order to facilitate the preparation and execution of the work, the necessary materials, working, measuring and testing tools as well as additional knowledge required for carrying out the exercises are specified for each instruction example, where necessary.

Moreover, working drawings are attached showing more details of the exercises.

Instruction Example 5.1. Connection of a Line for Fixed Laying to an Electrical Equipment

Material

Plastic cable, electrical equipment with socket screw joint

Working tools

Side cutting plier, cable stripper (knife), sheath stripper, insulation stripping plier, screwdriver, hexagon–head wrench, round–nose plier

Measuring and testing tools

Scale

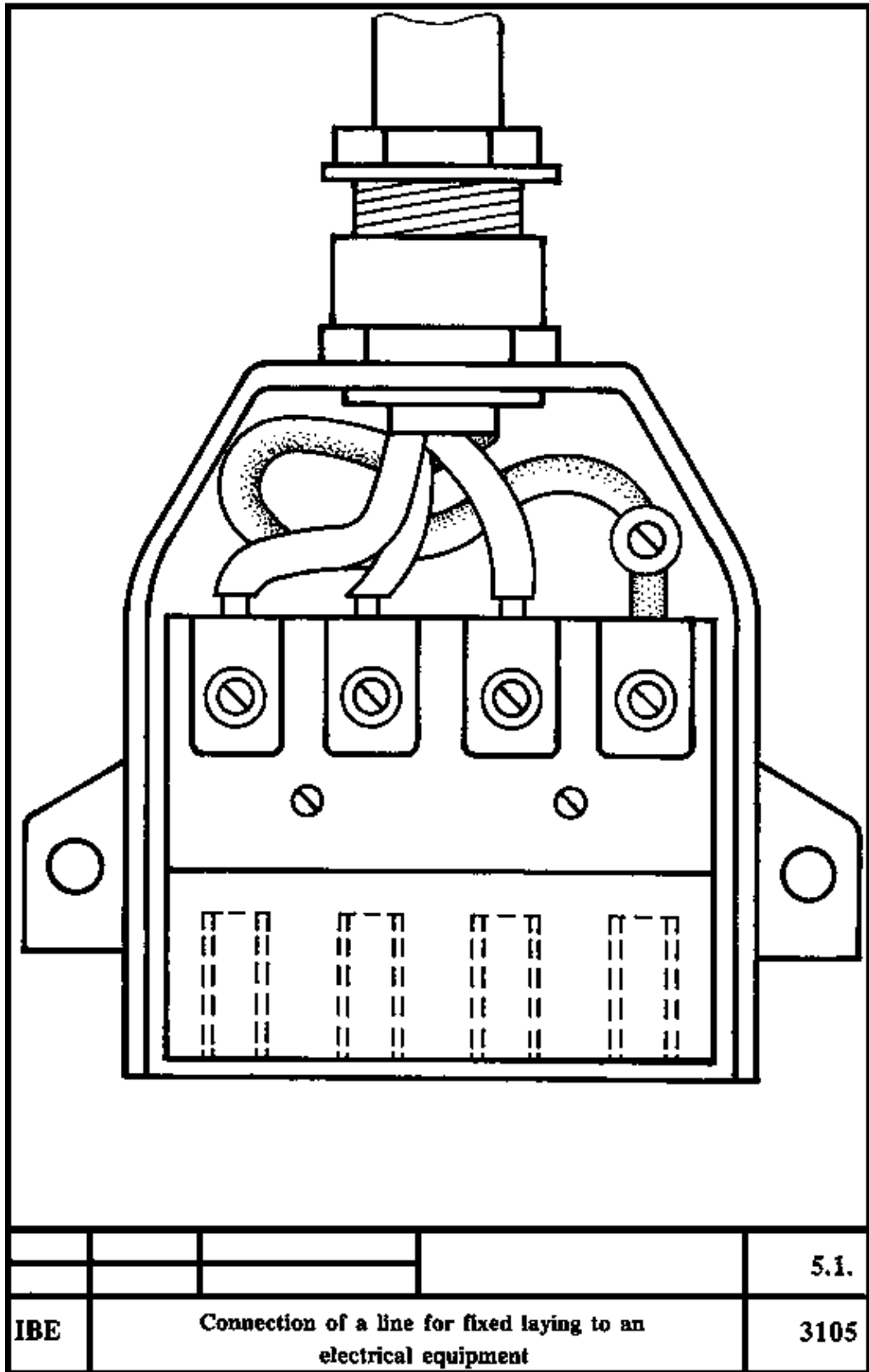
Accessories

Anti–corrosive grease

Necessary additional knowledge

Knowledge of types of lines and core coding as well as phase conductor sequence, making fastening joints

Sequence of operations	Comments
1. Cutting the cable to length required.	
2. Opening the point of connection of the electrical equipment.	
3. Removing the insulation sheath.	
4. Taking out and arranging the elements of the gland screw joint on the cable.	
5. Feeding-in the cable into the electrical equipment.	
6. Adapting the conductors to the points of connection.	
7. Stripping the individual conductors.	Pay attention to type of connection. (clamping, bending of lugs etc.)
8. Clamping of the conductors.	Protective conductor first and then the phase conductor. In case of Al conductors, grease with anti-corrosive grease!
9. Tightening the screw joint.	
10. Closing the electrical equipment.	If necessary, take further protective measures to improve the safety quality.



Instruction Example 5.2. Installation and Connection of Devices with Different Types of Connection

Material

Plastic cables of different cross sections, branch box with gland screw joint, socket with gland screw joint, line fixing clamps

Working tools

Side cutting plier, cable stripper (knife), sheath stripper, insulation stripping plier, screwdriver, round-nose plier, pressing plier, gimlet

Measuring and testing tools

Folding rule, continuity tester

Accessories

Press-sleeves, fastening screw for devices and clamps, anti-corrosive grease, sealing compound for gland screw joints

Necessary additional knowledge

Knowledge of cable types and core coding as well as phase conductor sequence, making fastening joints, making pressed joints

Sequence of operations	Comments
1. Marking the arrangement of the line and the location of the electrical equipment.	
2. Installation of the equipment and mounting of the line fixing clamps.	
3. Cutting the cables to the required length.	
4. Opening the points of connection of the equipment.	
5. Removing the insulation sheath at either end of the cable.	If the cable is to be laid between two electrical equipments repeat operations 5 and 61
Taking out and arranging the elements of the gland screw joint on the cable.	
Feeding-in the cable into the electrical equipment.	
Laying the cable, fixing with clamps and aligning up to shortly before the other equipment.	
6. Repeating the operations as per 5. with the other equipment.	
7. Adapting the conductors to the points of connection.	
8. Stripping of the individual conductors.	

9. Connecting the conductors.

Type of connection

– by means of
press–sleeves

– by means of
lugs

– by means of
clamping

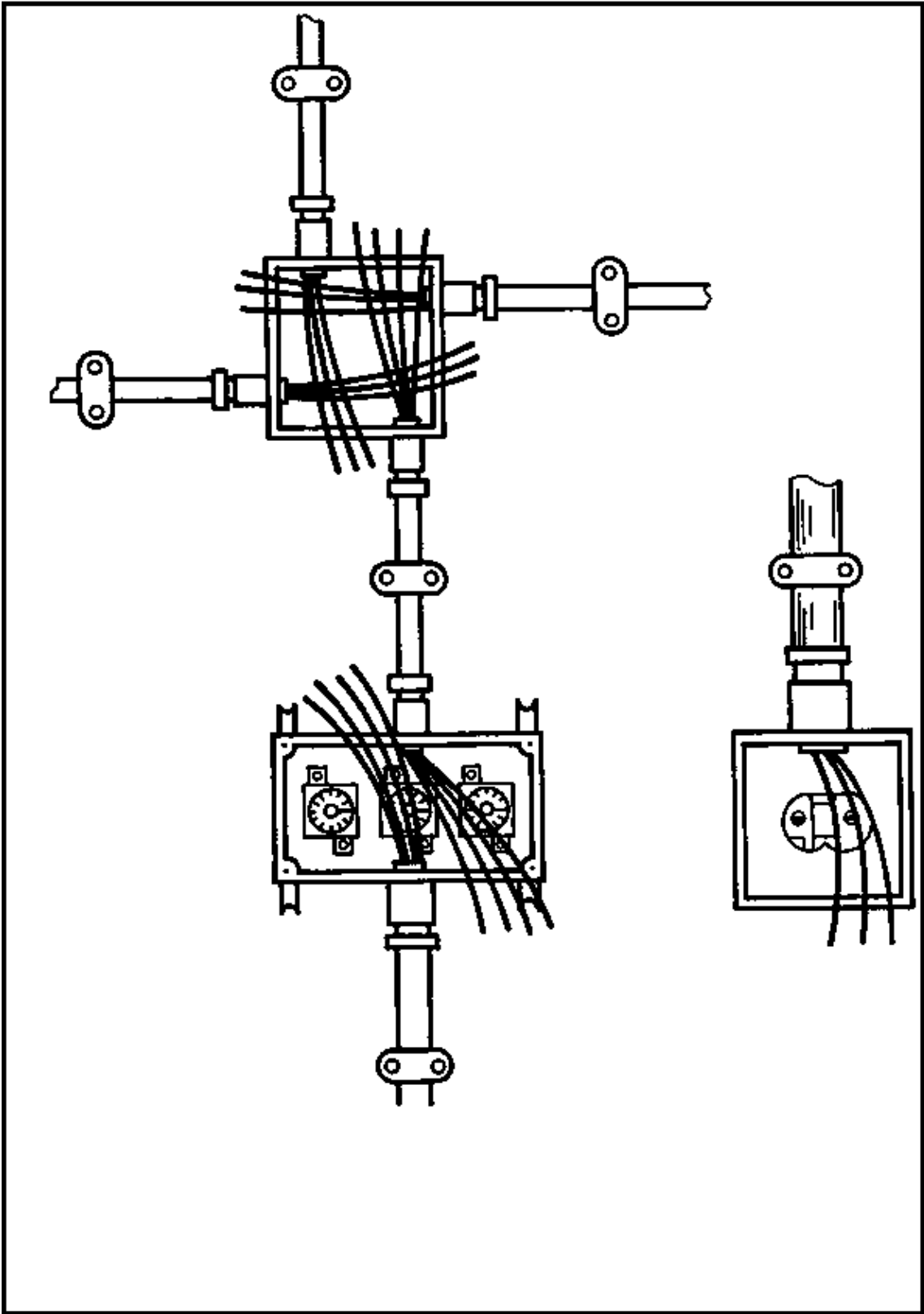
to be considered!

10. Tightening the screw joints.

11. Testing the connected lines by means of continuity tester.

12. Closing the electrical equipment.

13. Sealing the gland screw joints.



				5.2.
IBE	Installation and connection of devices with different types of connection			3105

Instruction Example 5.3. Handling Plastic–sheathed Wires, Connecting them to Tag Blocks and Combining them into Wiring Harnesses

Material

Plastic–sheathed wires NY or NYF (1mm²), tag blocks (multi–step)

Working tools

Side cutting plier, cable stripper (knife), insulation stripping plier, long flat–nose plier, soldering iron, paint scraper

Measuring and testing tools

Folding rule

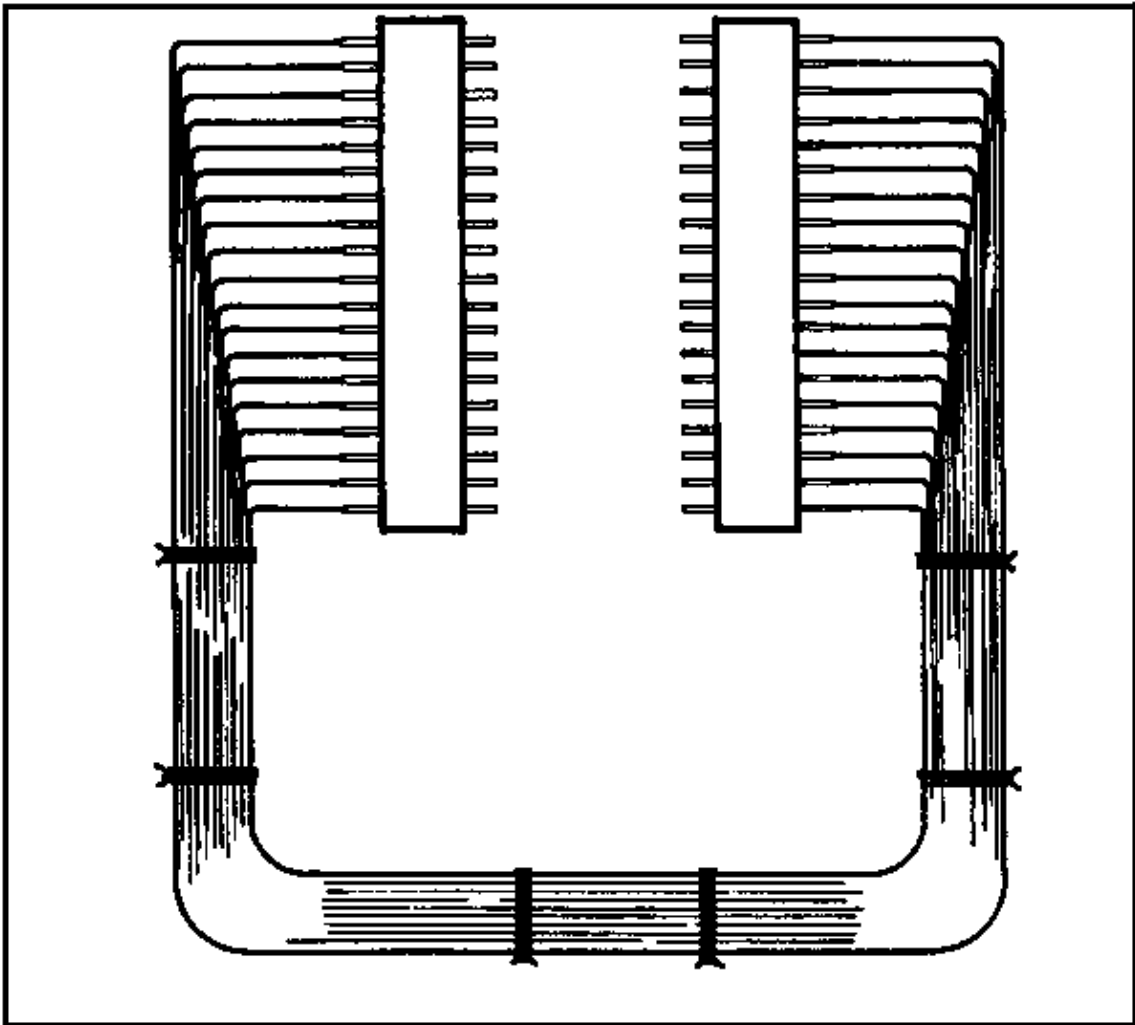
Accessories

Wiring harness form, soldering–iron stand, extension line, Perfol tape, flux, soldering tin

Necessary additional knowledge

Knowledge of core lines, solder, flux, making permanent joints

	Sequence of operations	Comments
1.	Uncoiling the plastic–sheathed wire.	
2.	Cutting the plastic–sheathed wire to size.	Pay attention to size!
3.	Bunching the plastic–sheathed wires into a wiring harness and binding by means of Perfol tape.	
4.	Adapting the wire ends to the tag blocks.	
5.	Stripping the wire ends.	
6.	Tin–coating the wire ends.	
7.	Soldering the wire ends to the soldering tags of the tag blocks.	



				5.3.
IBE	Handling plastic-sheathed wires, connecting them to tag blocks and combining them into wiring harnesses			3105

**Handling and Connection of Cables and Lines for Fixed Laying –
Course: Basic Skills and Knowledge of Electrical Engineering.
Trainees' Handbook of Lessons**

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Handling and Connection of Cables and Lines for Fixed Laying – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Author: Gerhard Klix

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Introduction

The present handbook is intended for trainees in electrical engineering trades.

It contains a description of the operations and tools required for the handling and connection of cables and lines for fixed laying.

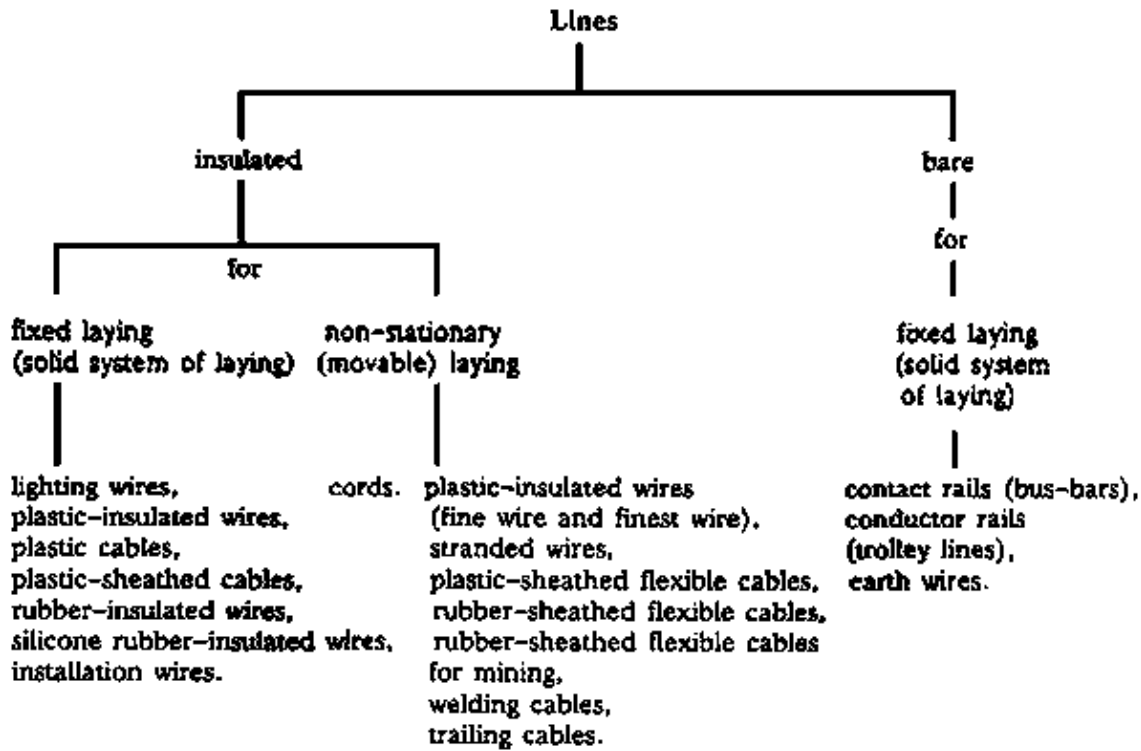
The methods required are explained in self-contained sections.

The necessary knowledge and skills are described in each section in the order of the steps of work required. The illustrations contained shall help to visualize, understand and supplement the text of the individual sections.

To assist the learning process, questions have been included for the trainees to test their knowledge.

1. Fundamentals for Handling and Connection of Cables and Lines for Fixed Laying

Classification of lines (survey)



Insulated lines

- Conductors are provided with plastic or rubber insulation (conductor insulation).
- Several conductors are stranded and sheathed by a common insulation (insulation sheath).

Bare lines

- Uninsulated conductors.

Lines for fixed laying (solid system of laying)

- Lines are fixed (permanently installed)

Lines for non-stationary laying (connection to portable equipment)

- Flexible (movable) insulated lines.

Features of lines for fixed laying

- Conductor of lines for fixed laying
- Conductor
 - single wire, code designation (e)
 - multi-wire, code designation (m)
 - round, code designation (r)
 - segmental, code designation (s)
- Wire insulation and insulation sheath can be slightly bent. (Bending radius to be considered)
- Line is intended for single laying and subsequent continuous operation (in unchanging position).

What is the difference of lines and cables for fixed laying compared to those for connection of non-stationary (mobile) equipment?

Examples of applications of cables and lines for fixed laying

Type of line	Indoors			Outdoors	Applications
	dry	humid	wet		
Plastic insulated wire	+				Installations, switchgear and distribution systems; light fittings
Plastic cables and plastic-sheathed cables	+	+	+	+	Installations of any kind
Installation wires	+				Concealed installation



Figure 1 Plastic-insulated line, single-insulation, single-wire, (Cu – NY, Al – NAY)



Figure 2 Plastic cable, double-insulation, multi-wire, (Cu – NYY 1 x 50 mm², Al-NAYY 1 x 50 mm²)



Figure 3 Plastic cable, multiple insulation, multi-core, single-wire, (Cu – NYY-I 4 x 2.5 mm² re, Al – NAYY-I 4 x 2.5 mm² re)

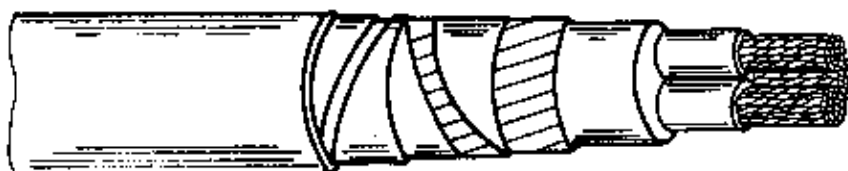


Figure 4 Plastic cable, multiple insulation, metal sheath, three-core, multi-wire, Al conductors

What are the criteria for the selection and application of cables and lines for fixed laying?

Operations required before the connection of the lines

- Bending of lugs
- Pressing-on of cable eyes
- Making pressed joints of conductors
- Soldering on conductors

2. Handling of Cables and Lines for Fixed Laying

The insulation can be removed by means of the following tools:

- cable stripper
- sheath stripper
- insulation stripping plier

Stripping process for a plastic–sheathed cable

Stripping of the insulation sheath

By means of the cable stripper

- Apply cable stripper angularly.
- Rip up the insulation sheath of the cable parallel to the conductor. (The knife is to be held at such an angle to the conductor that the knife blade cannot damage the conductor insulation).
- Tear apart the plastic sheath.
- Carefully cut off the insulation sheath all around.

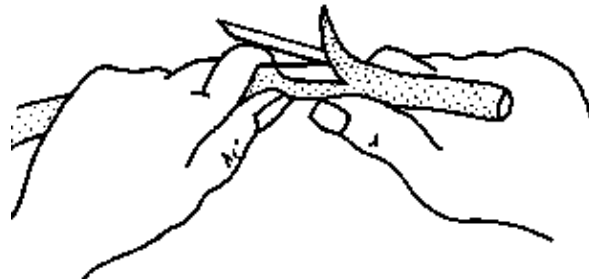


Figure 5 Stripping of the insulation sheath by means of cable stripper

For stripping of insulation use knife with sharp blade only!

By means of the sheath stripper

- Set adjustable blade according to the line diameter.
- Put the stripper on the line.
- Rip up the sheath.
- Tear apart the plastic sheath.
- Carefully cut off the insulation sheath all around.

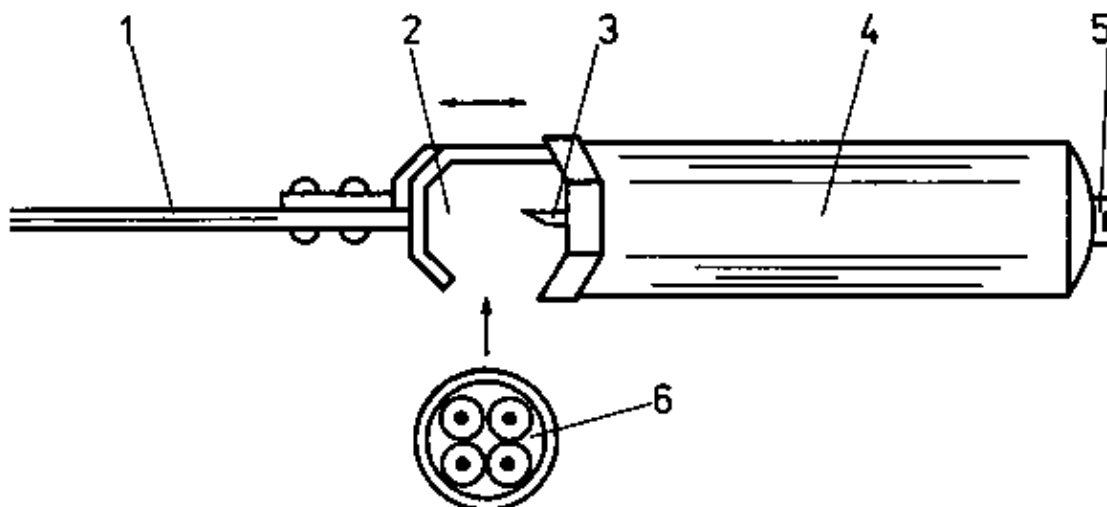


Figure 6 Sheath stripper for removing the insulation sheath from plastic–sheathed cables

1 blade, 2 area for the cable, 3 adjustable blade for scoring the insulation sheath, 4 handle, 5 adjusting screw for setting the blade, 6 cable

Removal of the filler

- Completely remove the filling material under the sheath up to the insulation from the stripped end of the cable.

Removal of the conductor insulation

By means of the cable stripper

- Cut off (peel off) one half of the insulation by means of the knife.
- Pull off the other half by hand and cut off by means of the knife.

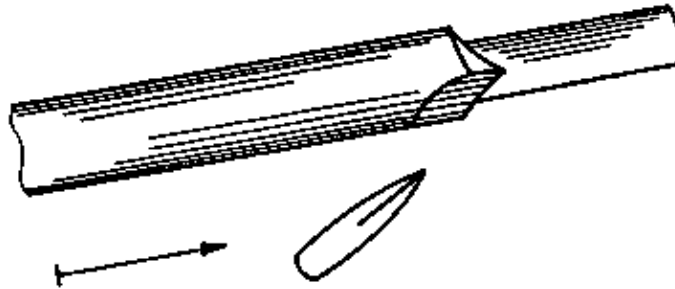


Figure 7 Stripping of the conductor insulation by means of the cable stripper

Make sure that the knife is guided correctly since the conductor may be damaged by wrong knife guidance and may break when being bent.

What are the risks involved in a conductor which has been damaged when stripping the conductor insulation?

By means of the insulation stripping plier

- Set adjustable stripping blades according to the cross section of the conductor.
- Put conductor into the pair of noses of the stripping plier and operate the stripping plier.

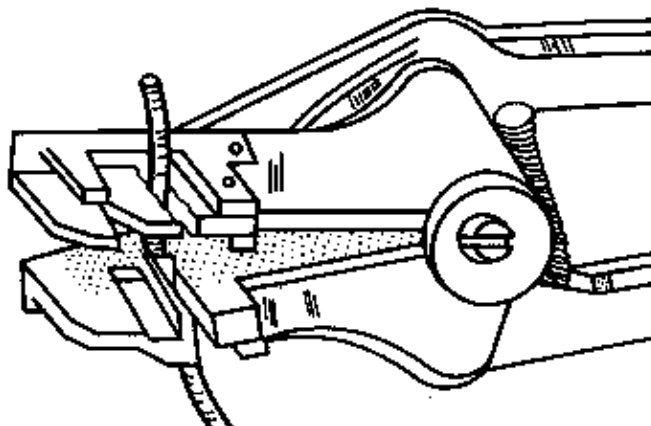


Figure 8 Stripping of the conductor insulation by means of an insulation stripping plier

Only use the cutting edge suitable and marked for the relevant conductor cross-section. Conductor cross-sections exceeding 6 mm² are to be stripped by means of the cable stripper!

For bending of wire lugs and pressing-on of cable eyelets see “Trainees’ Handbook of Lessons” of Making Fastening Joints” and “Making Permanent Joints”.

What is to be considered for bending of wire lugs?

What is to be considered for making a joint with wire lugs?

What is to be considered for pressing-on cable eyelets?

3. Connection of Cables and Lines for Fixed Laying to Electrical Equipment

Cables and lines of up to 4 mm² (inclusive) are to be laid with a spare loop at the points of connection so that the conductor can be re-adjusted.

The cross section of conductors must **not** be reduced at their points of connection and joints. Points of the connection and joints must be easily accessible!

The colour of the core must comply with the function of the conductor!

Example for making of lines for use in heavy current installations of up to 1 kV

Function of the conductor		Colour of the insulation
Main circuits	also auxiliary circuits for industrial controls	black
	preferably, however, as middle wire (neutral wire) with no protective function	blue
	also auxiliary circuits having switch contacts	brown
Protective wires (neutral wires, auxiliary earth wires), potential equalization wires		green-yellow

3.1. Making Screw Joints

- Before the lines are fed into and connected in the electrical equipment, it is recommended to strip (remove) the insulation as per section 2 hereof.
- For the stripping length, the arrangement of the connections in the equipment is important.
- The connecting lines are to be fed into the connection area of the electrical equipment with their entire sheathing.
- The sheathing of the line must project into the equipment approximately 3 mm.

- When feeding-in lines into equipment with screw joints (e.g. moisture-proof equipment), correct assembly of the screw joint is of utmost importance.

Feeding-in the line with the sheathing prevents the conductor insulation from being worn through by sharp edges of the equipment and, consequently, eliminates possible sources of faults!

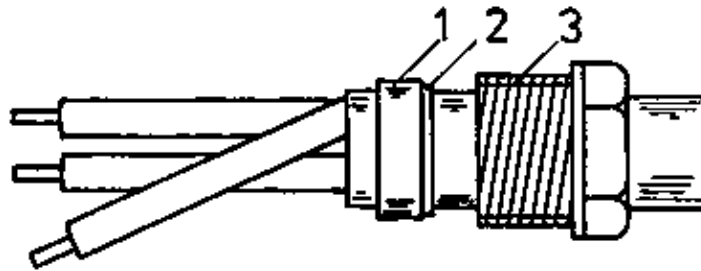


Figure 9 Arrangement of the elements when assembling a gland screw joint

1 sealing ring, 2 pressure ring, 3 plug

- The conductor insulation must end 1 mm before the point of clamping.

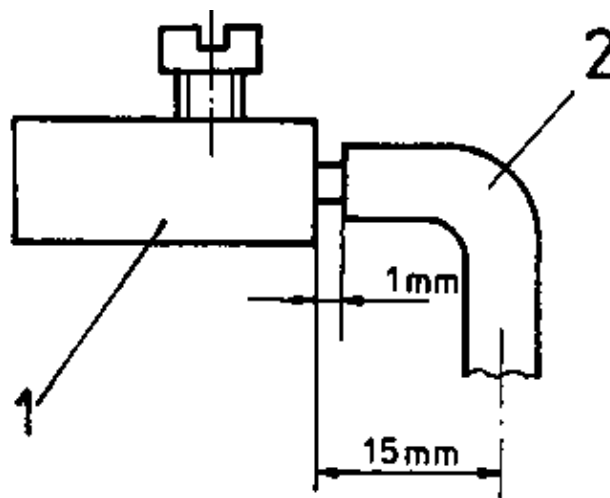


Figure 10 Connection of a conductor to a terminal

1 terminal, 2 conductor

Clamping of the conductor insulation might be detrimental to the function of the connection!

Conductors stripped too much may result in short circuits!

When are lugs to be bent for clamped connections?

- One conductor only is to be connected to terminals of installation switches, sockets and electrical equipment
- Points of connection and joints must not be covered by other conductors.
- Conductors are to be connected only in the direction of rotation of the clamping screw.

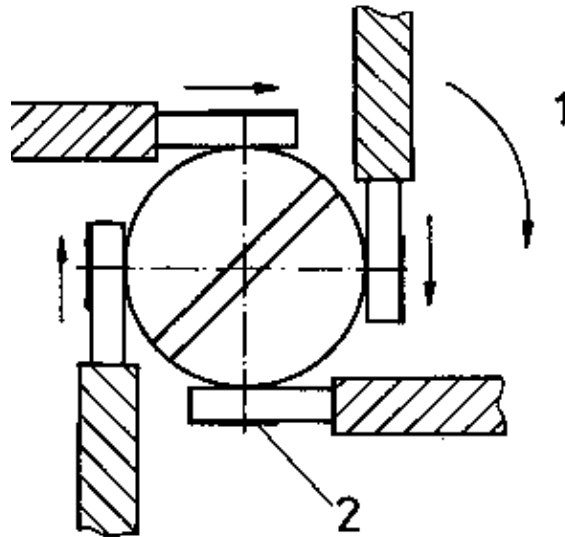


Figure 11 Connection of 4 conductors to one terminal with distributor plate

1 direction of rotation of the screw, 2 distributor plate

- Aluminium conductors are slightly to be greased with acidless grease (anti-corrosive grease) before they are clamped.
- If Cu and Al conductors are to be jointly clamped to one joint, it is to be made sure that the two conductors are not in direct contact.

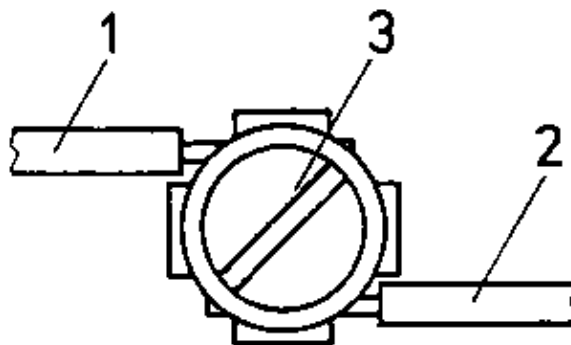


Figure 12 Connection of a Cu conductor and Al conductor to one terminal

1 Cu conductor, 2 Al conductor, 3 terminal

- The clamped conductor must be supported by the whole contact area of the point of connection or joint.
- If several conductors are connected to one connection bolt, it is to be made sure that a washer is inserted between the conductors and a lock washer at least after every three conductors.

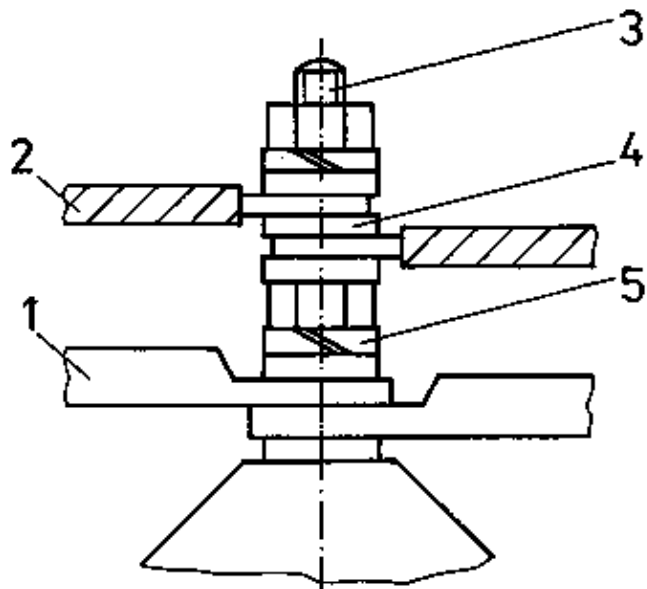


Figure 13 Connection to a connection bolt

1 cable eye, 2 conductor with lug, 3 connection bolt, 4 washer, 5 lock washer

- For connections of protective conductors or middle conductors **one** conductor per point of connection is admissible only.
- Series connection of the protective conductor from built-in unit to built-in unit is admissible only if the protective conductor is looped.

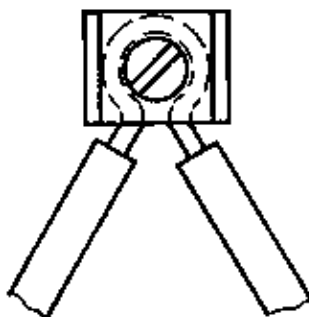


Figure 14 Looping of a line over a terminal

Looped lines are admissible only within one assembly (e.g. from lamp to lamp within one luminous band).

- When connecting a cable eye and a lug to a connection bolt, the cable eye and lug must be separately connected. (See also Figure 15)
- When connecting conductors to cap screws without clamping saddle or distributor plate, no more than three conductors, which may differ by up to two cross-sectional steps, must be connected with one washer each to be inserted between the conductors.

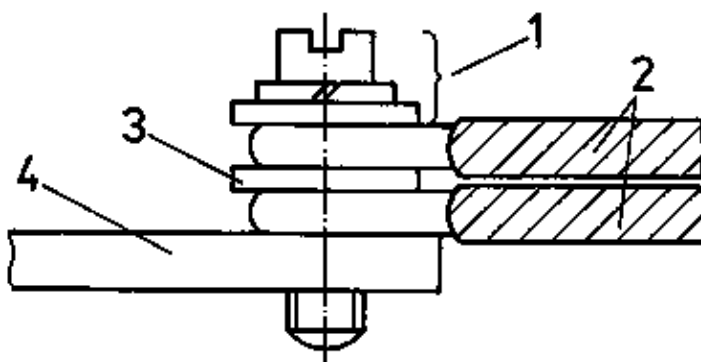


Figure 15 Connection to a connection strap with cap screw without clamping saddle

1 pressure elements (cap screw, lock washer, washer), 2 conductor, 3 washer, 4 connection strap

– When connecting conductors to cap screw with clamping saddle, one conductor only must be connected per saddle side. (The conductors may differ by one cross-sectional step.)

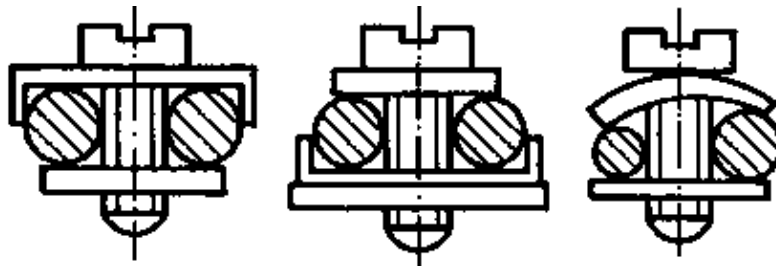


Figure 16 Connection to cap screw terminals with clamping saddle

– When connecting conductors to cap screws with distributor plate, one conductor only must be connected per distributor plate. (The conductors **must** have the same cross section).

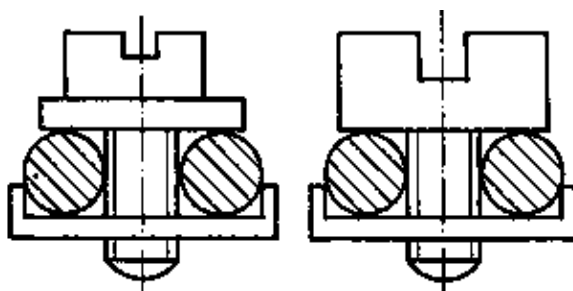


Figure 17 Connection with cap screw and distributor plate

– Conductors to be connected to connection bolts or screws with no connection facilities must have at least the following cross sections:

Screw/bolts	Minimum cross section
M 3 to M6	1 mm ²
M 8	1.5 mm ²
M 10	4 mm ²
M 12	6 mm ²
M 16	10 mm ²

Washers used for connection of conductors to screws or bolts must cover at least two thirds of the conductor!

Screw slots must not be damaged by wrong-size or defective screwdrivers!

3.2. Criteria for Clamped Joints in Electrical Installations

– For clamped connections of lamps it is important that the neutral conductor is always connected to the ring contact and the switch-lamp-wire always to the floor contact.

– Disconnection through switches is allowed for phase conductors only.

– Switches are to be connected so that the so-called TRR rule is observed, i.e. the circuit is closed when the switch is in

- top position
- rear position
- right-hand position.

– For connection of switches, attention is to be paid to switch connection marks. (Always connect phase conductors to the terminals marked accordingly.)

– For connection of sockets, the phase conductors are to be clamped at the left-hand side and the neutral conductor with protective conductor function (PEN) or the neutral conductor and protective conductor at the right-hand side.

– The phase conductor sequence (e.g. in the order black, blue, brown) is to be observed when connecting power sockets and other installation units.

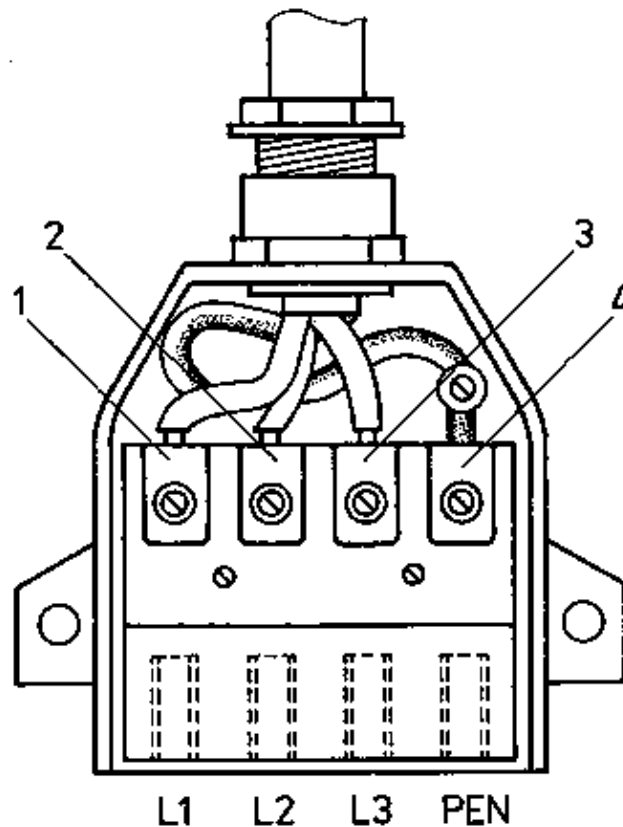


Figure 18 Connecting of a power socket

1 conductor 1, 2 conductor 2, 3 conductor 3, 4 PEN, phase conductor sequence, for example, black, blue, brown, green/yellow starting with conductor 1

Non-observance of the correct phase sequence within an installation will result in malfunctions, such as wrong direction of rotation of motors etc.

– In branch or conduit boxes, the phase conductors are to be connected on the left-hand top and the neutral conductor or neutral conductor with protective function on the right-hand bottom.

– If branch or conduit boxes have a fifth connection terminal, the protective conductor **only** is to be connected to that terminal.

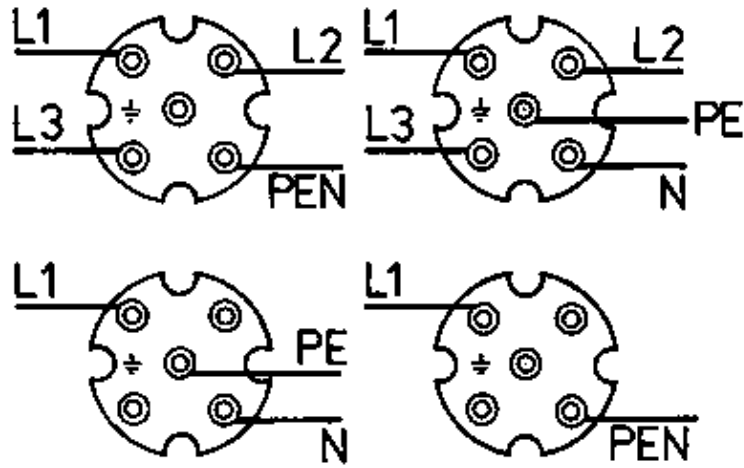


Figure 19 Examples for terminal connections in branch boxes

What are the advantages of a consistent system of clamped connections in electrical installations?

3.3. Pressed Joints

Criteria for connections by means of press-sleeves

- Hand pressing plier required.

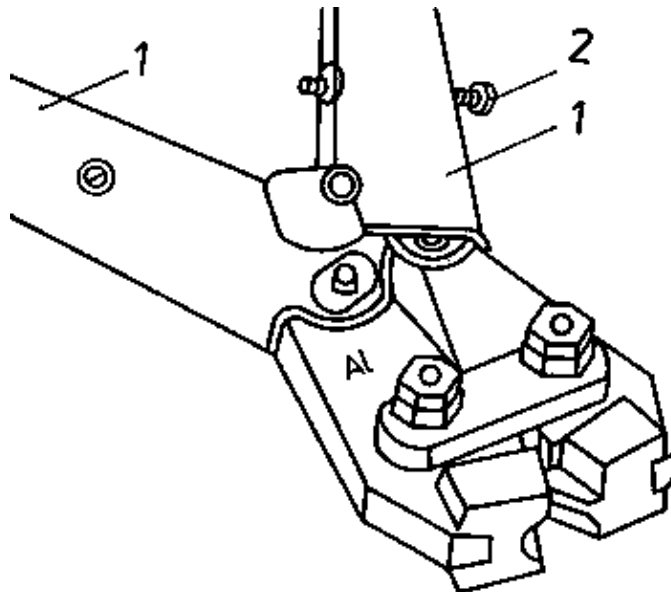


Figure 20 Pressing plier

1 grips with pawl bolt, 2 setscrew for mechanical end stop

- Applicable for Al and AlCu conductors only.
- Applicable only for three or four conductors with a cross section of 2.5 mm². (If two conductors are to be connected only, a third or fourth conductor is to be pressed in as filler).
- Shorter assembly time.
- Clamping inserts are not required.
- Longer lasting contact than that of other types of joints.

Sequence of operations

- Conductor length to permit three times re-adjustment. (150 mm are sufficient)
- Strip conductor ends and remove any oxide or other contamination layers.

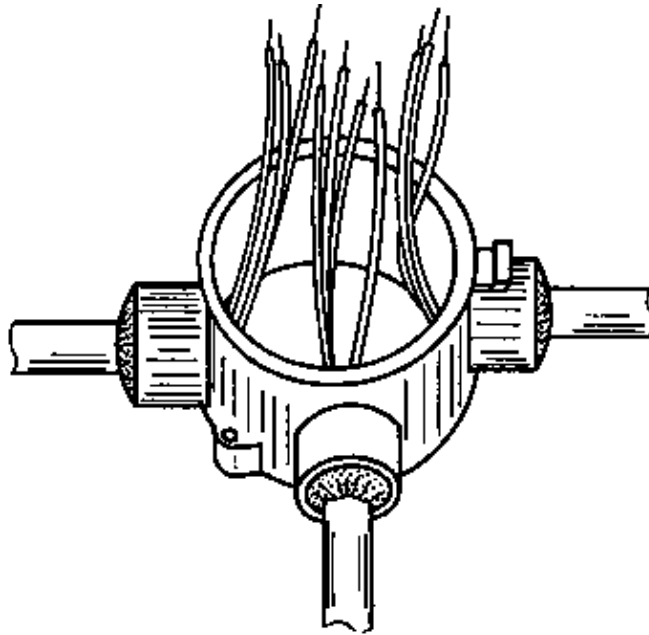


Figure 21 Branch box prepared for pressing

- Slip press-sleeve over stripped conductor ends with rotary motion. Make sure that all conductor ends contact the bottom of the sleeve!
- Distance between sleeve opening and beginning of conductor insulation should not be more than 3 mm!
- Apply pressing plier at front and compress up to stop.
- Slip insulation sleeve onto pressed sleeve until conical end of insulation sleeve closely fits on press-sleeve.

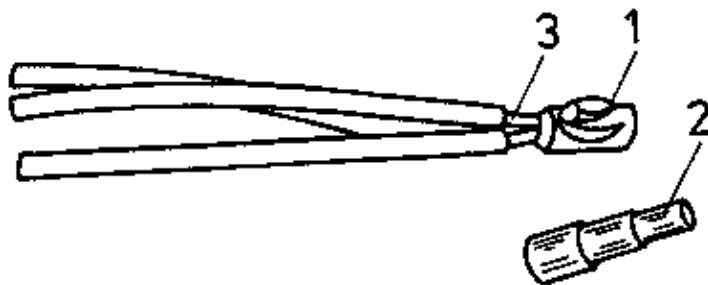


Figure 22 Finished pressed-joint

1 press-sleeve, 2 insulation sleeve, 3 distance sleeve opening to conductor insulation

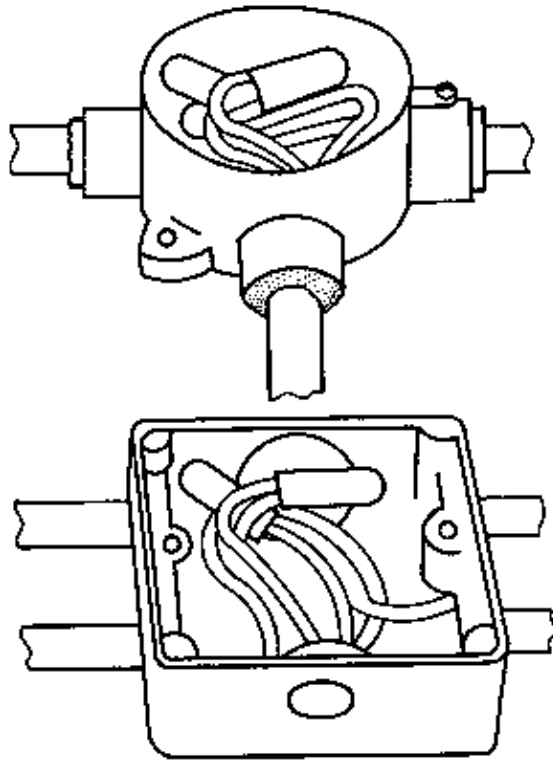


Figure 23 Pressed joint in a branch box/conduit box, made and insulated

What are the advantages of pressed joints over clamped joints?

3.4. Making Wire-wrap Joints

3.5. Making Soldered Joints

For these two types of joints see "Trainees' Handbook of Lessons – Making Permanent Joints".

What operations are required for making wire-wrap joints?

What operations are required for making soldered joints?

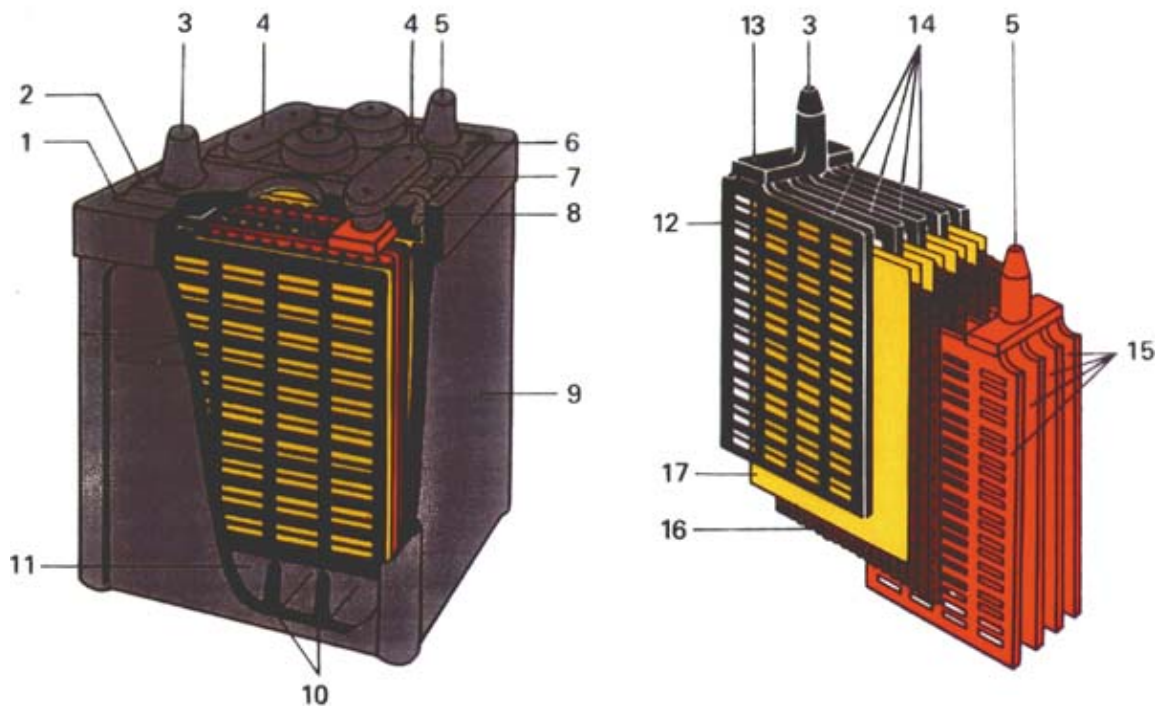
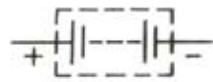
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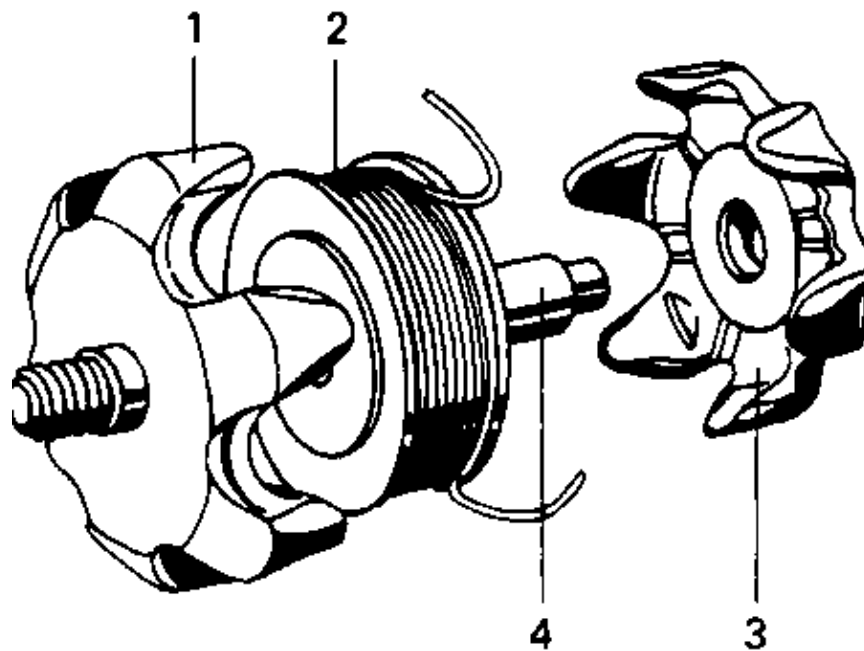
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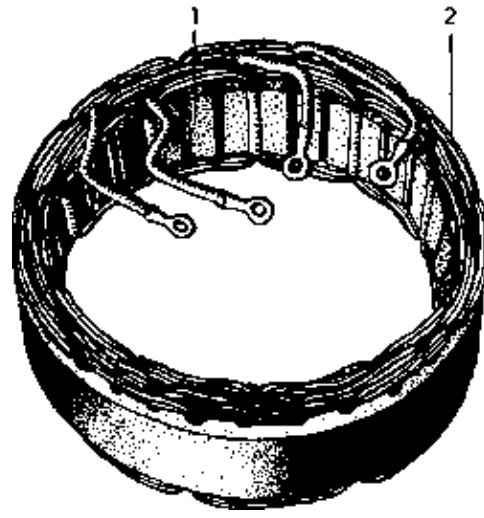
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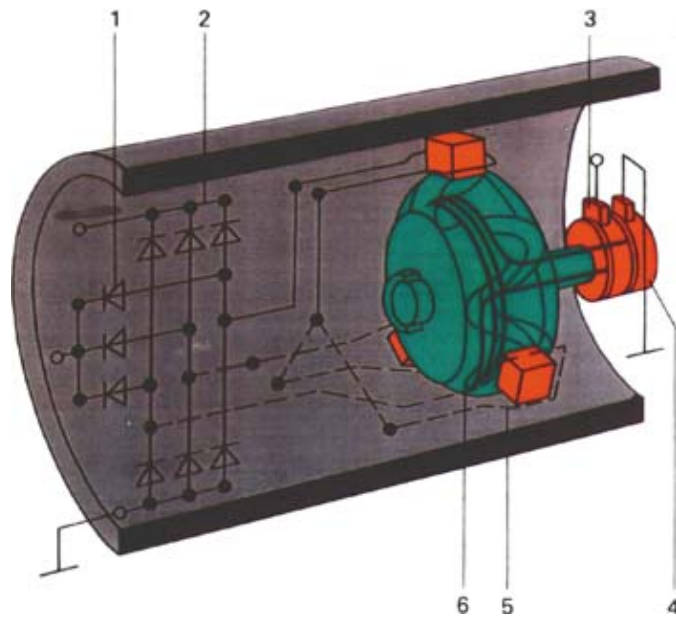
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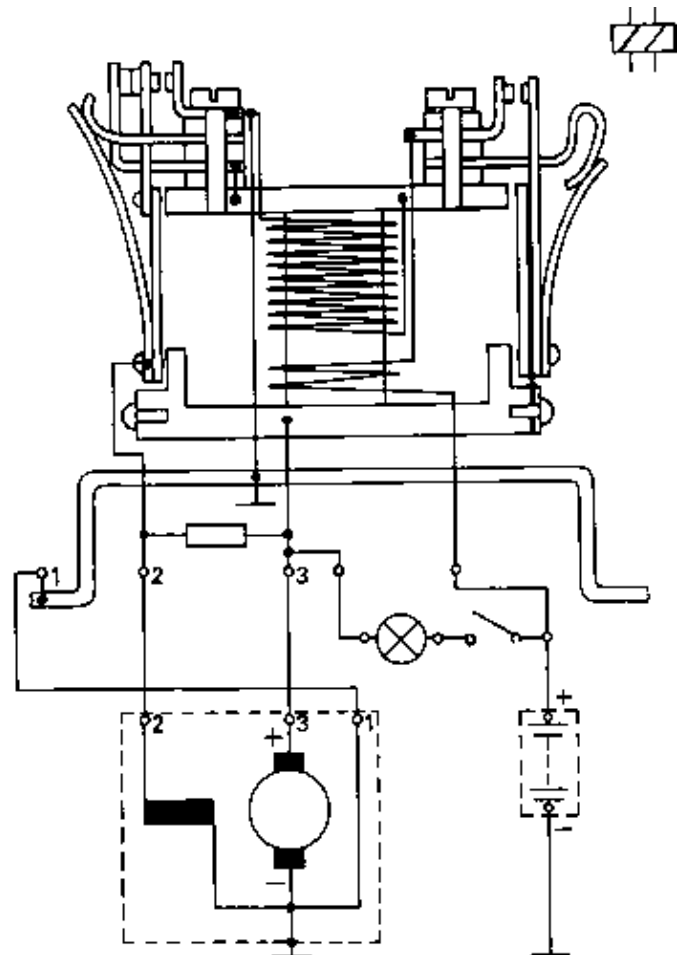
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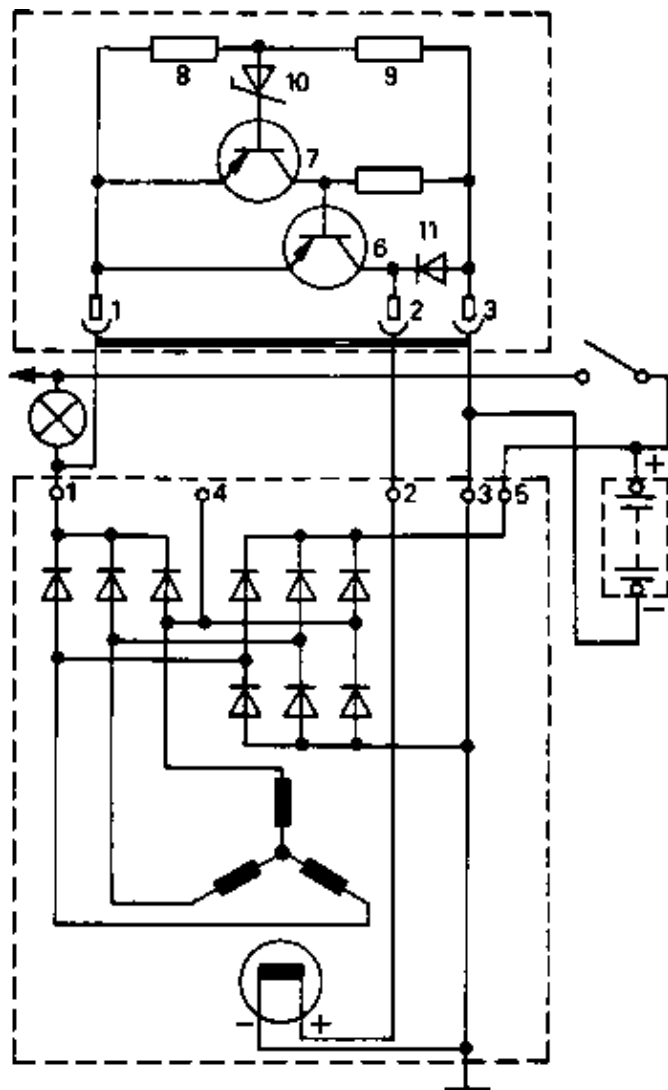
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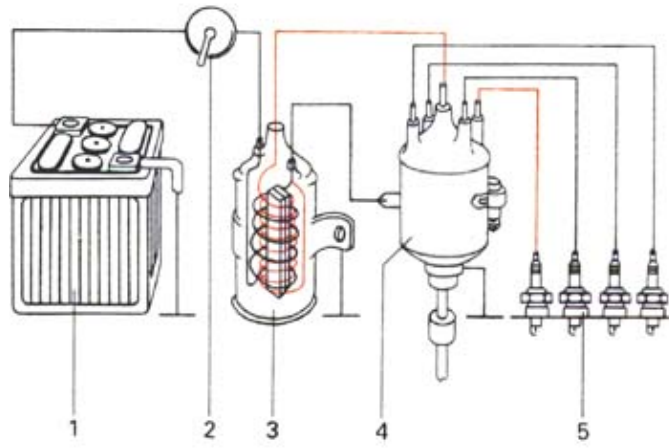
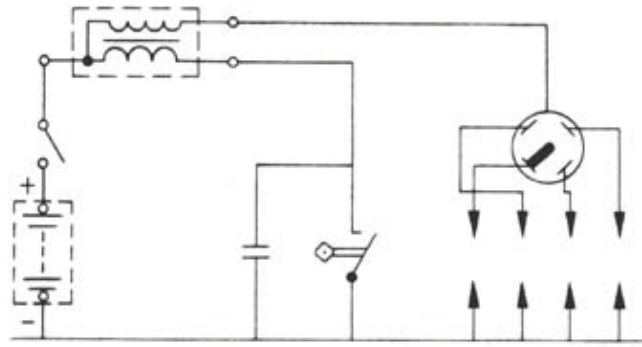
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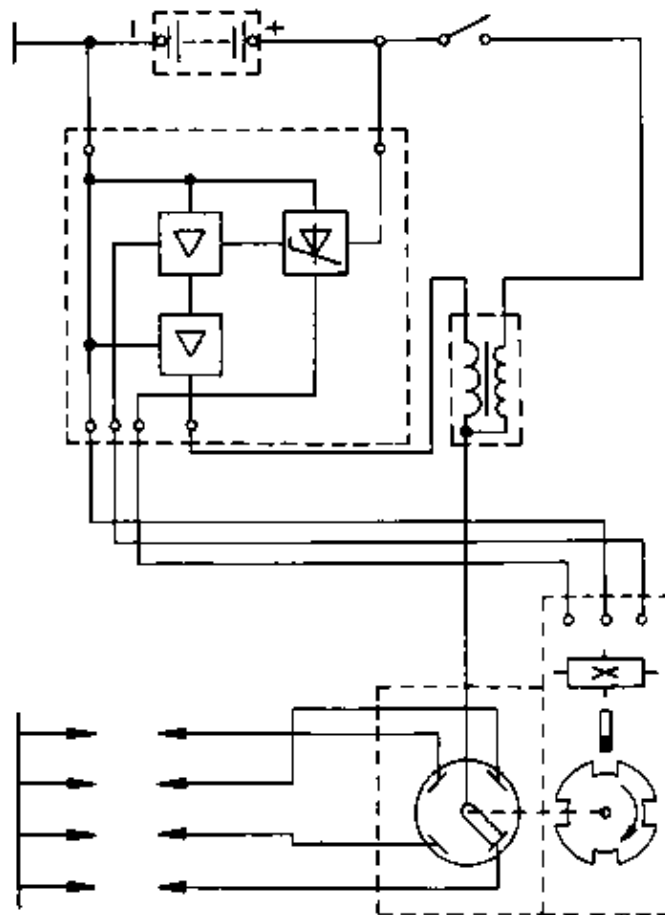
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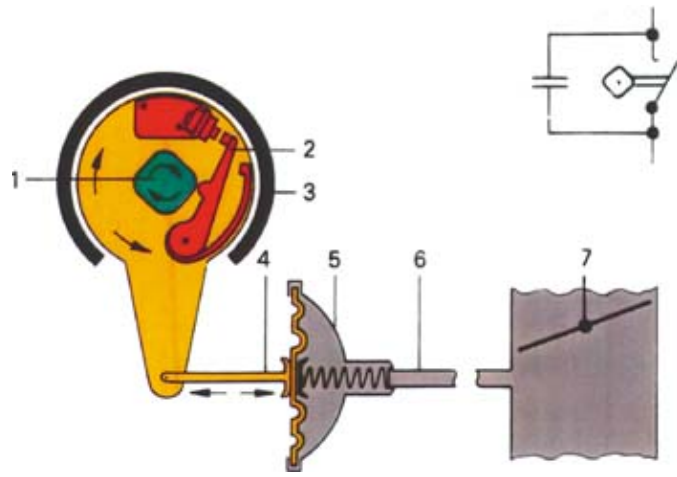
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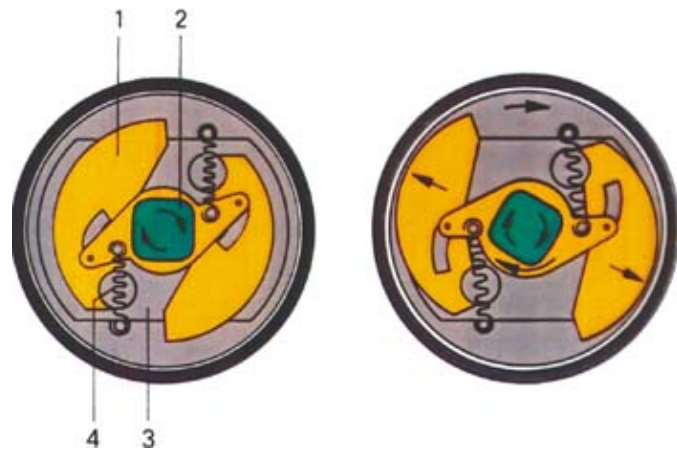
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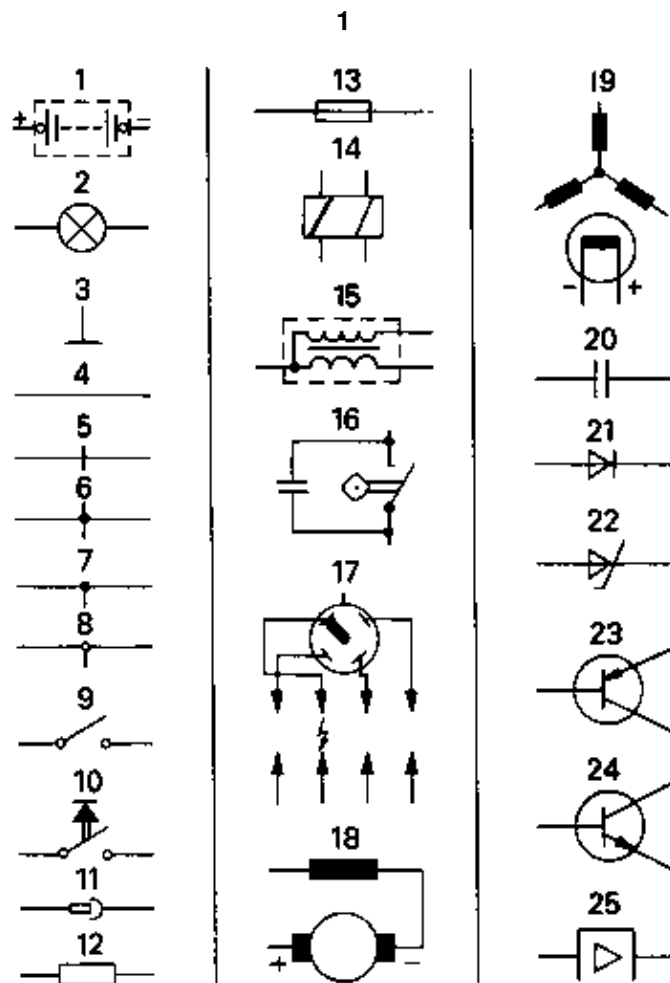
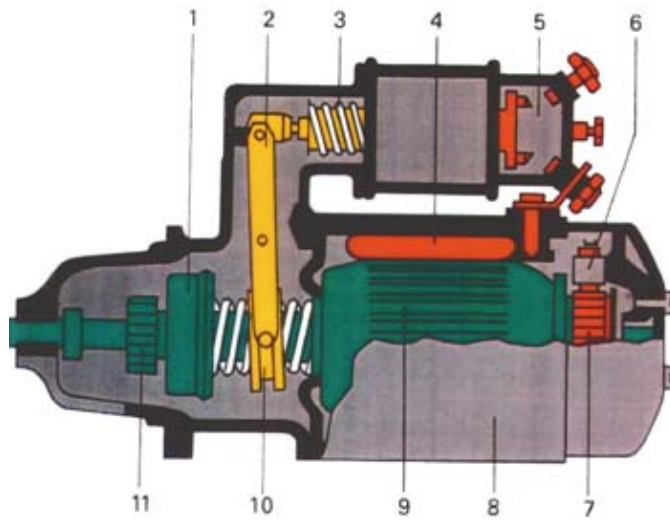
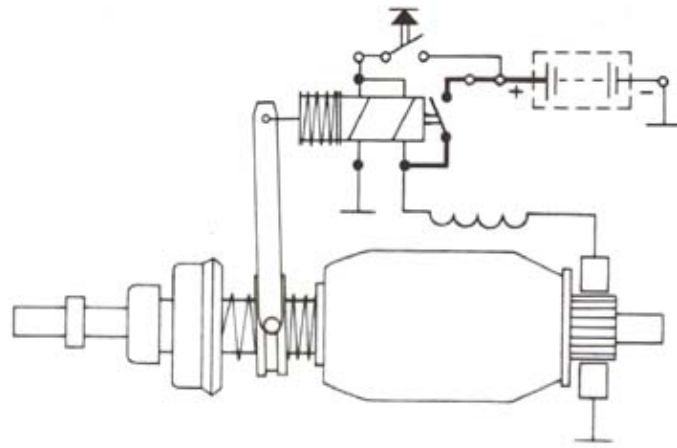
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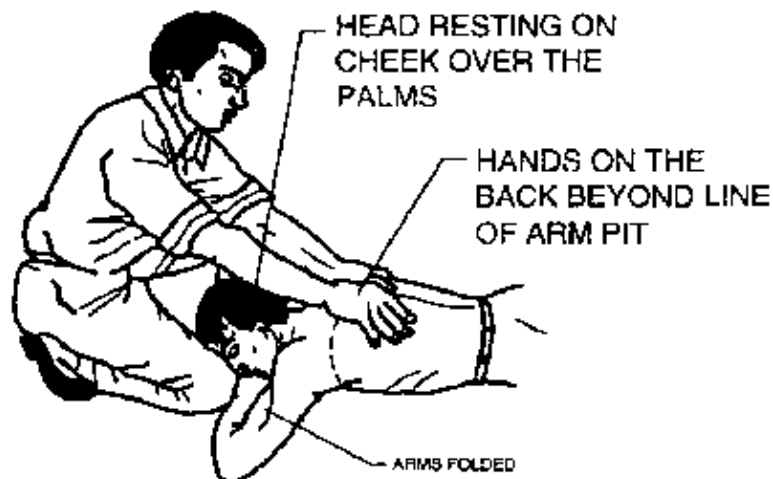
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Artificial respiration – Nelson’s Arm–lift back–Pressure Method

– Place victim prone (that is, face down) with his arms folded with the palms one over the other and the head resting on his cheek over the palms. Kneel on one or both knees at victim’s hand. Place your hands on the victim’s back beyond the line of armpits, with your fingers spread outwards and downwards, thumbs just touching each other as shown.



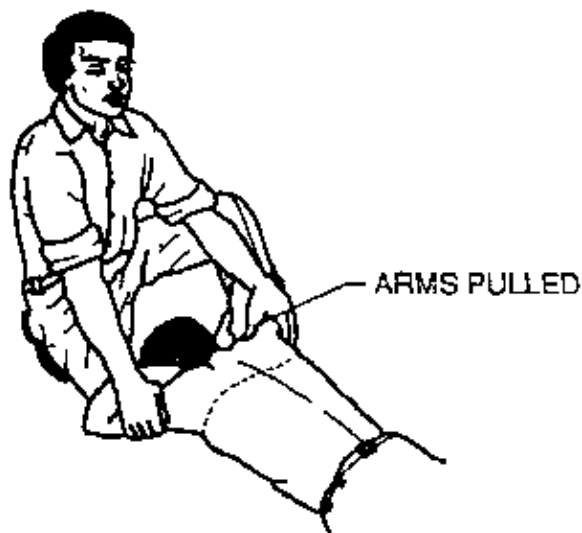
– Gently rock forward keeping arms straight until they are nearly vertical thus steadily pressing the victim’s back as shown to force the air out of the victim’s lungs.



– Synchronizing the above movement rock backwards, releasing pressure and slide your hands downwards along the victim's arms and grasp his upper arm just above the elbows as shown. Continue to rock backwards.



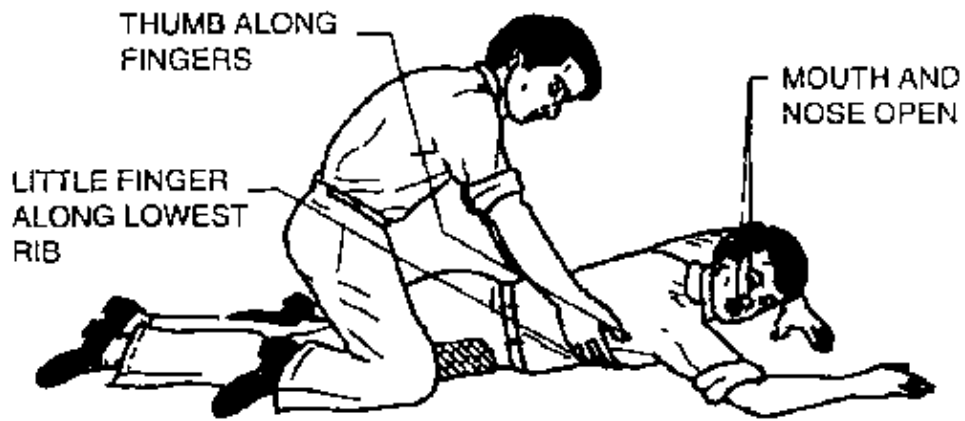
– As you rock back, gently raise and pull the victim's arms towards you as shown until you feel tension in his shoulders. To complete the cycle, lower the victim's arms and move your hands up or to initial position.



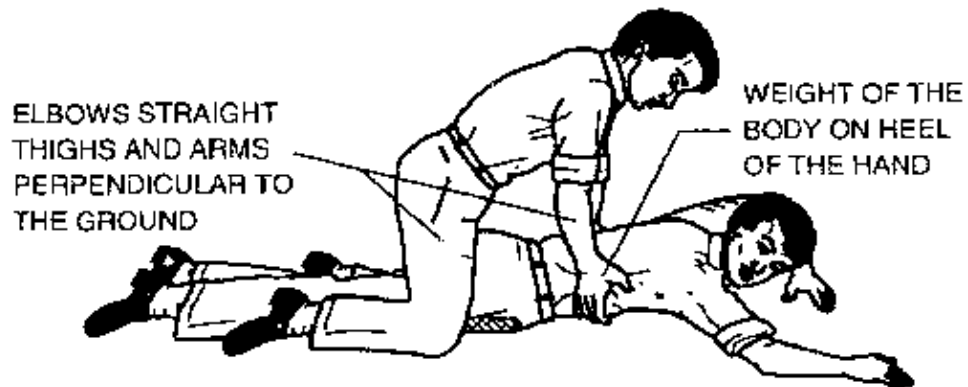
Artificial Respiration – Scaffer's Method

Lay the victim on his belly, one arm extended directly forward, the other arm bent at the elbow and with the face turned sideward and resting on the hand or forearm as shown.

Kneel astride the victim, so that his thighs are between your knees and with your fingers and thumbs positioned as shown.

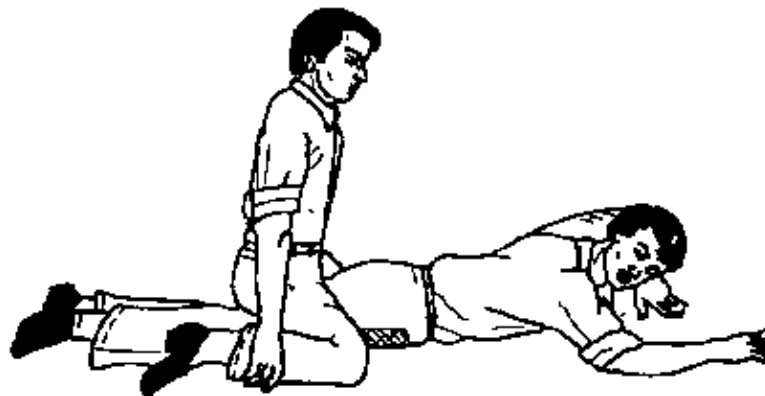


With the arms held straight, swing forward slowly so that the weight of your body is gradually brought to bear upon the lower ribs of the victim to force the air, out of the victim's lungs as shown.



Now immediately swing backward removing all the pressure from the victim's body as shown and thereby allowing the lungs to fill with air.

After two seconds, swing forward again and repeat the cycle twelve to fifteen times a minute.



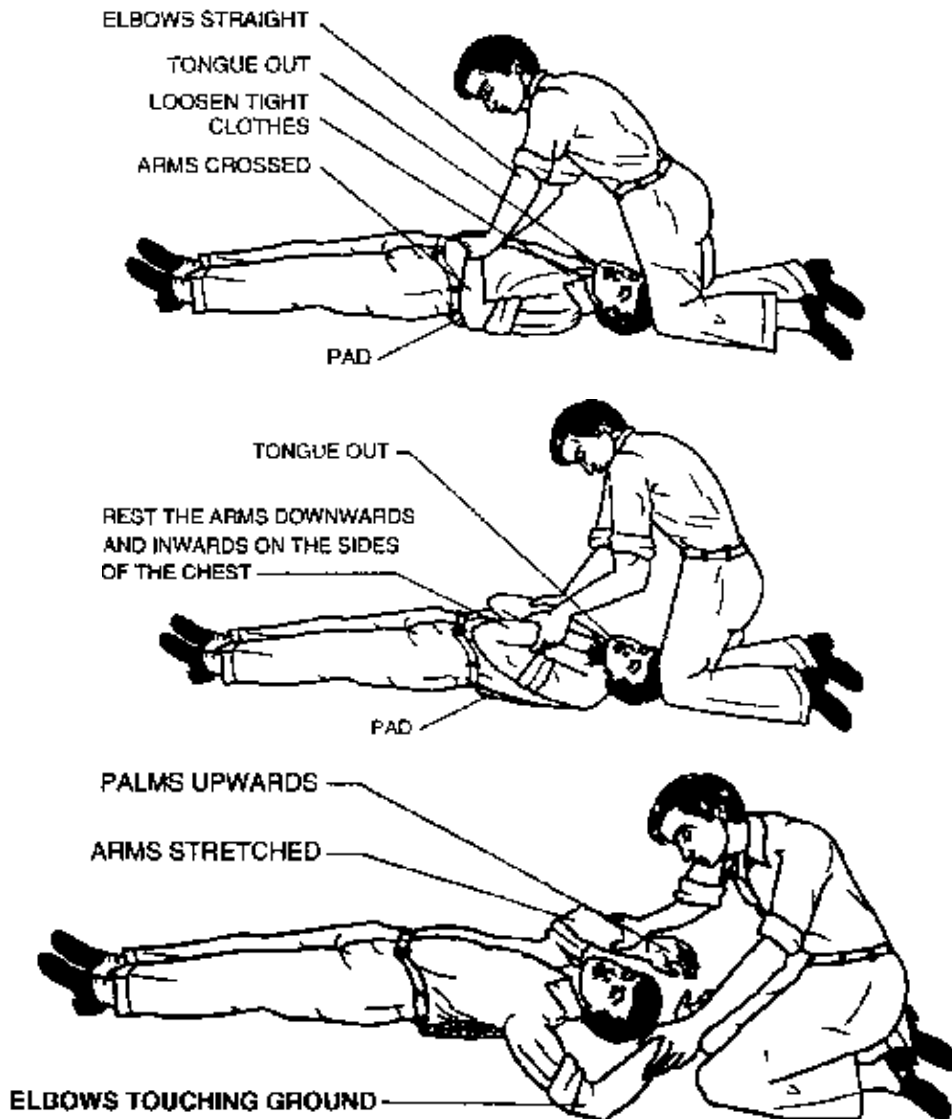
Artificial respiration – Silvester's Method

To be used if the victim cannot lie on his belly or chest due to injury.

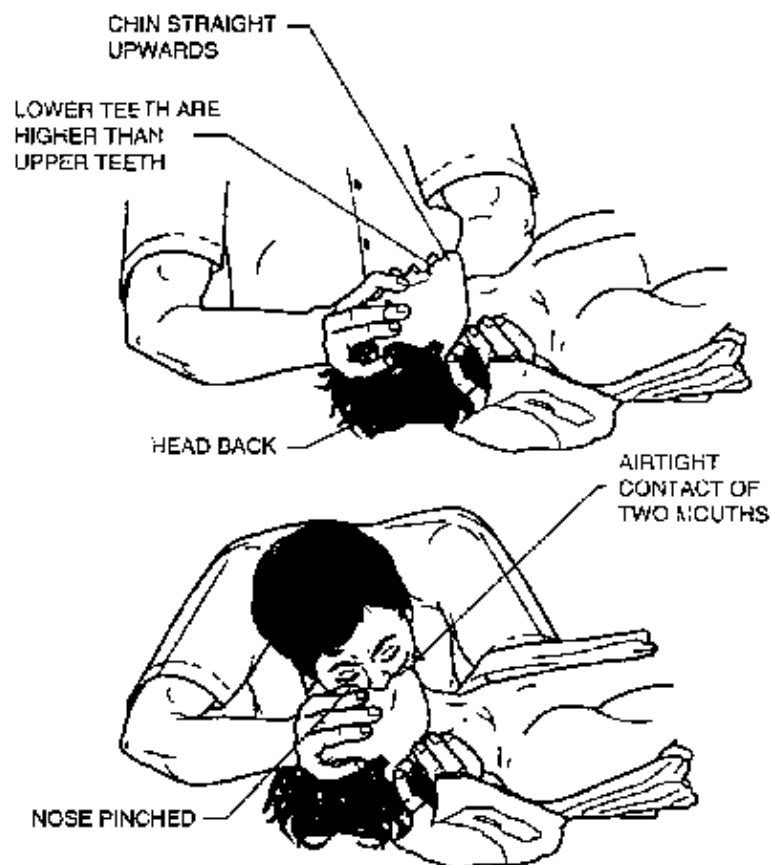
– Lay the victim flat on his back and place a roll of clothing under his shoulders to ensure that his head is thrown well back.

– Wipe saliva out of his mouth: Pull the tongue forward and towards the chin and hold it in this position if there is an assistant if not, tie it with a strip of cloth, cross the strip under the chin, and tie below the neck to prevent the tongue from blocking the wind pipe.

- Kneel over the Victim's head and grasp his arms above the wrist as shown.
- Swing forward and press his arms steadily and firmly downwards and inwards against the sides of the chest to force the air out of the lungs as shown.
- Bring the victim's arms steadily first upward and then backwards until they are in line with the body and the elbows are almost touching the floor as shown, this allowing the lungs to fill the air.
- After three seconds, swing forward again and repeat the cycle. The complete cycle should take about six seconds.



Artificial respiration – Mouth to mouth Method



– Lay the victim flat on his back and place a roll of clothing under his shoulders to ensure that his head is thrown well back. Tilt the victim's head back so that the chin points straight upward.

– Grasp victim's jaw as shown and raise it upward until lower teeth are higher than upper teeth; or place fingers on both sides of jaw near ear lobes and pull upward. Maintain jaw position throughout the artificial respiration to prevent tongue from blocking the air passage.

– Take a deep breath and place your mouth over victim's mouth as shown making airtight contact. Pinch the victim's nose shut with thumb and fore finger. If you dislike direct contact, place a porous cloth between your and victim's mouth. For an infant, place your mouth over its mouth and nose.

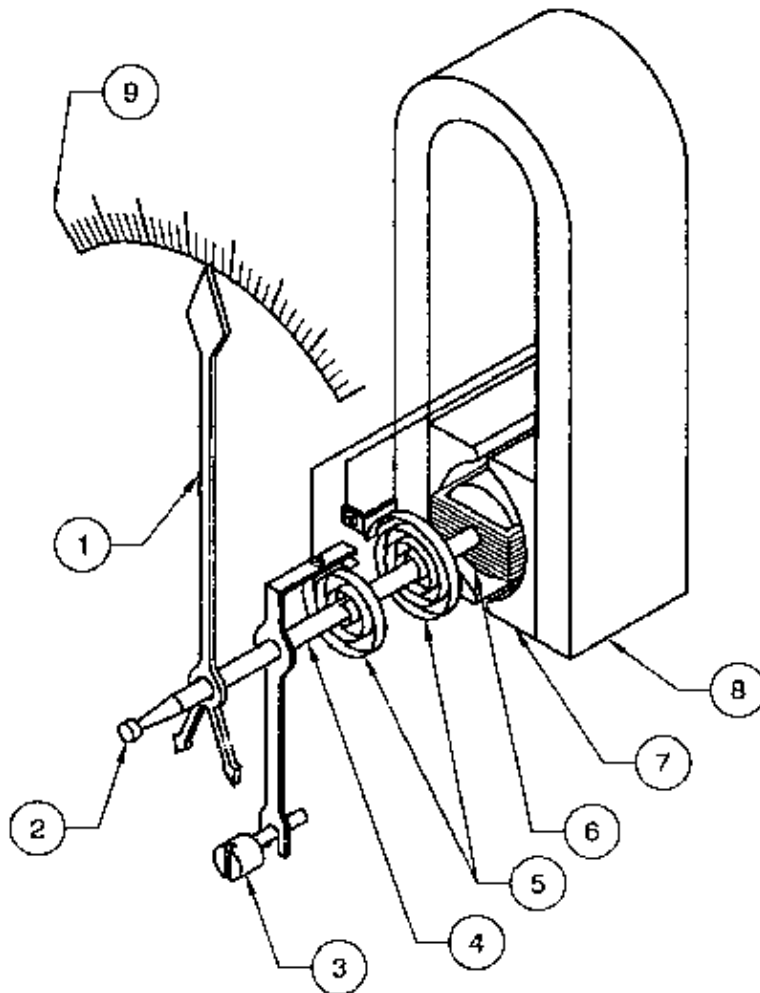
– Blow into victim's mouth (gently in the case of an infant) until his chest rises. Remove your mouth and release the hold on the nose, to let him exhale, turning your head to hear out-rush of air. The first 8 to 10 breaths should be as rapid as victim responds, thereafter rate should be slowed to about 12 times a minute (20 times for an infant).

Note:

(a) If air cannot be blown in, check position of victim's head and jaw and re-check mouth for obstructions, then try again more forcefully. If chest still does not rise, turn victim's face down and strike his back sharply to dislodge obstructions.

(b) Sometimes air enters Victim's stomach evidenced by swelling stomach. Expel air by gently pressing stomach during exhalation period.

Parts of a moving coil instrument



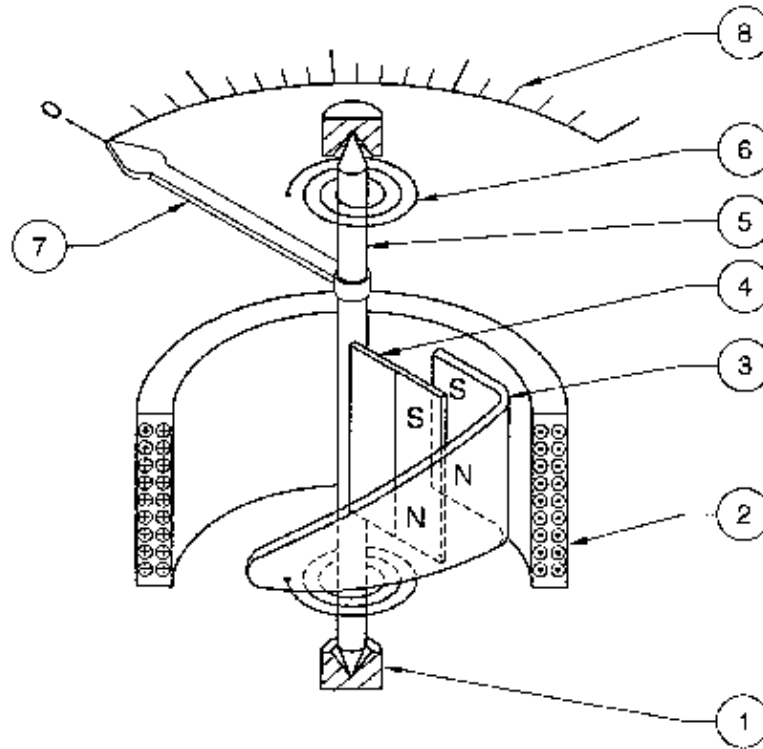
- 1 Pointer
- 2 Jewel bearing
- 3 Zero adjustment screw
- 4 Spindle
- 5 Phosphor Bronze springs
- 6 Moving coil
- 7 Pole shoe
- 8 Horse Shoe magnet
- 9 Graduated scale

Moving coil (6) which is free to move with help of spindle (4) and the bearing (2) is kept in the magnetic field produced by the horse shoe magnet (8) and the pole shoes (7)

When a current proportional to the electrical quantity to be measured is passed through the moving coil (6), it produces a magnetic field which interacts with the main field produced by the magnet (8) and a force is developed. This force moves the moving coil (6), there by the spindle (4) attached to the coil (6) moves. This enables the pointer (1) attached to the spindle (4) to moves over the graduated scale (9).

As the flux is constant due to the permanent magnet (8), the torque becomes proportional to the current. Because of this, the graduation of the scale is uniform. Only used in D.C. quantitative measurement.

Parts of a moving iron instrument



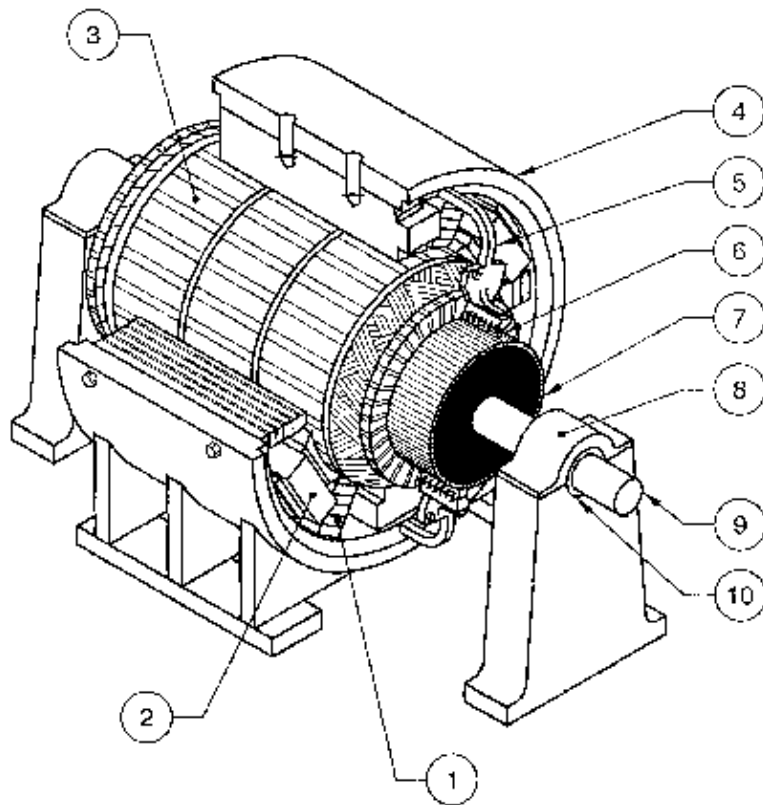
- 1 Jewel bearing
- 2 Electro magnetic coil
- 3 Fixed iron vane
- 4 Moving iron vane
- 5 Spindle
- 6 Control spring
- 7 Pointer
- 8 Graduated scale

The electro magnetic coils (2) carries an alternating or direct current proportional to the quantity of electricity to be measured and produces a magnetic field depending upon the type of current.

Both the fixed (3) and moving (4) iron vanes produce similar type of poles at their ends due to the magnetic field. Hence magnetic repulsion takes place and the moving vane (4) moves away from the fixed vane (3). As the moving iron vane (4) is fixed to the spindle (5) it deflects. The pointer (7) attached to the spindle (5) moves over the graduated scale (8).

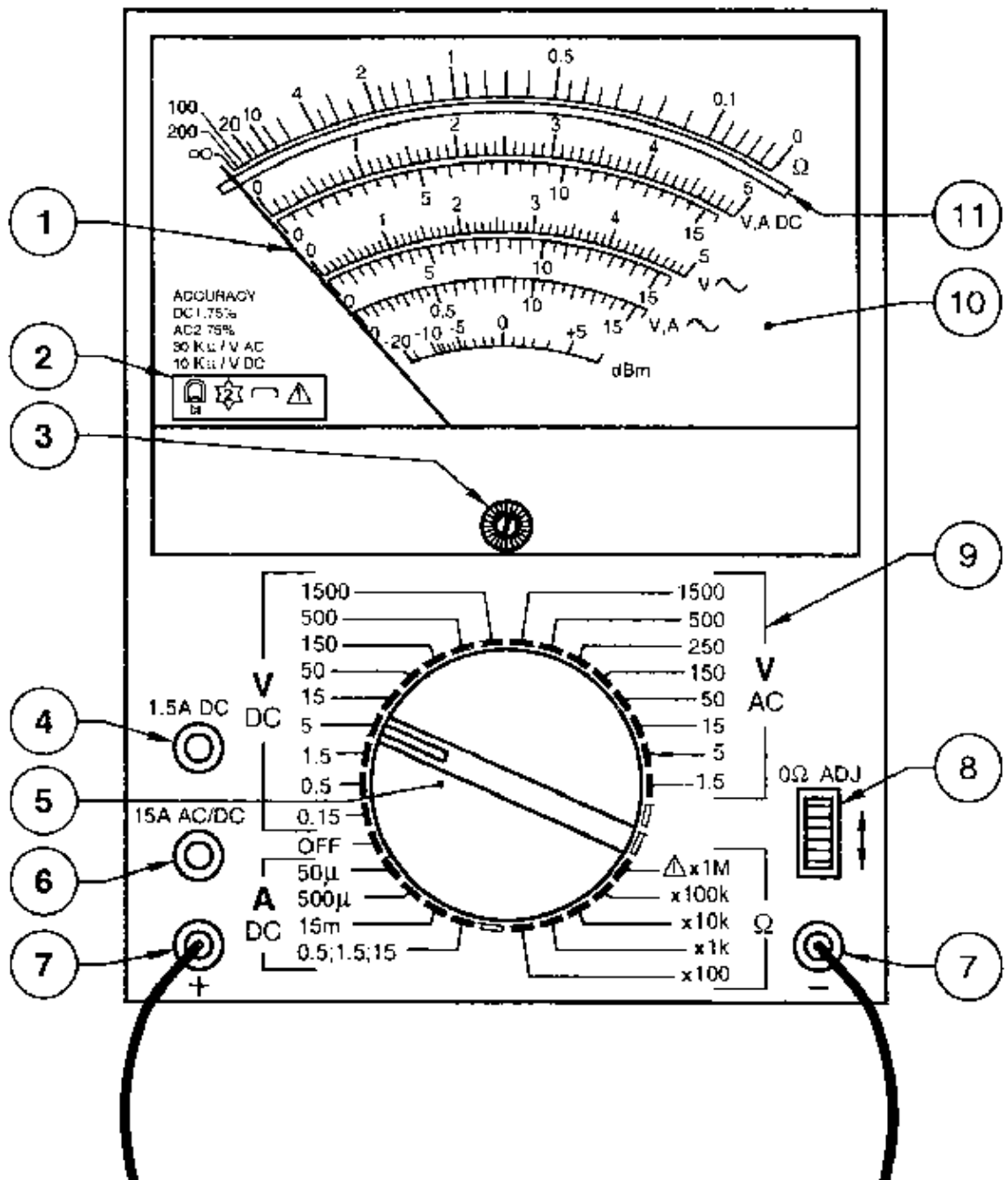
Control spring (6) offers control torque, The shape of the fixed iron van (3) enables the torque developed to be proportional to the current in the coil hence the scale is more or less uniform.

Parts of a D.C. Machine

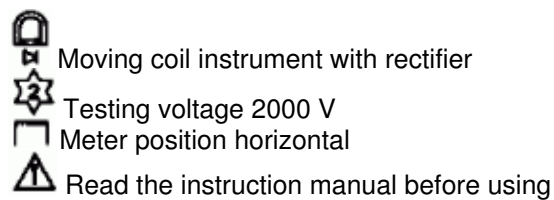


- 1 Interpole
- 2 Main pole
- 3 Armature
- 4 Main frame (Yoke)
- 5 Rocker arm
- 6 Brush holder
- 7 Commutator
- 8 Bearing housing
- 9 Shaft
- 10 Bearing

Multimeter – 1



- 1 Pointer
- 2 Dial symbols



- 3 Mechanical zero adjustment
- 4 Jack 1.5 A DC
- 5 Function and range selector switch
- 6 Jack 15 A AC/DC
- 7 Input jacks

+ positive probe
 - negative probe

- 8 Zero ohm adjuster
- 9 Function and ranges
- 10 Dial scale

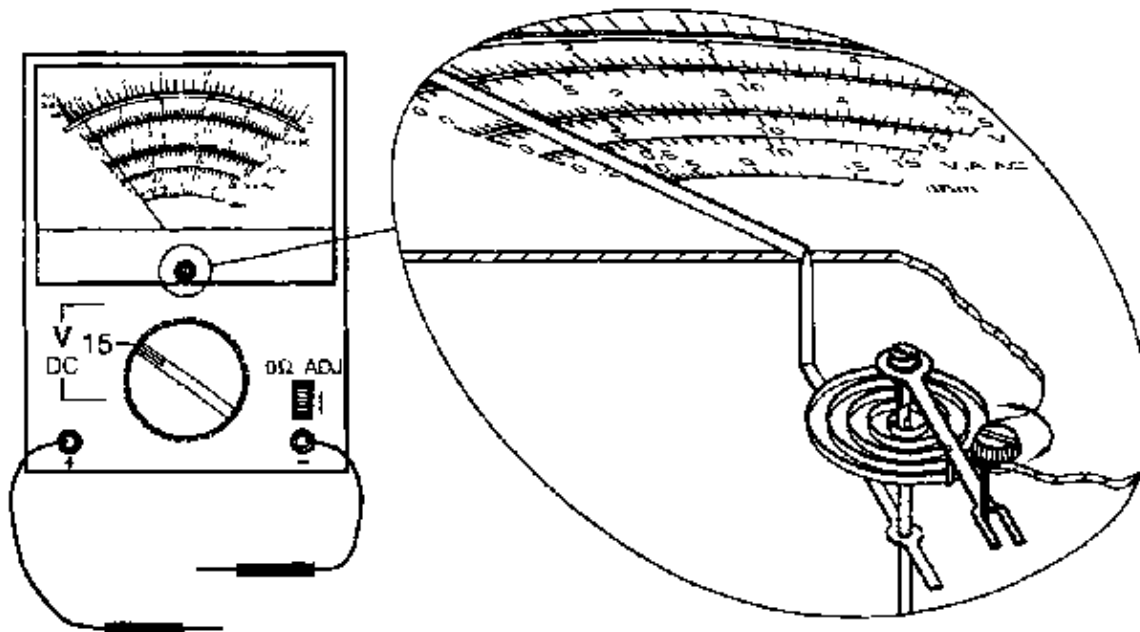
V.A.DC volt, and amp dial for DC
 V~ volt dial for AC
 V.A ~ volt and amp dial for AC
 dBm decibel scale

- 11 Dial scale for resistance ?

Multimeter – 2 Zero adjustment

A Mechanical Zero adjuster

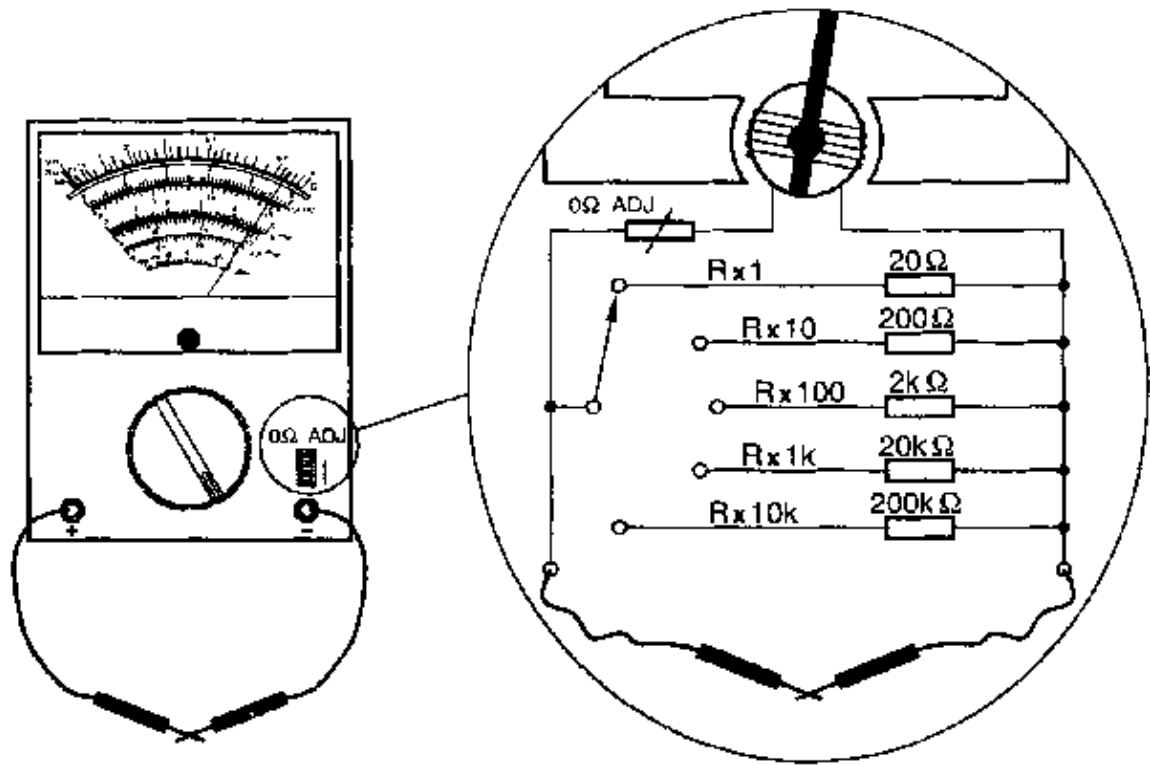
Zero adjuster is a screw which adjusts the pointer to the zero position before measuring a value. Turn the screw to 1/4 of a turn maximum in either direction for zero adjustment.



B Zero ohm adjuster

Before measuring the resistance, the pointer has to be adjusted to the zero-ohm position in the ohm's scale by touching the measuring leads together and turning the knob until the pointer shows zero –ohm value.

Whenever a new resistance range is selected, the zero – ohm position must be adjusted.



Current Carrying conductor in magnetic field

Instructor asks the trainees to:-

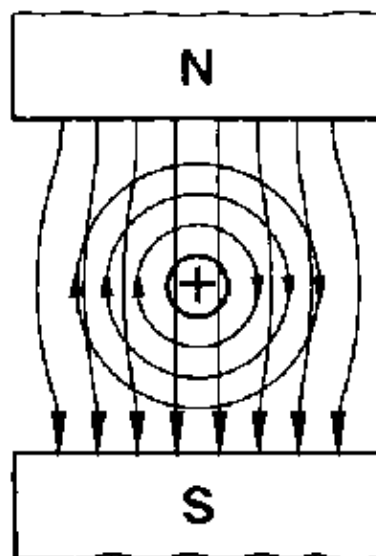


Fig A Indicate the direction of magnetic field around the current carrying conductor according to Maxwell's Corkscrew rule.

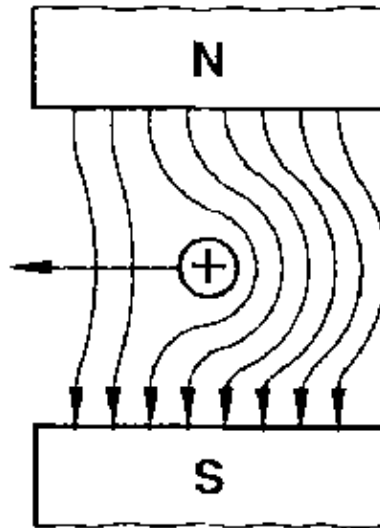


Fig B Discuss with the trainees about the resultant field and the direction of force on the conductor

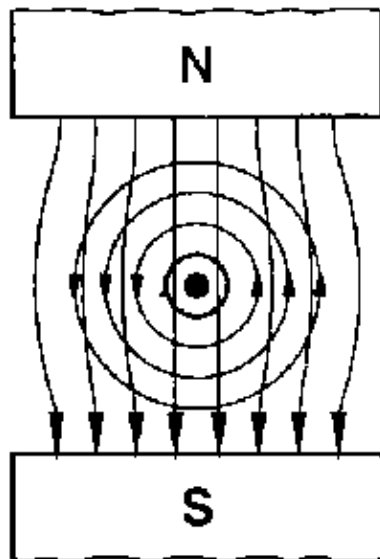


Fig C Indicate the direction of the magnetic field around the current carrying conductor

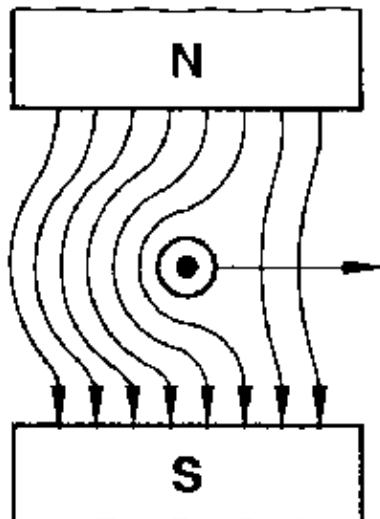


Fig D Discuss and determine the direction of force on the current carrying conductor

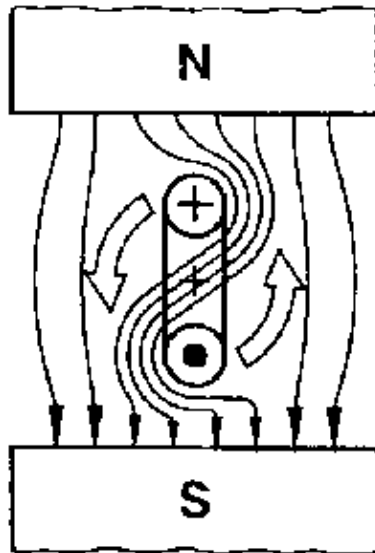


Fig E Discuss about the forces on conductor of a loop and the resultant circular motion

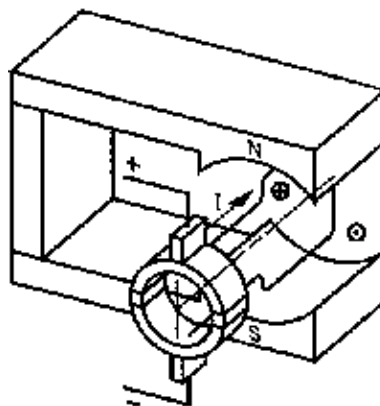
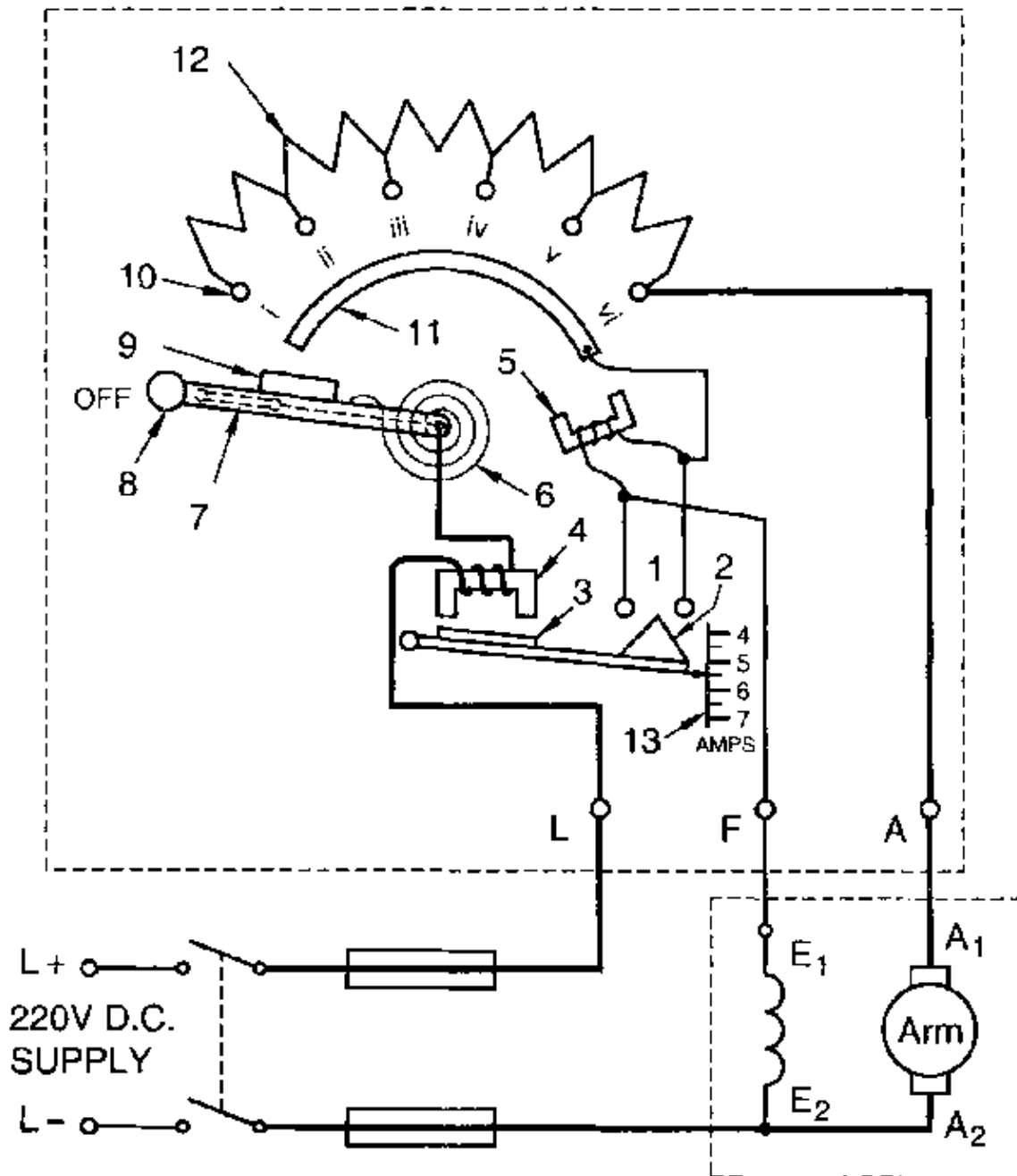


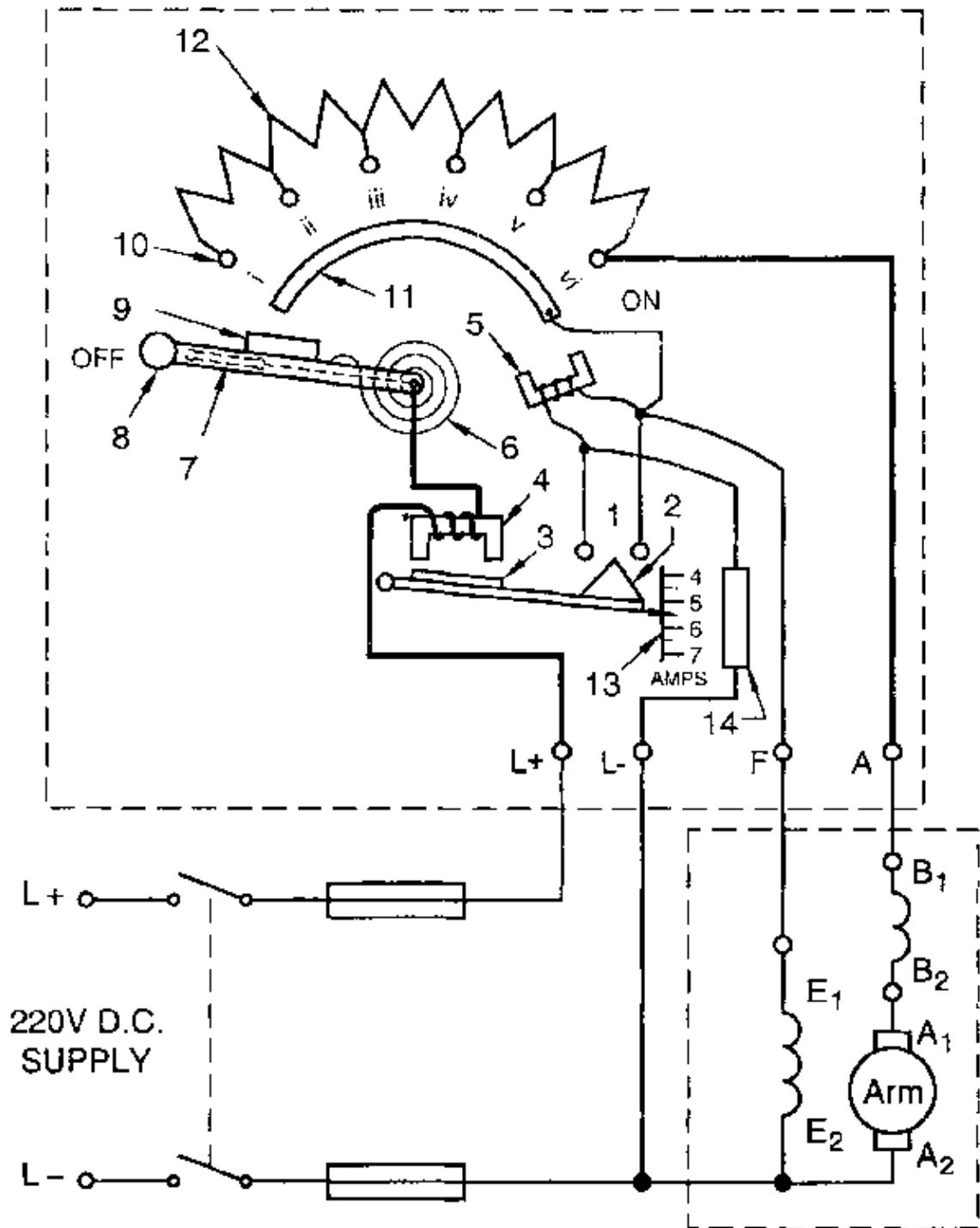
Fig F Correlate the above findings with the motor shown in Fig.

Three point starter



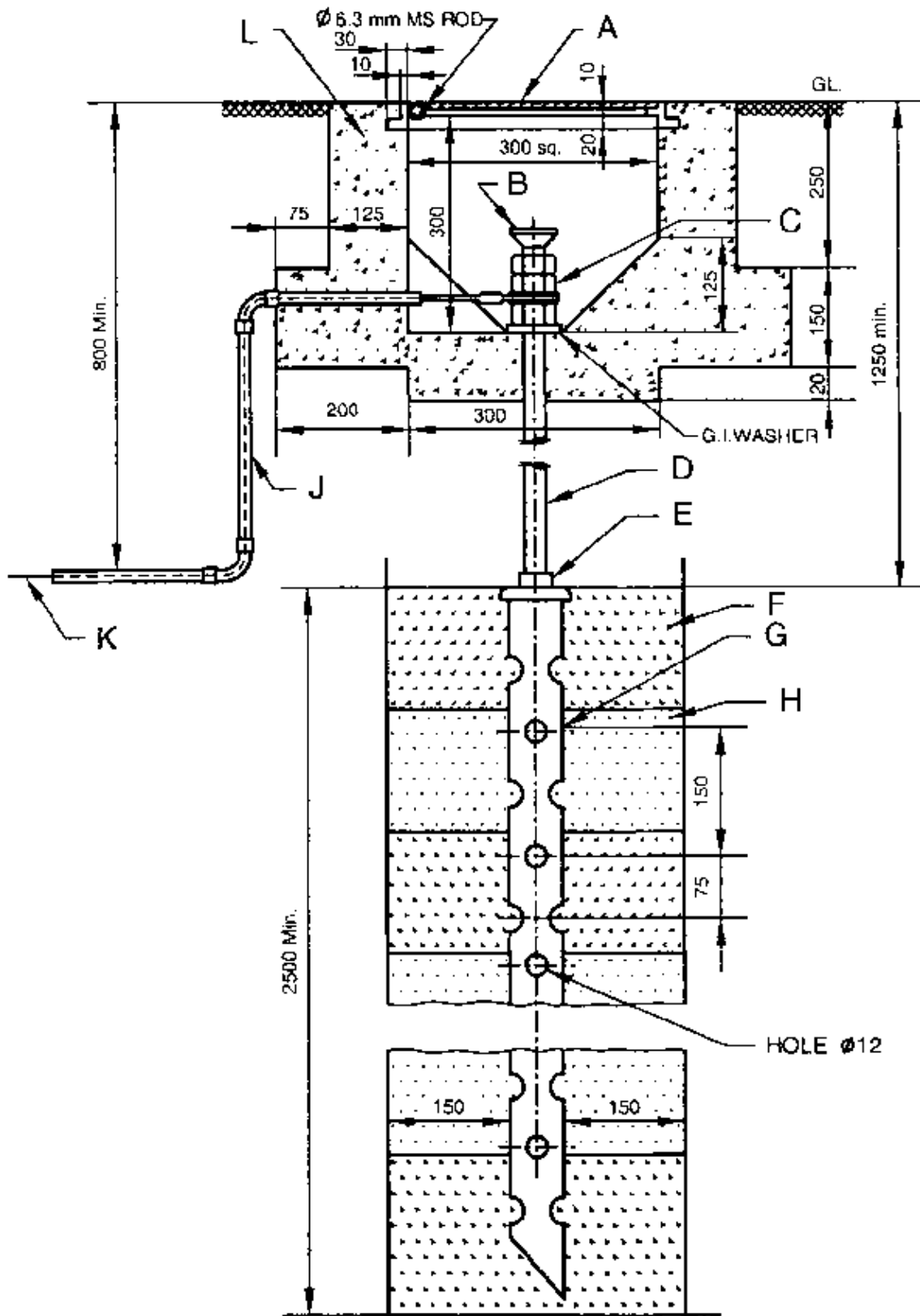
- 1 Hold-on coil terminals
- 2 Shorting contact of O/L armature
- 3 Keeper of the O/L relay electro magnet
- 4 O/L relay magnet
- 5 No-volt (Hold-on) coil and core
- 6 Handle spring
- 7 Shorting contact link of starter
- 8 Starter handle
- 9 Keeper of the hold-on coil electro magnet
- 10 Starter contacts
- 11 Direct contact strip for field connection
- 12 Starter Resistance (Nichrome Wire)
- 13 Overload setting

Four point starter



- 1 Hold-on coil terminals
- 2 Shorting contact of O/L armature
- 3 Keeper of the O/L relay electro-magnet
- 4 O/L relay electro-magnet
- 5 No-volt (hold-on) coil and core
- 6 Handle spring
- 7 Shorting contact link of starter
- 8 Starter handle
- 9 Keeper of the hold-on coil electro magnet
- 10 Starter contacts
- 11 Direct contact strip for the field connection
- 12 Starter resistance (Nichrome wire)
- 13 Over load settings
- 14 Series resistance

Pipe earthing

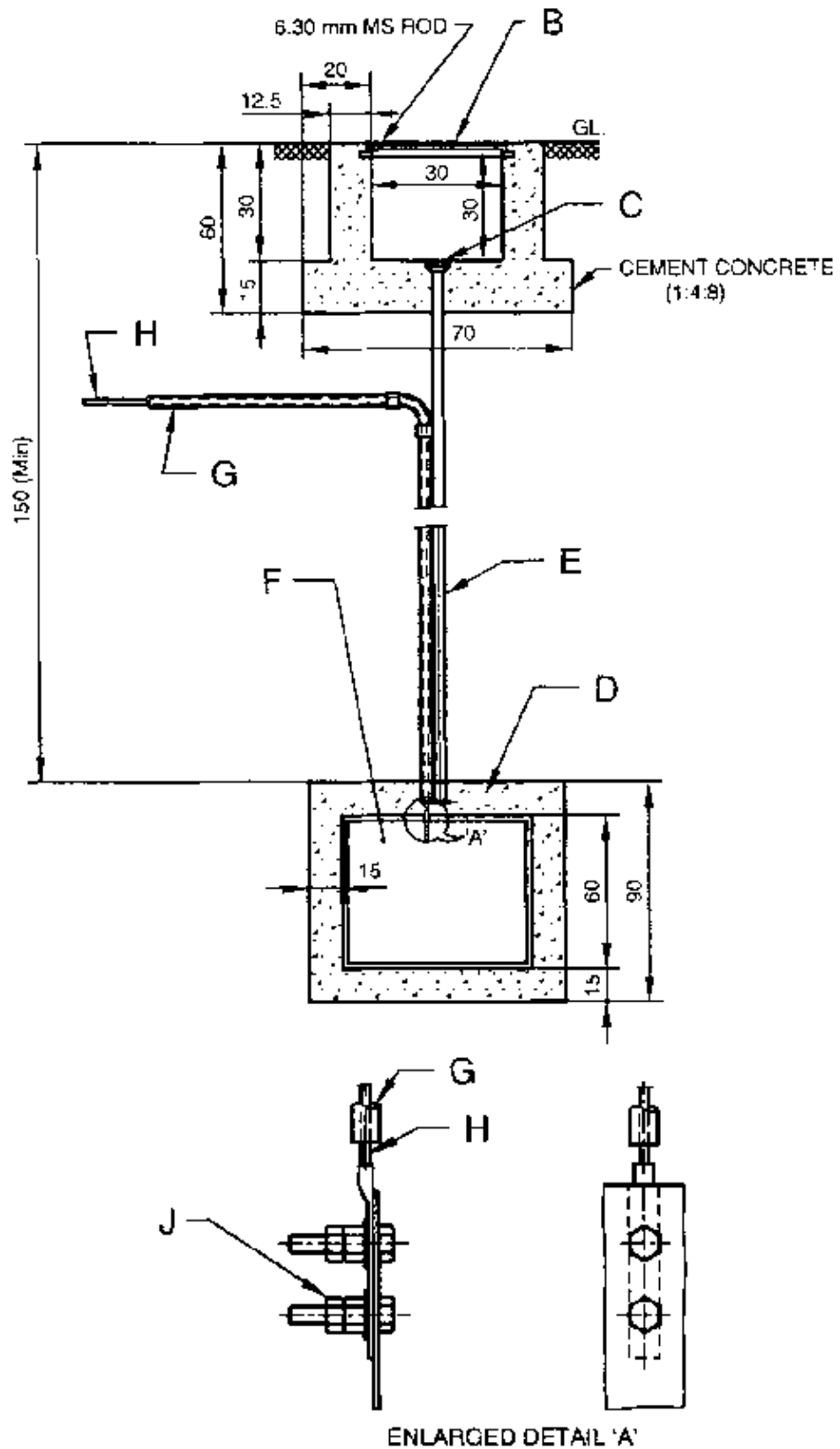


NOTE: DIMENSIONS ARE IN mm UNLESS OTHERWISE SPECIFIED.

- A – C.I. Cover hinged to C.I. frame
- B – Funnel with Wire Mesh
- C – G.I. Nut and Check nut
- D – 19 mm G.I. Pipe
- E – 38 x 19 mm reducing socket.
- F – Charcoal Layer

- G – 38 mm G.I. pipe (earth electrode)
- H – Salt layer
- J – 12.7 mm G.I. pipe
- K – Copper or GI wire (Main earth lead)
- L – Cement Concrete

Plate earthing



NOTE:- DIMENSIONS ARE IN cm UNLESS OTHERWISE SPECIFIED

B – C.I. cover hinged to C.I. frame

C – Funnel with Wire mesh

D – Charcoal

E – ∅19 mm G.I. pipe

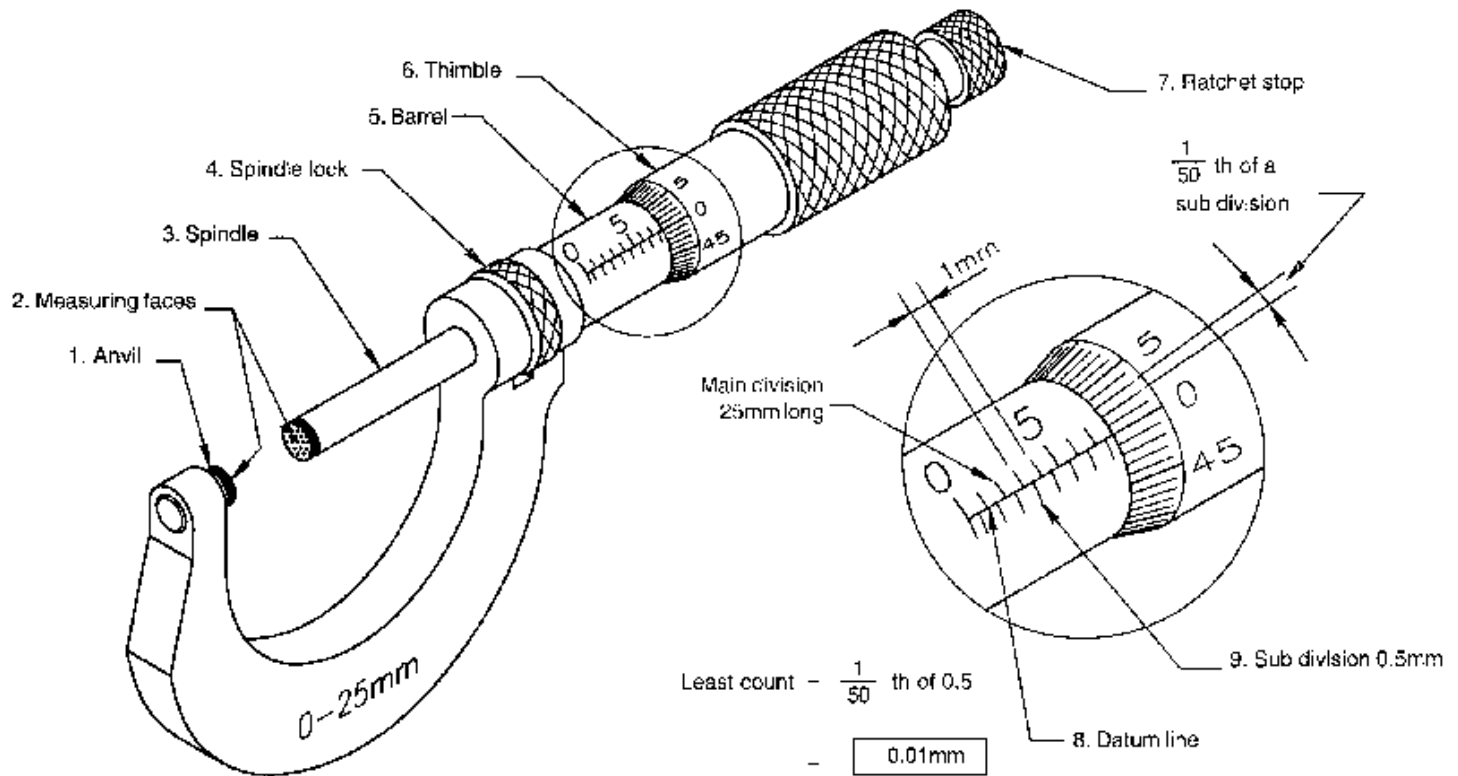
F – 60 x 60 cm x 6.3 mm G.I. plate or 60 x 60 cm 3.15 mm copper plate (earth electrode)

G – ∅12.7 mm G.I. pipe

H – Copper or G.I. wire (Main earth lead)

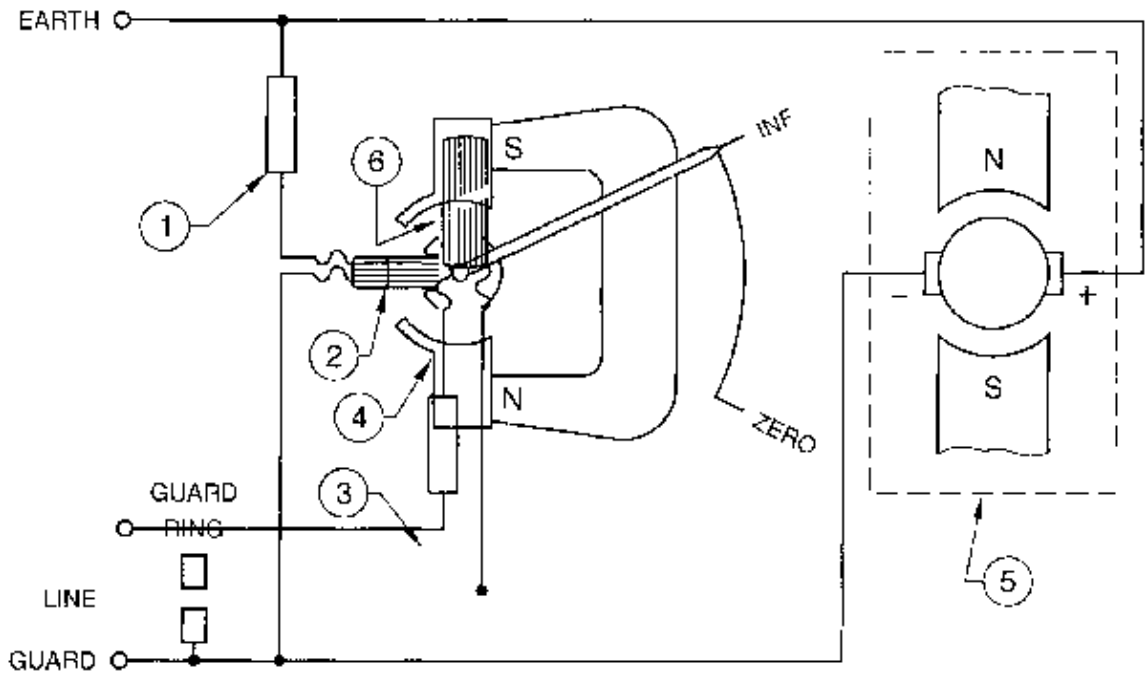
J – Bolt, Nut, Check Nut and Washer to be of copper for copper plate and G.I. for G.I. plate.

Micrometer parts and graduations



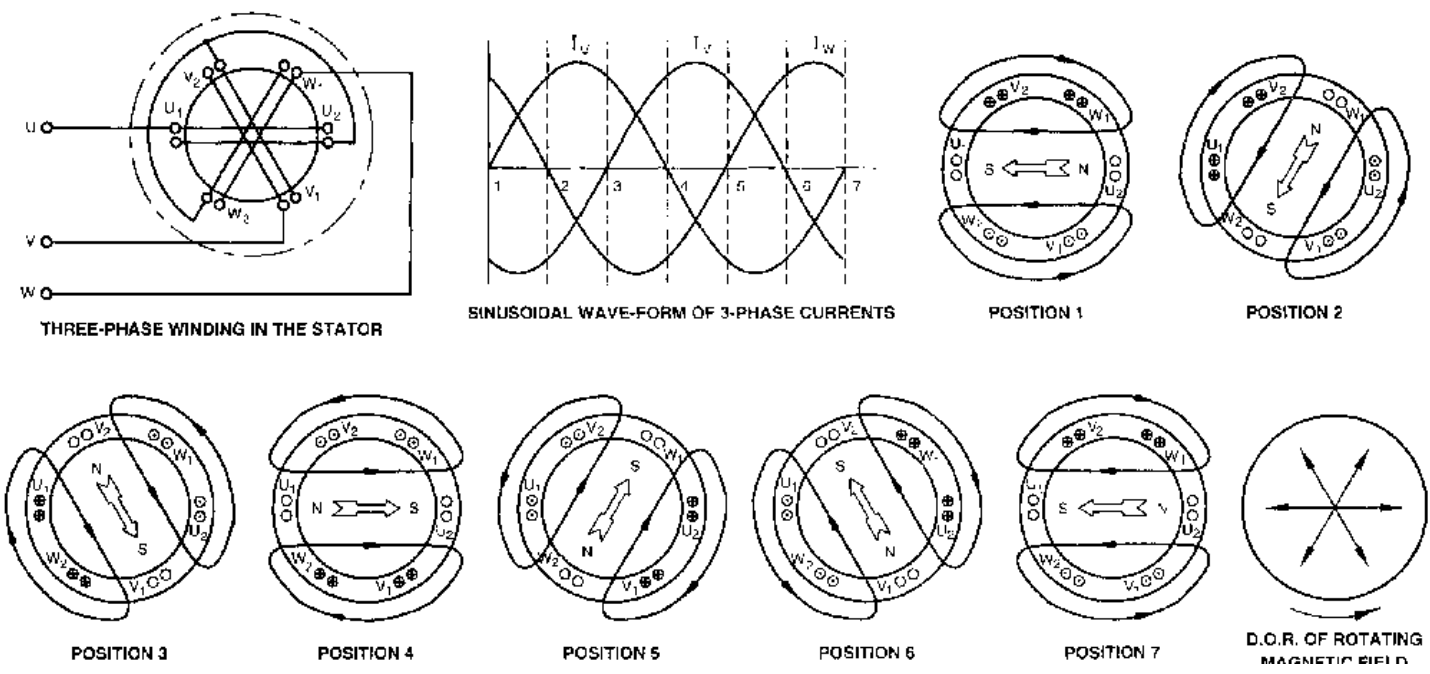
The range of the Micrometer is 0 – 25 mm.

Internal connections of the Megger (Insulation tester)

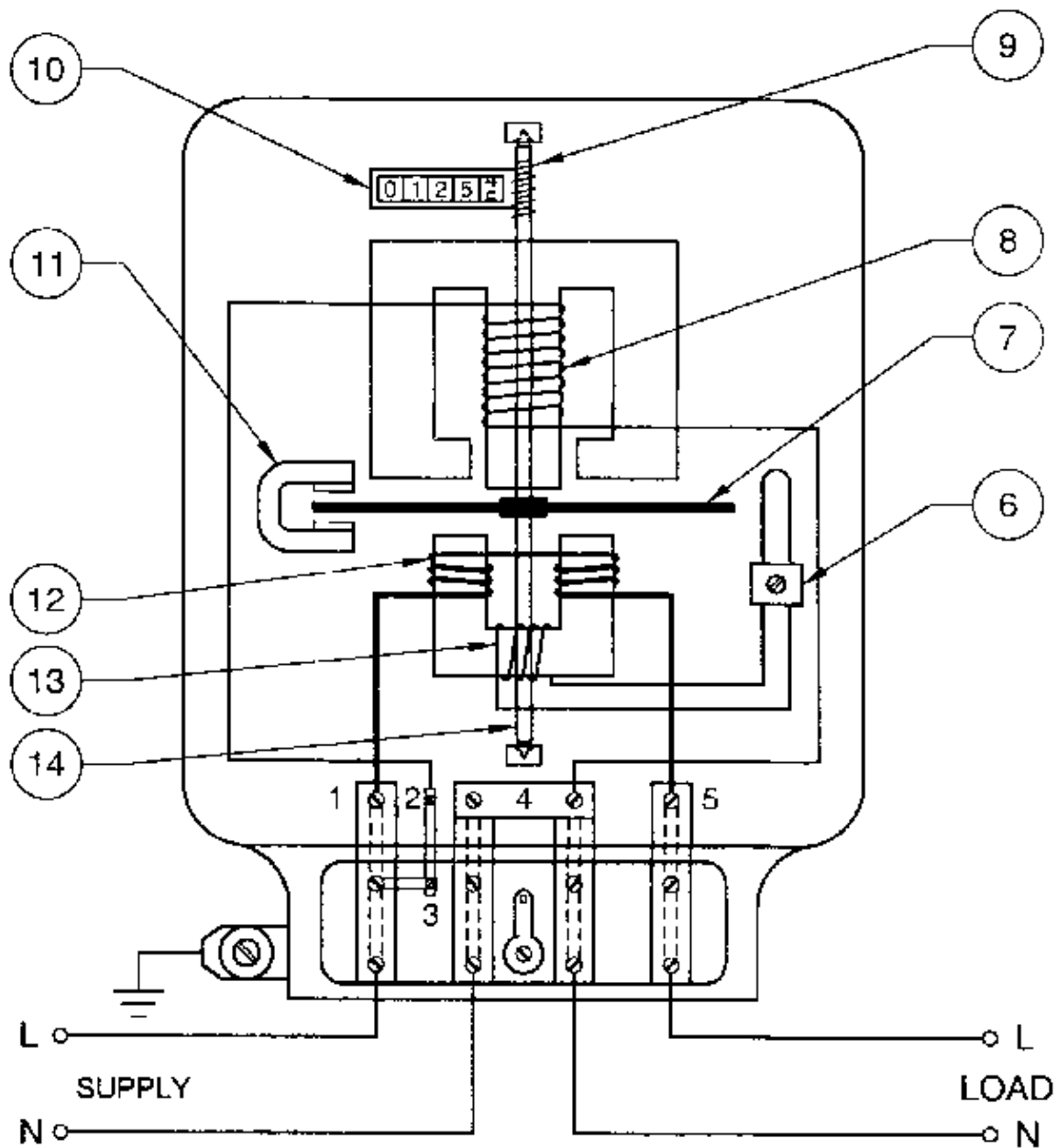


- 1 Control circuit resistance
- 2 Control coil
- 3 Deflecting circuit resistance
- 4 Ligaments
- 5 D.C. generator
- 6 Deflecting coil.

Rotating magnetic field from a three-phase stator

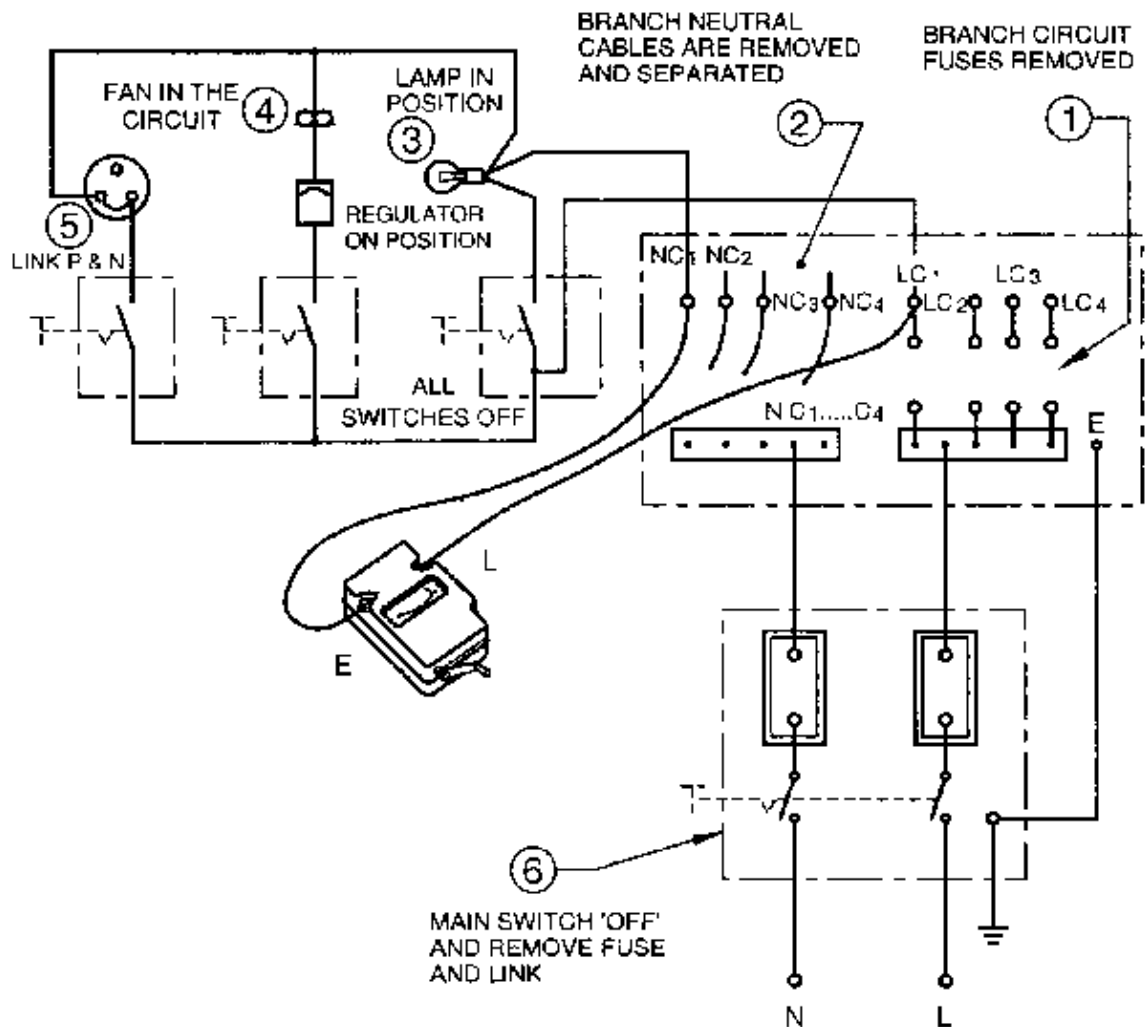


Single phase energy meter – Induction type



- 1 Current coil terminal (incoming)
- 2 Pressure coil terminal
- 3 Shorting link
- 4 Common link of neutral
- 5 Current coil terminal (outgoing)
- 6 P.F. Adjustment link
- 7 Aluminum disc
- 8 Pressure coil
- 9 Worm Gear
- 10 Register window
- 11 Brake Magnet (Damping magnet)
- 12 Current coil
- 13 P.F. Adjustment coil
- 14 Spindle

Test on domestic wiring installation – Continuity test



Necessity of the test

This test is carried out to check the continuity of cables in the individual sub circuits

Condition

As in the figure of the key

Connection

Connect the Megger terminals to individual sub circuit phase and neutral.

Test procedure

Operate the Megger and switch 'ON' and 'OFF' the switches one by one.

Result

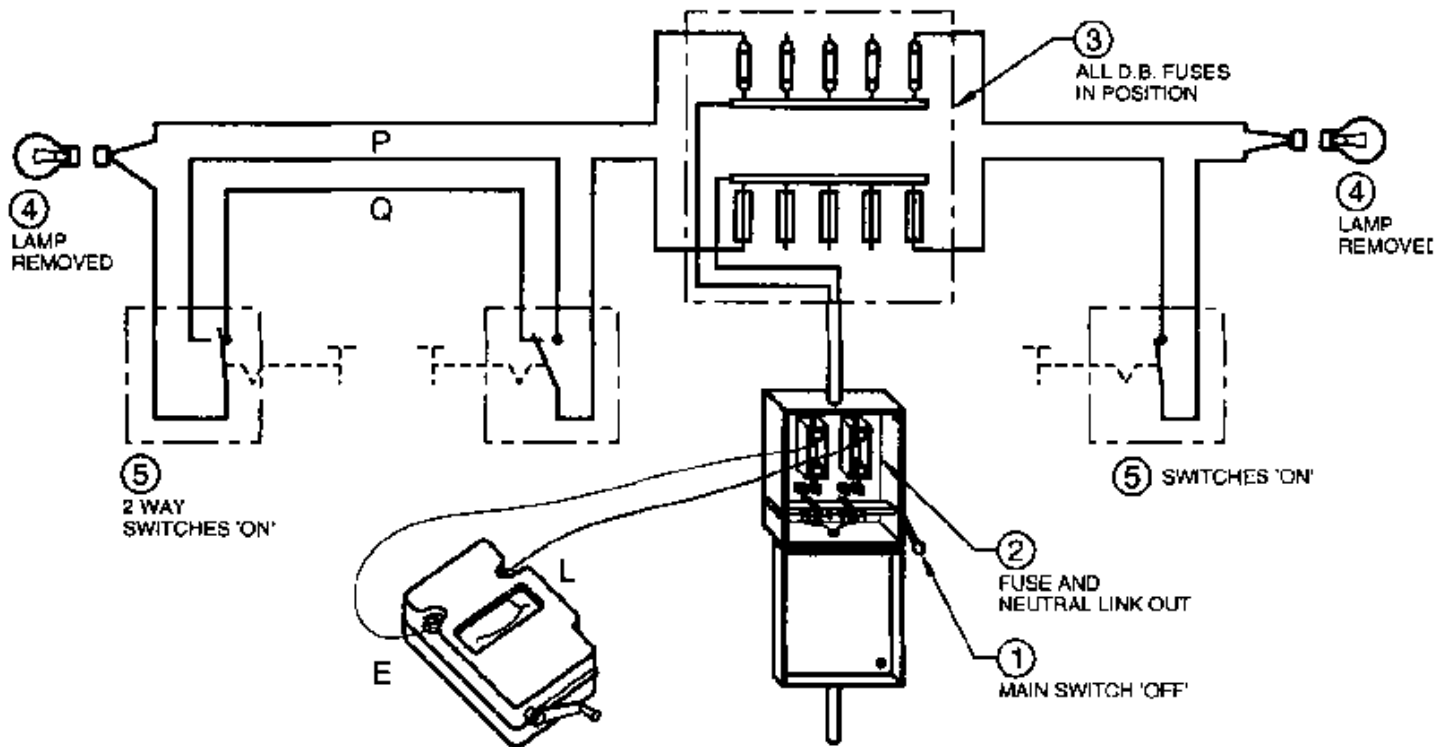
Megger should show zero reading and infinity alternatively with respect to 'On' and 'OFF' positions of the switch.

If the Megger shows infinity when the switch is 'ON', the circuit is open. If the Megger shows zero reading in 'ON' and 'OFF' position of the switch, the circuit is short circuited.

Precaution

The shorting links of the sockets should be removed after the test.

Test on domestic wiring installation – Insulation resistance test between conductors



Necessity of the test

This test is carried out to check the soundness of the cable insulation in the installation.

Condition

As in key

Connection

Connect the Megger terminals to the out going side of the I.C.D.P. switch.

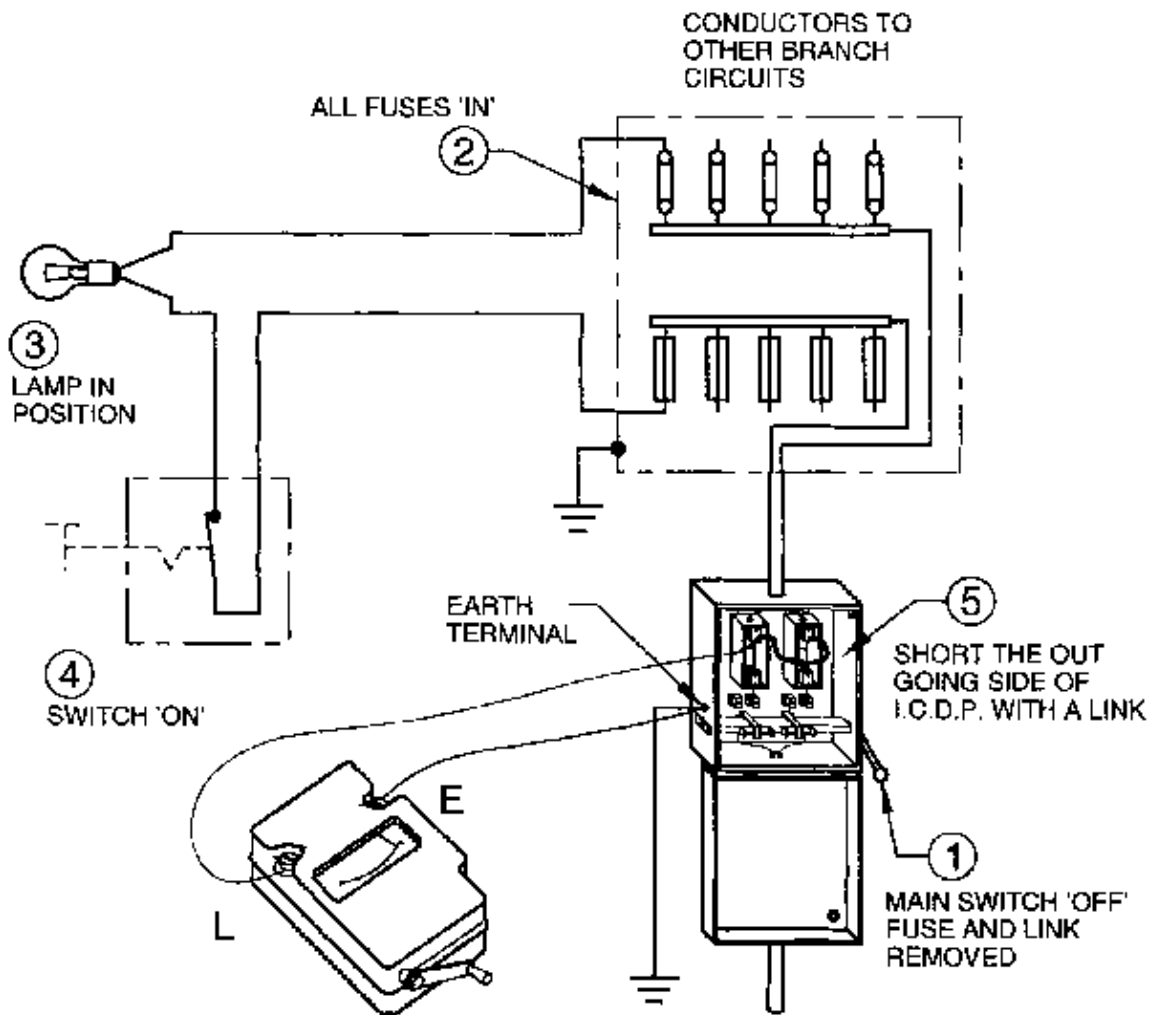
Test procedure

Operate the Megger and measure the insulation resistance.

Result

Measured insulation resistance of an installation should not be less than one megohm.

Test on domestic wiring installation – Insulation resistance test between conductors and earth



Necessity of test

This test is carried out to check the correctness of the insulation between conductors and earth.

Condition

As in key

Connection

Connect one terminal of the Megger to the shorted jumper and other terminal of the Megger to the earth connection.

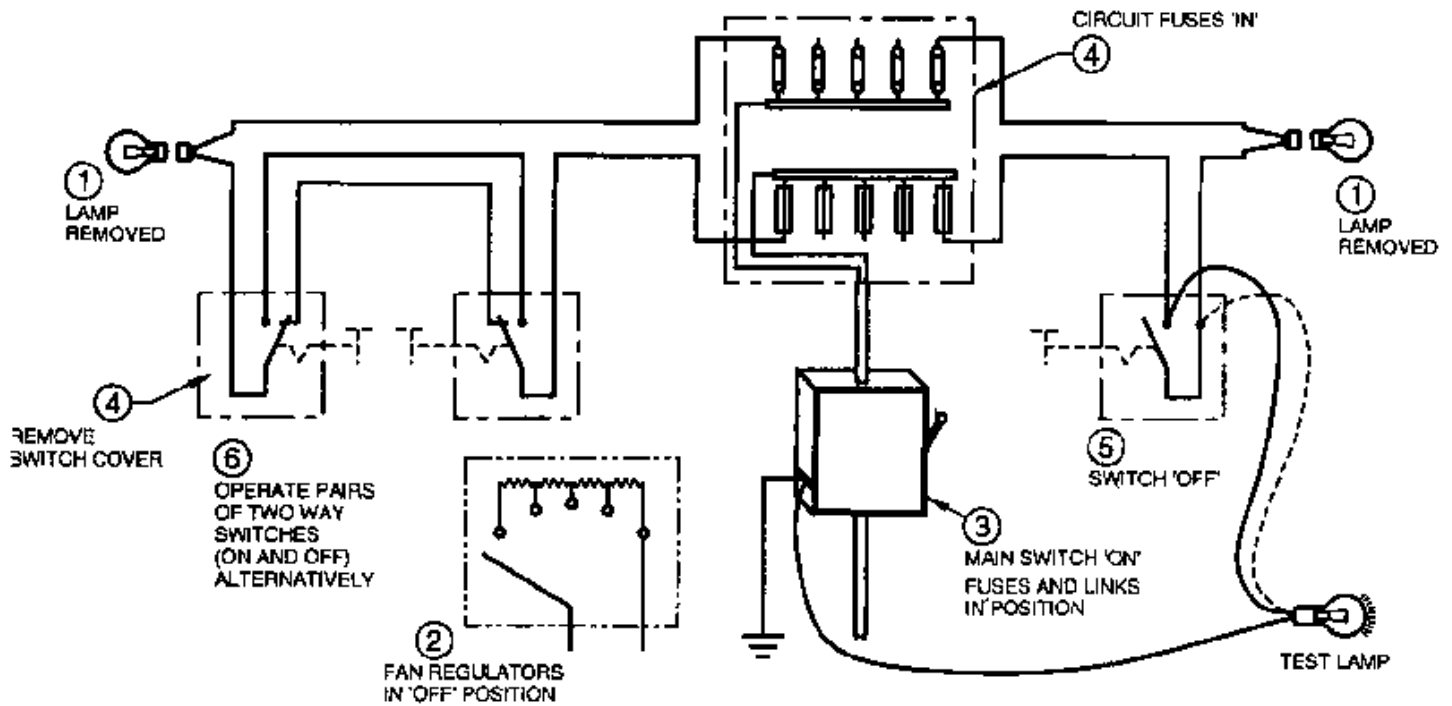
Test procedure

Operate the Megger and measure the insulation resistance.

Result

Measured insulation resistance of an installation should not be less than one megohm.

Test on domestic wiring installation – Polarity test



Necessity of the test

This test is conducted to check whether the switch controls the phase/live cable or not.

Condition

- 1 Remove lamps from their holder.
- 2 Keep fan regulators in 'OFF' position:
- 3 Insert fuse in main switches and distribution boards.
- 4 Remove the switch covers.
- 5 Keep the light and fan switches in 'OFF' position.
- 6 Switch 'ON' the mains.

Connection

Connect one end of the test lamp to the earth terminal of the I.C.D.P. switch.

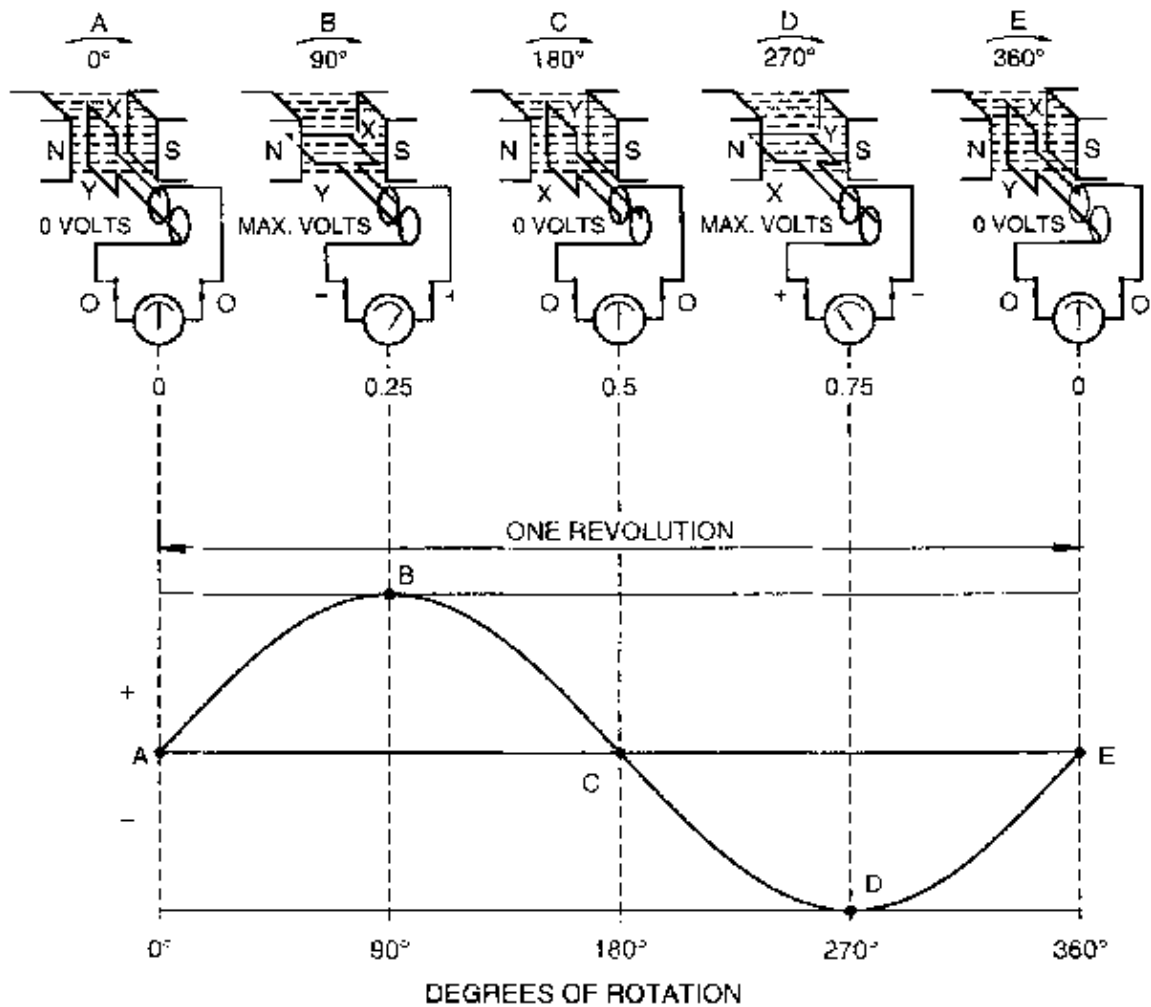
Test procedure

Touch the other end of the test lamp to the either terminal of the switch.

Result

Lighting of the test lamp in either of the terminals indicates that the phase/live cable is controlled by the switch.

Generation of AC

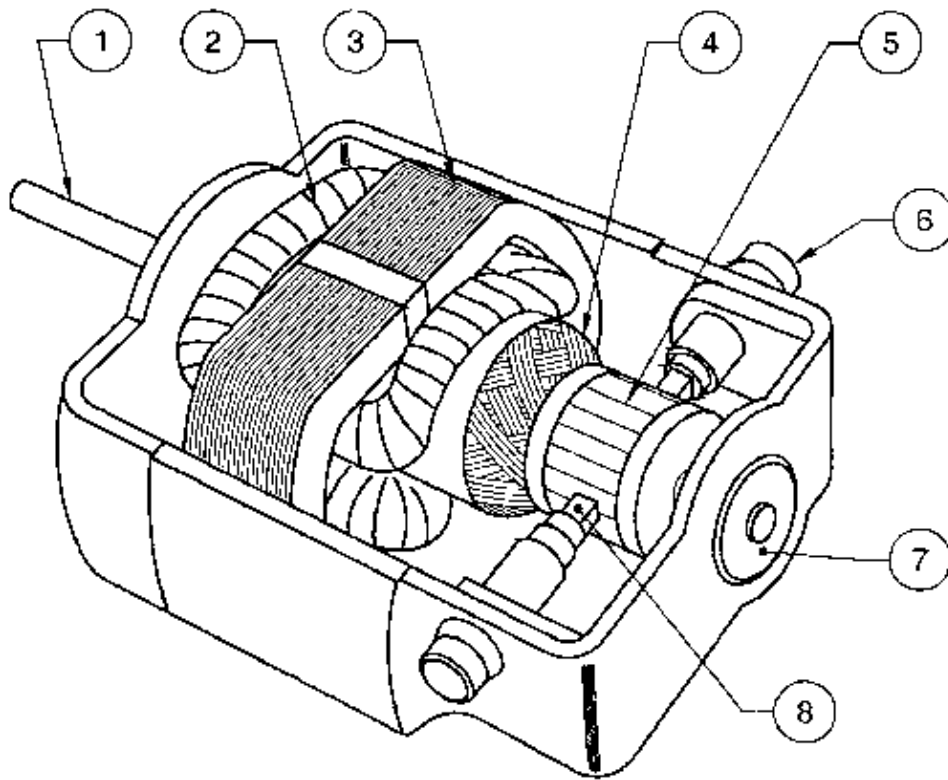


GENERATION OF AN ALTERNATING VOLTAGE:

AS THE LOOP ROTATES THROUGH THE MAGNETIC FIELD, THE MAGNITUDE AND DIRECTION OF THE VOLTAGE CHANGES WITH ANGLE AND DIRECTION OF MOTION.

Trainees are asked to determine the pointer position of the voltmeter and then asked to draw the Sine waveform depending on the conductor position.

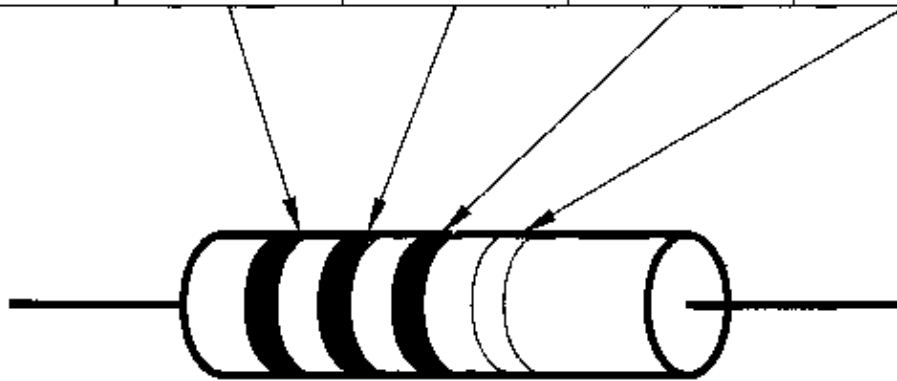
Parts of a universal motor



- 1 Shaft
- 2 Field Coil
- 3 Field Core
- 4 Armature
- 5 Commutator
- 6 Brush holder
- 7 Self-aligning bush bearing
- 8 Carbon brush

Resistor colour coding

COLOUR	1st NUMBER	2nd NUMBER	MULTIPLIER	TOLERANCE
BLACK	0	0	1	
BROWN	1	1	10	
RED	2	2	100	
ORANGE	3	3	1000	
YELLOW	4	4	10 000	
GREEN	5	5	100 000	
BLUE	6	6	1 000 000	
VIOLET	7	7	10 000 000	
GRAY	8	8	100 000 000	
WHITE	9	9	1 000 000 000	
GOLD			0.1	5
SILVER			0.01	10
NONE				20
	BAND 1	BAND 2	BAND 3	BAND 4



**Making Fastening Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Instruction Examples for Practical Vocational
Training**

Table of Contents

Making Fastening Joints – Course: Basic Skills and Knowledge of Electrical Engineering.

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Making Fastening Joints – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Author: M. Liesegang

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**Institut für berufliche Entwicklung e.V.
Parkstraße 23
13187 Berlin**

Order No.: 91-33-3102/2

Introduction

The present booklet contains 3 selected instruction examples to practise the main techniques of making fastening joints (detachable joints), including joints with lugs, with cable eyes and direct connection with distributor plate.

The instruction examples 1 and 2 are a continuation of the instruction example 1 of "Making Permanent Joints" and may be used, for example, as connection between a motor and a protective motor switch. Instruction example 3 may represent, for example, the connection of the conductors to a socket or a plug. In that case the correct connection of the phases and of the neutral conductor is to be ensured.

In order to facilitate the preparation and execution of the work, the necessary materials as well as working, measuring and testing tools are specified for each instruction example. The additional knowledge required for carrying out the work is also mentioned. Moreover, working drawings are attached to show more details of certain steps of work.

Instruction Example 2.1. Detachable Joint with Wire Lug

To practise the manufacture of a detachable joint with wire lug.

Material

Stripped flexible rubber sheathed
cable $3 \times 2.5 \text{ mm}^2$
(from instruction example 1 of "Making Permanent Joints"),
Length: 2000 mm
Stripped length: 80 mm

Working tools

Cable stripper (cable stripping knife) or stripping tool, round nose plier, open ended wrench, 100 W soldering iron

Measuring and testing tools

Folding rule or steel rule

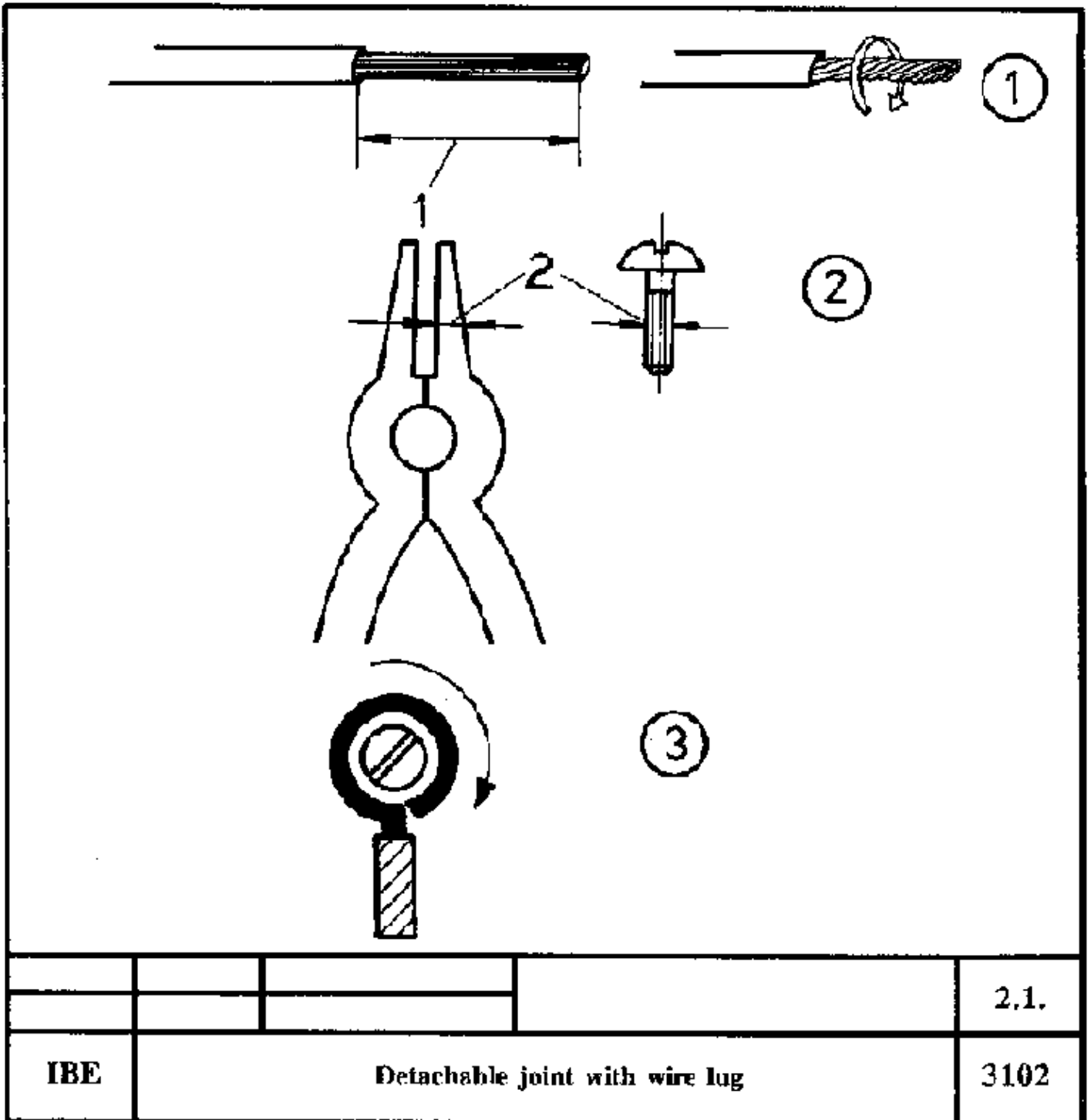
Accessories

Soldering flux, soldering tin

Necessary additional knowledge

Reading of drawings, treatment of cables and lines, making permanent joints, measuring

Sequence of operations	Comments
1. Preparation of workplace. Making available the working materials.	Check tools, materials and accessories for completeness.
2. Checking of initial lengths.	Cut to length, if necessary.
3. Stripping of conductors.	The stripping length 1 to be determined by means of the formula in the "Trainees' Handbook of Lessons". Twist stripped wire ends by clockwise rotation. (1)
4. Tin-coating of conductors.	Moisten conductors with flux first.
5. Bending of lugs.	Apply round nose plier according to required diameter 2. (2)
6. Bending of lugs to centre of conductor.	(2)
7. Connection (clamping) of lugs.	See to correct composing order. Insert lugs so that they will be drawn in when the joint is tightened. (3)



Detachable joint with wire lug

Instruction Example 2.2. Detachable Joint with Cable Eye

To practise the manufacture of a detachable joint with cable eye.

Material

Stripped flexible rubber sheathed
 cable $3 \times 2.5 \text{ mm}^2$ (from instruction example 1 of "Making Permanent Joints"),
 Length: 2000 mm,
 Stripped length: 80 mm

Working tools

Screwdriver

Necessary additional knowledge

Reading of drawings

Sequence of operations

Comments

1. Preparation of workplace. Making available the working materials.

Check for completeness.

2. Unscrewing of screws.

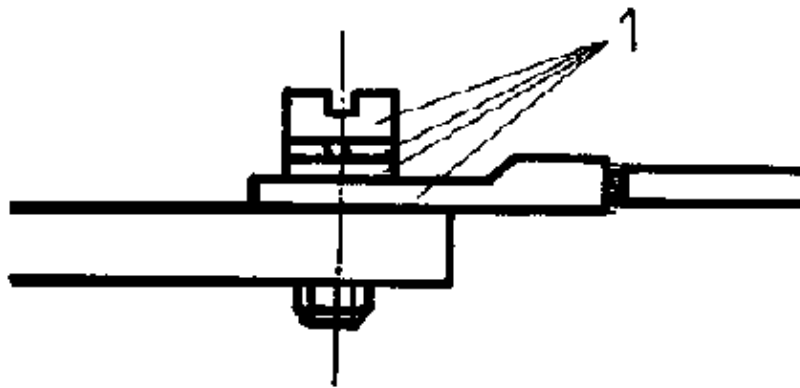
Unscrew screws with suitable screwdriver.

3. Composing of screw assemblies.

See to correct composing order. (1)

4. Tightening of the screws.

Srew in the screw by hand, then tighten it firmly with screwdriver.



				2.2.
IBE	Detachable joint with cable eye			3102

Detachable joint with cable eye

Instruction Example 2.3. Detachable Joint with Distributor Plate

To practise the manufacture of a detachable joint with distributor

Material

Stripped plastic-sheathed
cable $2 \times 1.5 \text{ mm}^2$, aluminium,
Length: 300 mm,
Stripped length: 60 mm

Working tools

Cable stripper (cable stripping knife) or stripping tool, screwdriver

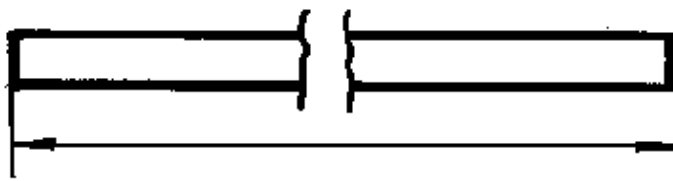
Measuring and testing tools

Folding rule or steel rule

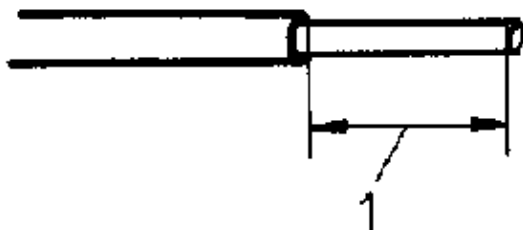
Necessary additional knowledge

Reading of drawings, treatment of cables and lines, measuring

Sequence of operations	Comments
1. Preparation of workplace. Making available the working materials.	Check tools and materials for completeness.
2. Checking of initial length.	Cut conductor to length, if necessary. (1)
3. Stripping of conductors.	Stripping length 1 depends on size of clamped joint 1. Don't notch the conductors when stripping them. (2)
4. Unscrewing of the screw.	Unscrew just as much as necessary for inserting the conductors.
5. Feeding in of conductors.	Insert conductors so that they are drawn into the clamped joint when the screw is tightened. (3)
6. Tightening of the screw.	



①



②



③

				2.3.
IBE	Detachable joint with distributor plate			3102

Detachable joint with distributor plate

**Making Fastening Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Methodical Guide for Instructors**

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Making Fastening Joints – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

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Author: M. Liesegang

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13187 Berlin

Order No.: 91–32–3102/2

1. Aims and Contents of Practical Vocational Training in the Working Techniques of "Making Fastening Joints"

After having finished their training based on this lesson, the trainees shall have achieved the following aims:

- They have the necessary knowledge and skills for making fastening joints (detachable joints).
- They can work with manufacturing documents, engineering drawings and working drawings.
- They are able to do the work in the quality required.
- They meet the safety requirements.

In order to achieve the above aims, the following knowledge and skills must be taught by the instructor:

Knowledge

- Design and applications of the tools.
- Steps of work required for making fastening (detachable) joints.
- Quality requirements for fastening (detachable) joints.
- Labour safety requirements.

Skills

- Handling of tools.
- Maintenance and servicing of tools.
- Direct connection of conductors.
- Indirect connection of conductors.
- Making plug-type joints.

2. Organizational Preparation

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared.

This includes:

2.1. Preparation of Labour Safety Instructions

Prior to the exercises the trainees must be instructed in brief on how to properly handle the working tools and prevent accidents.

It is recommended to prepare a book in evidence of the labour safety instructions given to note down in brief outlines all instructions given for preventing accidents and for handling the working tools properly. The trainees should then confirm by their signature that they have been instructed accordingly.

The instructions should include the following:

- Screwdrivers and wrenches must be suitable for the size of the screw or nut.
- Screwdrivers and wrenches must be applied correctly to prevent slipping off.
- When using screwdrivers, never put the hand under the screw for counterpressure. The screwdriver might slip off and produce a dangerous stab.
- Unscrew/slacken rusty screws or nuts by means of ring wrenches (if possible).
- Cover sharp edges with textiles (if possible).
- Never hold your face over the screw joint to be tightened or unscrewed. The screw or nut might be thrown into your face when it shears off.
- Tools and materials are to be deposited clearly and neatly arranged.

Other labour safety instructions can be given for special local conditions.

2.2. Preparation of teaching aids

- The theoretical instructions should be given at a place where the trainees are able to make notes, preferably in a class-room with blackboard, desk and mains supply.
- When the instructions are given in the workshop at the workplace, the tables should be provided with clean supports for the papers etc. to be deposited.
- For demonstrations during the instructions a workplace should be equipped as follows:
 - tools for preparing the conductors, various terminals (with and without distributor plates), tools for making fastening joints (detachable joints).
 - For indirect connection of conductors: prepared conductors with cable eyes, terminals, tools for making fastening joints (detachable joints).
 - For making plug-type joints, devices/appliances or installations, which are in operation in the shop, should be used as examples.
- Sufficient copies of the "Trainees' Handbook of Lessons – Making Fastening Joints" are to be made available to provide one copy to each trainee.
- Tables etc. are to be written on the blackboard prior to the instructions.
- All tools and accessories for making fastening joints (detachable joints) as mentioned in section 3 are to be made available as visual aids.

2.3. Preparation of Working Tools and Materials

- Sufficient copies of the "Instruction Examples for Practical Vocational Training – Making Fastening Joints" are to be made available to provide one copy to each trainee as theoretical basis for the exercises to be done.
- The initial materials necessary for the exercises as specified in the "Instruction Examples..." are to be prepared and kept ready in sufficient quantity.
- Each trainee must have a workplace with a vice and mains supply connection.
- The trainees' workplaces are to be checked for complete equipment with tools and accessories for the planned exercises.

Recommended basic equipment:

- Screwdrivers 2, 4, 6, 8, 10 mm
- Double head (open ended) wrenches and box wrenches (socket wrenches) from 5.5 to 17 mm opening or ring wrenches
- Combination plier
- Round nose plier
- Adjusting plier
- Side cutting plier
- Stripping plier
- Cable stripper
- Scraper
- Hand hacksaw with metal saw blade
- Bastard file and smooth file 200 mm (half round)
- Hammer
- Soldering iron
- Soldering flux
- Spirit.

2.4. Time Planning

Based on the total hours available, the times for the individual training sections of this lessons should be planned individually.

Time planning is recommended for the following sections:

- Introduction into the relevant working technique in the form of instructions including labour safety instructions.
- Necessary demonstrations.
- Job-related instructions to prepare the exercises.
- Exercise/practising.
- Recapitulations and tests.

In such time planning the following factors should also be taken into consideration:

- Level of training reached by the trainees,
- training conditions,
- future assignment of the trainees,
- level of difficulty of the relevant training section.

The emphasis in each training section should be on the acquisition of practical skills and abilities by practising. Any waiting times occurring for the trainees in spite of good planning should be bridges by suitable preparatory work, such as preparation of conductor material.

3. Recommendations for Realizing the Practical Vocational Training in the Working Techniques of "Making Fastening Joints"

The following sections contain recommendations on how to organize and implement the instructions, demonstrations of the working techniques as well as exercises and tests. The instructions for making the joints can be given regardless of the order specified.

3.1. The Introductory Instructions, Demonstrations and Exercises

The introductory instructions for each working technique can be given in a class-room. During the instructions the trainees should be advised to note down necessary additions or answers into the "Trainees' Handbook of Lessons".

The arrangement of the contents of the "Trainees' Handbook of Lessons" is adapted to the introductory instructions and the main points therein contained should be taught.

The knowledge of the working techniques of treating cables and wires and of making permanent joints should be repeated and referred to since a good command of those working techniques is a precondition for acquiring the working techniques of "Making Fastening Joints".

The knowledge and skills of "Making fastening joints" should be taught intensively using all teaching aids available.

Types and meaning of fastening joints (detachable joints)

In order to make clear the types and meaning of detachable joints, it is recommended to show to the trainees finished joints, such as screw or plug-type joints.

The applications of detachable joints in practice, their advantages as well as possibilities of making them can then be derived in discussions with the trainees.

Tools for making fastening joints (detachable joints)

Original tools should be used to explain the design, applications and handling of the tools required and used for making screw-type joints. Possible defects of tools and their causes should also be discussed. For this purpose, damaged tools should be shown to the trainees, such as broken handles or blades of screwdrivers, enlarged wrenches, etc.

To test the trainees knowledge, the instructor should show tools and let the trainees repeat their design and handling. Then the trainees should answer the questions in the "Trainees' Handbook of Lessons". The answers are to be checked by the instructor for correctness.

Direct Connection

In this working technique the trainees shall acquire basic skills and abilities for direct connection of different conductor materials.

The emphasis should be on the following points:

- Correct preparation of the conductor to be connected.
- Bending of wire lugs.
- Use and handling of the tools.
- Observing the rules for connection.
- Meeting the labour safety requirements.

In practice, there is a variety of forms of clamped joints. The different forms require different sequences of operations for direct connection.

The following sequences of operations and their systematic procedure are to be explained and demonstrated to the trainees:

- Sequence of operations for making a wire lug
 - Stripping of the conductor
 - Bending of the wire lug

- Sequence of operations for connecting wire lugs
 - Unscrewing of the fastening screw
 - Composing the screw assembly
 - Tightening of the fastening screw

- Sequence of operations for straight–line connection
 - Stripping of the conductor
 - Unscrewing of the fastening screw
 - Feeding in of the conductor into the clamped joint
 - Tightening of the fastening screw.

The demonstration of the steps of work involved is to be well prepared. To enable all trainees to see the demonstration, it is recommended to form groups of 6 to 8 trainees. The trainees of one group should be positioned around the place of demonstration so that they can easily watch the individual operations demonstrated. Then the instructor demonstrates the sequence of operations necessary for direct connection. It is important

- that each sequence of operations is individually demonstrated,
- that the instructor explains the purpose of his activities during the demonstration,
- that the trainees realize that direct connection calls for great care, calmness and expertise,
- that the instructor's example is a decisive factor motivating the trainees in their work.

The demonstration may then be repeated by one trainee. The instructor must see to it that it is properly done and correct any mistakes immediately. Then the group is exchanged. To bridge any waiting times, the trainees may answer the respective questions in the "Trainees' Handbook of Lessons" on their own. The answers are to be checked by the instructor.

To develop the trainees' practical skills it is then necessary for the trainees to practise direct connection. The exercises can be carried out using any conductor materials and connectors available. It is recommended to have the exercises carried out in the order of the sequences of operations taught. The examples from the "Instruction Examples for Practical Vocational Training" may also be used for practising.

For carrying out the work it is recommended to determine criteria for observation and evaluation, such as:

Stripping of the conductor

- Does the trainee use the right tool?
- Does the stripped length comply with the relevant joint?
- Is the conductor undamaged?

Bending of the wire lug

- Does the inside diameter of the wire lug comply with the outside diameter of the screw?
- Is the centre of the wire lug in line with the centre line of the wire?
- Is the bent wire lug circular?

Connection of wire lugs

- Is the screw joint firmly tightened?
- Have the rules for composing the screw assembly been observed?
- Has the wire lug been correctly inserted in the screw joint?

Straight–line connection

- Does the stripped length comply with the clamped joint?
- Has the wire been put correctly into the clamped joint?
- Is the screw joint firmly tightened?

Such criteria of evaluation should be made known to the trainees before they start with the exercises.

Indirect connection

In this working technique the trainees shall acquire basic skills and abilities for indirect connection.

The emphasis should be on the following main points:

- Making fastening joints (detachable joints).
- Observing the rules for connection.
- Use and handling of the tools.
- Meeting the labour safety requirements.

The trainees should already have a good command of making detachable joints which is a pre–condition for indirect connection. The other main points of indirect connection have already been taught for direct connection. Therefore, it is possible to have the technological sequence described and demonstrated by trainees. Any mistakes are to be corrected by other trainees in the form of discussions. Then the instructor should point out the possibility of combination of direct and indirect connection. Practical skills already acquired should be consolidated by further exercises according to the criteria of evaluation for indirect connection.

Plug–type joints (plug–and–socket connectors)

In this working technique the trainees shall acquire the necessary knowledge and skills for working with plug–type joints.

The emphasis should be on the following main points:

- Types and design of plug–and–socket connectors.
- Applications of plug–and–socket connectors.
- Rules for working with plug–and–socket connectors.

At first the instructor should explain the fundamentals, such as types, design and applications. After such introduction, the disconnection and connection of plug–type joints is to be demonstrated to the trainees by means of plug–and–socket connectors used in the factory. Any pulling tools necessary are to be shown and their handling is to be explained.

After the demonstration a repetition by the trainees is recommended. Any mistakes should be immediately corrected.

Further development of practical skills is recommended only if the trainees have to do repair or similar work on such devices, appliances or installation. This will avoid early fatigue of plug–and–socket connectors.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

The "Instruction Examples" describe the sequence of operations and contain a working drawing for making fastening joints (detachable joints) by direct connection and indirect connection. Moreover, the recommended materials, and a list of the necessary working, measuring and testing tools as well as accessories are included for each example. Thus the trainees have any information required for properly doing the exercises.

The following should be considered in the organization of the work:

- The trainees should do himself any work involved in the instruction example, from preparing the initial material up to completion of the exercise. This is the only way of ensuring a just

evaluation.

3.3. Examples for Recapitulation and Tests

This section contains questions to strengthen and test the knowledge and skills acquired. The answers to the questions are also given. Questions, which are also contained in the "Trainees' Handbook of Lessons", are marked with the letter "A".

1. What are detachable joints (fastening joints)?

(Joints which can be detached without damaging the joining elements and can be re-used.)

2. What tools are mainly required for making detachable joints?

(Screwdrivers, wrenches)

3. What are the effects when using a screwdriver the blade of which is too small?

"A" (The screwdriver blade will be damaged; the screw cannot be unscrewed because of insufficient force transmitted.)

4. Why must a screwdriver with defective handle not be used?

"A" (Risk of injury of hands.)

5. Why must the size of the screw/nut comply with the opening of the wrench?

"A" (If the opening is too small, it will not fit onto the screw or nut. If the opening is too big, the screw or nut will be damaged. The wrench will not drive the screw or nut, there is the risk of injury when slipping off.)

6. What tool can be used for slackening a nut if no suitable wrench is available?

"A" (Flat nose plier, combination plier, water pump plier.)

7. Why must no more than two aluminium conductors be connected to a connection bolt?

"A" (Aluminium conductors shrink in cross section. If more than two conductors are connected, the pressure piece cannot compensate for it.)

8. What tools are used for stripping of conductors?

"A" (Scraper, stripping plier, cable stripper.)

9. Why must the wire lug be bigger than the connection bolt?

"A" (The wire lug must easily go on the connection bolt.)

10. What tool is used for unscrewing a slotted screw and a hexagon-head screw?

"A" (Slotted screw – screwdriver, hexagon-head screw – wrench.)

11. What is the sequence of operations for making a bolt joint with 4 aluminium conductors?

"A" (– Stripping of the conductor.

– Bending of the wire lug.

– Composing of the bolt assembly in the following order:

- washer
- wire lug 1
- washer
- wire lug 2
- washer
- lock washer 1
- nut 1
- washer
- wire lug 3
- washer
- wire lug 4
- washer
- lock washer 2
- nut 2

– Tightening of the fastening nuts)

12. Why must the wire be applied at the left-hand side of a distributor plate?

"A" (Because the wire shall be drawn into the screw joint during tightening.)

13. What is the sequence of operations for connecting a protective conductor with cable eye to a screw connector?

"A" (Unscrewing the screw, putting the lock washer or serrated lock washer onto the screw, putting the cable eye on, screwing the complete screw in by hand, tightening the screw by screwdriver)

**Making Fastening Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Trainees' Handbook of Lessons**

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Making Fastening Joints – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Introduction

The present handbook is intended for trainees in electrical engineering trades. It contains a description of the tools and the sequences of operations required for the manufacture of fastening joints (detachable joints).

The necessary knowledge and skills are described for the individual types of connections in the order of the steps of work required. The illustrations contained shall help to visualize, understand and supplement the text of the individual sections.

To assist the learning process, questions have been included for the trainees to test their knowledge.

1. Types and Meaning of Fastening Joints (Detachable Joints)

Fastening joints (detachable joints) are made between two or more parts and serve to join or fasten components or assemblies in devices/appliances and plants/installations.

Features of detachable joints are:

- The joint can be detached at any time.
- The joining elements are not destroyed.
- The joining elements can be re-used.

There are two groups of detachable joints.

Detachable joints

form-closed (positive) joints:

screw-type joints (screw connectors)

spring-type joints

pin-type joints

plug-type joints (plug-and-socket connectors)

force-closed (non-positive) joints:

keyed joints

clamped joints

Detachable joints permit easy mounting, dismantling and repair of devices, appliances and installations. For making electrical joints, screw-type joints (screw connectors) and plug-type joints (plug-and-socket connectors) are used.

2. Tools for Making Detachable Joints

Screwing is the most common type of joining mechanical or electromechanical components. For making or detaching such joints, screwdrivers and wrenches (spanners) of various types and sizes are used.

Screwdrivers

The types and sizes of screwdrivers required depend on the types of the screw.

Screwdrivers for slotted screws

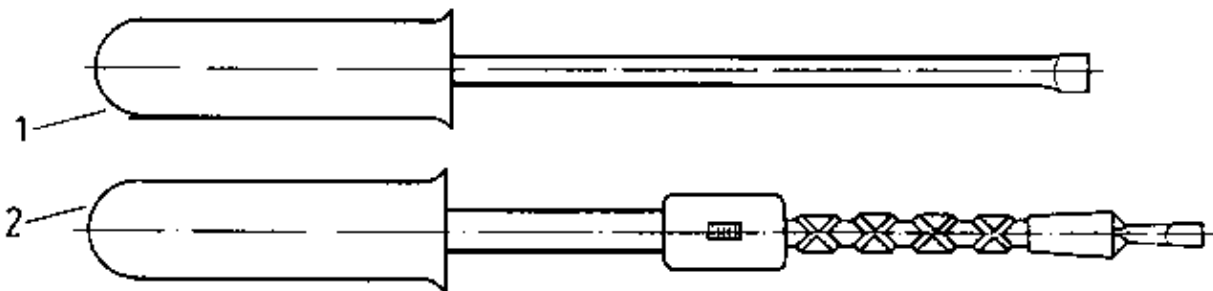


Figure 1 – Screwdrivers 1 – 1 screwdriver with fixed blade, 2 spiral-ratched screwdriver

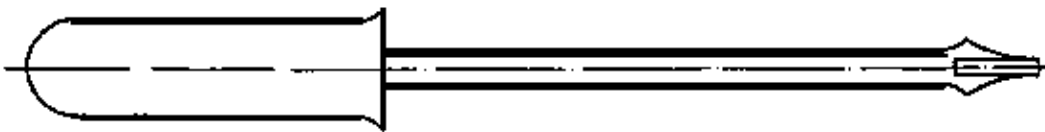


Figure 2 – Screwdrivers for recessed-head screws (*Phillips screwdrivers*)

When using screwdrivers, attention is to be paid to the following:

- The blades must perfectly fit into the slots of the screws.
- The clearance between the blade and slot must be very small.
- The width of the blade must be slightly smaller than the diameter of the screw head.

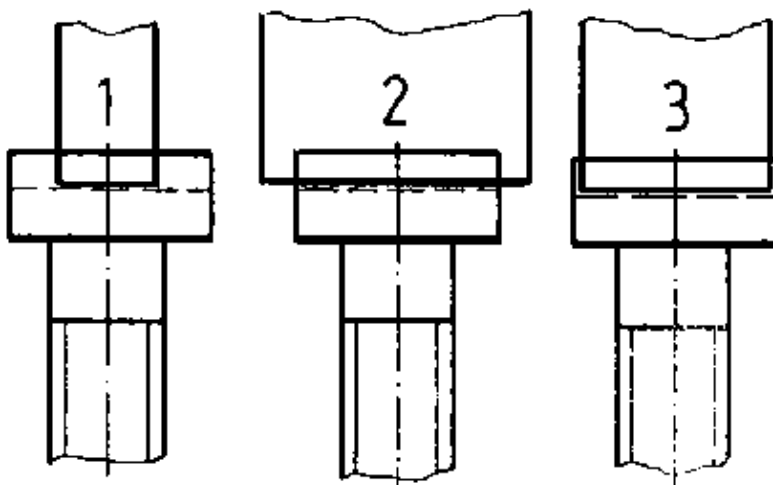


Figure 3 – Selection of a screwdriver – 1 screwdriver blade too small, 2 screwdriver blade too big, 3 correct screwdriver blade

What are the effects when using a screwdriver the blade of which is too small?

Why must a screwdriver with defective handle not be used?

Wrenches (spanners)

Wrenches differ with respect to their type and (width of) opening.

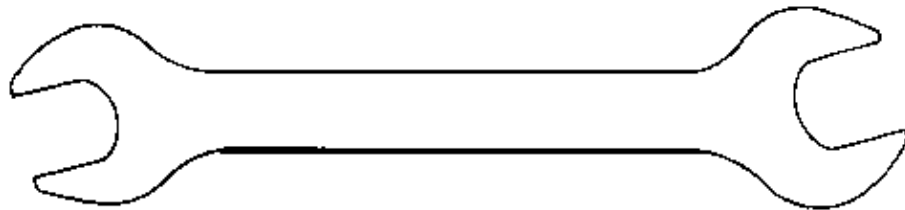


Figure 4 – *Double head (open ended) wrenches*

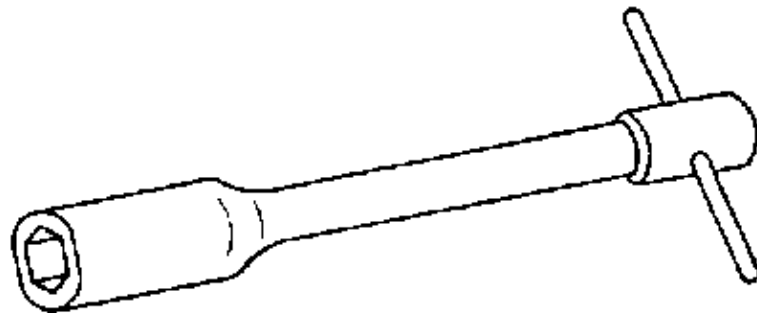


Figure 5 – *Box wrenches (socket wrenches)*

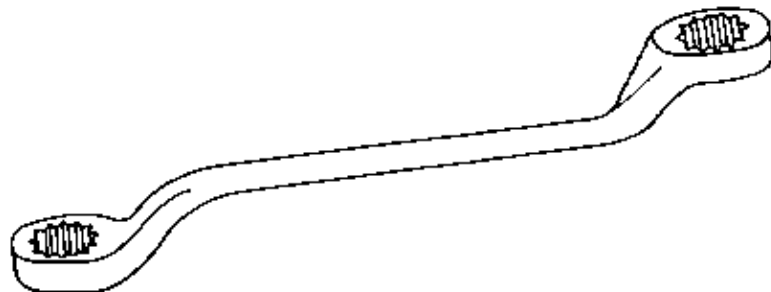


Figure 6 – *Ring wrenches*

When using wrenches, attention is to be paid to the following:

- Wrenches must suit the width across flats (wrench size) of the screw or nut.

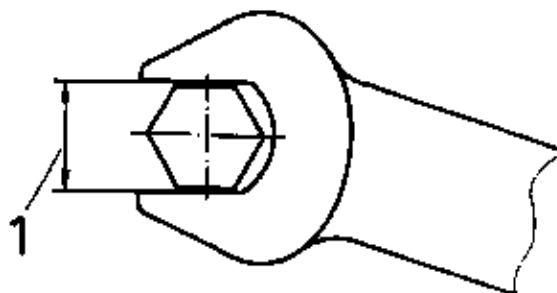


Figure 7 – *Wrench with nut – 1 wrench size*

Why must the size of the screw/nut comply with the opening of the wrench?

What tool can be used for slackening a nut if no suitable wrench is available?

3. Making Detachable Electrical Joints (Connectors)

Conductive electrical joints are made by connecting (clamping) the wires to a connection element (screw connector). Depending on the material and cross section of the wire, such connection is of direct or indirect type.

With direct connection the wire is held by the screw connector without any additional means. For large cross sections indirect connection is used, i.e. cable eyes are fixed to the wire ends by soldering, pressing or clamping.

Another way of making conductive electrical joints are plug-type joints (plug-and-socket connectors).

They are mainly used to connect non-stationary electrical appliances or to connect plug-in units in devices, appliances and installations. Plug connectors permit the interchange of assemblies and devices in case of repair.

3.1. Direct Connection

Direct connection is done in two ways:

Connection of the conductor by means of a wire lug to be bent or straight-line connection. Flexible conductors must be tin-coated before they are connected.

Connection of wire lugs

The following rules for connection are to be observed:

- A maximum of two aluminium conductors differing in up to two cross-sectional steps can be connected.
- A maximum of three copper conductors differing in up to two cross-sectional steps can be connected.
- Several conductors can be connected to connection bolts if a pressure piece is inserted after every two aluminium conductors or after every three copper conductors.
- A washer is to be inserted between the individual conductors.
- For connection of protective conductors or neutral conductors one conductor per connection point is admissible only.
- Each connection point is to be secured by a lock washer.

Why must no more than two aluminium conductors be connected to a connection bolt?

Sequence of operations for making wire lugs

Wire lugs are bent on copper or aluminium conductors of up to 16 mm² cross section. For flexible copper conductors the maximum cross section is 4 mm².

Stripping of the conductor

The stripping length of the conductor depends on the diameter of the screw joint used.

It can be calculated to:

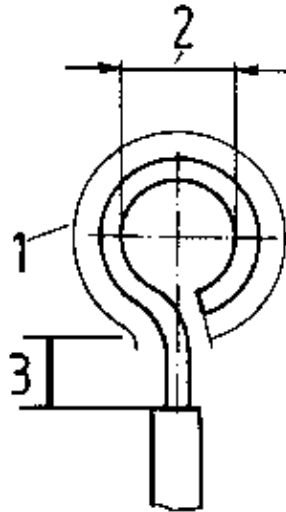


Figure 8 – Representation of a wire lug – 1 length to be stripped, 2 lug diameter, 3 distance from beginning of lug to conductor insulation

$$1 = (d + 0.5) + a$$

1 = length to be stripped in mm

$$? = 3.14$$

d = bolt diameter in mm

a = distance from beginning of lug to conductor insulation

(d + 0.5) = lug diameter

What tools are used for stripping of conductors?

Bending of the wire lug

The wire lug is bent by means of a round nose plier in the direction of rotation of the fastening screw.

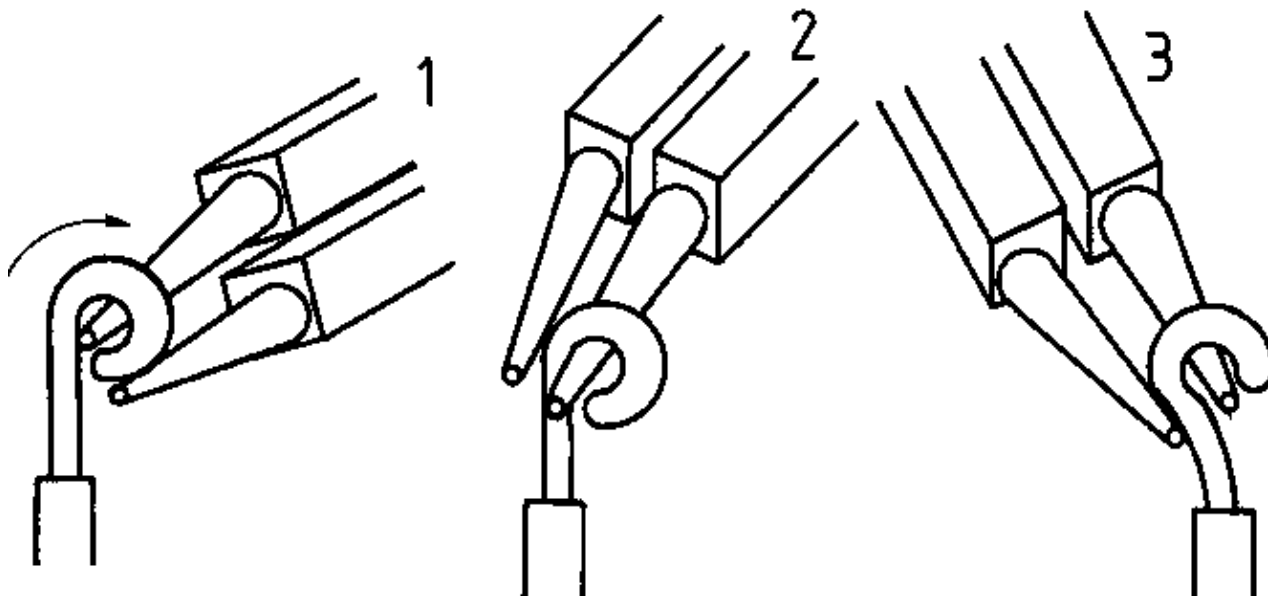


Figure 9 – Bending of a wire lug – 1 applying the round nose plier, 2 closing the wire lug, 3 bending of the lug to the centre of the conductor

The wire end is slightly pre-bent with the round nose plier. The conical plier noses are to be applied so as to give the correct lug diameter required. The round nose plier is then to be re-applied for finish-bending of the lug, preferably in one pass.

The lug should be tested on the screw joint to be used. If the lug does not have the required diameter, the plier noses are to be applied at a point where their diameter is slightly bigger to re-bend the lug. If the required diameter is reached, the lug is bent to the centre of the conductor.

Why must the wire lug be bigger than the connection bolt?

Sequence of operations for connecting wire lugs by means of screw connectors

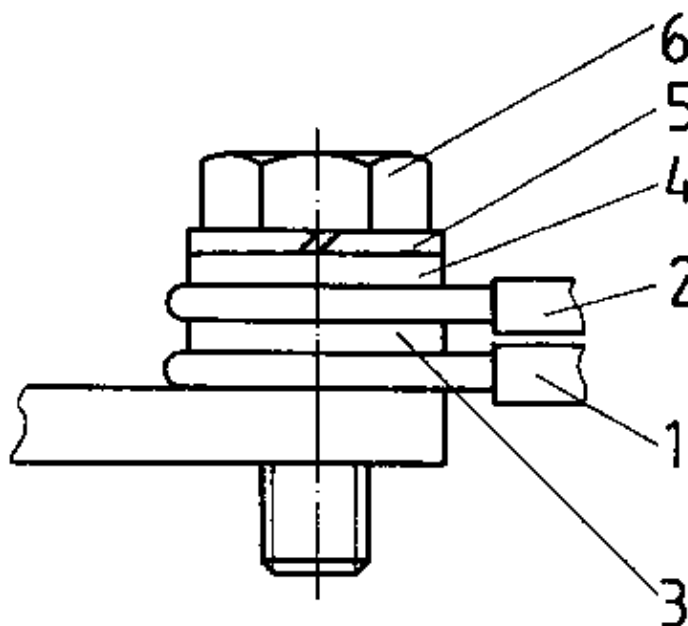


Figure 10 – Construction of a screw connector – 1,2 conductor, 3,4 washer, 5 lock washer, 6 screw

Unscrewing of the fastening screw

What tool is used for unscrewing a slotted screw and a hexagon-head screw?

Composing the screw assembly

The screw assembly is to be composed in the following order:

- lock washer
- washer
- wire lug conductor 1
- washer
- wire lug conductor 2

The lugs of the conductors are to be inserted so that the bending direction of the wire lug complies with the direction of rotation of the screw.

Tightening of the fastening screw

The complete fastening screw is screwed into the thread by hand and then tightened with the respective tool.

What is the sequence of operations for making a bolt joint with 4 aluminium conductors?

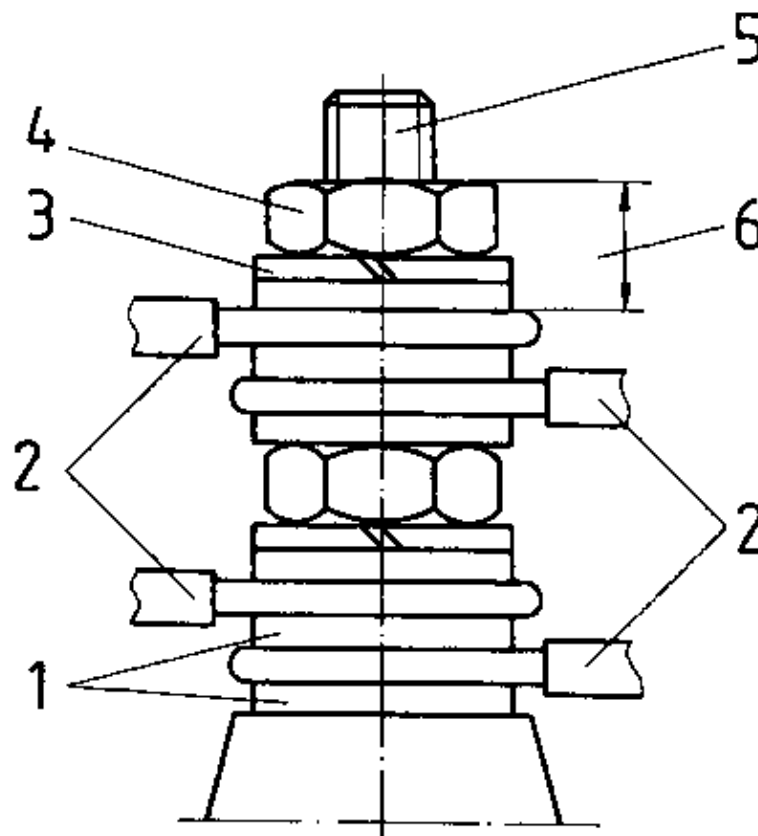


Figure 11 – Construction of a bolt joint with four aluminium conductors – 1 washer, 2 conductor, 3 lock washer, 4 nut, 5 bolt, 6 pressure piece

Straight-line connection

If lateral escaping of the conductor is limited by the screw head, bending of lugs is not necessary. The conductor is prevented from escaping by clamping saddles, distributor plates and connector blocks.

For straight-line connection attention is to be paid to the following:

– If conductors are fixed at the point of connection by means of clamping saddles, one conductor per saddle side must be connected only. The conductors may differ by one cross-sectional step.

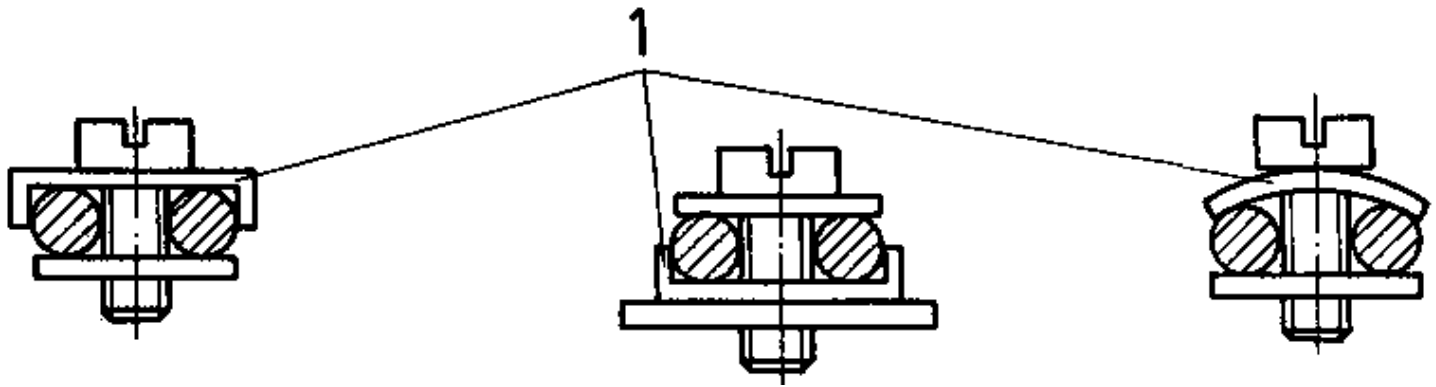


Figure 12 – Clamping saddle connections – 1 clamping saddle

– If conductors are fixed by means of cap screw and distributor plate, one conductor per distributor plate must be connected only. The conductors must have the same cross section. The conductor(s) is (are) to be inserted so that it (they) will be drawn into the point of clamping when the screw is tightened.

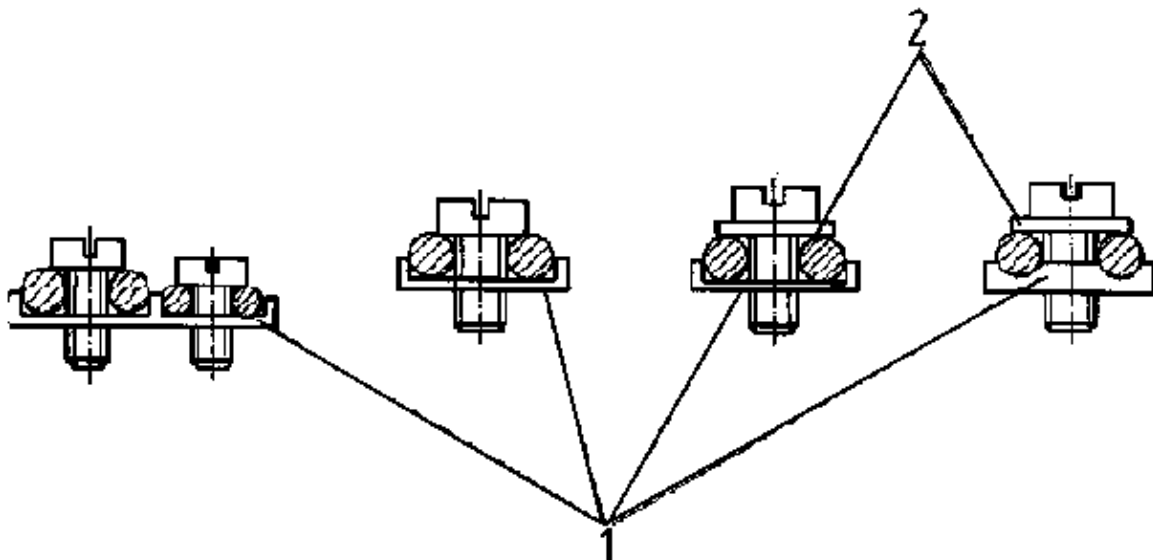


Figure 13 – Connection of conductors by means of cap screw and distributor plate – 1 distributor plate, 2 washer

– If conductors are fixed by means of connector blocks, no more than two conductors, which have been soldered first, must be connected at each side.

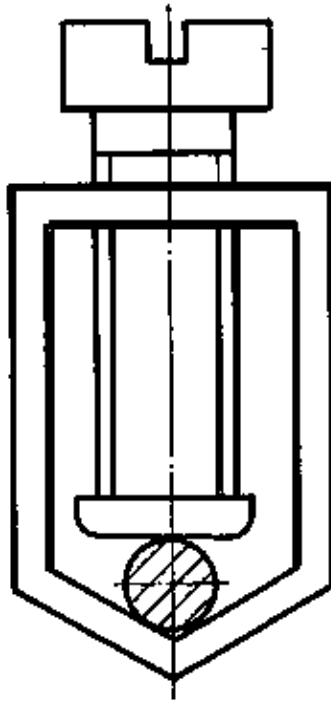


Figure 14 – Connection by means of connector block

Sequence of operations for straight-line connection

The sequence of operation for connection by clamping saddles, distributor plates and connector blocks is the same:

Stripping of the conductor

The stripping length depends on the size of the clamped joint.

To avoid clamping of any conductor insulation, the stripping length must be approx. 1... 2 mm longer than the clamped joint.

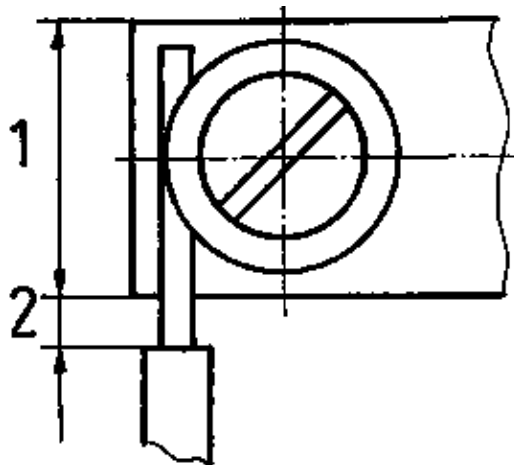


Figure 15 – Determination of the stripping length – 1 size of the clamped joint, 2 1... 2 mm in excess

Unscrewing of the fastening screws

The fastening screws are unscrewed just as much as necessary to feed in the conductor.

Feeding in of the conductor into the clamped joint

The conductor is fed in under available washer or clamping saddles.

Why must the wire be applied at the left-hand side of a distributor plate?

Tightening of the fastening screw

The fastening screw is firmly tightened by a screwdriver suitable for the size of the screw.

3.2. Indirect Connection

Large conductor cross-sections render the bending of lugs difficult and would require big screw joints for direct connection. Therefore, the conductor ends are provided with cable eyes by soldering, pressing and squeezing.

Connection of cable eyes

For connection of cable eyes the same rules apply as for connection of lugs.

Sequence of operations for connecting cable eyes to a bolt joint

- Slackening of the fastening nut
- Composing of the bolt assembly

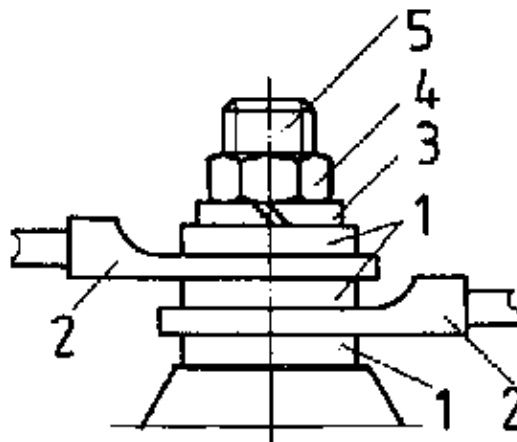


Bild 16 – Construction of a bolt joint – 1 washer, 2 cable eye, 3 lock washer, 4 nut, 5 bolt

The bolt assembly is to be composed in the following order:

- washer
- cable eye 1
- washer
- cable eye 2
- washer
- lock washer
- fastening nut

Tightening of the fastening nut

The fastening nut is screwed on by hand and then firmly tightened by a wrench.

What is the sequence of operations for connecting a protective conductor with cable eye to a screw connector?

Combined connection of cable eyes and lugs

It is possible to fasten cable eyes and lugs together to a screw connector. For connection the same rules and the same sequence of operations apply to the two types. When composing the bolt assembly, the lug is always to be put on the cable eye.

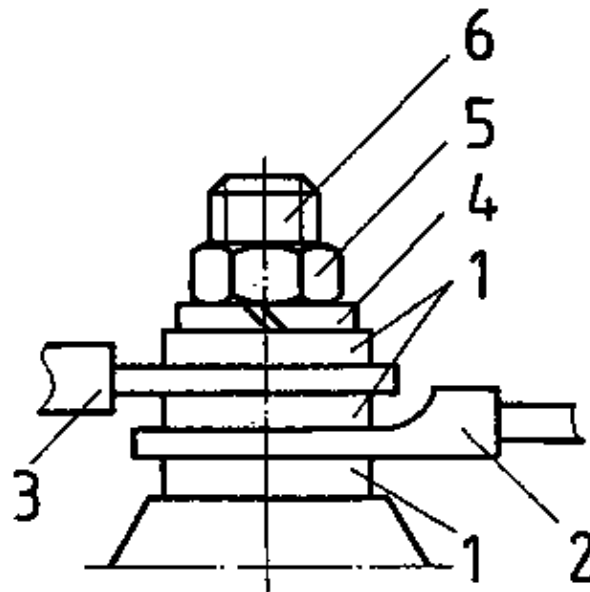


Figure 17 – Construction of a bolt joint – 1 washers, 2 cable eye, 3 wire lug, 4 lock washer, 5 nut, 6 bolt

3.3. Plug-type Joints (Plug-and-socket Connectors)

Plug-and-socket connectors consist of two components, the plug and the socket. The connections to plug-and-socket connectors (wire connection or printed circuit conductors) are made by soldering, wrapping, squeezing or clamping. Plug-and-socket connectors are used in various forms as panel connectors (flat plug connector) and circular connector as well as single-pole (tip plug) and multi-pole (multi-point) connectors.

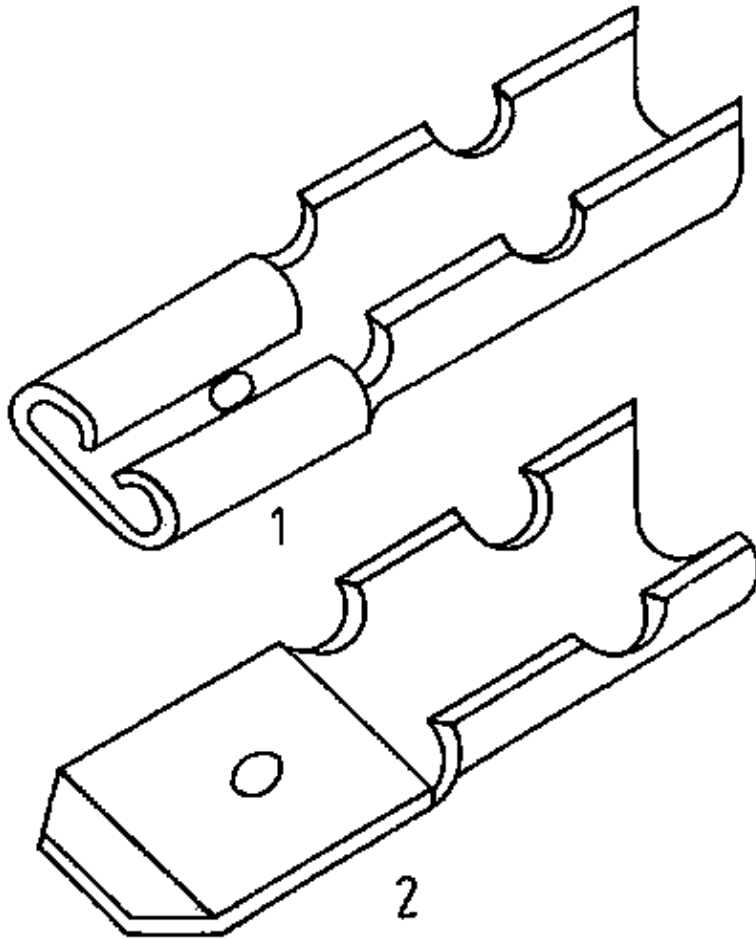


Figure 18 – Single-pole connector – 1 flat socket (*quick-connect receptacle*), 2 flat plug

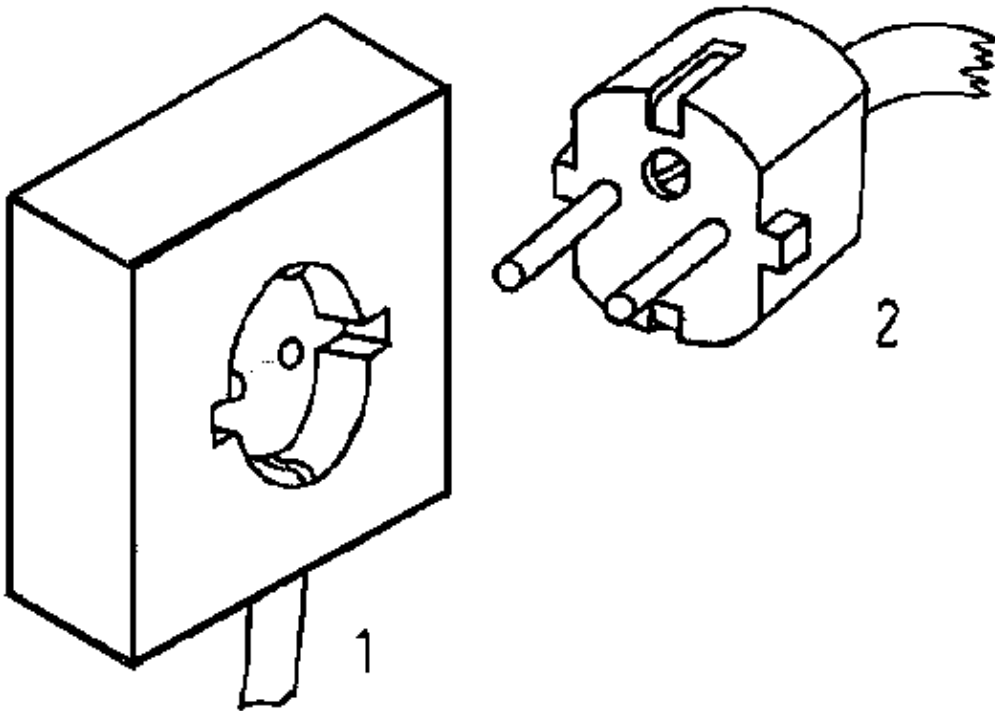


Figure 19 – Heavy-current plug-and-socket connector – 1 plug, 2 socket

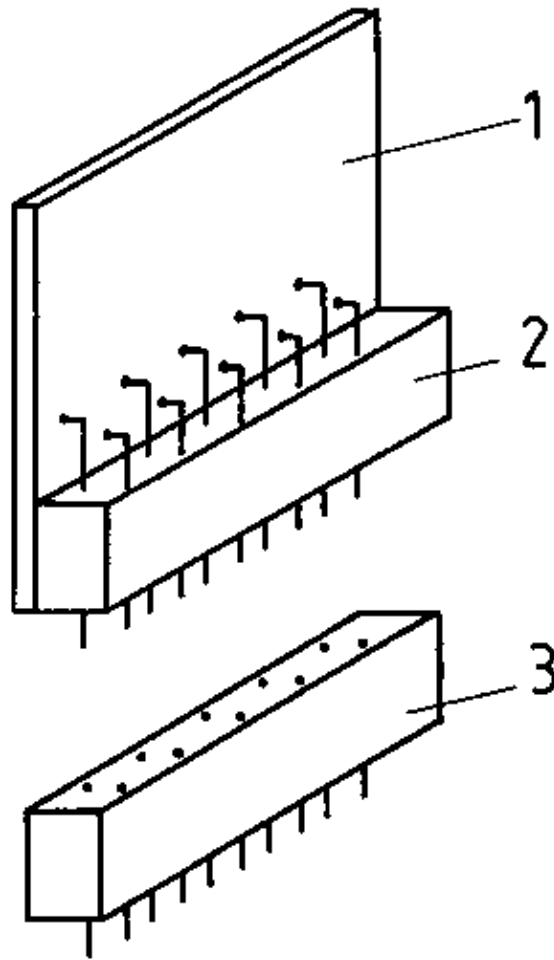


Figure 20 – Multi-pole plug-and-socket connector – 1 printed circuit board, 2 multi-point connector, 3 socket board

When working with plug-and-socket connectors the following rules are to be observed:

- Do not tilt plug-and-socket connectors when connecting or disconnecting them.
- Do not disconnect plug-and-socket connectors by pulling at the cable or line.
- Plug-and-socket connectors of plug-in units or printed circuit boards are to be disconnected by means of the appertaining pulling mechanism.
- Attention is to be paid to guides for plug-in units and printed circuit boards when inserting such units/boards.

**Protective Measures against Hazardous Contact Voltage – Course:
Basic Skills and Knowledge of Electrical Engineering. Methodical
Guide for Instructors**

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Protective Measures against Hazardous Contact Voltage – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

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1. Aims and Contents of Practical Vocational Training in the Field of "Protective Measures against Hazardous Contact Voltage"

At the end of the training in these lessons the trainees must have reached the following objectives:

- The trainees have acquired the necessary knowledge and skills in the field of protective measures against hazardous contact voltage.
- The trainees are able to make practical use of the respective protective measures when working at electrical plants.
- The trainees are able to check the protective measures installed.
- The trainees observe the regulations on industrial health and safety.

In order to reach the required goals, the instructor must impart the following contents:

Knowledge

- Necessity of taking protective measures against hazardous contact voltage.
- Subdivision of the protective measures against hazardous contact voltage.
- Criteria of the individual protective measures.

Skills

- Putting into practice of protective measures at devices or electrical plants.
- Checking of the protective measures installed.

2. Organizational Preparation

In order to guarantee that the instructions and exercises go off smoothly, the training should be well organized.

This comprises the following steps:

2.1. Preparation of the Instruction about Industrial Health and Safety

Before starting the exercises, a brief instruction should be given about the proper use and handling of the working means and how to avoid accidents.

As a proof of these instructions on industrial health and safety standards it is recommended to keep a book in which all instructions on accident-free working and proper use and handling of working means are entered in brief outlines.

The trainees confirm by signature that they were taught.

The following hints should be included:

- Every work in and at electrical plants has to be carried out in dead condition.
- The dead condition has to be checked with the help of testing instruments.
- Make sure that the plant is not reconnected by other people.
- If test work is necessary in alive plants, there must be one supervisor to look after the person carrying out the work.
- All works in connection with protective measures have to be carried out especially carefully.
- How to act after accidents caused by electric current.

Perhaps further hints on industrial health and safety are to be given according to the local requirements

2.2. Preparation of the Teaching Aids

For theoretical instruction, the trainees should have a writing place. Recommendable is a room equipped with blackboard, desks and electric connection.

If instruction takes place in the workshop or at the workshop place, clean pads should be put on the working tables for the trainees to put their papers on and take notes.

For demonstration purposes, a working place with the following equipment should be prepared:

On the necessity of taking protective measures:

Devices and parts of plants showing

- natural ageing
- destruction due to inexpert use
- premature ageing caused by the influence of moisture, chemical gas, vapours etc.

Illustrations showing people who had accidents caused by lacking or not functioning protective measures.

On potential equalization:

Here, the thing to do would be on the spot to show plants and parts of plants which require the measure of potential equalization or where potential equalization has already been created.

On the individual protective measures:

- Visual aids from which the mode of functioning can be seen.
- Equipment and accessories required to put the individual protective measures into practice.
- Also here, it would be convenient to show the respective plants on the spot.

The "Trainees' Handbook of Lessons" – protective measures against hazardous contact voltage has to be distributed according to the number of trainees.

Tables and switching diagrams are drawn on the blackboard before the lesson begins.

2.3. Preparation of the Working Means

As a theoretical basis of the exercises to be carried out, the "Instruction Examples for Practical Vocational Training/Protective Measures against Hazardous Contact Voltage" are to be distributed according to the number of trainees.

The material required for the exercises has to be prepared and laid out ready in sufficient quantity and/or number according to the instructions given in the "Instruction Examples...".

Each trainee must have his own place to work and exercise.

2.4. Time Planning

Starting from the total number of teaching hours, the times for the individual sections of this lesson should be planned separately.

Time planning is recommendable for the following sections of training:

- For the introduction into each respective working technique in the form of an instruction.
- For necessary demonstration.
- For task-related instructions in preparation of the exercises.
- For the carrying out of the exercises.
- For recapitulations and tests.

In addition, the following factors should be taken into consideration:

- The education level of the trainees.
- The training conditions.
- The future job of the trainees.
- The degree of difficulty of the respective section of training.

In each section of training, main emphasis should be put on the acquisition of abilities and skills by practical exercise.

If – in spite of good planning – it comes to waiting periods for the trainees, these should be filled by appropriate tasks such as the preparation of materials for exercises.

3. Recommendations for Practical Vocational Training in the Working Techniques of "Protective Measures against Hazardous Contact Voltage"

The following sections give suggestions as to how the instructions, demonstrations, exercises and checks can

be organized.

3.1. Introductory Instructions, Demonstrations and Exercises

The respective instructions on each working technique can be held in a teaching room. During these instructions, make sure that the trainees write down additional remarks or answers in the "Trainees' Handbook of Lessons". The "Trainees' Handbook of Lessons" is structured correspondingly to the introductory instruction. The main points have to be imparted. A precondition for learning the working techniques in the field of "protective measures against hazardous contact voltage" is that the trainees are able to lay cables, to install and connect devices and to carry out testing and measuring work. In imparting the above mentioned knowledge, therefore, these working techniques have to be referred to in the form of a repetition.

The "protective measures against hazardous contact voltage" should be imparted by making intensive use of all available teaching aids as well as practical experience on the spot.

Necessity of taking protective measures against hazardous contact voltage

In order to make the trainees aware of the necessity of taking protective measures against hazardous contact voltage, their attention should be drawn especially to the protection of human life, health and labour as a basic human concern. It presents itself in this context to point to the harmful effects of electric current on human organism.

In support, the representation of the sensation measurements with passing of alternating current may be used which is contained in the complex material "How to Act after Accidents Caused by Electric

Current". Also it can be dealt with known electricity-caused accidents due to inexpert installation or defective protective measures. With the help of examples, the trainees should be made aware of the importance of working carefully, reliably and free of faults.

It should also be mentioned that the manufacturer of electrical devices, motors, cables etc. is obliged to insulate them for the respective working voltage.

Protection of man has priority over functioning of any electrical device!

Potential equalization

Here, the instructor together with the trainees should repeat the factors which may lead to the destruction of the insulation. Furthermore, the trainees must realize that by insulation defects voltages may be transferred to metallic parts that do not belong to the service circuit. Also it must be made clear that the thus created potentials between the metallic parts are dangerous for man. Starting from this, it is explained to the trainees how potential equalization and zero potential are created.

Therefore the knowledge of the zero potential the trainees have already acquired should be used. It is of paramount importance to draw the attention to the point that counting devices and plastic parts (non-conducting materials) in pipe systems have to be bridged.

The potential equalization must not be interrupted by the removal of certain parts.

Protective measures against hazardous contact voltage

Here, it is started from the fact that in electrical plants – except test and pilot plants – protective measures against hazardous contact voltage are required.

It is also important to explain to the trainees the division of the protective measures in two groups as well as the possibilities of further subdivision.

The fault-current circuit (Fig. 3 of the Trainees' Handbook...) should be explained in detail to the trainees with the help of a blackboard drawing or projected diagram, because the fault-current circuit is the basis of the understanding of the individual protective measures.

Protective insulation

In explaining this protective measure, special emphasis should be put on the following points:

- forms
- fields of application
- testing.

The criteria have to be mentioned and demonstrated by appropriate examples.

For the chapter of testing, the complex material of "Testing of Electrical Plants" may be used. Do not forget to point out that defects of the protective insulation must not be repaired by provisional mending.

Defects are repaired only by replacing the original parts.

Protective low voltage

Point out to the trainees that this is the most effective and safe protective measure. Its application is limited, though. This results from the reduced rated voltage and the involved operating currents which – with equal transferred power – are approximately 5 to 10 times greater than, for instance, with 220 V alternating voltage. For the trainees it is important to understand from this that for the low voltage plant and the service equipment required essentially greater conductor cross sections are necessary.

Protective low voltage plants are operated only up to approximately 4 kW.

Then, the criteria, required devices and fields of application are explained.

Plants of this kind, if available, should be demonstrated. Also give demonstration of inspection and measurement. If possible, the trainees should practise this at the plants shown to them.

Protective isolation

Before explaining the main points of this protective measure, repeat the term "galvanic isolation" together with the trainees.

Input and secondary end of the devices that create the protective isolation must be connected with each other only through the magnetic flux. There must be no current-conducting connection.

After this, the fields of application are deduced. Underline why not fault current can flow with the protective isolation because of "non-earthing". Explain to the trainees what measures enable the operation of more than one electrical device with this protective measure. (Potential equalization leads and common base.)

Lacking potential equalization leads and the existence of two faults at different conductors of the supply line may lead to a dangerous contact voltage.

Protective conductor system

Here, the criteria and conditions of this protective measure should be dealt with first. Then, the mode of action is explained, which may be repeated by some trainees. The fields of application should be determined together with the trainees. Point out the high degree of safety of this protective measure. As the reason of this mention the great extent of this measure.

Also, demonstrate the testing of this protective measure. Demonstration should be followed by the trainees exercising the testing.

Protective earthing

The mode of action of the measure of protective earthing is explained for both possibilities:

- closing of the fault-current circuit by the ground and
- closing of the fault-current circuit through the water pipe system.

For this purpose, prepare appropriate diagrams on the blackboard. Then, explain the criteria of the measure of protective earthing and demonstrate one calculation of the protective earthing resistance for the two possibilities, each.

When explaining the fields of application of the measure of protective earthing, make sure that the trainees understand that this measure has some disadvantages, though. When coming to the testing of the protective measure, explain to the trainees, that at first the earthing resistance has to be calculated and then checked by measuring.

Connection to neutral

This protective measure can be elaborated together with the trainees on the basis of Fig. 11 of the "Trainees' Handbook of Lessons".

In doing so, the difference to the measure of protective earthing must become clear.

Most of the criteria of this protective measure, too, can be found out together with the trainees with the help of the illustration. The rest of the criteria is explained by the instructor.

Then, the fields of application and the testing of this measure are dealt with.

In the context of this protective measure, put the main emphasis on the explanation of the following points:

- If the conductors are very long, the resistance has to be kept as low as possible. (This is achieved by earthing the neutral conductor at the network ends).
- The neutral conductor must not be fused or separately switched.
- This protective measure becomes inefficient, if too strong fuses are used.
- In the case of fracture of the conductor before the plant, all casings of the devices that are switched on carry the full mains voltage in the absence of potential equalization.

Fault-voltage protective system

To explain the mode of action of this protective measure, a blackboard diagram for projection may be prepared, too.

Fig. 12 of the "Trainees' Handbook of Lessons" would also be suitable. It is also important to show a fault-voltage protective switch and demonstrate its mode of action.

This is followed by the explanation of the criteria and application of this protective measure.

In doing so, put special emphasis on the following points:

- The resistance of the auxiliary earthing must not exceed a certain maximum admissible value.
- The cross section of the protective conductor must not be less than a definite value.
- Testing of the serviceability.
- Measuring the resistance of the auxiliary earthing. (Therefore, use the Fig. 13 of the "Trainees' Handbook of Lessons". It is suitable to support the explanation of the measuring circuit.)

Fault-current protective system

For explaining the mode of action start from the fact that with normal operation the sum of all conductor currents including the neutral conductor amounts to zero.

(Unequal intensity in the external conductors is of no importance in this respect!)

Only if a fault current flows, the total of these currents is unequal to zero and the protective system comes into action.

While afterwards the criteria and application of this protective measure are elaborated with the trainees, it is absolutely necessary to calculate an example of the resistance of the protective earthing system.

With this protective measure, too, the functioning of the protective system has to be demonstrated and then practised by the trainees.

Put special emphasis on the following points:

- Fault-current protective switches are manufactured, for instance, with rated fault-current intensities of 15 mA, 30 mA, 80 mA, 100 mA, 200 mA, 300 mA and 500 mA.
- The fault-current protective system can be combined with the connection to neutral.
- Switches are manufactured for rated current intensities up to 80 A. (Beyond this limit, they are used in combination with transducer cores, trip coils and contactors.)
- The fault-current protective system needs a good insulation value. (Otherwise, currents caused by insulation damages lead to the switching off.)
- The fault-current protective system may also be used in three-phase systems without earthed net point.

Isolating fault-current protective system

In explaining this protective measure, start from the fact that its mode of functioning is similar to that of the fault-current protective system.

In contrast to the fault-current protective system, this system is operated with the help of an isolating transformer the neutral point of the secondary side of the transformer being earthed over a coil.

In elaborating the criteria of this protective measure, special value should be attached to the breaking fault current, the resistance of the protective earthing and the insulation resistance between conductor and protective conductor as well as to the capacity between conductor and earthing.

The functional testing has to be demonstrated especially carefully because, for this purpose, the input end of the isolating transformer has to be disconnected from the supply system.

It is not allowed to work at the alive system, except for certain special conditions and observing all required protective measures.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

In the instruction examples, the sequence of operations including a diagram is to be found. Furthermore, they contain a list of the materials, working tools, testing and measuring tools, auxiliary means as well as basic knowledge required for each instruction example. Appropriate comments are made to the sequence of operations in order to provide the trainees with all the information they need to fulfill their tasks orderly and taking into consideration the respective protective measures. When organizing the work with the instruction examples, the following hint should be heeded:

- The trainees shall carry out the tasks of the instruction examples by themselves.

This enables the instructor to watch the work of each trainee, to correct it and to assess them justly.

3.3. Examples for Recapitulation and Tests

For consolidating and testing the knowledge and skills acquired, questions are composed in this section.

To each question the respective answer is given.

Questions contained in the "Trainees' Handbook of Lessons" are marked with the letter "A".

1. What is the aim and purpose of protective measures?

(Protection of human life, health and ability to work)

2. Why is it necessary to take protective measures even if cables, electrical devices and plants are sufficiently insulated?

"A" (Natural ageing, destruction due to inexpert use, premature ageing by climatic influences and chemical effects may lead to dielectric breakdowns that make conductive parts alive.)

3. Why must the potential equalization not be broken when certain parts are removed?

(Because in this case a potential may be created which, when bridged by the body, may cause a mortal current flow.)

4. How can a potential equalization to zero potential be achieved?

"A" (When all metallic parts, such as water pipes, gas mains, central heating, metallic sheathings of cables and other metal constructions, are connected with one another and with the ground in a conductive way.)

5. What line cross-sections should be used for potential equalization?

"A" (10 mm² copper, 25 mm² aluminium, 50 mm² steel.)

6. Where is the protective insulation preferably used?

"A" (household appliances/except thermal appliances, cosmetic and massage as well as do-it-yourself equipment.)

7. Where is the protective low voltage used?

"A" (Electrical toys, cosmetic and massage appliances without protective insulation, inspection lamps and electrical tools for boiler and large pipe systems, vibrating devices.)

8. Where is the protective isolation used?

"A" (In all plants and parts of plants in which especially great danger may be evoked by contact with large metallic constructions, furthermore, for operating physiotherapeutical equipment for medical purposes as well as for shaving sockets in washrooms of passenger trains.)

9. Where is the protective conductor system used?

"A" (In factories where the failure of one machine leads to a disturbance of the entire manufacturing process; with electrical plants in operating theatres; in miming.)

10. What value must the test resistance of a protective conductor system have with a mains voltage of 220 V?

"A" (5.5 kilohms)

11. Where is the protective earthing used?

"A" (Mainly in all nets which cannot be connected to neutral.)

12. Why can the protective earthing give a limited protection only?

(Because the earth transistor resistance – due to climatic influences – is subject to fluctuation; because the required earthing resistances are difficult to achieve; because the single-pole switching-off of three-phase current consumers may cause defects at these consumers.)

13. Where is the connection to neutral used?

"A" (In all nets with sufficiently earthed neutral conductor/zero conductor; because of the simple and cheap application in all fields of electric current.)

14. Why does the protective measure of "connection to neutral" become inefficient if a too strong fuse is connected before?

(The defective external conductor does not switch off quickly enough so that the fault voltage remains at the defective equipment.)

15. Where is the fault–voltage protective system used?

(In order plants, where it has not yet been replaced by the fault–current protective system. By fault–voltage protective switches, neutral conductors can be controlled.)

16. Where is the fault–current protective system used?

"A" (It can be installed in all electrical plants with three–phase or alternating current and can be combined with the protective measure of "connection to neutral".)

17. Where is the isolating fault–current protective system used?

"A" (Mainly in ship building.)

**Protective Measures against Hazardous Contact Voltage – Course:
Basic Skills and Knowledge of Electrical Engineering. Instruction
Examples for Practical Vocational Training**

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Protective Measures against Hazardous Contact Voltage – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Introduction

The present material contains 3 selected instruction examples on the basis of which essential skills shall be exercised in the field of protective measures against hazardous contact voltage.

Since these protective measures against hazardous contact voltage are mastered only by much practice, the instruction examples have to be repeated continuously.

In order to facilitate the preparation and accomplishing of the exercises, for each instruction example – if required – the necessary materials, measuring and testing tools, auxiliary means and basic knowledge are mentioned, which must be available to carry out the tasks.

In addition to the sequence of operations, sketches are enclosed illustrating the carrying out of the exercises.

Instruction Example 4.1. Preparation of a Potential Equalitation

Material

Potential equalization bar,
Pipe clips of the required size,
Potential equalization lines of the required lengths and cross section

Working tools

Screw driver, wrench, round-nose-pliers, wire brush, cable stripper, soldering iron or blow lamp for soldering

Measuring and testing tools

.Folding rule

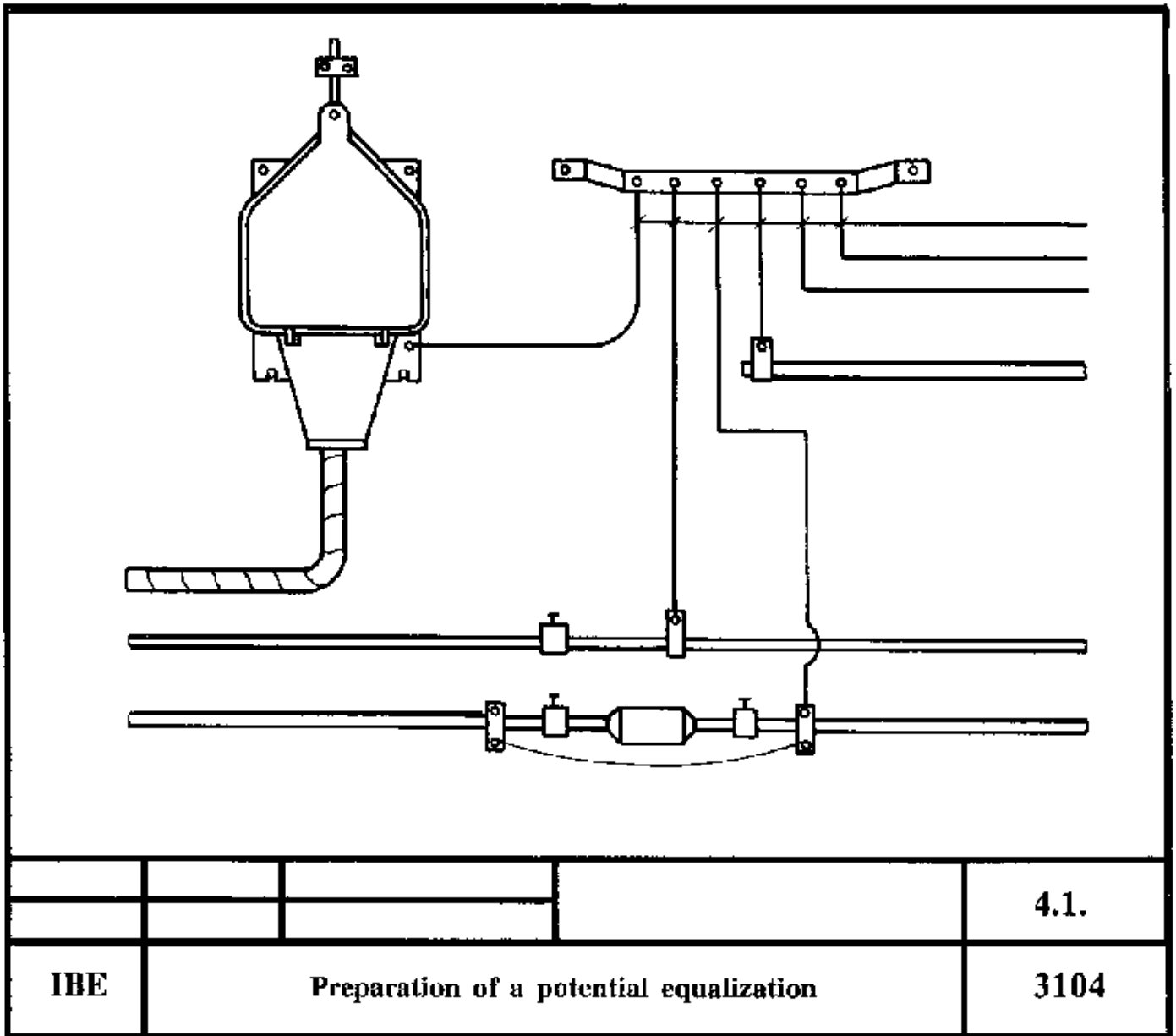
Auxiliary means

Cable fixing clips, cable eyes, flux, tin-base solder, flameproofing tape, insulating tubing or winding tape, anti-corrosive grease

Required basic knowledge

Knowledge of the necessity of potential equalization, measuring, application of pipe clips, working at, fixing and connecting of lines

Sequence of operations	Comments
1. Finding out which parts, building constructions and plants have to be included in the potential equalization	All conductive parts, such as pipe systems, heating systems, metal jackets, other metal constructions etc.
2. Application of the potential equalization bar	
3. Determining the path of the potential equalization lines	
4. Application of the pipe connecting clips	Gas and water meters in pipe systems have to be bridged!
5. Application of the cable fixing clips	
6. Laying the potential equalization lines	
7. Connecting the potential equalization lines	
8. Testing the potential equalization	Visual inspection, measuring



Preparation of a potential equalization

Instruction Example 4.2. Testing of the Protective Measure of "Protective Insulation"

Measuring and testing tools

Protective insulation testing instrument, insulation resistance measuring instrument

Auxiliary means

Measuring lines, test prods

Required basic knowledge

Criteria of the protective insulation, handling of measuring and testing tools, knowledge of measuring and testing processes, how to act after accidents caused by electric current

Sequence of operations

Comments

1. Visual inspection

- Determination of the form of the protective insulation
- No visible damage of the insulation
- No protective conductor connections

2. Measuring

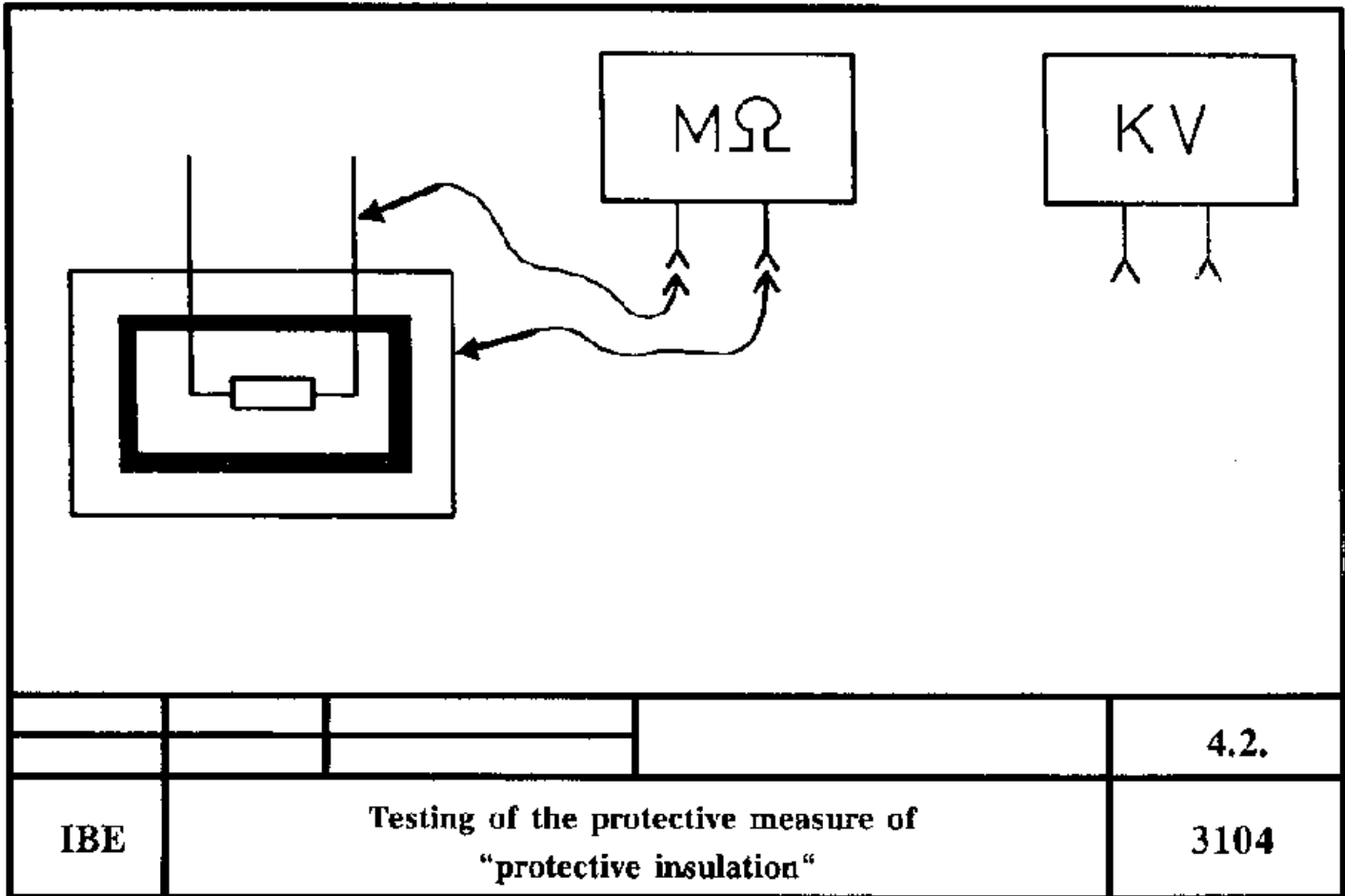
- Testing of the protective insulation

Attention "high voltage" – observe safety instructions!

The protective insulation must stand an alternating current test voltage of 4 kV for at least one minute. (After testing, no damage must be visible at the insulation, such as rupture, arcing or deformation.) With high voltage testing at electronically controlled machines, electronics have to be disconnected or bridged.

- Testing the insulation resistance

The insulation resistance must be at least 1.5 megaohm with a measuring voltage of 100 V!



Testing of the protective measure of "protective insulation"

Instruction Example 4.3. Testing of the Protective Measure of "Protective Conductor System"

Testing and measuring tools

Insulating resistance measuring instrument

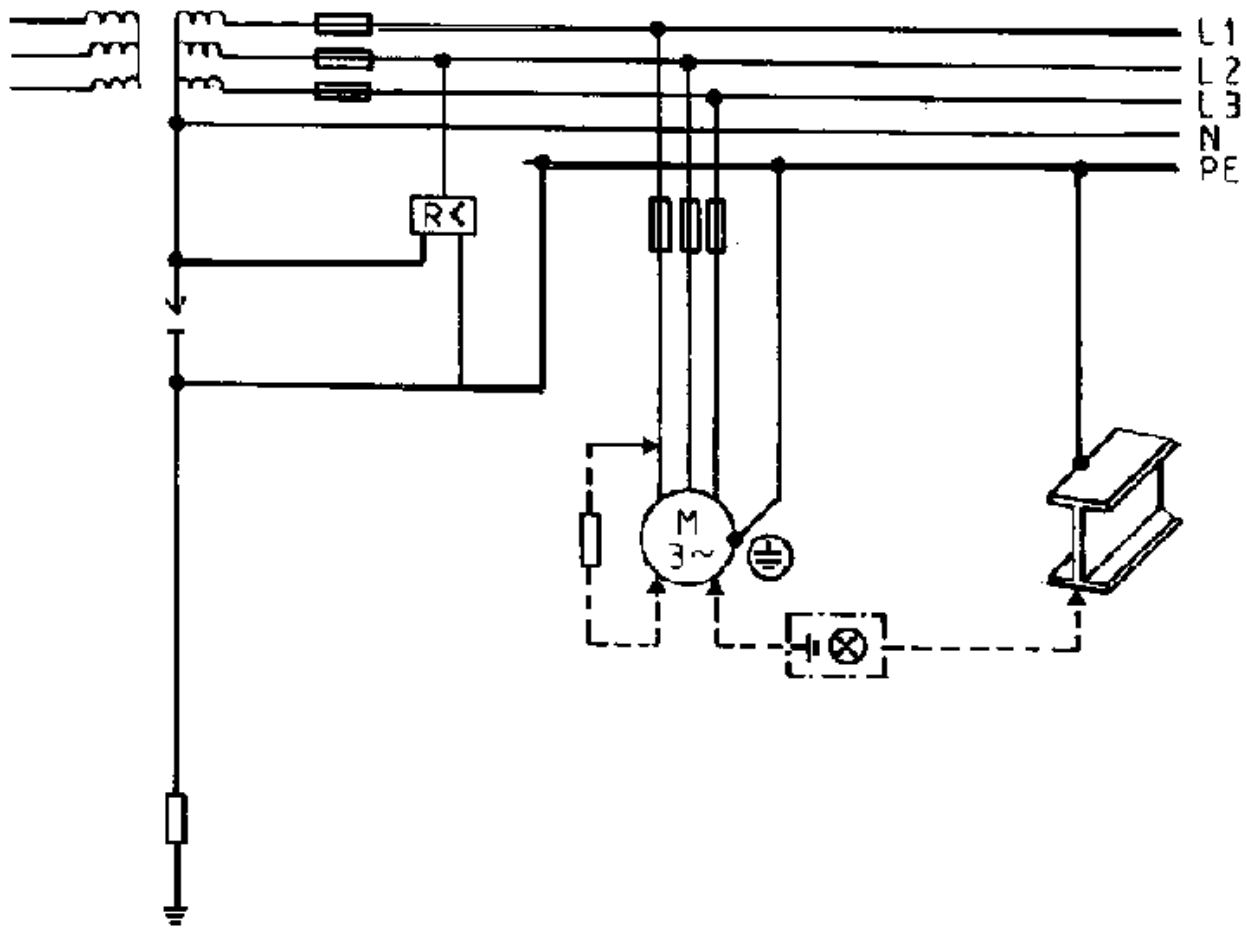
Auxiliary means

Measuring lines, test prods

Required basic knowledge

Criteria of the protective conductor system, handling of measuring and testing tools, knowledge of measuring and testing processes, how to act after accidents caused by electric current

Sequence of operations	Comments
1. Visual inspection	
– Plant has an own transformer	
– Neutral point of transformer is earthed by a fusible cut-out	
– All metallic pans that do not belong to the service circuit are connected with each other by a protective conductor	The protective conductor must not be connected with the neutral conductor!
2. Measuring	
– The insulation resistance is greater than 25 ohms/volt	
3. Functional testing	
– The insulation resistance is to be reduced to a value less than 25 ohms per volt	Supervisory facility must switch off!



				4.3.
IBE	Testing of the protective measure of "protective conductor system"			3104

Testing of the protective measure of "protective conductor system"

**Protective Measures against Hazardous Contact Voltage – Course:
Basic Skills and Knowledge of Electrical Engineering. Trainees'
Handbook of Lessons**

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Protective Measures against Hazardous Contact Voltage – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Introduction

The present handbook is meant for training in electrical engineering trades.

It describes the activities and equipment required for protective measures against hazardous contact voltage.

The required methods are described in self-contained sections. The required knowledge and skills are explained in the necessary sequence of actions in each section. The illustrations included support the text and broaden the contents of the individual sections.

In support of the learning process questions are included for the trainee to check his knowledge.

1. The Necessity of Protective Measures against Hazardous Contact Voltage

The protection of human life, health and capacity for work is a basic human concern. Therefore, in electrical plants with or without earthed net point, it is necessary to take protective measures against hazardous contact voltage if the conductor-earth voltage exceeds

- 50 V with alternating current or
- 120 V with direct current!

Accidents due to electricity are often caused by improper installation or missing and/or defective protective measures.

Manufactures of electrical equipment are obliged to insulate this equipment for the respective working voltage.

Why is it still necessary to take protective measures, even if cables, electrical equipment and plants are sufficiently insulated?

The protection of man against hazardous contact voltage has priority over function!

2. Potential Equalization

The voltage of a conductor or body to earth is called the "potential" of this conductor or body. The earth is electrically neutral and thus has the potential "zero". The unit of measurement for the potential is volt.

A conductor or body has the potential "zero" – earth potential – if it is conductively connected with the earth.

As a consequence of damages to the insulation, voltages may be transmitted to metal parts which do not belong to the service circuit.

This causes the development of potentials between the metal parts which might be dangerous for man.

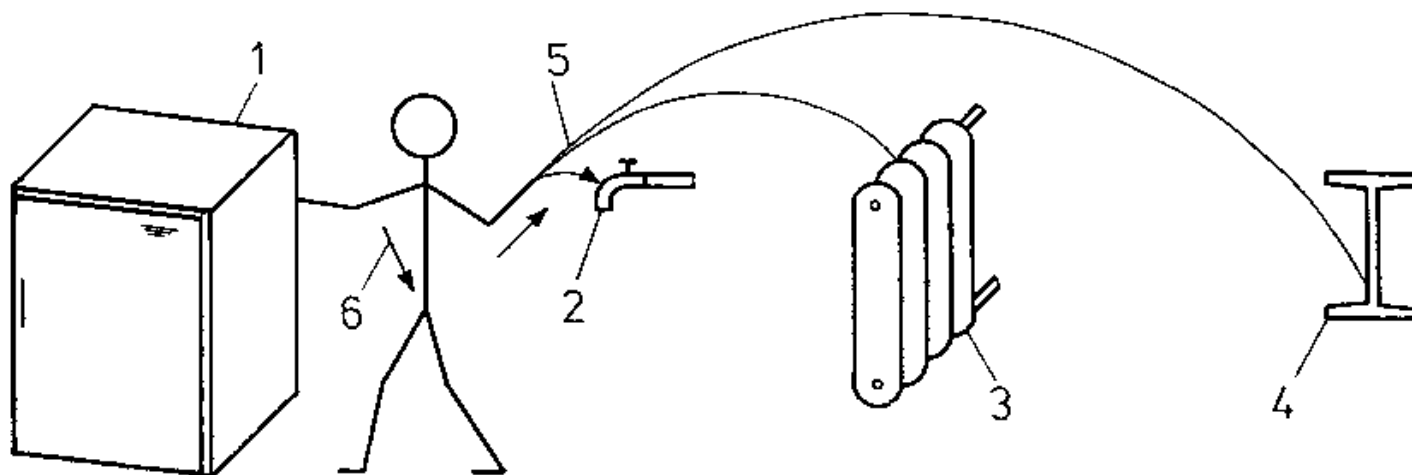


Figure 1 – Potential development between metallic parts with insulation damage – 1 defective device, 2 pipe conduites, 3 central heating, 4 metallic constructions, 5 potential developed, 6 current through human body

If a man touches two different metal parts at a time – for instance an electrical device and a water pipe – he bridges the existing potential and a current flows through his body.

If an electric current flows through the body of a human being, this might be mortal.

A remedy to this is a potential equalization to zero potential.

How can a potential equalization to zero potential be achieved?

The potential equalization must not be broken by the removal or demounting of parts.

What line cross-sections should be used for potential equalization?

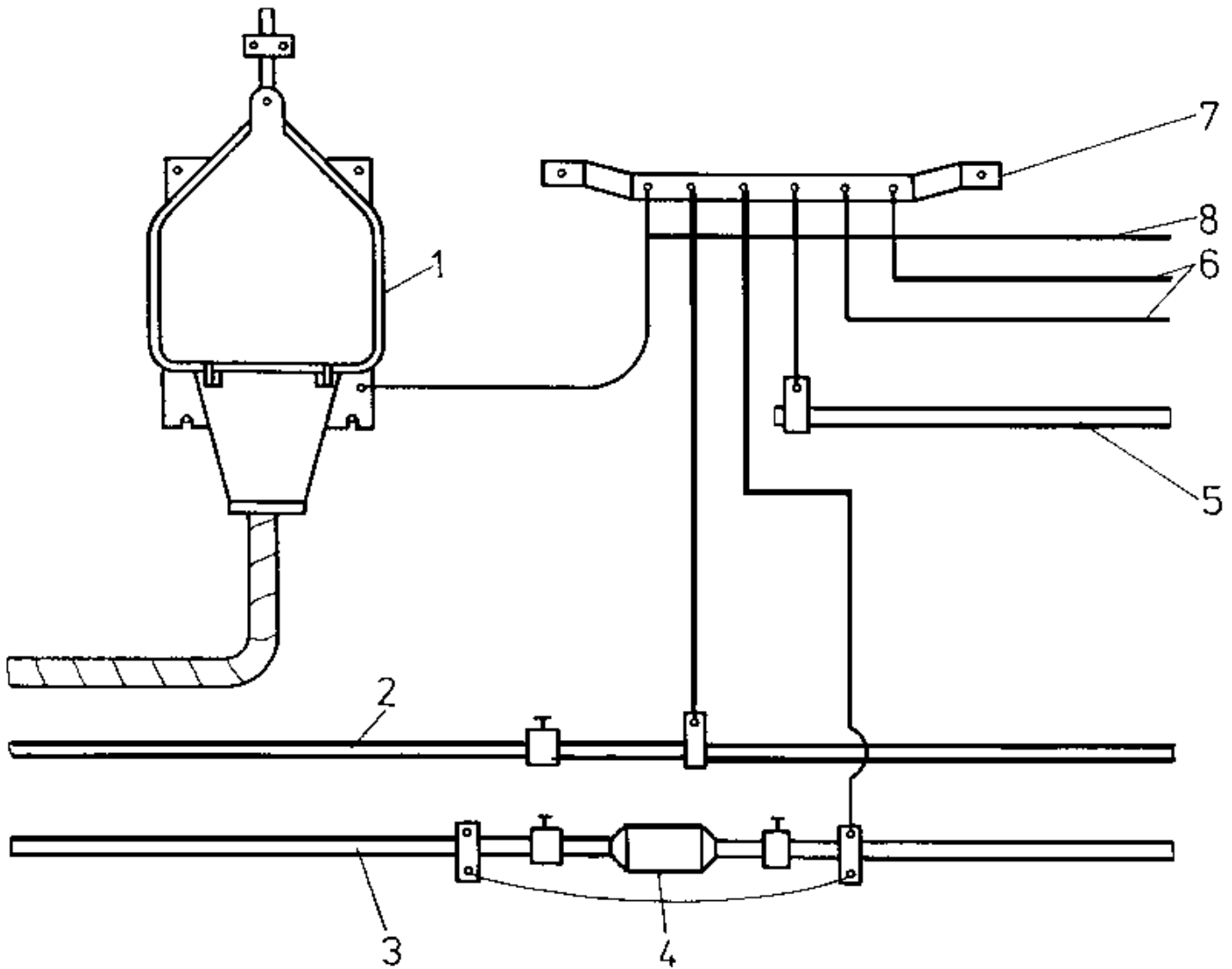


Figure 2 – Potential equalization – 1 service box, 2 gas main, 3 water pipe, 4 water meter, 5 heating pipe, 6 leads for further metallic parts, 7 potential equalization bar, 8 potential equalization leads

3. Protective Measure against Hazardous Contact Voltage

These are subdivided in two groups.

Group 1: Protective measures preventing the development of hazardous contact voltage.

- protective insulation
- protective low voltage
- protective isolation
- protective conductor system

Group 2: Protective measures which prevent that hazardous contact voltage continue to exist.

- protective earthing
- connection to neutral
- fault-voltage protective system
- fault-current protective system
- isolating fault-current protective system

If the protective measures are categorized with respect to the presence of a protective conductor, the following subdivision results:

Protective measures "without" protective conductor

- protective insulation
- protective low voltage
- protective isolation

Protective measures "with" protective conductor

- protective conductor system
- protective earthing
- connection to neutral
- fault-voltage protective system
- fault-current protective system
- isolating fault-current protective system

Technical terms recurring with the individual protective measures have to be used according to Figure 3:

- contact voltage (1)
- fault-voltage (2)
- fault-current (3)
- body resistance between current entry and exit points (4)
- transition resistance of the station point (5)
- resistance of earth (ground) (6)
- resistance of earth bus (7)

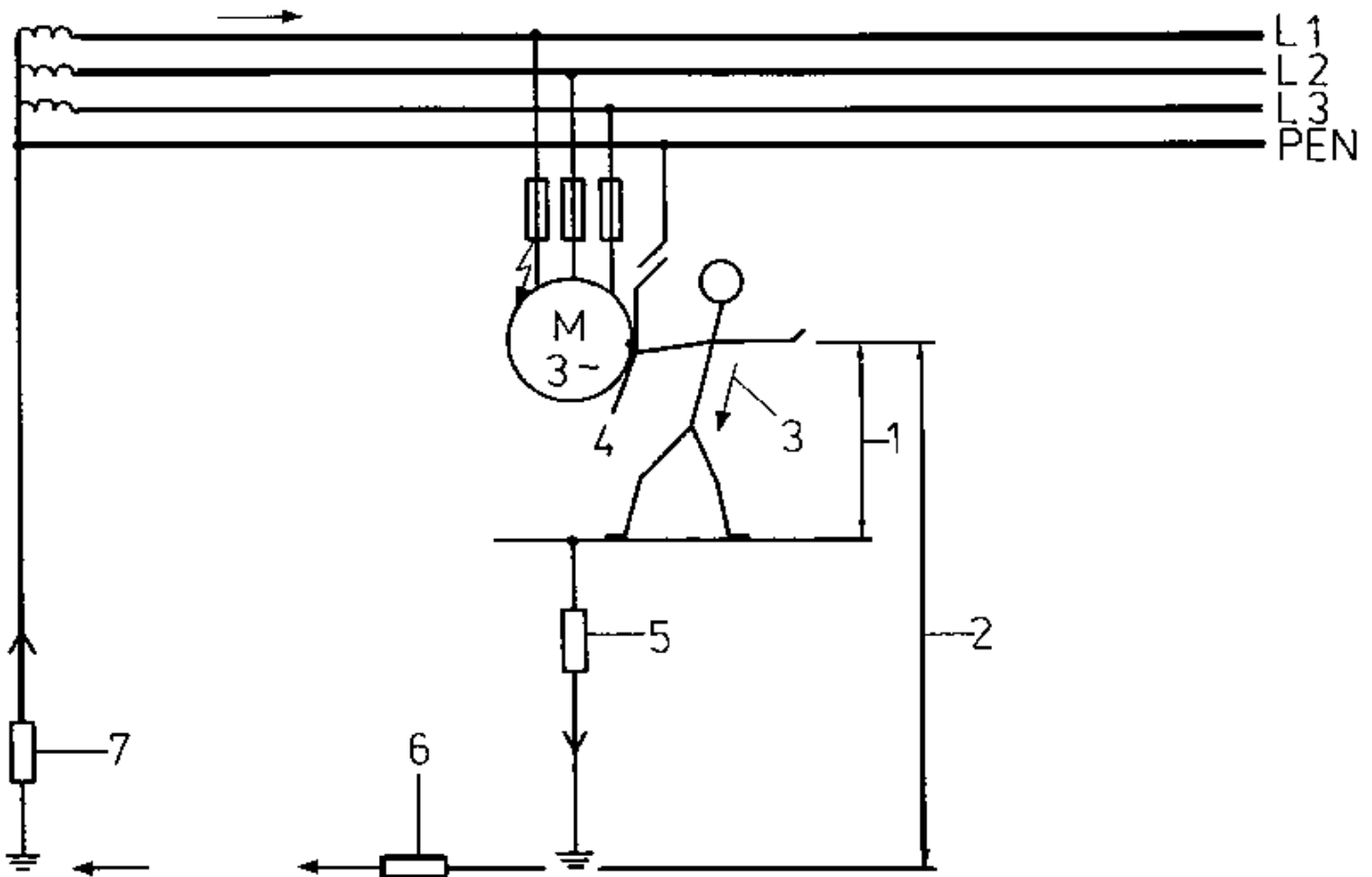


Figure 3 – Fault-current circuit – 1 contact voltage, 2 fault voltage, 3 fault current, 4 body resistance between current entry and exit points, 5 transition resistance of station point, 6 resistance of the ground, 7 resistance of earth bus

3.1. Protective Measures Preventing the Development of Hazardous Contact Voltage

Protective insulation

Criteria of the protective insulation

- The protective insulation is used in addition to the operating insulation.
- The protective insulation must stand an alternating current test voltage of at least 4 kV for one minute without any damage to the insulation being visible afterwards.
- Protection-insulated electrical equipment is not provided with safety plugs by the manufacturer. If a repair should require that such a plug is fitted and if the connecting line should have a protective conductor, this has to be connected to the plug – not to the device.
- Protection-insulated electrical equipment is marked by a double square on the casing.

Protection-insulate electrical equipment is not connected by a safety plug.

Forms of protective insulation are:

- protective insulation sheathing
- intermediate protective insulation
- reinforcing insulation a b c

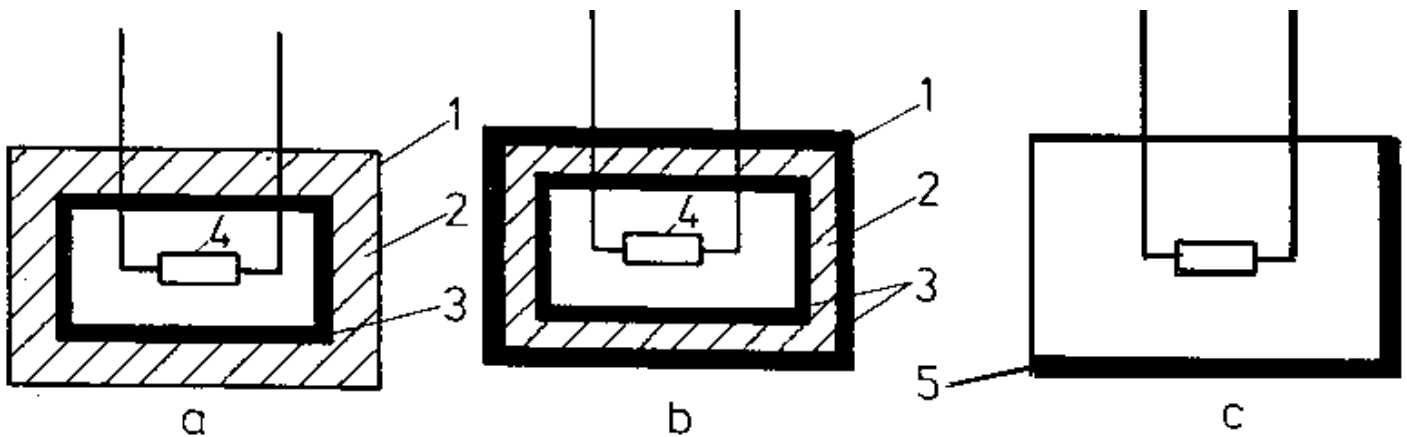


Figure 4 – Forms of protective insulation a protective insulating sheathing, b intermediate protective insulation, c reinforcing insulation – 1 casing (metal or plastic), 2 protective insulation, 3 service insulation (normal), 4 live parts, 5 service insulation (reinforced)

Where is the protective insulation preferably used?

Checking of the protective measure of "protective insulation"

Inspection:

- visible defects of the protective insulation
- no connection of protective conductor
- marking by double square

Measuring:

- measuring of the insulation resistance between life parts and accessible conductive parts

The resistance of the insulation must be at least 1.5 megaohms with a measuring voltage of 100 V direct current voltage

Protective low voltage

Criteria of the protective low voltage

- The protective low voltage must not exceed an alternating current voltage of
 - 25 V with load and
 - 50 V without load.
- The parts generating the protective low voltage as well as the conductors must not be secondary–earthed.
- The secondary side must not be connected with leads of other circuits.
- Plug connections must have no secondary protective contacts.
- Electrical equipment operated with protective low voltage must have no connecting points for the protective conductor.
- Accumulators have to be disconnected from the circuit of protective low voltage by all poles during the process of charging.

For protective low voltage, only special plug–in devices must be used.

Devices for generating protective low voltage are:

- insulation transformers
- generators
- transformers with electrically separated windings
- accumulators
- galvanic cells

Where is the protective low voltage used?

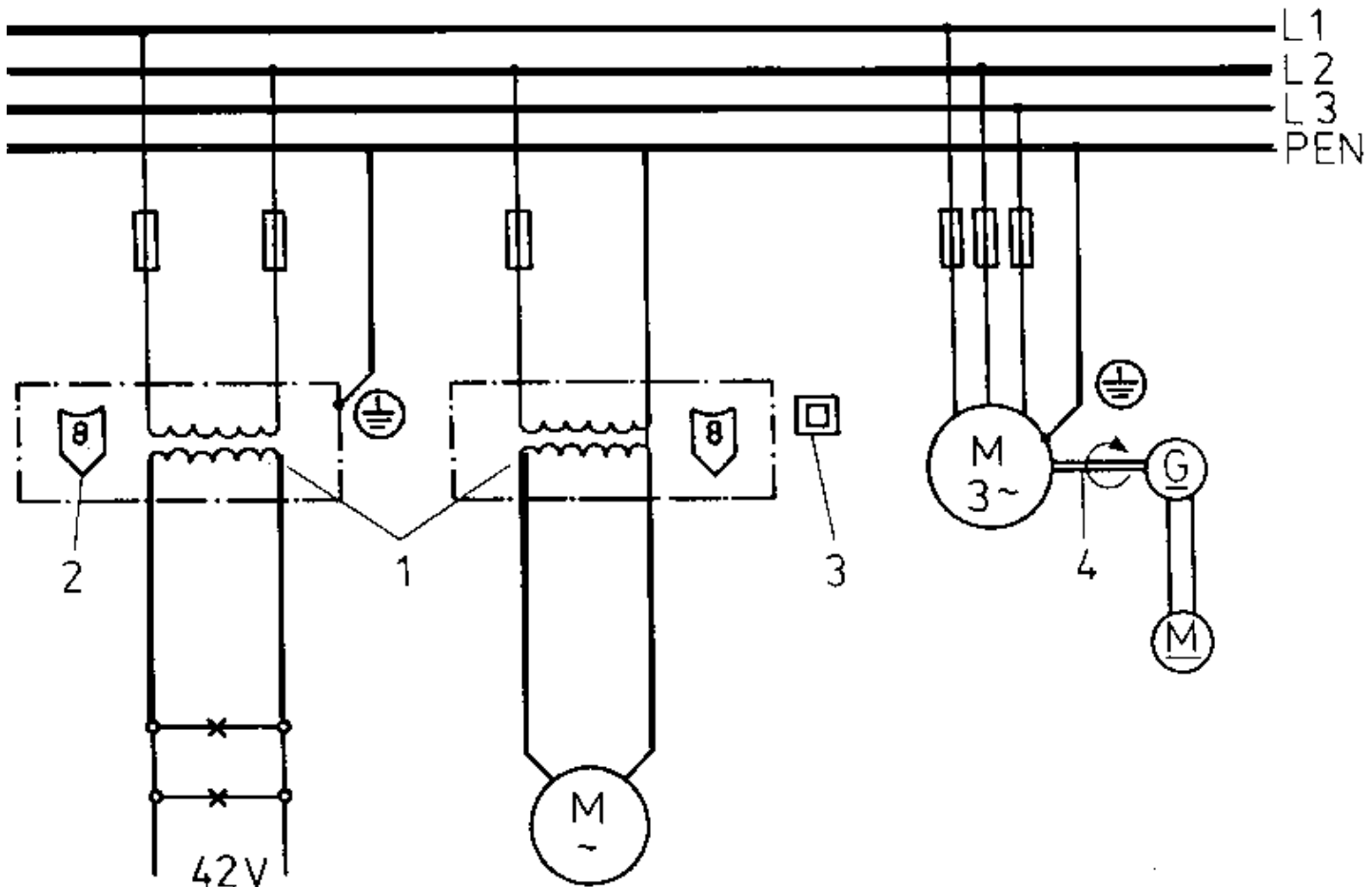


Figure 5 – Generation of a protective low voltage by protective transformer or motor generator – 1 protective transformer, 2 symbol of protective low voltage, 3 symbol of protective insulation, 4 motor generator

Checking of the protective measure of "low voltage"

- By inspection whether the plant and devices meet the required criteria.
- By measuring whether the permissible voltage is not exceeded.

Protective isolation

Criteria of protective isolation

- The protective isolation is accomplished if there is a galvanic isolation between the service circuit and the circuit supplying the energy. (The input end and the secondary end must be connected only through the magnetic flux!)
- When isolating transformers are used, only one device must be connected to each secondary winding.
- Circuits with protective isolation must not be earthed or connected with conductors of other circuits.
- Metal casings of electrical tools, which are used in boiler plants or other kinds of metal constructions, have to be connected in a conductive way with the latter. (Potential equalization has to be created!)
- The working voltage with load must not exceed 380 V three-phase current.

With the protective isolation, no electric connection must come into existence between the input end and the secondary end!

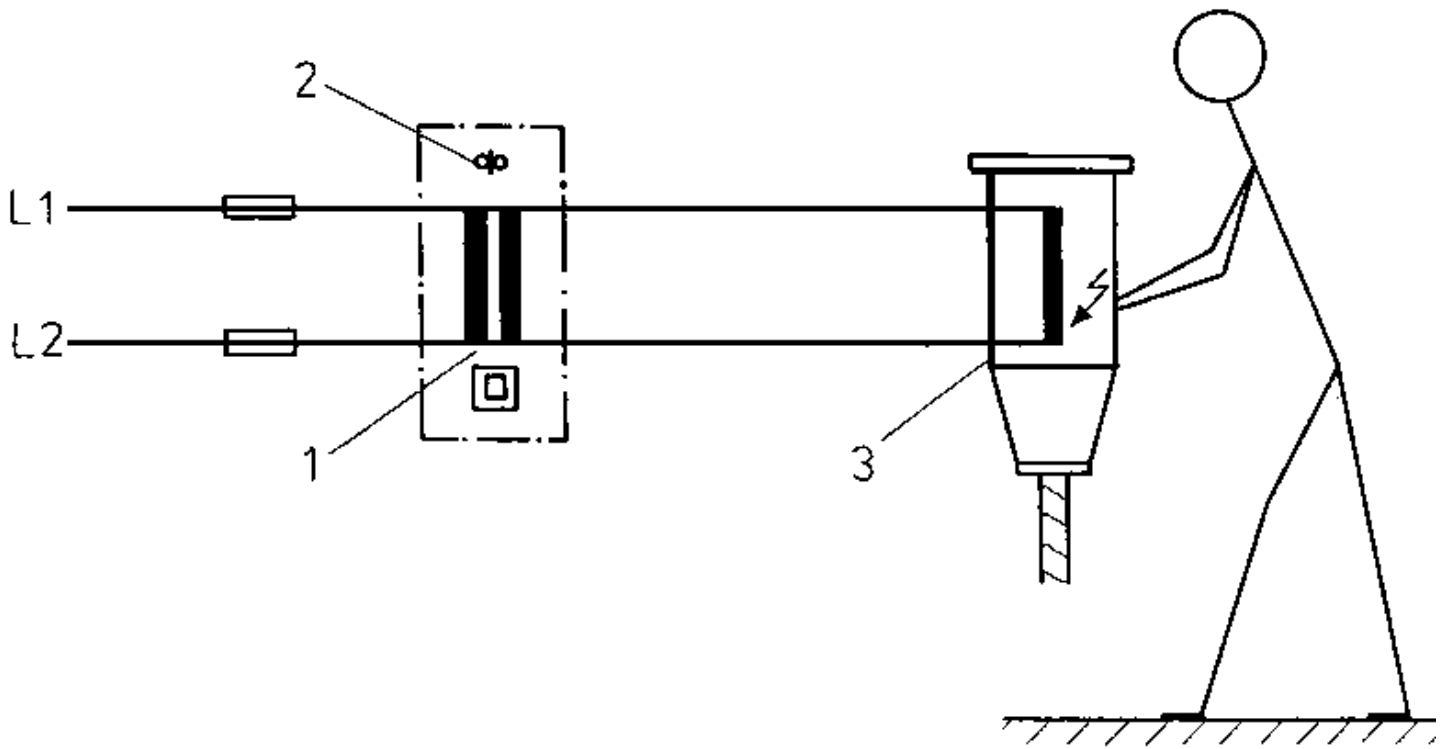


Figure 6 – Protective isolation – 1 isolating transformer, 2 symbol of protective isolation, 3 device

Devices for creating the protective isolation are:

- isolation transformers with a transformation ratio 1:1
- motor generators
- transformers with galvanically isolated windings

Where is the protective isolation used?

Checking of the protective measure of "protective isolation"

- By inspection whether the plant and devices used meet the required criteria.

Protective conductor system

Criteria of the protective conductor system

- The protective conductor system can only be used in plants with an own transformer.
- The neutral point of the transformer must be earthed through a fusible cut-out.
- All metallic parts and casings that do not belong to the service circuit, have to be connected with each other through the protective conductor.
- The protective conductor must not be connected with the neutral conductor.
- The maximum value of the earthing resistance of the protective conductor is 20 ohms.
- The supervisory equipment must switch off or signalize if the insulation resistance of current-carrying conductors towards the earth falls below 25 ohms/volt.

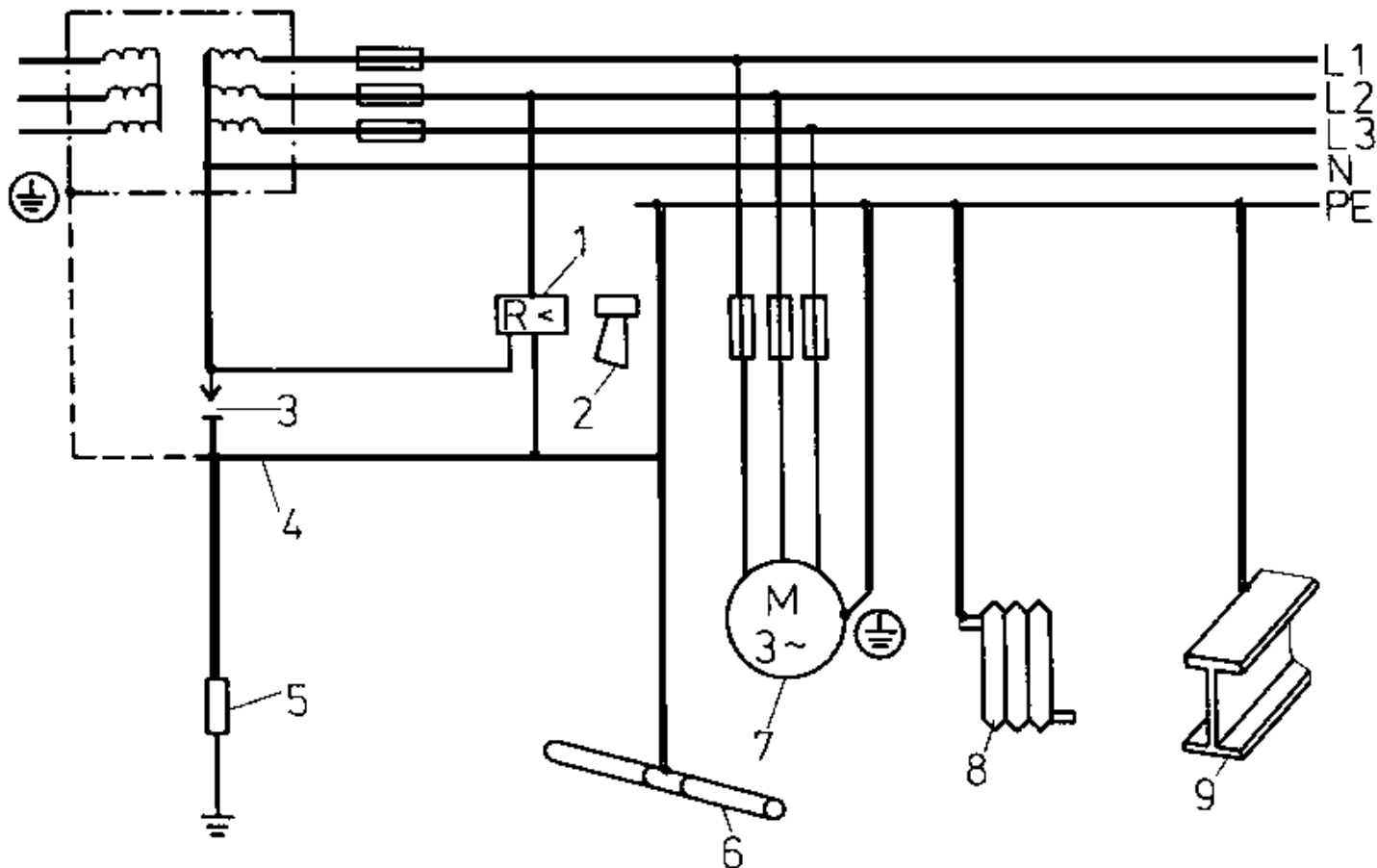


Figure 7 – Principle of the protective conductor system – 1 supervisory equipment, 2 alarm, 3 fusible cut-out, 4 protective conductor, 5 resistor, 6 water pipe system, 7 motor, 8 heating system, 9 metal construction

Where is the protective conductor system used?

Checking of the protective measure of "protective conductor system"

- The criteria of this protective measure are checked by visual inspection.
- By measuring, the insulation resistance between current-carrying conductor and earth as well as between the metallic parts is checked.

With the insulating test 25 ohms/volts are required.
If this level is not achieved, the supervisory equipment must switch off the plant and/or circuit.

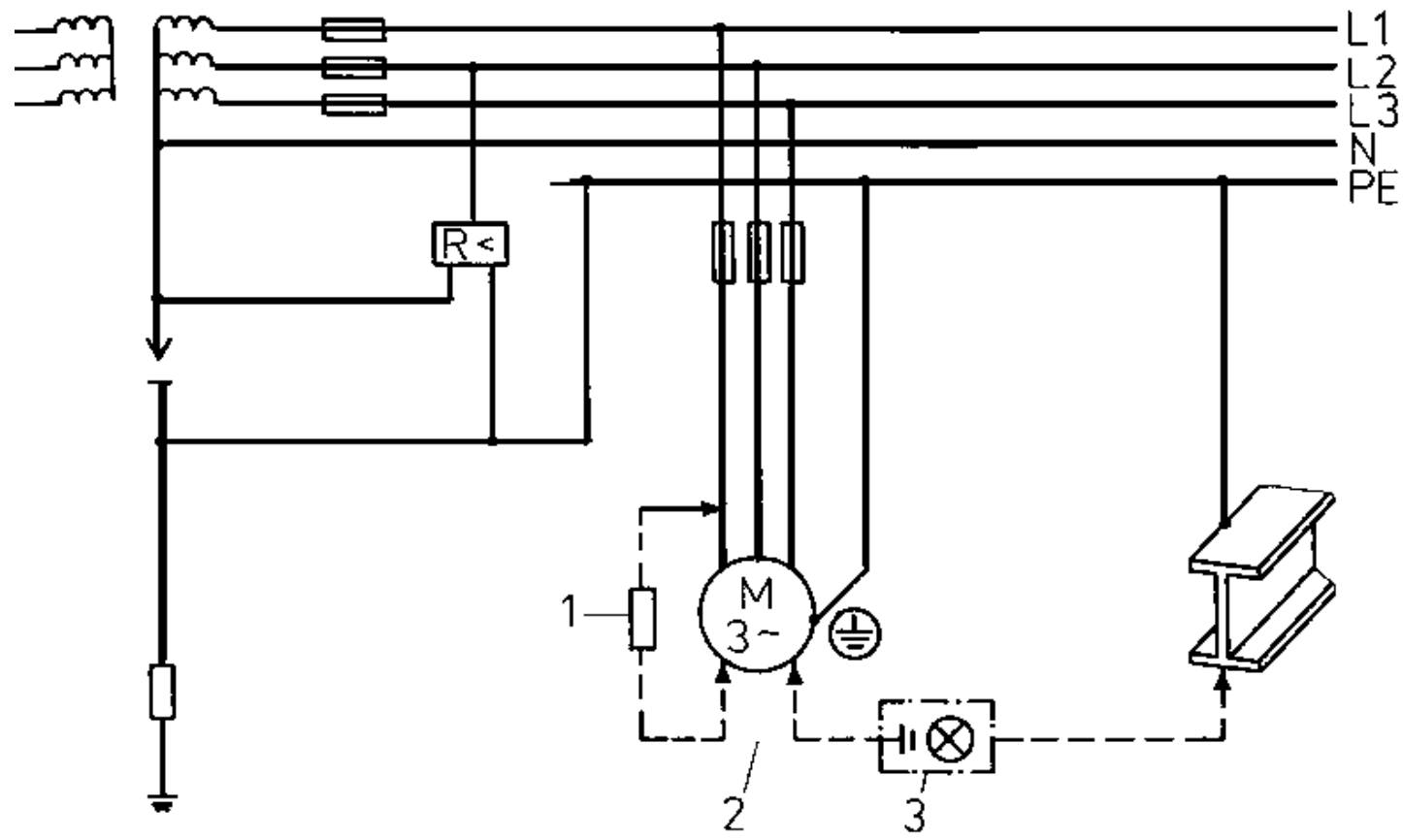


Figure 8 – Testing process – 1 test resistance, 2 test prods, 3 continuity tester

What must be the value of the test resistance with a mains voltage of 220 V?

3.2 Protective Measures which Prevent that Hazardous Contact Voltages Continue to Exist

Protective earthing

Mode of action of the protective earthing – When it comes to fault current, the fault-current circuit is closed by

- earth or
- via metallic conductors, such as water pipes or cable sheathings

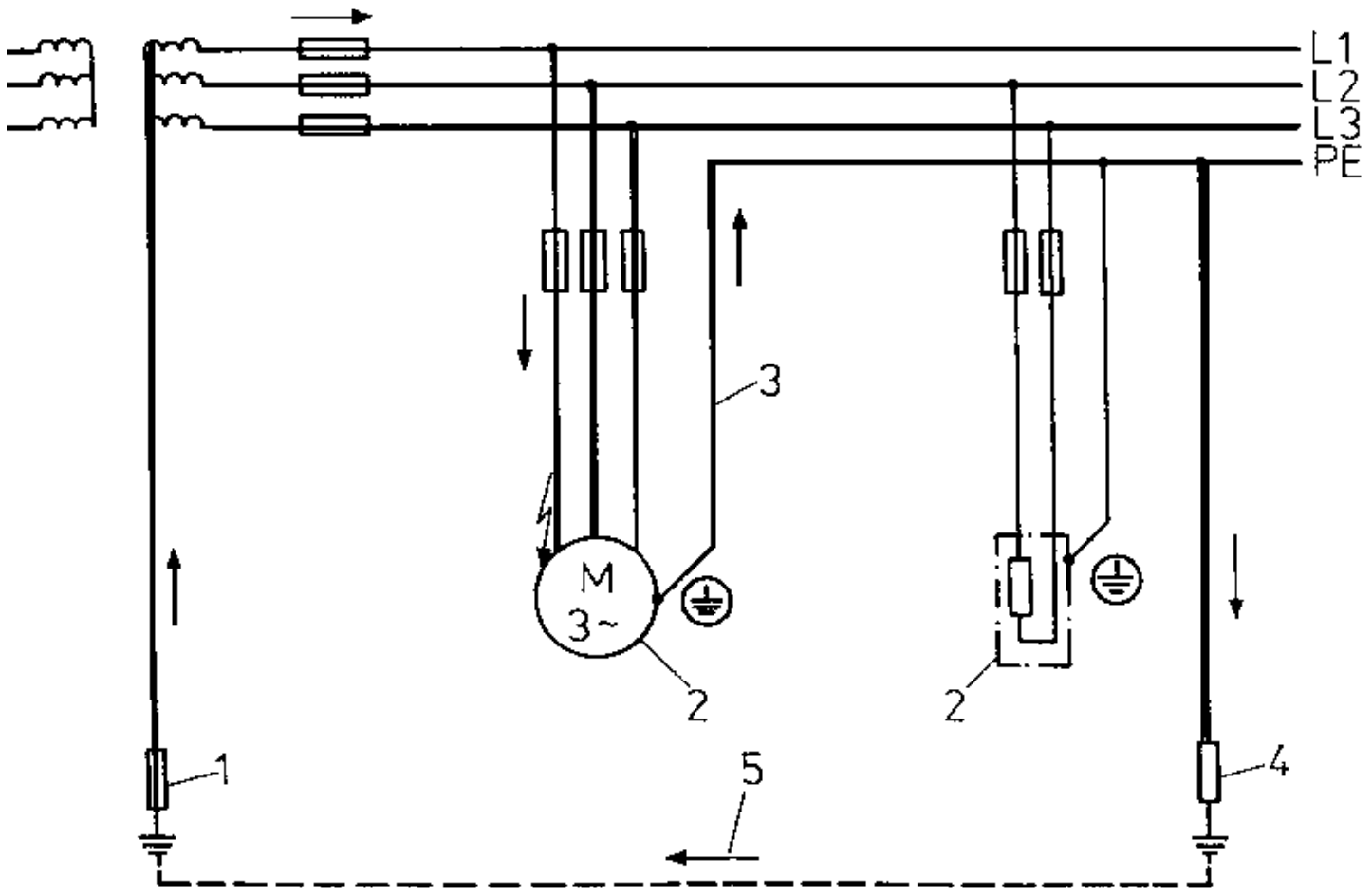


Figure 9 – Protective earthing (return flow of the fault current through the ground) – 1 resistance of the service earthing, 2 devices, 3 protective conductor, 4 resistance of the protective earthing system, 5 fault current

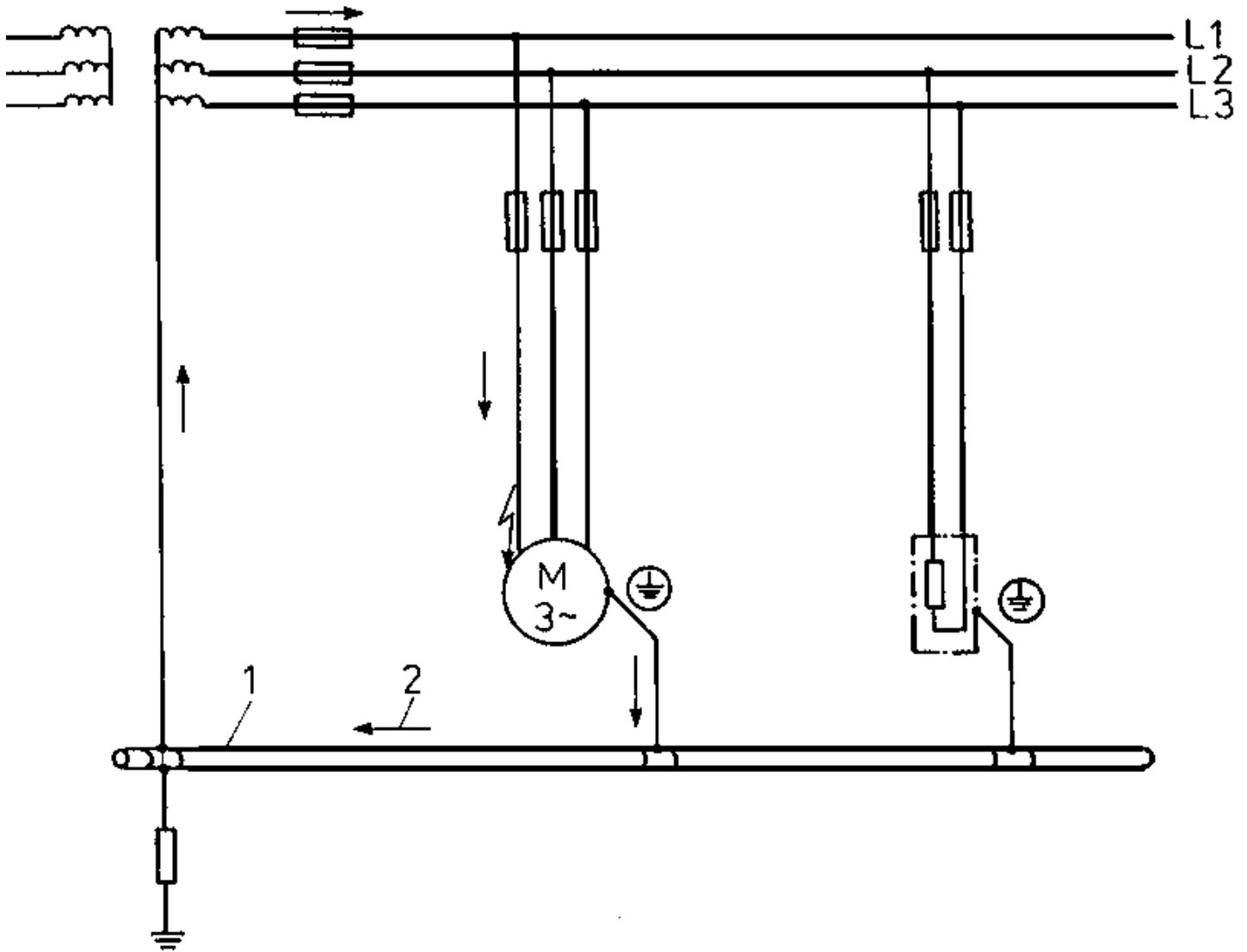


Figure 10 – Protective earthing (return flow of the fault current through the water pipe system) – 1 water pipe system, 2 fault current

Criteria of protective earthing

- All metallic casings and metallic parts of electrical equipment must be connected with one another through a protective conductor.
- The protective conductor must be connected with the earth electrode.
- With the return flow of the fault current through the earth, the resistance must not exceed a certain value (Fig. 9./Legend 4).

This has to be calculated according to the following equation:

$$R = \frac{U_B}{K \times I_n} \text{ ohm}$$

The symbols have the following meaning:

- Rs Resistance of the protective earthing
- U_B Permissible contact voltage
- k Factor for the switching off

k = 3.5 for fuses up to 50 A

k = 5 for fuses over 50 A

In Amperage of the uses of the protected device

With the return flow of the fault current over the water pipe system, the resistance must not exceed the value which is calculated by the following equation:

$$R = \frac{U_{LE}}{K \times I_n} \text{ ohm}$$

U_{LE} – stands for voltage between conductor and earth.

Where is the measure of protective earthing applied?

Disadvantages of the protective earthing

- The earth transition resistance is subject to climatic influences.
- The required earthing resistances are achieved only with great difficulties.
- The unipolar switching off of devices consuming three-phase current may lead to damage to the electrical equipment.

Checking of the protective measure of protective earthing

- The required connections of the protective conductor are checked by visual inspection.
- By a continuity test the connections of the metallic parts between each other are checked.
- The earthing resistance has to be calculated and tested by measuring.

Connection to neutral

Mode of action

- Instead of being returned to the earthed mains point through the earth or the water pipe system, the fault current is returned through the "neutral conductor with protective function" (PEN) – the neutral conductor.
- A body contact that might occur as a result of a fault is turned into a unipolar short circuit by the connection between casing and neutral conductor.

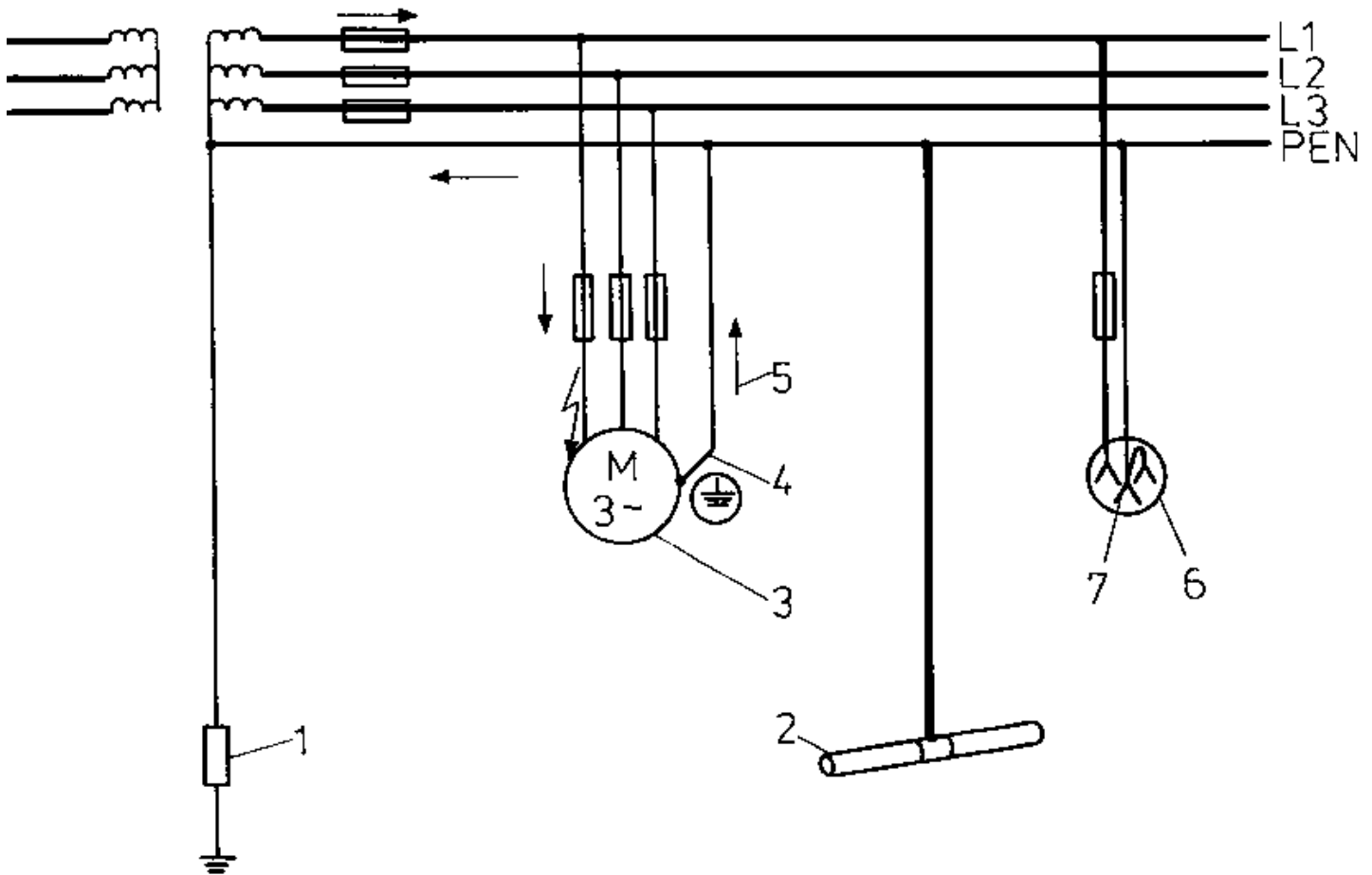


Figure 11 – Protective measure of connection to neutral in a threephase four–wire system – 1 resistance of the service earthing, 2 pipe system, 3 motor, 4 protective conductor, 5 fault current, 6 socket with protective contact, 7 protective contact

Criteria of the connection to neutral

- All metallic casings of electrical equipment are connected to the neutral conductor through the protective conductor.
- The neutral conductor has to be earthed at the neutral point of the transformer, at the ends of the mains and evenly distributed in the mains.
- With cables with metallic sheathing, the latter has to be connected with the neutral conductor.
- With plastic cables, the neutral conductor has to be earthed at the casing connection.
- With the connection of the neutral conductor to electrical equipment, the protective function must be accomplished first. Only then it is connected to the operating contact.
- The protective measure is accomplished, if – with short circuit between external conductor and neutral conductor – a current flows that is 2.5 times the rated current of the fuse connected before.

The neutral conductor, at the electrical equipment, must be bridged from the protective contact to the operating contact.

Where is the connection to neutral used?

Checking of the protective measure of "connection to neutral"

- It has to be inspected whether the protective conductor is connected according to the required conditions.
- The fault current with short circuit between external conductor and neutral conductor can be measured.

Fault-voltage protective system

Mode of action

- Similar to the protective earthing. Only that here the release, in the case of fault, is not actuated directly through the connection of the parts of the plant to be protected with the earth but all-polarly over a trip coil.
- The fault current flows through the voltage coil and excites it. The coil actuates the control element, and the part of the plant which is at risk is switched off in an all-polarly way.

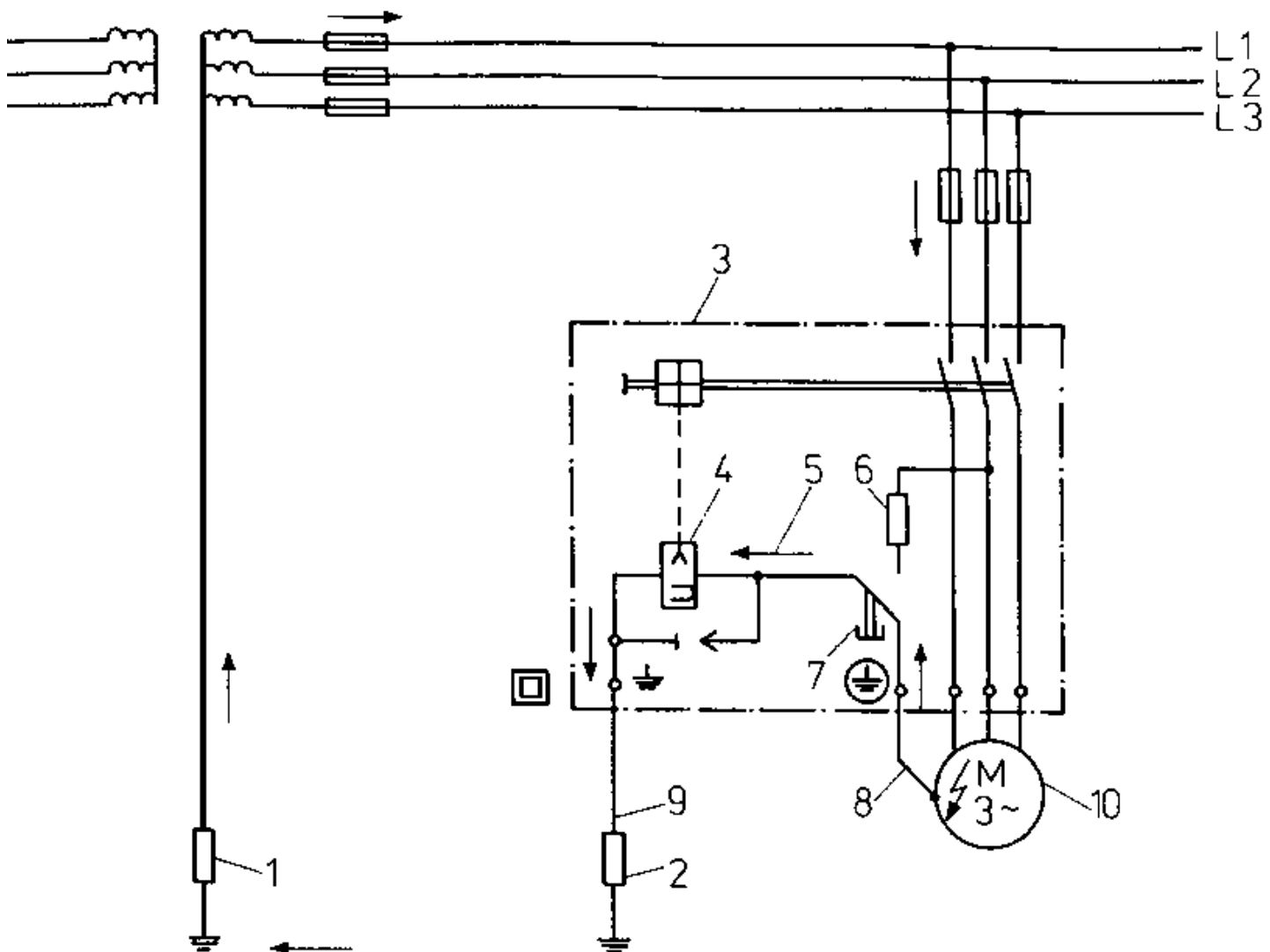


Figure 12 – Fault-voltage protective system in a threephase system – 1 resistance of the service earthing, 2 resistance of the auxiliary earthing, 3 protective switch, 4 voltage coil, 5 fault current, 6 test resistance, 7 test key, 8 protective conductor, 9 auxiliary earth lead, 10 motor

Criteria of the fault-voltage protective system

- The protective conductor has to be connected with the casing of the equipment and with the voltage coil.

- The protective conductor has to be insulated against earth.
- The protective conductor has to be led separately from the auxiliary earth.
- The auxiliary earth has to be connected over an auxiliary earth lead.
- The resistance of the auxiliary earthing, with a highest admissible contact voltage of 24 V must not exceed 200 ohms and with 65 V or 100 V 800 ohms.
- The cross section of the protective conductor and of the auxiliary earth lead with fixed protected laying must not be greater than 1.5 mm² copper or 2.5 mm² aluminium and with fixed unprotected laying not greater than 4 mm² copper or 10 mm² aluminium.
- Pipe systems may be used as auxiliary earthing, if they provide the required resistance value.

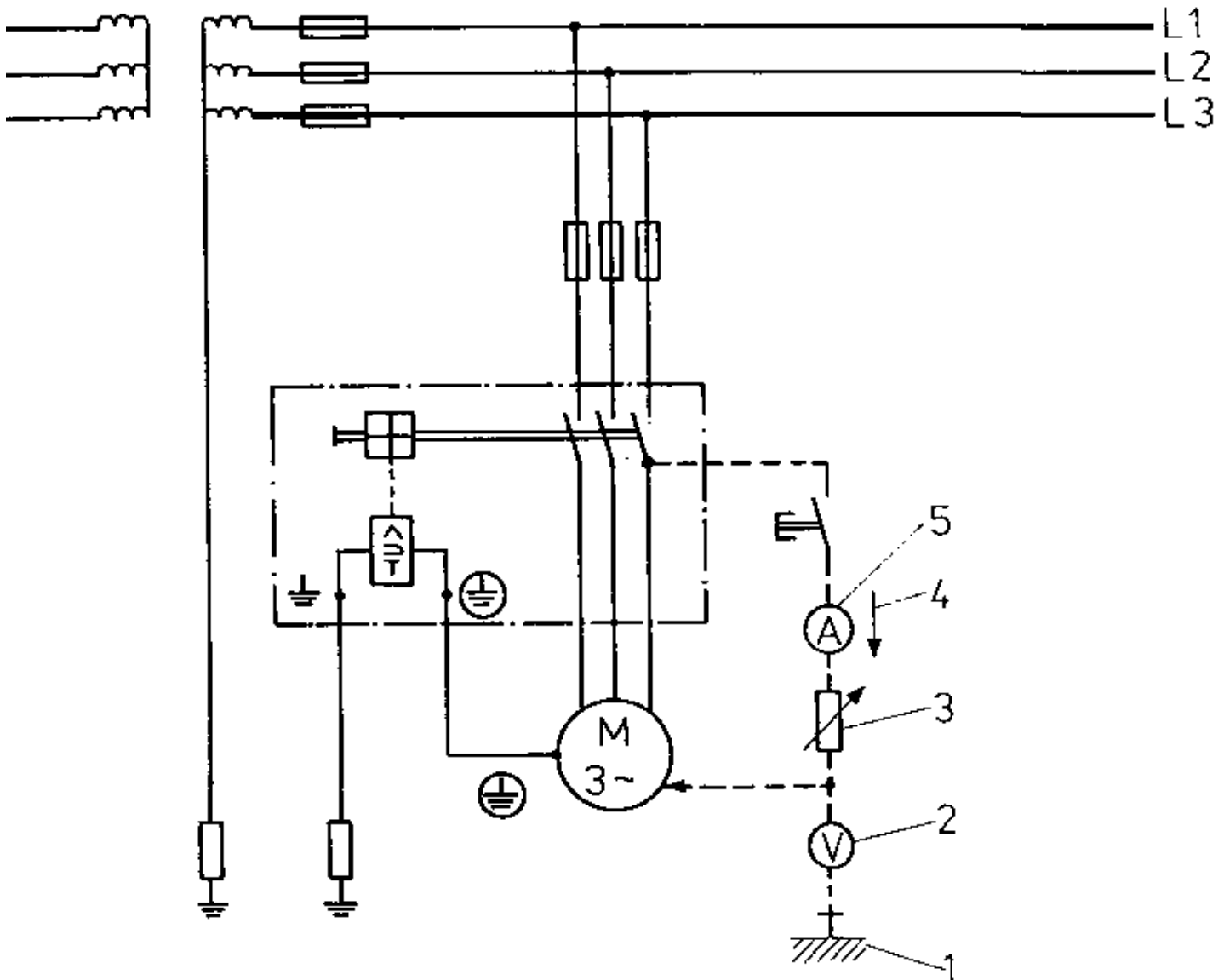


Figure 13 – Testing of the fault-voltage protective system by probe 1 probe, 2 voltmeter for test voltage, 3 test resistance, 4 test current, 5 amperemeter for test current

Where is the fault-voltage protective system used?

Checking of the protective measure of "fault-voltage protective system"

- Inspection whether the required conditions are fulfilled.
- Checking of the fault–voltage protective switch by actuating the test key.
- Measuring the resistance of the auxiliary earthing with the help of a probe.

Fault–current protective system

Mode of action

- If the operating current of a consumer is led through the summation transformer of a fault–current protective switch, the sum of the currents flowing in both the directions is normally zero.
- In the case of fault, the equilibrium of the currents is disturbed and the trip coil of the fault–current protective switch causes the all–polar switching off of the part of plant that is at risk.

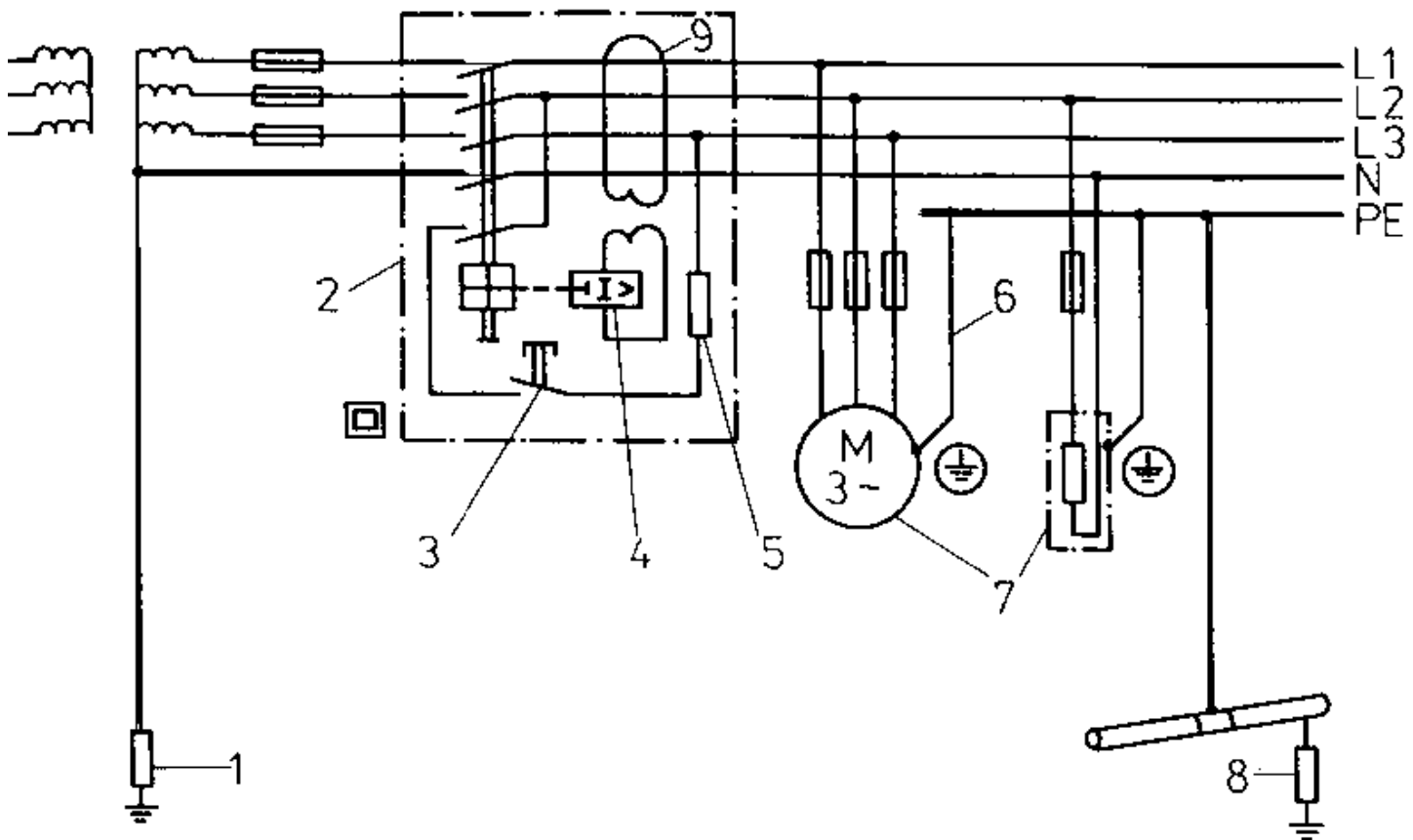


Figure 14 – Fault–current protective system in a threephase system – 1 resistance of the service earthing, 2 protective switch, 3 test key, 4 current coil, 5 test resistance, 6 protective conductor, 7 devices, 8 resistance of the protective earthing system, 9 current transformer

Criteria of the fault–current protective system

- All metallic casings of the electrical devices have to be earthed by a protective conductor.
- The protective conductor has to be layed separately.
- The switching–off time must not exceed 0.2 seconds.
- The resistance of the earthing system of the fault–current protective system must not exceed a certain value.

This is calculated with the help of the below equation:

$$R_S = \frac{U_{Bzul}}{I_{fn}}$$

The letters read:

U_{Bzul} highest admissible contact voltage

I_{fn} rated fault current of the fault-current protective switch

Where is the fault-current protective system used?

Checking of the protective measure of "fault-current protective system"

- Inspection as to the required conditions.
- Testing of the functioning of the fault-current protective switch by repeated actuation of the test key.

Isolating fault-current protective system

Mode of action

- Similar to that of the fault-current protective system.
- In the case of fault, the fault current flows through the current coil of the isolating fault-current protective switch, the coil is excited and causes the all-polar switching-off of the plant.

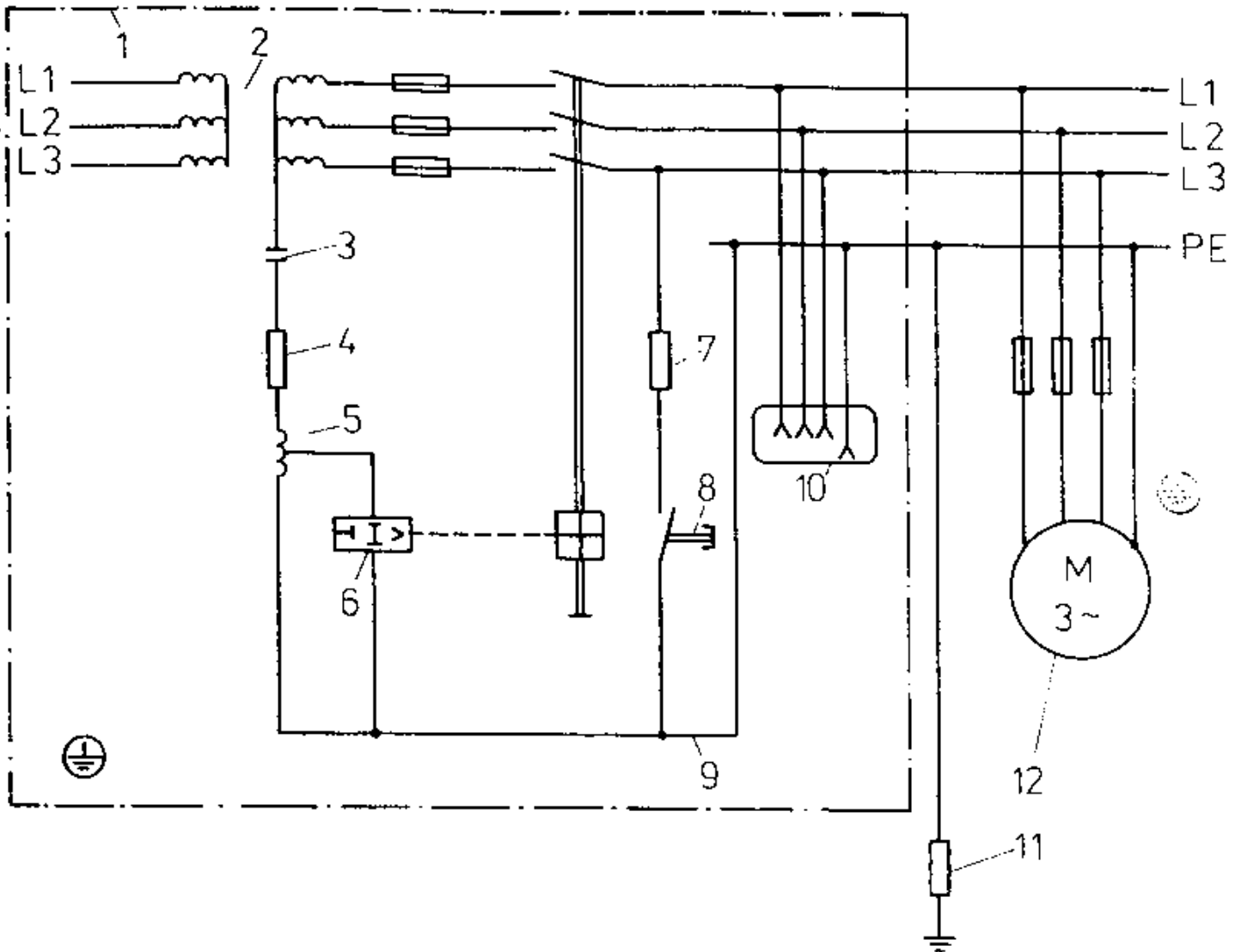


Figure 15 – Isolating fault-current protective system in a threephase system – 1 isolating fault-current protective switch, 2 isolating transformer, 3 capacity between conductor and ground, 4 ohmic resistance, 5 coil, 6 current coil, 7 test resistance, 8 test key, 9 protective conductor, 10 test socket, 11 resistance of the protective earthing system, 12 motor

Criteria of the isolating fault-current protective system

- The plant is operated through an isolating transformer.
- The neutral point of the secondary side of the transformer is earthed through a coil.
- This coil is switched as a voltage divider and limits the fault current to 7 mA.
- The switch switches the plant off all-polarly with a fault current of
 - 6 mA with alternating current and
 - 10 nA with direct current.
- All conductive parts of the plant which do not belong to the service circuit have to be connected to a protective earthing.

Service life conductors, with this protective system, must not be earthed.

- The protective conductor has to be earthed near the supply device. (With plants on ships, it has to be connected with the metallic body of the ship.)

On principle, the protective conductor has to be separated from leads before the isolating transformer!

- The resistance of the protective earthing must not exceed 500 ohms.
- The resistance of the insulation between a conductor and the protective conductor must not fall below 20 kilohms.
- The capacity between conductor and earthing must not exceed 100 nanofarads.

Where is the isolating fault–current protective system used?

Checking of the protective measure of "isolating fault–current protective system"

- Inspection as to the required criteria.
- Function test – the protective switch must switch the plant off.

Necessary measures:

- The isolating transformer has to be separated from the supply system at its primary side.
- A release current of 6 mA a.c. or 10 mA d.c. has to be applied to the protective conductor.

Treatment of Lines for Mobile Devices and Appliances – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Treatment of Lines for Mobile Devices and Appliances – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Introduction

The present material contains 3 selected instruction examples on the basis of which essential skills in connection with the treatment of lines for mobile devices and appliances can be practised.

Since skills in the field of treatment of lines for mobile devices and appliances are acquired and mastered only by much practice, the instruction examples have to be constantly repeated.

In order to facilitate the preparation and performance of the exercises, for each instruction example the materials, testing and measuring equipment as well as basic knowledge are mentioned which are required to carry out the exercises.

In addition to the sequence of operations, drawings are attached showing how the exercises are done.

Instruction Example 6.1. Pressing-on of a Cable Eye on a Multiple-wire Cable

Material

Cable, moulded cable eye according to the cable

Tools

Side cutting pliers, cable stripper, deinsulating device, cleaning brush, half-round file, triangular scraper, flat-nose pliers, pressing device

Testing and measuring instruments

Rule

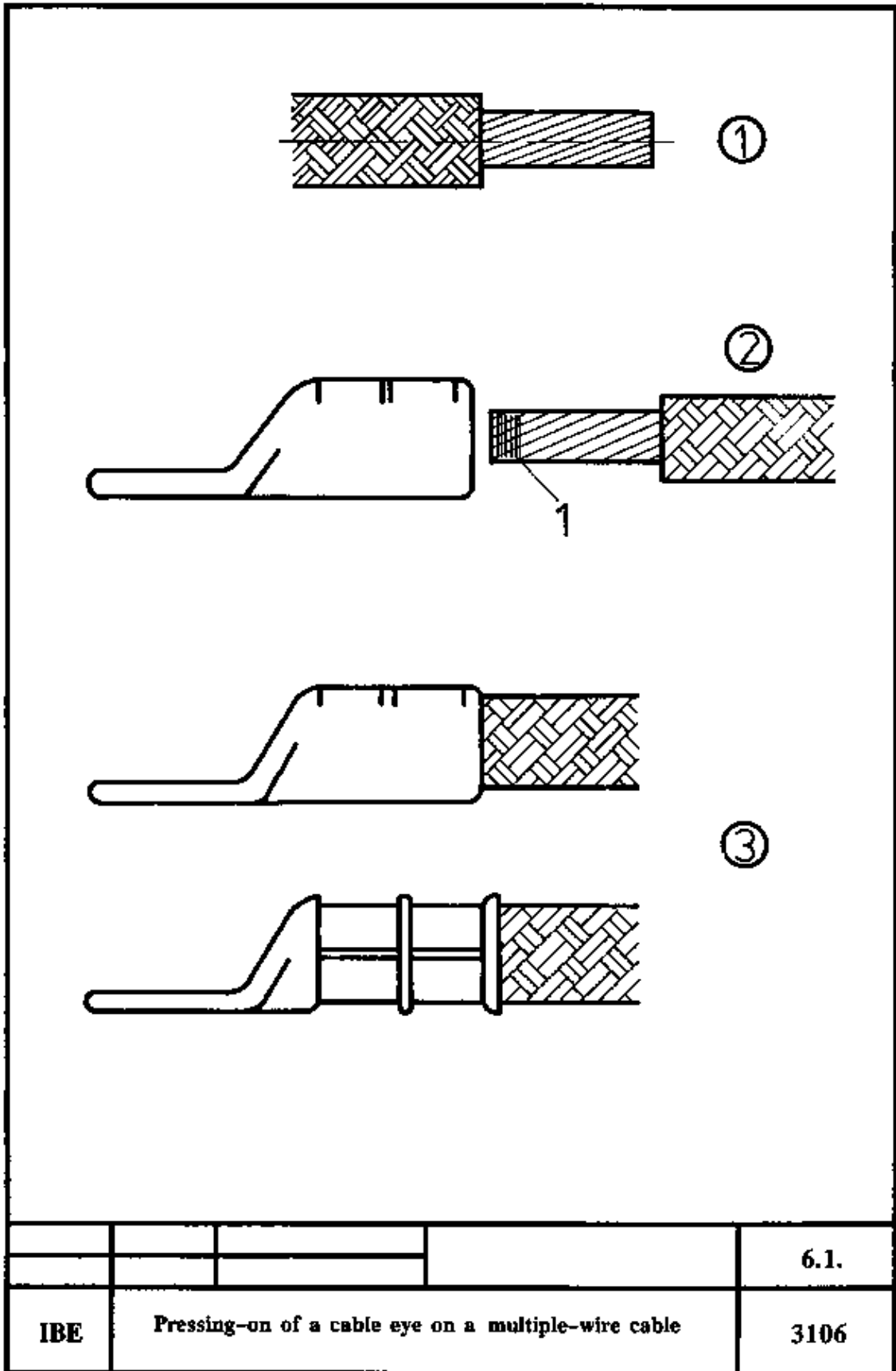
Auxiliary equipment

Pressing inserts according to cable eye, anti-corrosive grease

Required basic knowledge

Making of permanent joints

Sequence of operations	Comments
1. Cutting the conductor to length	With hexagonal pressings the change of the length due to pressing process has to be considered.
2. Removal of the core insulation (1)	Pay attention to the deinsulation length!
3. Cleaning of the contact surfaces	There should not be more than 10 minutes between cleaning and pressing.
4. Putting the conductor into the cable eye (2)	The conductor should perhaps be provided with a wire binding (1) before being put into the cable eye.
5. Carrying out of the pressing (3)	After having touched the pressing jaws no further pressure must be exercised on the pressing tool.



Pressing-on of a cable eye on a multiple-wire cable

Instruction Example 6.2. Connection of a Safety Plug to a Cable with Cab-tyre Sheathing

Material

Cable with cab–tyre sheathing, safety plug

Tools

Side cutting pliers, cable stripper (electrician's knife), wire strippers, deinsulating device, screw driver, round–nose pliers/arbor, soldering iron

Testing and measuring equipment

Rule, continuity tester

Auxiliary equipment

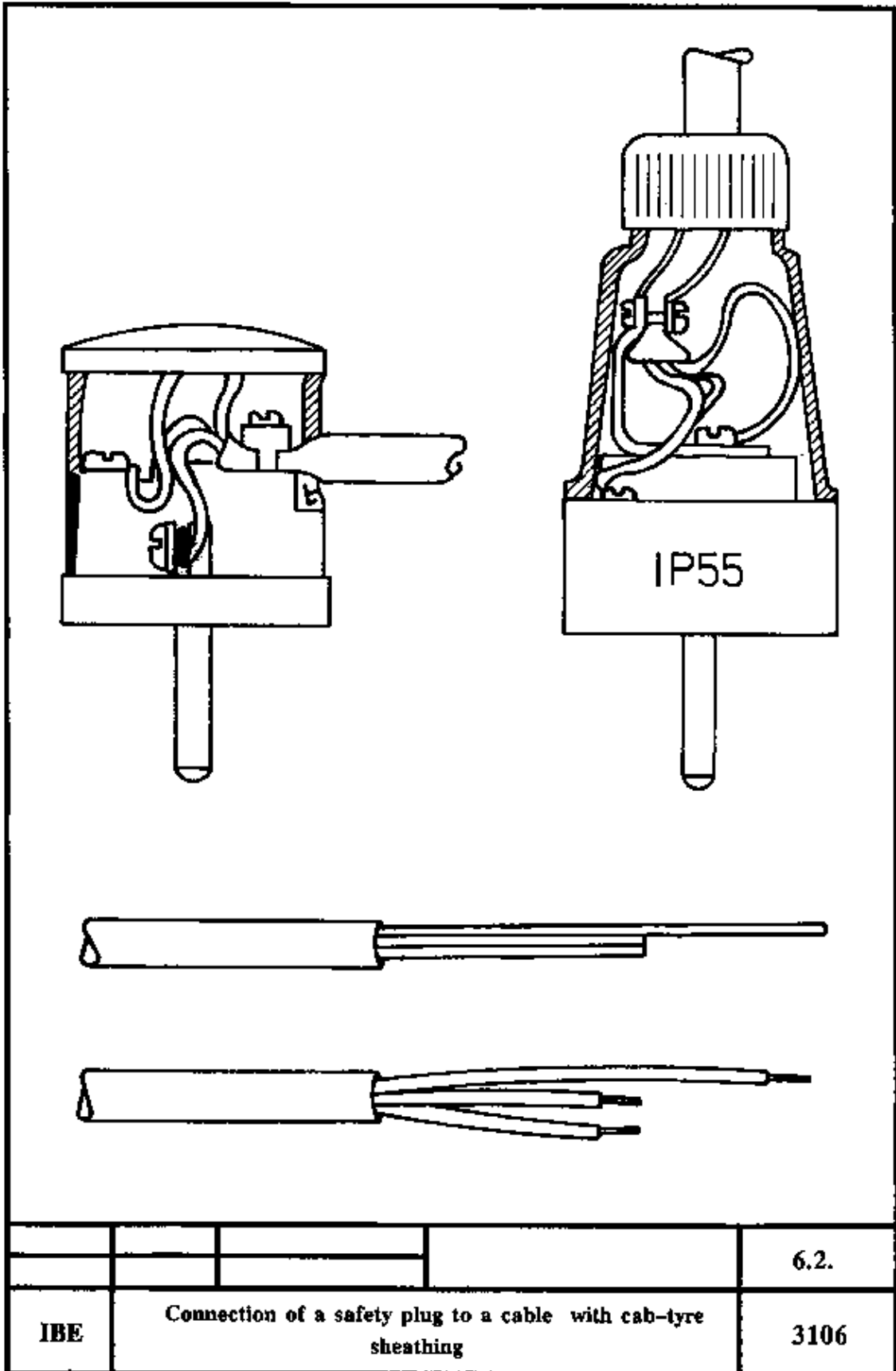
Soldering tin, flux,

Required basic knowledge

Knowledge of the kinds of electric lines and the colour coding as well as the order of connection of the conductors;

Making permanent joints.

Sequence of operations	Comments
1. Cutting the cable to a certain length.	
2. opening the plug.	
3. Removing the sheath insulation (external sheathing).	Rules of thumb: Remove the sheath insulation over a distance of approximately 45 mm.
4. Shortening the external conductor.	Shortening the active cores to approximately 30 mm.
5. Deinsulating of the individual conductors.	Remove 8 mm of the core insulation.
6. Removing the oxide film.	
7. Clockwise twisting of the conductors.	
8. Moistening the conductors with flux and tinning them.	
9. Shoving the upper part of the plug on the line.	
10. Bending the cores as required for connection.	Normally plug–in connection eye, if necessary bending of eyes.
11. Undoing of the tension relief.	
12. Clamping of the conductors.	First the protective conductor, then the rest of the conductors. (The active cores, too are led to the connections in a slight curve.)
13. Fastening the tension relief.	
14. Shoving the upper part of the plug on the lower part and closing the plug.	



				6.2.
IBE	Connection of a safety plug to a cable with cab-tyre sheathing			3106

Connection of a safety plug to a cable with cab-tyre sheathing

Instruction Example 6.3. Testing of Mobile Devices and Appliances

Material

Extension cords, flexible cables, movable multi-way connectors (sockets), mobile devices and appliances

Tools

Screw drivers (nick and cross nick), grub screw drivers, socket wrenches of various sizes, adjusting pliers, sealing tongs

Testing and measuring equipment

Continuity tester (high- and low-resistive), insulation detector, protective conductor testing device

Auxiliary equipment

Instrument leads, measuring terminals, seals, sealing wire, measuring card file

Required basic knowledge

Knowledge of the protective measures against hazardous contact voltage; instructions for use of the individual testing and measuring instruments.

Sequence of operations

Comments

Mobile devices and appliances, especially portable electric hand appliances, have to be examined at regular intervals. Approximately every six months.

Control checks are allowed to be carried out only by authorized people who have the appropriate experience and knowledge.

1. Inspection

General condition, completeness, marking.

2. Testing of the insulating capacity of the device or appliance.

3. Testing of the efficiency of the protective measure against hazardous contact voltage of the device or appliance.

Pay attention to the connection between casing and earth bushing by means of instrument lead.

4. Testing of the functioning of the device or appliance

5. Providing the examined device or appliance with a test seal or badge.

Only if all tests have proved the proper condition of the device or appliance.

6. Entering the date of the examination, the result of the control check and the seal number into the testing card file.

Legends to the drawings

(1) Front panel of a protective conductor testing instrument – example –

(2) Example of carrying out an examination of extension cords

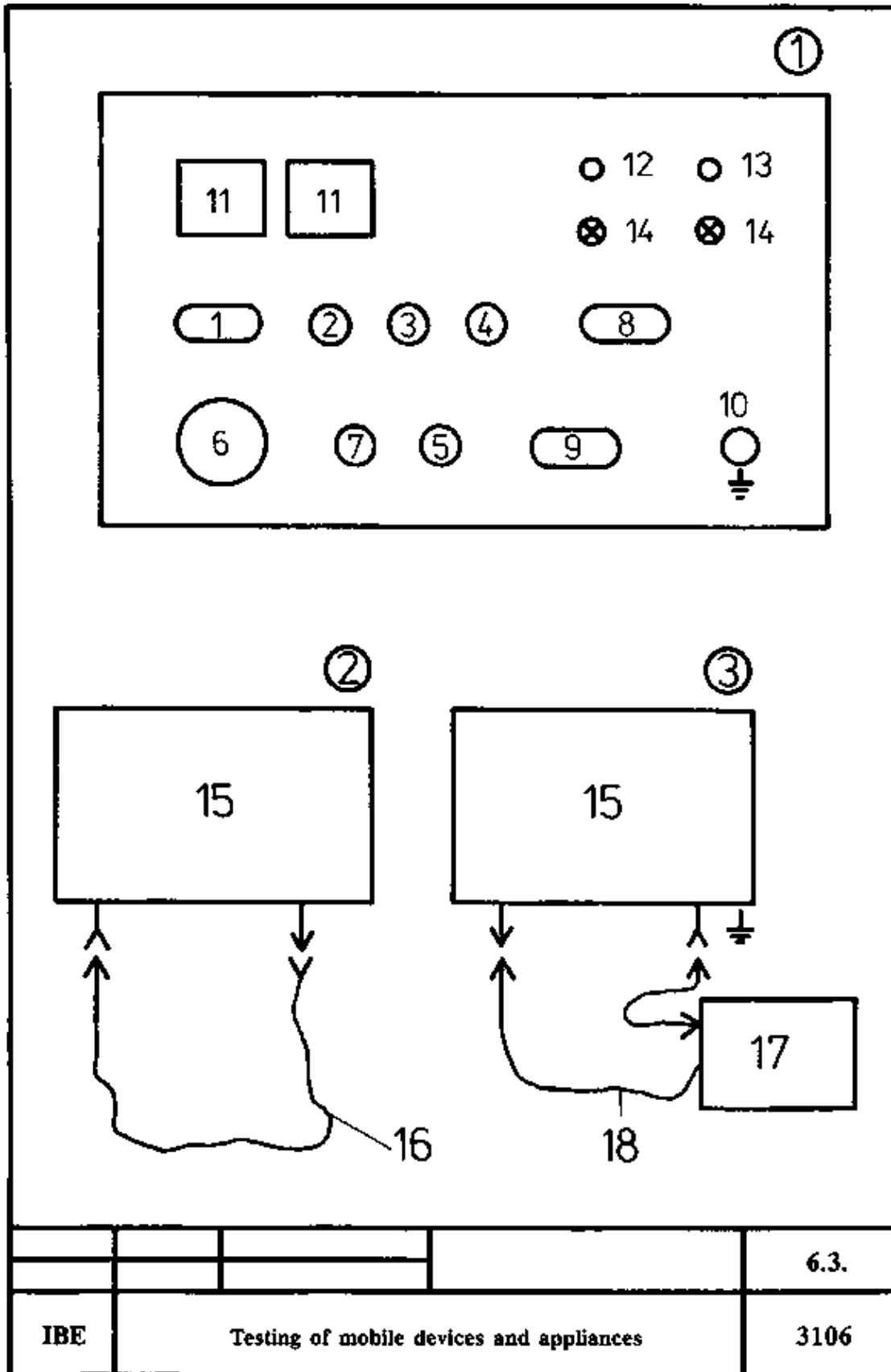
– Test voltage maximally 500 V

– Test current of the protective conductor loop for cross sections

- . from 0.75 to 1.5 mm² – approximately 30 A and
- . from 2.5 to 10 mm² – approximately 50 A

(3) Example of how to carry out a control check of devices and/or appliances

- 1 Built-in plug; 2 F appliance coupler (IEC standard coupler socket, interchangeable);
- 3 A appliance coupler (IEC standard plug for cold appliances);
- 4 Bipolar appliance coupler (hot appliance plug with inundation nozzle);
- 5 Double-pole appliance plug with earthing contact;
- 6 IF ED 16 socket with shrouded contacts for flash installation;
- 7 Double-pole socket with earthing contact;
- 8 Flush-mounted socket with shrouded contacts (six-pole, not interchangeable);
- 9 Flush-mounted socket with shrouded contacts (three-pole, with N-type and PE-type contact);
- 10 Measuring terminal, (earth bushing); 11 Measuring instrument; 12 Rocker switch;
- 13 Push-button switch; 14 Telltale lamps; 15 Protective conductor testing device;
- 16 Extension cord; 17 Device/appliance to be checked;
- 18 Plug-in device and connecting line of device/appliance;
- 19 Instrument lead between casing and earth bushing.



Testing of mobile devices and appliances

Treatment of Lines for Mobile Devices and Appliances – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

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1. Aims and Contents of Practical Vocational Training in the Field of "Treatment of Lines for Mobile Devices and Appliances"

At the end of this studying unit, the trainees must have achieved the following aims:

- The trainees have acquired the necessary knowledge and skills for working lines for mobile devices and appliances.
- The trainees have command of the respective working techniques and operations for treating lines for mobile devices and appliances.
- The trainees are able to check completed operations as to their correctness.
- The trainees observe the labour safety regulations.

In order to achieve the required aims, the instructor has to impart to the trainees the below mentioned contents:

Knowledge

- On the working and connecting of lines to mobile devices and appliances.
- On the selection of the corresponding technique as required by the line and connection.

Skills

- Accurate preparation of the connecting points.
- Faultless working of the cable material.
- Making of perfect connection points.
- Testing of the work completed.

2. Organizational Preparation

In order to guarantee a smooth course of instructions and exercises, the training must be well organized. This includes the following measures:

2.1. Preparation of the Labour Safety Instructions

Before beginning with the exercises, a brief instruction has to be given as to the proper use of the working means and including hints on accident-free working.

To prove that the labour safety instructions were given, it is recommended start a book in which all instructions on accident-free working as well as on the correct use of tools and auxiliary means are entered in the form of keywords. The trainees confirm by their signatures that they have got the instructions.

The following hints should be given:

- Any work in or at electric plants has to be carried out only if and when the plant is in dead condition.
- This dead condition has to be verified with the help of continuity testers.
- It has to be made sure that no other person switches the plant on while it is being worked at.
- Do only use perfect tools. Defective tools have to be repaired or replaced by new or regenerated ones.
- When removing the insulation by the electrician's knife make sure that the blade is sharp. With a sharp blade there is less danger to slip off and hurt oneself.
- Always cut "a way" from the body.
- Do never leave electric devices or appliances alone in the factory or workshop.
- After use electric devices or appliances have to be switched off and mains plug has to be drawn out.

Further hints on labour safety that may perhaps be necessary should be given according to the local requirements.

2.2. Preparation of the Teaching Aids

For the theoretical instructions the trainees must have a place where they can take notes. Recommendable is a room equipped with blackboard, desks and electric connection.

If the instructions are held in a workshop or directly at the workshop place, clean desk pads should be placed on the working tables for the trainees to put their papers and exercises books on.

For demonstration during the instructions a workshop place for exercises should be prepared with the following outfit:

- Exercise pieces such as cables and electric devices and appliances
- Folding rule
- Combination pliers, side cutting pliers, round-nose pliers
- Screw driver, hexagonal spanner
- Electrician's knife
- Wire strippers
- Thermal deinsulating device
- Deinsulating fixtures
- Pressing fixture, pressing pliers
- Conductor end tubes, contact eyes
- Pressing tools with accessories
- Pressing cable eyes

- Pressing cable temples
- Binding material
- Soldering iron and soldering accessories

The "Trainees' handbook – treatment of lines for mobile devices and appliances" is distributed according to the number of trainees. Surveys and circuit diagrams are drawn on the blackboard before the lesson begins.

2.3. Preparation of the Working Means

As a theoretical basis, the "Instruction Examples for Practical Vocational Training / Treatment of Lines for Mobile Devices and Appliances" are distributed among the trainees according to their number. The materials which are required for doing the exercises have to be prepared and placed at the trainee's disposal on the basis the "Instruction Examples ..." in sufficient number and / or quantity. There must be a working place for each trainee.

2.4. Time Planning

Starting from the total number of teaching hours, the time for each step of this teaching unit should be planned individually.

It is recommended to work out a schedule for the following steps:

- For the introduction onto each respective working technique in the form of an instruction.
- For necessary demonstration.
- For a task-related instruction in preparation of the exercises
- For the carrying out of the exercises.
- For repetitions and control.

In scheduling, the following factors should also be taken into consideration:

- Level of education of the trainees
- Training conditions
- Future work of the trainees
- Degree of difficulty of the respective training section.

Focal point of each training section is the acquisition of the respective abilities and skills by exercises. If – despite a good planning – it should come to waiting periods, the trainees should be given smaller suitable tasks such as the preparation of materials for the exercises to bridge such slacks.

3. Recommendations for Practical Vocational Training in the Techniques of "Treatment of Lines for Mobile Devices and Appliances"

The following sections contain suggestions of how to structure the instruction of the trainees, the demonstration of the individual training steps as well as the exercises and tests.

3.1. Introductory Instructions, Demonstration and Exercises

The introductory instructions on each working technique may be held in a class-room. During these instructions, make sure that the trainees write down supplements or answers in the "Handbooks".

The contents of the "Handbook" is structured in a way corresponding to the introductory instruction.

The focal points contained in the "Handbook" have to be imparted to the trainees.

A precondition of learning the working techniques of treatment of lines for mobile devices and appliances is the command of the techniques of making of fastening and permanent joints.

Therefore, in imparting the knowledge, the last-named techniques should be referred to in the form of a repetition.

Elementary knowledge of the connection of lines for mobile devices and appliances and their use

Before the trainees get to know the various possibilities of treating lines for the connection of mobile devices and appliances, they should become familiar with the different kinds of such lines.

Here, it is recommendable to draw the trainees' attention to the ready-made products from their immediate working sphere such as extension cords, flexible cables, portable multiple sockets etc.

By showing these products the instructor points to the teaching objective.

After this, the typical and most commonly used kinds of cables and their abbreviated names should be mentioned. The mechanical and electric stressability of the individual cables should also be dealt with. Examples of application should be given.

The terms 'multiple-wire, fine-wire and finest-wire conductors' should be explained.

In connection with the use of the cables, the examples from the survey of the "Handbook" have to be discussed and, if required, to be extended corresponding to the local conditions.

Treatment of lines for mobile devices and appliances

Previous to the instruction and demonstration in this context, it is absolutely necessary that a working place is properly prepared and the tools and auxiliary means are arranged in an exemplary way. All the time, the trainees must be shown how to do the exercises and mistakes must be corrected immediately. If a certain mistake is made very frequently and becomes typical, the trainees should be called to one workshop place where they are explained the reasons of the respective mistake and where they are shown how the mistake can be avoided.

Removing the insulations

When demonstrating this sequence of operation make sure that all trainees are able to watch the demonstration well.

Each step of the process of removal should be demonstrated and explained. It is important to point to the different lengths of removal and write these on the blackboard.

Make sure that the insulation is very accurately removed from the conductor ends. There must be no remains of the insulation or notches on the conductor.

In this connection, the possible consequences of inaccurately removed insulations and/or damaged conductor insulations and conductors should be mentioned. When using wire strippers point out that the cutting edge used must correspond to the conductor cross-section. In this context, the advantages of deinsulating devices such as thermal devices for removing the insulation should be dealt with.

If such devices are used the operating instructions given by the manufacturer must be strictly observed.

When knives are used make sure that the cut is directed "away from the body".

Preparation of the conductors for further use

In this context, it is important to explain why mobile lines must be prepared in a special way for connection. The individual methods of working have to be mentioned or worked out together with the trainees or – if they are already known – to be repeated.

This refers mainly to operations such as

- cleaning the conductor
- tinning the conductor
- soldering on of cable eyes and
- pressing on of cable eyes.

Here it is recommendable again to use the handbook of "Making of Fastening and Permanent Joints". It should be made clear to the trainees that the tin-coating of cables and the use of sweating thimbles should be avoided to the farthest possible extent and that conductor end sleeves or contact eyes should be used instead.

The tinning of cables is required if eyes must be bent or if pressed cable eyes cannot be used.

Once again the trainees' attention should be drawn to the following point in connection with soldering:

- For soldering in electrical plants soldering irons of 80 watt are used according to the cross-section of the conductor.
- On principle, tin-base solder (thread or bar tin) of 60% tin content is used for soldering in electrical plants.
- Only acid-free flux such as colophony solved in spirit or acid-free soldering grease must be used.

It is also important to mention the characteristics of a faultless soldered joint and to explain the care of an electric soldering iron.

Bending of eyes

Here, the two methods of bending eyes are explained.

- Either, to shape the twisted and tinned conductor into an eye with the help of round-nose pliers,
- or to form an eye of the untinned twisted conductor by an arbor or round-nose pliers, or dividing the untinned conductor, twisting the two halves separately, put them around the arbor, join them and twist them one another.

Then tin-coat them.

When making eyes pay attention, that

- the eye is 0.1 to 0.2 mm larger than the diameter of the locking bolt,
- the eye is placed evenly on the junction block in order to avoid contact problems.

Putting on of conductor end sleeves and contact eyes

Especially hint to the advantages compared with tinning. Give very careful demonstration of the sequences of operation for conductor end sleeves and contact eyes and explain them.

In doing so, deal with the special characteristics of these techniques and demonstrate the correct operation of pressing tools so that any risk is avoided.

The trainees must be made familiar with the assignment of conductor end sleeves to the appropriate conductor cross-sections, and it has to be pointed out to them that this is of special importance because the conductor end sleeves and contacts eyes are not marked.

Connection of cables to mobile devices and appliances

Making of screw connections

In this paragraph all important requirements of the connection of mobile devices and appliances should be combined and imparted to the trainees. In doing so, it should be pointed out to the trainees that these requirements must be met at all devices, machines and clamping points.

It is recommendable to show and explain the trainees the order of the screwing elements such as screws and bolts as well as the arrangement of the conductors on terminals with the help of blackboard drawings or transparencies for overhead projection before giving them demonstration and have them exercise afterwards.

Only then the special kinds and characteristics should be dealt with.

The following focal points should be given special attention:

- Lengths of removal of insulation
- Putting the conductor into the connection space
- Connection of the protective conductor
- Number of conductors to be connected to one terminal (connecting point)
- Connection to cap–screws with or without clamping bow or conductor fixing device
- Connection to connection bolts
- Washers to be used
- Use of conductors with conductor end sleeves or contact eyes.

Tension relieving

In this context make clear why tension relieving is absolutely at mobile devices and appliances. Then, pass to the various ways of tension relieving. Also, point to the fact that tension relieving is possible inside and outside the connection space of mobile devices and appliances.

The protective system of an electric device or appliance must not be lowered by an external tension relieving.

It is also important to point out that there must be a buckling protection at device entrances and exits.

Boltings that only serve to maintain the protective system must not be used as tension relieving.

Basic rules on plug and socket connectors

Here especially the direction of the energy flux must be considered.

Plug and socket or coupler socket must be installed in such way that, under no circumstances, the plug pins are alive as long as the plug is not put into the socket.

Combination of mobile lines in bank cables or formed cables

First of all the trainees are explained that in addition to cables for the connection of mobile devices there are cab cables which consist of multiple–wire or fine–wire conductors.

- This is mainly the case with plants exposed to strong vibration and great mechanical strain.
- The combination of conductors in bunches is a method of cable laying.
- If, in such plants, conductors are combined in bunches, this is called "bunch wiring" and prefabrication in the form of preformed cables is recommendable.

In this context it would be helpful to use the handbook "Manufacture of Preformed Cables".

In the course of demonstration the following focal points should be referred to:

- Making of templates
- Laying of the cables and combining them in bunches
- Tying the bunches up with binding material
- Testing and marking of the cables.

In this context it is important to explain that the cables always have to be tested as to their conductivity before they are laid and afterwards as to correct cable running.

When marking the conductor make sure that the marking will remain and be legible even after a longer period of time and that also other people will be able to read it.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

In the instruction examples the sequence of operation is described and a survey of how to carry out the required operations is given.

Furthermore, a list of materials, tools, measuring and testing equipment, auxiliary means as well as required basic knowledge is attached to each instruction example.

During the practical exercises corresponding remarks are made so that the trainees are given all required information to do their work properly and to observe the protective measures.

When organizing the work on the basis of the instruction examples the following hint should be taken into consideration:

- The trainees put the instruction examples into practice independently and without assistance.

So the instructor will be able to supervise the work of each trainee, to correct it and to assess it justly.

3.3. Examples for Recapitulation and Tests

This section includes tasks for the consolidation and checking of the knowledge and skills acquired by the trainees. To each task the corresponding answer is given.

Tasks, which are included in the "Handbook" are marked by the letter "A".

1. What is the difference between lines for the connection of mobile devices and appliances and such for permanent wiring?

"A" (Mobile lines are meant for mobile and/or portable electric devices and appliances. They are flexible and the conductors consist of fine wire.)

Lines for permanent wiring are single-wire or multiple-wire lines, they are fixed – permanent wiring – and can be bent only once and according to a certain bending radius.)

2. On what criteria does the selection and use of lines for mobile devices and appliances depend?

"A" (Rated voltage; kind of mechanical strain; range of temperature; place of use.)

3. Why must mobile lines be treated in a special way before connection?

"A" (Connections made with the help of bolts, clamping nuts and others exert torques and spreading forces on the twisted conductor. If these are not tinned or provided with a conductor end sleeve, the fine conductor cores will give way to the pressure and leave the point of connection. This may cause a reduction of the cross-sectional area and perhaps to the destruction of the connection by thermal influences.)

4. What sequences of operation have to be carried out before the connection can be made?

"A" (Cleaning of the conductors; twisting of the conductors; tinning of the conductors; bending of eyes; soldering–on of cable eyes; pressing–on of cable eyes; fixing of conductor end sleeves and contact eyes.)

5. What must be considered when bending eyes for connection?

(Do only use arbors or roun–nose pliers; do not damage the conductor; the eye for connection must be closed; the eye must be in accordance with the diameter of the thread or bolt.)

6. What are the advantages of conductor end sleeves and contact eyes compared with tinning?

"A" (Saving of working time by the simple and problem–free assembly; better movability of the core up to directly to the point of connection and thus reduction of the risk of breaking; saving of auxiliary materials such as tin; colophony and/or other fluxes as well as electric energy; replacement of tools susceptible to interference such as soldering irons by mechanically robust tools for pressing–on.)

7. Why should with lines for mobile devices and appliances preferably conductor end sleeves and contact eyes as well as cable eyes be applied?

"A" (Easier working technology; less sources of error; substitution of material; with soldering – valuable tin, with pressing–on copper; better contacts; better movability of the core up to the point of connection.)

8. What must be taken into consideration with the pressing–on of cable eyes?

(The cable eye must be in accordance with the conductor cross–section; pressing inserts must correspond to the cable eye; V–shaped slots are made only at copper conductors; alternation of length with hexagonal pressing; contact areas of cable eyes and conductors must be free of contamination and layers of oxide; if required wire binding for putting in sector–shaped, multiple–wire conductors; with hexagonal pressing, remove the burr occurring at the cable eye.)

9. Why must the protective conductor in the connecting space of the device or appliance be the longest connecting core?

"A" (This guarantees the effect of the protective measure even if – with extreme tensile strain – the rest of the conductors are torn from the point of connection.)

10. Why is tension relieving required with mobile devices and appliances?

"A" (Additional securing of the functioning of the device; the tearing–off of the connections is prevented; the effectiveness of the protective measure is increased.)

11. What is the importance of the breaking protection at devices entrances and exits?

"A" (Prolongation of the service life of the device or appliance; avoiding of body contact and thus reduction of accident hazard.)

12. What could be the consequences of transposing connection within a plant?

"A" (Non–functioning of the plant; extensive testing and controlling; time and material–consuming reworking of the preformed cable; short circuits and body contact in the plant.)

Treatment of Lines for Mobile Devices and Appliances – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Treatment of Lines for Mobile Devices and Appliances – Course: Basic Skills and Knowledge of Electrical Engineering. Trainees' Handbook of Lessons

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Introduction

The present handbook is a studying aid for trainees in the field of electrical engineering.

It describes the operations and auxiliary means required for the treatment of lines for mobile devices and appliances.

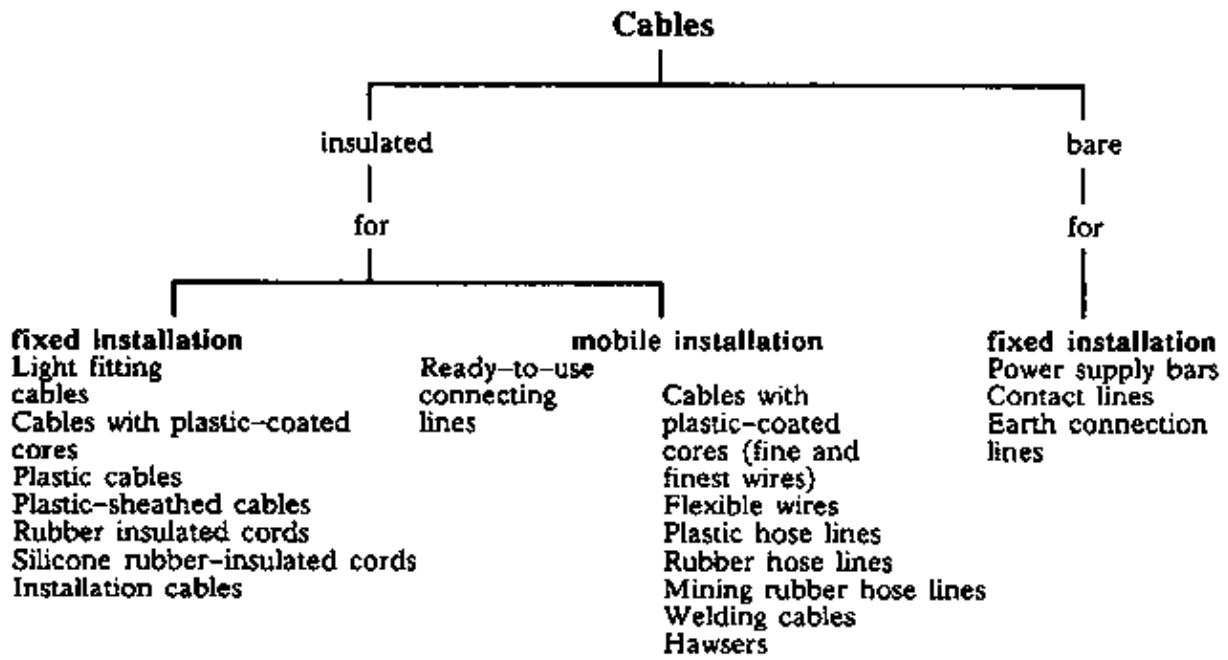
The required methods are explained in individual sections. The required knowledge and skills are described in the order of the necessary operations in each paragraph. The included illustrations promote the understanding of the text and add to the contents of the individual sections.

In support of the process of learning, questions are included for the trainers to test their knowledge.

1. Elementary Knowledge of the Connection of Lines for Mobile Devices and Appliances and their Use

Mobile service equipment such as devices and appliances are used in all fields of economy, production and everyday life.

They are connected to the electric mains by reusable cables, which are not fixed such as extension cords, mobile multi-way connectors, flexible cables and so on.



Survey of cables

Insulated cables

- Conductors are fitted with a plastic or rubber insulation (core insulation).
- Several conductors are twisted and covered by a common sheath (sheath insulation).

Bare cables

- Uninsulated conductors

Cables for mobile installation

- Flexible (mobile) insulated cables.

Lines for permanent installation

- Lines are fixed – permanent installation.

Characteristics of lines for mobile installation

- Material of conductor Cu
- Conductor
 - . fine wire
 - . finest wire
- Core and sheath insulations flexible.
- Line is designed for repeated use,

What is the difference between cables to be connected to mobile equipment and those for permanent installation?

Examples of use of the lines for mobile devices and appliances

Kind of line		Room		In the open	Use

	dry	moist	wet		
Light plastic hose cables	+	+	+		Lighting fittings, extension cables, refrigerators
Light rubber hose cables	+				Light heat appliances, irons, electric heat pads, extension cables
Medium plastic hose cables	+	+	+		Hand drills, industrial refrigerators, light X-ray units, office machines
Strong rubber hose cables	+	+	+	+	Construction equipment, machine tools

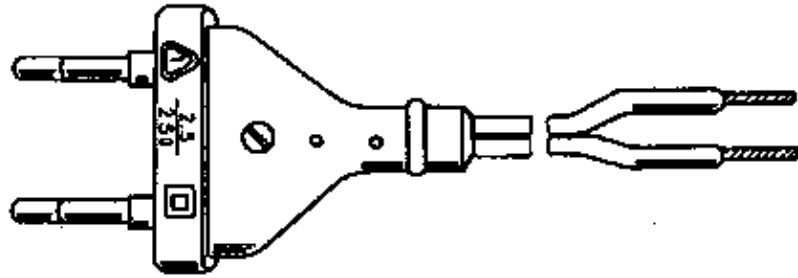


Figure 1 Light plastic hose cable (ready-made cable)



Figure 2 Light rubber hose cable (ready-made cable)



Figure 3 Light rubber hose cable with yarn wrapping (ready-made cable)

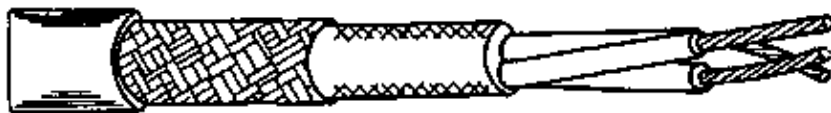


Figure 4 Medium-size rubber hose cable (covered)



Figure 5 Strong rubber hose cable

On what criteria does the selection and use depend of cables to be connected to mobile equipment?

Plastic hose cables are allowed to be used for electric heat appliances only if it is absolutely impossible that the cable gets in touch with parts of the device that may be heated up to more than 85° Celsius.

For electric devices or appliances with plastic case no rubber hose cables must be used!
Rubber contains an age-protecting agent, which passes over into the plastic material when it gets in contact with it and discolours it under the effect of light.

2. Treatment of Lines for Mobile Devices and Appliances

2.1. Removing of Insulations

For removing the insulation, the following tools may be used as auxiliary means:

- Cable strippers
- Automatic deinsulating tongs
- Thermal deinsulating device
- Deinsulating fixtures

Removing the sheath insulation

- Cutting the rubber sheath in between the cores until it can be taken hold of by hand.
- Ripping the rubber sheath apart up to the given measure.
- Cutting the sheath insulation carefully all around.

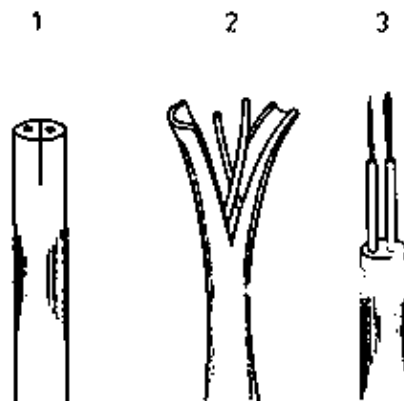


Figure 6 Stripping of a light rubber hose cable

- 1 notching the rubber coating between the cores,*
- 2 thearing the rubber sheath apart,*
- 3 cutting off the sheath insulation carefully*

Make sure that the core insulation is not cut when removing the sheath insulation!

Removing the core insulation

- By the cable stripper
 - . Cutting off one half of the insulation by a longitudinal cut by the knife (stripping off).
 - . Cutting off the second half by a longitudinal cut, too.

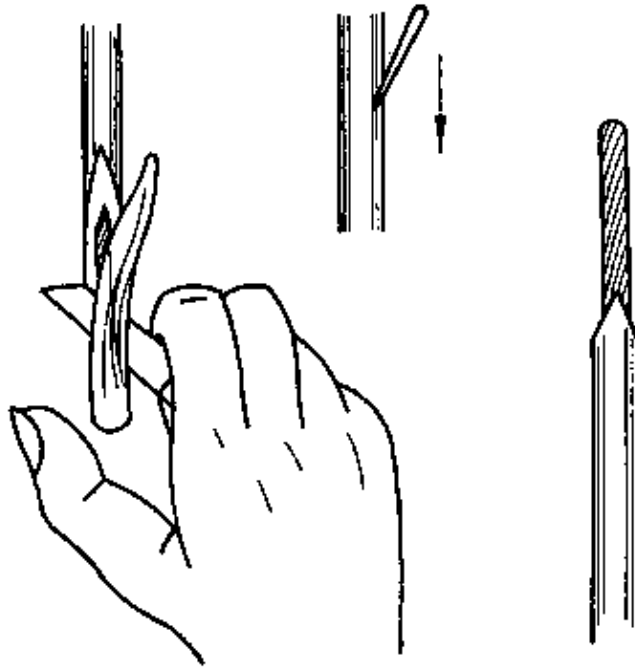


Figure 7 Stripping the core insulation by the electrician's knife

Pay attention to the correct handling of the knife, because the fine-wire conductor might be damaged by a wrong touch of the knife and break in the course of further working.

– By the deinsulating tongs

- . With movable deinsulating edges, these are adapted to the cross-section of the conductor.
- . The conductor is put into the pair of jaws of the deinsulating tongs and the tongs are actuated.

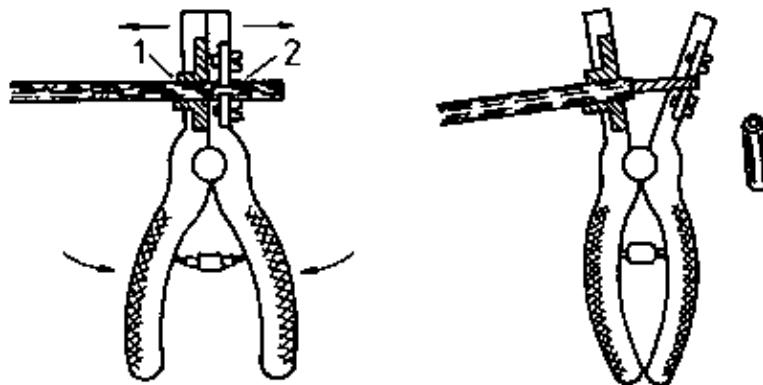


Figure 8 Stripping the core insulation off with the help of the wire strippers

*1 clamping jaw,
2 stripping jaw*

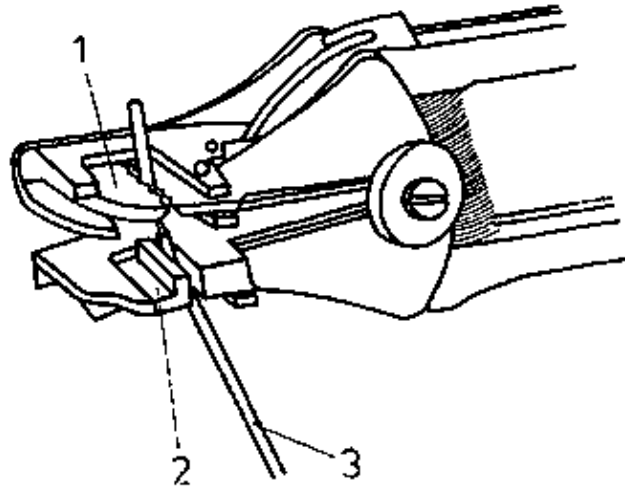


Figure 9 Wire strippers

- 1 cutting edge for various diameters,
- 2 clamping jaw,
- 3 conductor

Do only use the cutting edge assigned to the cross-section of the conductor and marked accordingly. Conductor cross-sections exceeding 6 mm² are deinsulated by the cable stripper.

By the thermal deinsulating device

- Switching the device on.
- Cleaning the resistance wire curl.
- Selection of temperature. (Core insulation must only melt, not burn.)
- Removing the core insulation by the deinsulating handle of the device.
- Switching the device off and pulling the plug after use.

The core insulation of heat-proof silicone and rubber-covered cables is not removed by thermal deinsulating devices due to their heat resistance and the strong smell that would develop.

Make sure that the ends of the conductors are always cleanly deinsulated. The conductor must neither show rests of the insulation nor indentations.

Removal of yarn wrappings from cables

- Cutting the yarn wrapping open.
- Prevent the yarn wrapping from undoing by ligaturing.
- Cutting the yarn wrapping open and removing it.
- Proceed as described above.

2.2. Preparation of the Conductors for Further Processing

Why must mobile cables get a special treatment before being connected?

What operations have to be done before the cable is connected?

For

- cleaning the conductor
- tinning the conductor
- soldering on of cable eyes
- pressing on of cable eyes

the handbook of "Making Permanent Joints" should be used.

After cleaning – also of the internal layers – the end of the conductor must be accurately retwisted clockwise.

Tinning of cables and the use of sweating thimbles has to be avoided to the farrest possible extent.

These methods should be applied only in special cases, for instance if and when eyes must be bent or pressing cable thimbles cannot be used.

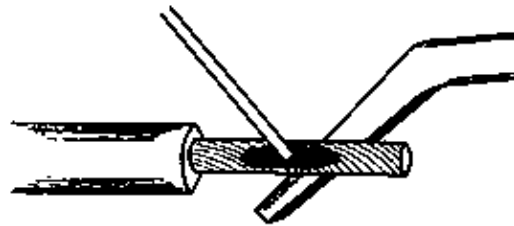


Figure 10 Tinning of a conductor

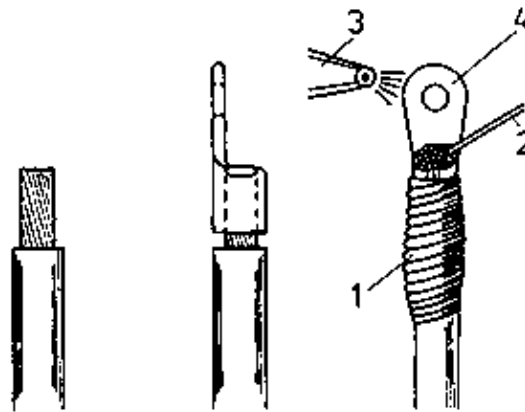


Figure 11 Soldering of a cable eye

- 1 fire-resistant wrapping,*
- 2 tin-base solder,*
- 3 nozzle of the sounder,*
- 4 cable eye*

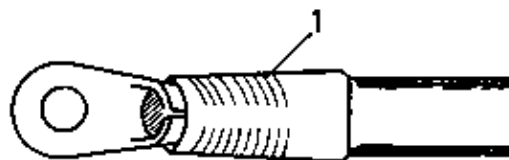


Figure 12 Cable eye soldered on

- 1 plastic hose or tape*

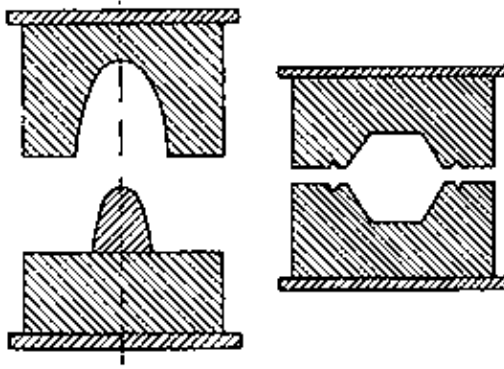


Figure 13 Pressing inserts for V-shaped grooving or hexagonal pressing

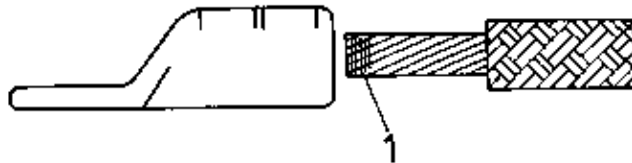


Figure 14 Putting a shaped conductor into the cable eye

1 binding for aerial line

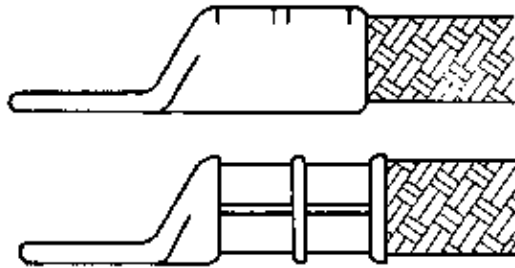


Figure 15 Cable eye before and after the pressing operation

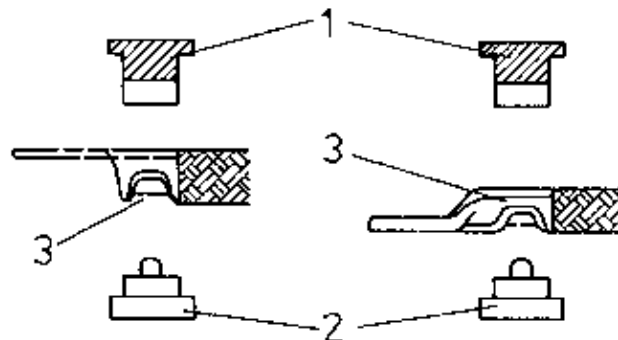


Figure 16 Making the V-shaped grooving at the top and bottom side of the cable eye

*1 top pressing insert,
2 bottom side pressing insert,
3 V-shaped grooving (left: D-shape, right: C-shape of the cable eye)*

Bending of eyes

- Twisting of the cleaned appropriately prepared core.
- Bending the eye with the help of an arbor or round-nose pliers. or
- Dividing the conductor and twisting it separately.
- Putting it around an arbor from both sides and joining the two ends by twisting them together.

When bending eyes, make sure that the internal diameter of the eye is 0.1 to 0.2 mm greater

than the diameter of the locking screw or bolt.

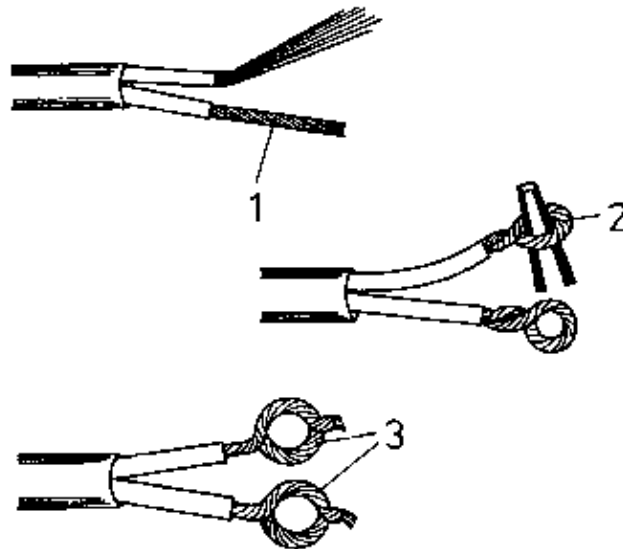


Figure 17 Bending of eyes

- 1 twisting of the cleaned conductor,*
- 2 eye bent over an arbor,*
- 3 completed eyes after the conductor having been divided up and twisted separately*

After this, the end of the conductor and the eye are tinned by soldering iron tin bath.

- If the twisted conductors are tinned first, they have to be shaped to an eye by round-nose pliers afterwards.

When tinned in a tin bath, the prepared and flux-coated end of the conductor is dipped into the fluid tin to approximately 3/4 of its lengths.

The process of tin-coating is completed, if and when the end of the conductor and the eye have a uniform, tin-covered surface.

Putting on of conductor end sleeves and contact eyes

- If not other forms are required, this technique should be preferred.
- It can be used with cross-sections up to 16 mm².

What are the advantages of this technique compared with tin-coating?

Sequence of operations for working conductor end sleeves

- The wires are stripped.
- The wide end of the sleeve is shoved on the blank end of the conductor.
- The end of the conductor together with the conductor end sleeve is put into the clamping fixture.
- Clamping by fastening the clamping screw by the required contact pressure.

Special fields of use of conductor end sleeves

- At terminal points with two cables, one conductor end sleeve of the appropriate size can be drawn over the two wires.

- Circuit bridges which must not be broken when being disconnected can be twisted and provided with a conductor end sleeve.
- Conductor of less than 0.75 mm² in cross-section are stripped over such length that they can be folded up two or three times and then put into a conductor end sleeve of a corresponding size.
- Size conductor end sleeves and contact eyes are not marked, attention must be paid that the conductor cross-sections and the end sleeves are fitting together.

Assignment of conductor end sleeves to the conductor cross-sections

(Cross-sections indicated in mm², main dimensions and length in mm)

Conductor cross-section	Conductor end sleeve	Main dimension		Length
		Internal diameter	External diameter	
0.5	1.3	1.3	1.8	12
0.75	1.3	1.3	1.8	12
1.0	1.5	1.5	2.2	12
1.5	1.8	1.8	2.6	12
2.5	2.2	2.2	3.4	12
4.0	2.9	2.9	4.1	12
6.0	3.5	3.5	4.8	16
10.0	4.4	4.4	5.7	16
16.0	5.5	5.5	6.8	16

Sequence of operations with the use of contact eyes

- Stripping the wire.
- Prebending the stripped conductor over an arbor.
- Pressing the contact eye on the prepared conductor.

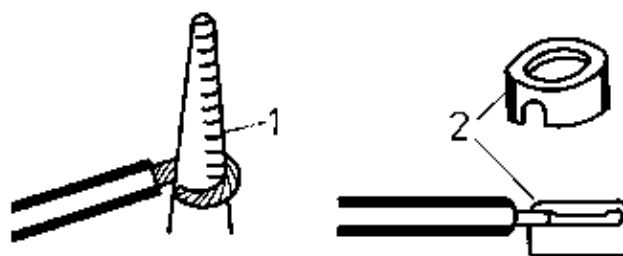


Figure 18 Prebending of the conductor over an arbor

1 arbor, 2 contact eye

- Putting the conductor with the contact eye in the mould of the pressing device or in the pressing pliers.

The conductor must be placed into the slot of the contact eye and in the slot of the matrix of the pressing device.

- Pressing on by pressing device or pressing pliers.

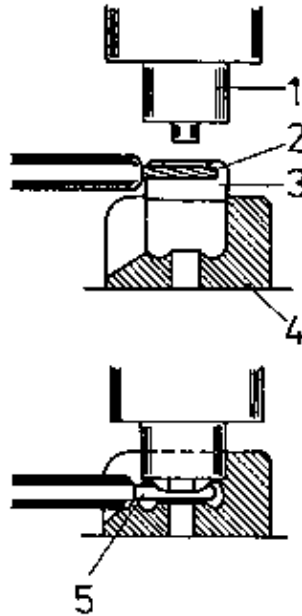


Figure 19 Principle of the pressing-on of contact eyes

1 punch, 2 conductor, 3 contact eye, 4 matrix, 5 contact eye with conductor after having been pressed in the matrix

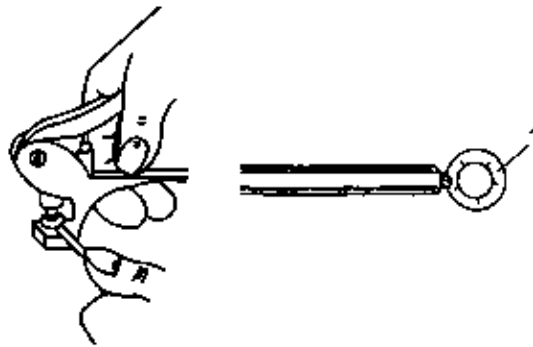


Figure 20 Pressing-on of contact eyes by the pressing tongs

1 completed contact eye

All individual wires of the flexible conductor must be held by the sleeve or by the eye.

Why should to cables, which shall be connected to mobile equipment, preferably conductor end sleeves and contact eyes be attached or cable eyes be pressed on?

3. Connection of Lines to Mobile Devices and Appliances

3.1. Making of Screw Fastenings

- Before a cable is put in and connected to a mobile device or appliance, this cable has to be stripped according to the requirements and prepared for connection.
- With the stripping length, the arrangement of the connections in the device or appliance has to be taken into consideration.

After putting the cable into the place of connection, a protective measure with protective conductor has to be taken and the external conductors have to be cut in such way that the protective conductor is the longest connecting core.

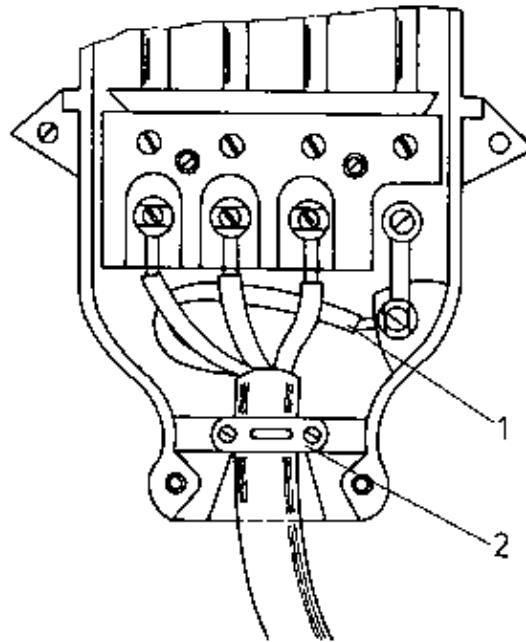


Figure 21 Collar coupler plug

*1 protective conductor,
2 tension relieving*

Why shall the protective conductor be the longest connecting core in the place of connection of the device or appliance?

– The covering of the cable must project into the device or appliance for approximately 3 mm.

By putting in the covered cables, the conductor insulation cannot be damaged by perhaps sharp edges of the device or appliance and sources of faults are avoided.

– The core insulation must end 1 mm in front of the connecting point.

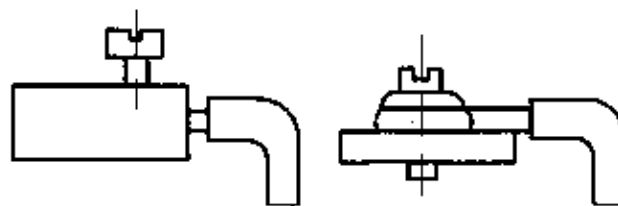


Figure 22 Connection points with correctly removed core insulation

Securing under terminals of the core insulation would put the functioning of the connection at risk. Too long stripping could lead to short circuits.

– Conductors equipped with eyes must only be connected in the direction of rotation of the terminal screw. (In doing so, make sure that the eye rests evenly on the junction block, because otherwise it may come to a deficiency of contact.)

– If several conductors are connected to one connecting bolt, pay attention that each conductor is followed by one washer and that – at least after every third conductor – one spring ring is inserted.

– If and when cable thimble and eye are connected to one connection bolt, the eye has to be connected separately.

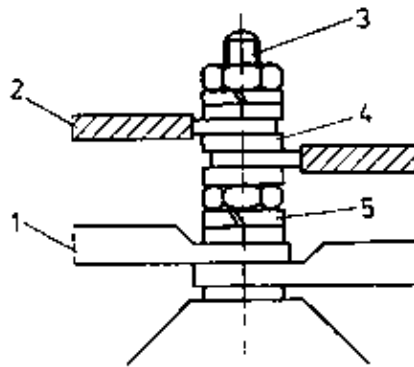


Figure 23 Connection to a connection bolt

1 cable eyes, 2 conductor with eyes, 3 connection bolt, 4 washers, 5 spring ring

– With the connection of protective conductor and middle wire, only one conductor per connecting point is permissible.

– To cap-screws without clamping bow or conductor holding fixture, three conductors which may differ by two cross-section steps at the most are allowed to be connected only if one washer is placed between the conductors, each.

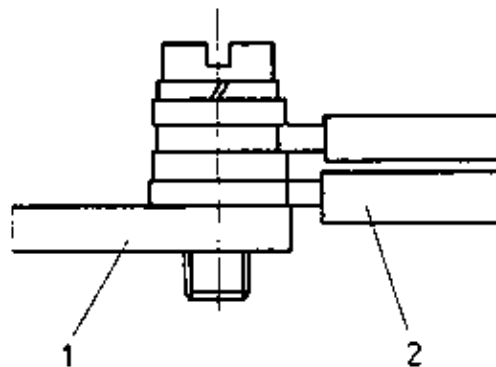


Figure 24 Connection by a cap-screw without clamping bow and holding fixture to a connection strap

*1 connection strap,
2 conductor*

– To cap-screws with clamping bow only one conductor is allowed to be connected on either side of the bow. The conductors to be connected may differ by one step in cross-section.

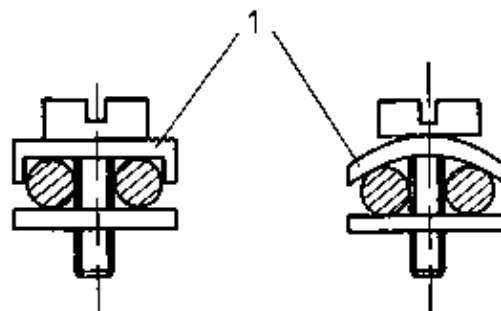


Figure 25 Connection to a cap-screw with clamping bow

1 clamping bow

– To cap-screws with conductor holding fixtures only one conductor is allowed to be connected to each holding fixture. The conductors to be connected must have the same

cross-sections.

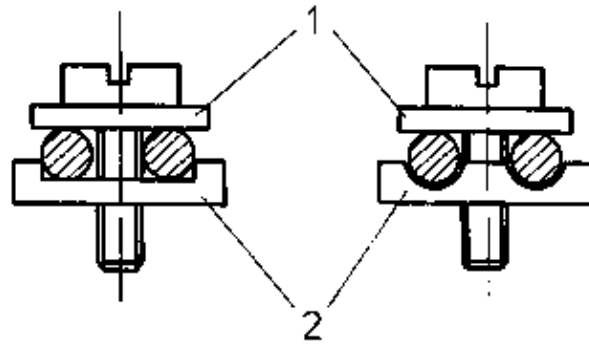


Figure 26 Connection to cap-screw with holding fixture

1 free disk, 2 conductor holding fixture

The washers used for the connection of conductors to screws or bolts must cover at least 2/3 of the conductor.

Screw slots must not be damaged by using wrong or defective screw drivers.

– To terminal blocks for sequencing two conductors are allowed to be connected to each terminal point, if they are soldered together at the connecting points and equipped with conductor end sleeves.

– When connecting conductors with end sleeves or eyes, make sure that

. the clip of each respective contact is sufficiently fastened, so that the conductor cannot the sleeve or eye,

. if the conductor end sleeve might be shifted on the conductor when it is put in the clip – for instance with cables that are put in from above – the sleeve should be slightly pressed on with the help of a suitable tool such as round-nose pliers or side cutting pliers.

3.2. Tension Relieving

Why is tension relieving required with mobile devices and appliances?

– Tension relieve is possible inside and outside the connection space of mobile equipment.

– Tension relieve must act immediately on one cable and not on intermediate layers.

– Mostly, tension relieve consists of one pressure clip with two fastening points. (See Figure 21).

– If tension relieve cannot be given within the connection space, it must be done outside at the casing or construction part of the device or appliance. However, the protective system of the device or appliance must thereby not be reduced.

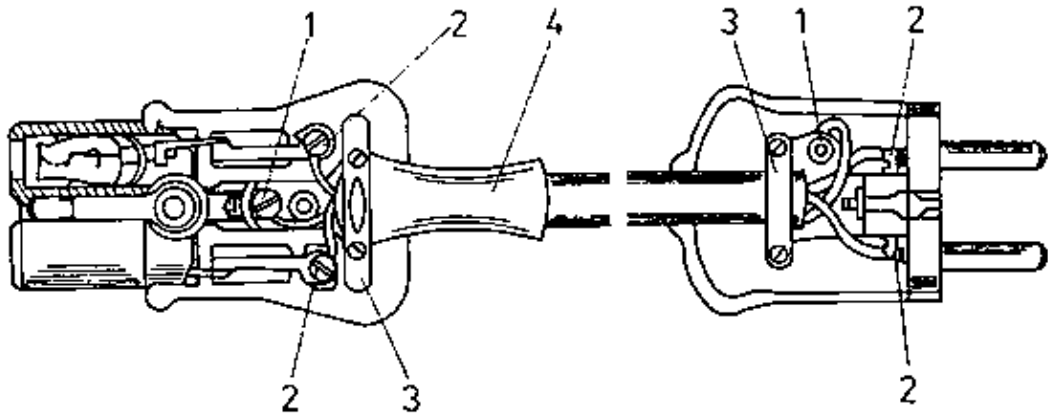


Figure 27 Tension relieving within the connection space of a protective contact flexible cable

1 protective contact connection, 2 external conductor, 3 tension relieving, 4 protection against buckling

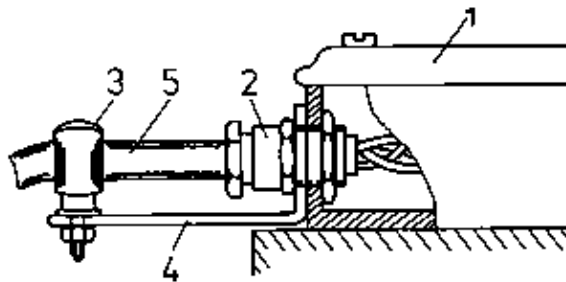


Figure 28 Tension relieving at an engine cable

1 clamping box, 2 cable entry,
3 tension relieving clip,
4 bow for tension relieving,
5 engine cable

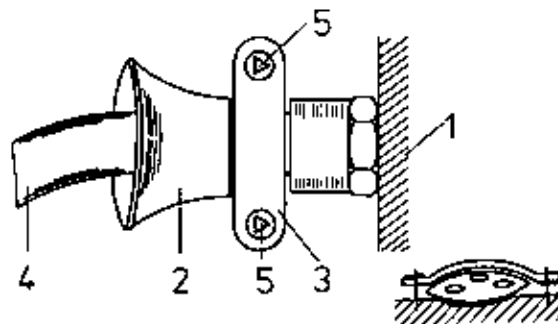


Figure 29 Trumpet-shaped entry at an explosion-proof lamp which is mobile to a certain extent

1 lamp casing, 2 trumpet-shaped entry, 3 tension relieving clip. 4 supply line, 5 screw with triangular heads

What is the importance of protection against buckling at device and/or appliance entries and exits?

Boltings which only serve the observance of the protective system or degree of protection of the device or appliance must not be used for tension relieving.

3.3. Principle Regulations for Plug-in Devices

– The order of plug and socket and/or coupler socket in the circuit is determined by the direction of the power flow.

– Plug and socket and/or coupler socket must be arranged in such a way that, under no circumstances, the plug pins are alive as long as they are not plugged in.

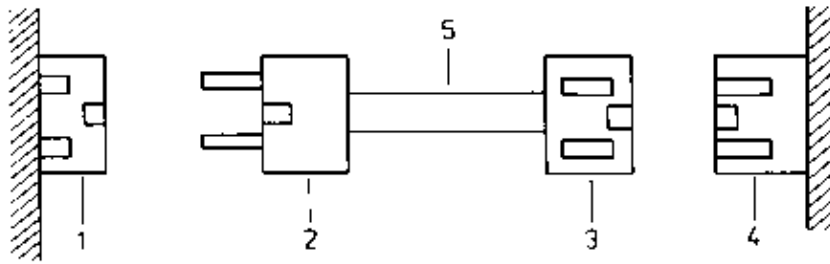


Figure 30 Direction of a power flow

1 socket, 2 plug, 3 appliance plug–socket, 4 appliance coupler, 5 cable

- For the supply of a number of devices or appliances fixed multiple sockets with earthing contact or mobile multiple sockets with earthing contact are preferred.
- It is not permissible to use plug–in devices in connection with lampholders and of free distributing plugs, even with shock protection.
- To a plug, a coupler socket or an appliance coupler only one mobile cable is allowed to be connected.

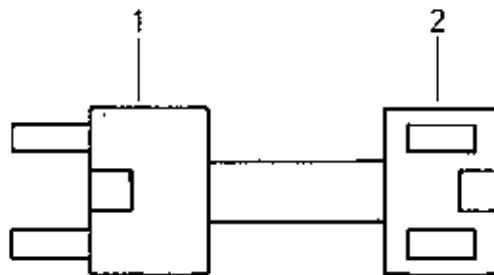


Figure 31 Correct installation of a mobile appliance connecting cable

1 plug, 2 coupling

3.4. Combining of Mobile Lines to Bank Cables in Plants and Devices

In addition to the cables for connecting mobile devices and appliances, there are pilot–wire circuits consisting of multiwire or thin–wire conductors.

Especially this is the case in plants which, during operation, are exposed to great mechanical strain and vibration.

If in such plants conductors are combined to bank cables, this is called bundled wiring and the manufacture of preformed cables presents itself.

In connection with the manufacture of preformed cables also use the handbook of "Manufacture of Preformed Cable".

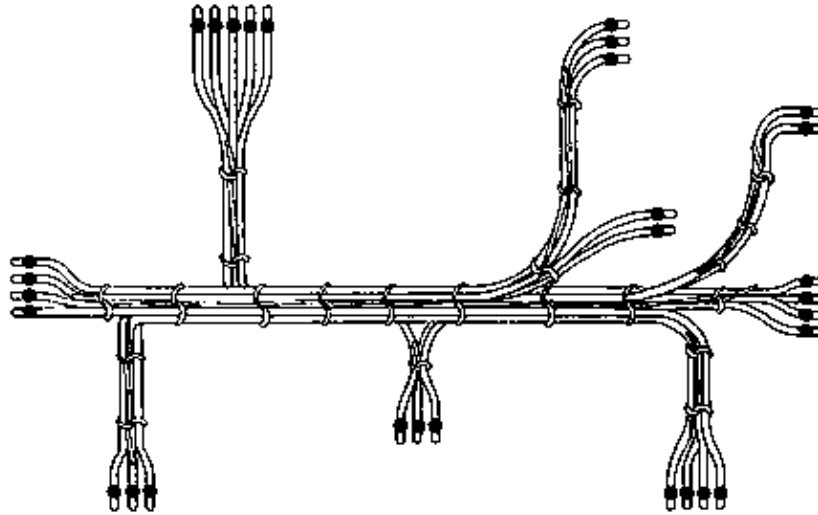


Figure 32 Manufacture of shaped cables on a matrix

Manufacture of a preformed cable

- Manufacturing of a model according to the individual conductor connections.
- Testing the cables as to continuity, unwinding them and cutting them to length.
- Combining them to bank cables.

If possible, use punched tape to tie them up with plastic string or cord.

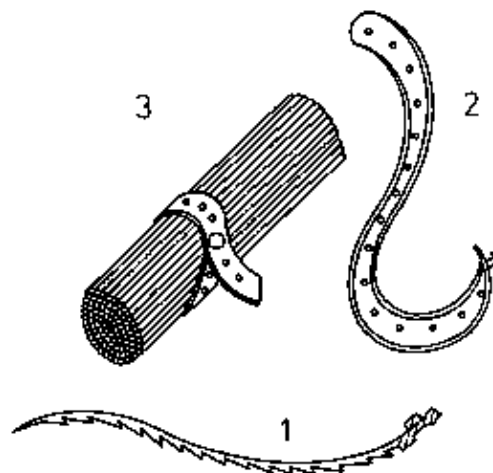


Figure 33 Binding material

*1 grit tape, 2 punched tape,
3 binding by punched tape*

- Fastening of the bank cables in the place where it shall be connected.
- Access to the connections and free connecting and disconnecting must be guaranteed.
- Testing and marking of the cables according to their respective purpose.

Marking the conductors by notches

This is the simplest and safest method of marking conductors.

- Suitable tools for notching are electrician's knives and side cutting pliers.
- The notches have to be started on the cable cross section at the end of the conductor and are continued away from there.

– Roman figures should be used for marking. (A correspondingly stripped piece of conductor is to be seen in Figure 34; it is equivalent to number 100.)

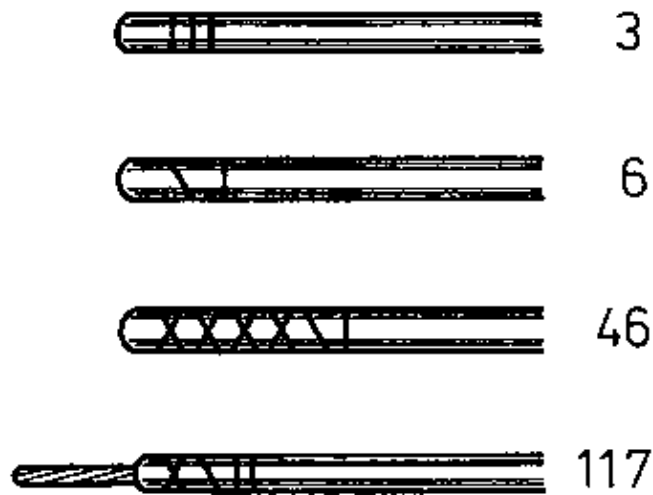


Figure 34 Notch marking by Roman figures

When notching, make sure that the marking remains legible even after a longer period of time and that also other people are able to read it.

What could be the consequences of mixed up connections in a plant?

**Making Permanent Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Trainees' Handbook of Lessons**

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Making Permanent Joints – Course: Basic Skills and Knowledge of Electrical Engineering.

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Introduction

The present handbook is intended for trainees in electrical engineering trades.

It contains a description of the tools and accessories required for the manufacture of permanent joints by soldering, wrapping, notching and pressing.

The individual types of joints are explained in self-contained sections. The necessary knowledge and skills are described in each section in the order of the steps of work required. The illustrations contained shall help to visualize, understand and supplement the text of the individual sections.

To assist the learning process, questions have been included for the trainees to test their knowledge.

1. Types and Meaning of Permanent Joints

Permanent joints are engineering joints of two or more parts (components, conductors) and are made by joining,

	Permanent joints	
material closed	force-closed (non-positive)	form-closed (positive)
soldered joints	pressed joints	wire-wrap joints
welded joints	crimped joints	
glued joints	notched joints	

- Permanent joints are used to join (connect) materials.
- Permanent joints must withstand the same mechanical and electrical stress as the materials to be joined.
- Permanent joints can only be detached by destruction of the joining elements or of the parts joined.

2. Tools for Making Permanent Electrical Joints (Bondings)

Tools for making permanent electrical joints are soldering irons, soldering baths, gasoline or gas blow torches, wrapping, notching and pressing tools. The use of such tools is to be adapted to the relevant application and local conditions.

Soldering irons

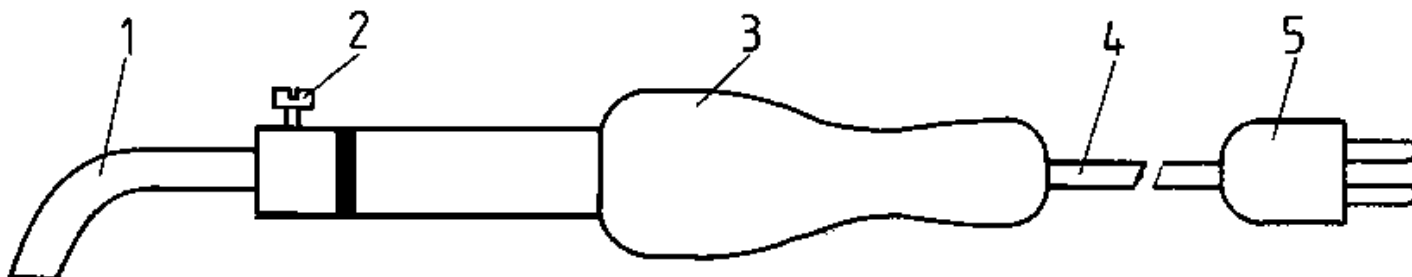


Figure 1 – Construction of an electric soldering iron – 1 bit, 2 fastening screw, 3 handle, 4 lead

Electrically heated by a current-carrying heating wire of a heating coil inside the metal housing of the soldering iron. The proper soldering iron is selected depending on the size of the soldering joint and on the necessary soldering temperature. Soldering irons with a capacity of from 6 to 400 W can be used.

Coordination of soldering iron – wire cross-section – solder diameter

wire cross-section (mm ²)	up to	1.0	1.5 to 6.0	10 to 25	up to 50
capacity of soldering iron (W)	up to	60	100	200	400
solder diameter (mm)	1.0		2.0	2.0	all types

- For soldering work on printed circuit boards soldering irons of maximally 60 W are to be used.
- Soldering irons with a perfect bit are to be used for any soldering work.

Soldering baths

Electrically heated by a current-carrying heating wire of a heating coil in a stationary housing where the solder is molten.

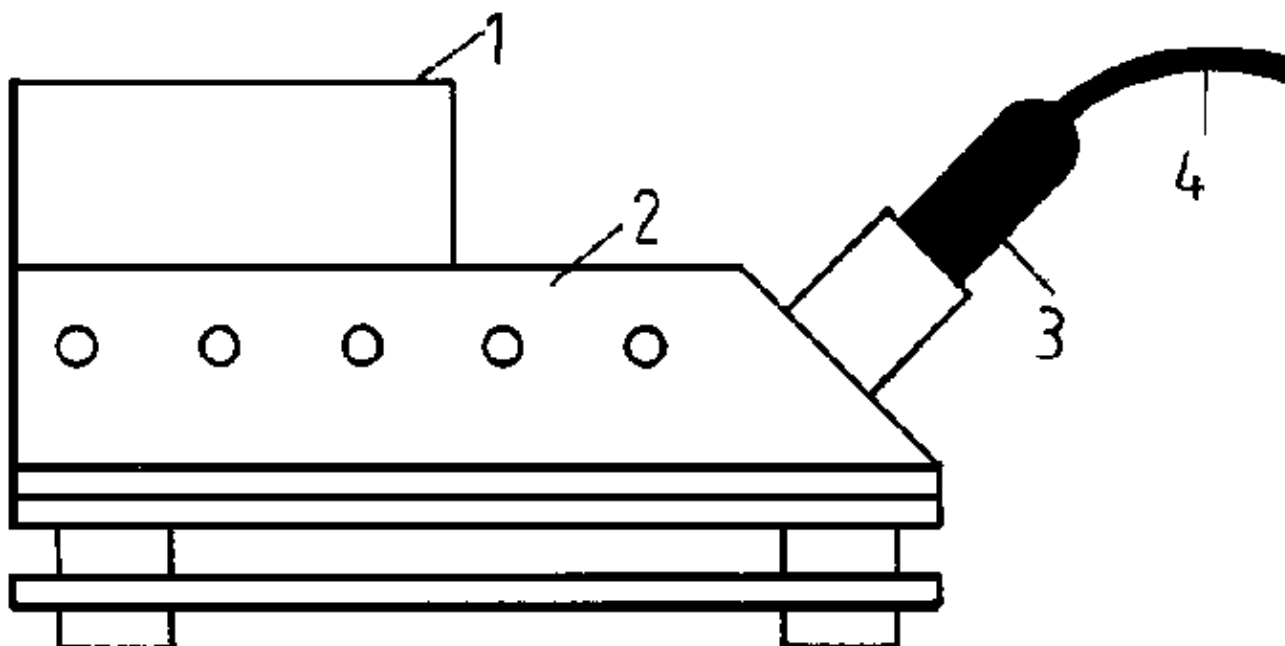


Figure 2 – Schema of a soldering plating bath – 1 soldering tin vessel, 2 electric heating, 3 plug, 4 lead

There are two types of soldering baths:

- Dipping bath for soldering of wires
- Flow–soldering bath for soldering of printed circuit boards.

Gasoline blowtorch

Gasoline blowtorches can be operated independently of the electric mains and are mainly used for soldering large cross–sections.

The following instructions are to be followed when working with the gasoline blowtorch:

- Don't fill the gasoline tank with more than three quarters of its capacity.
- Close the gasoline tank tightly – make sure that the sealing in the screw cap is fitting well.
- Pour the spirit into the preheating bowl and ignite it. By preheating, the gasoline absorbed by the wick is heated and gasified in the gasifier.
- Before the spirit flame extinguishes, let gas from the nozzle into the blow pipe by opening the control knob and ignite the gas. The vent slots in the blow pipe will supply air so that the correct mix of gas and air will be generated.
- Adjust the flame correctly by means of the control knob.
- Use the first third of the flame for soldering.

Gas blowtorch

Gas blowtorches can be used independently of the electric mains and are universal in use by various nozzles and attachable bits. The following instructions are to be followed when working with the gas blowtorch:

- Make sure that all connections are tightly fitting.
- Don't interfere with the pressure relief valve.
- When working in cable shafts etc., place the gas cylinders outside the cable shafts.

Wrapping tools

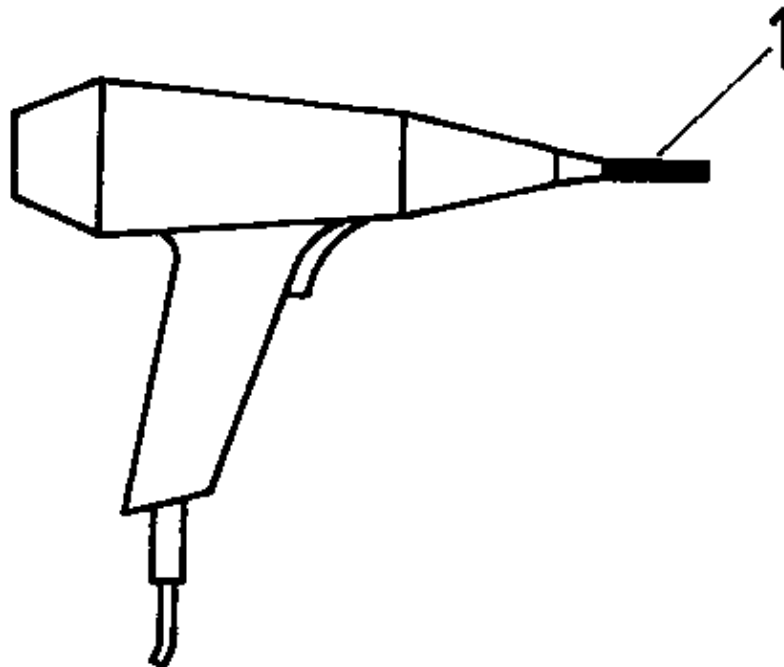


Figure 3 – Wire wrapping tool (wrapping gun) – 1 *wrapping mandrel*

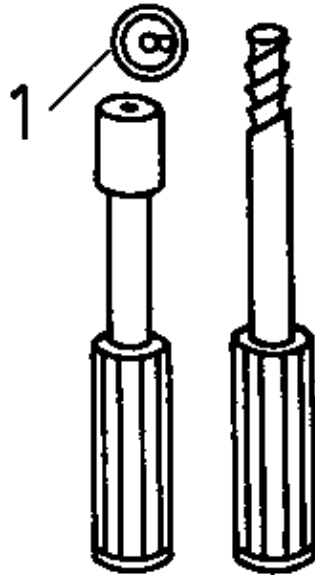


Figure 4 – Wrapping mandrels – 1 front bores

Wrapping tools are required to join one more solid copper conductors of 0.3 mm to 1.0 mm diameter by a tag or to separate them.

The wrapping mandrel is the front pan of the wrapping gun or wrapping needle, i. e. the actual wrapping tool. It is provided with two holes at its front end, one is exactly in the centre and one is off-centre. The centre hole accommodates the wrap pin to be joined with the wire. Because the wrapping mandrel must rotate around the wrap pin, this hole must be 0.1 to 0.2 mm larger than the wrap pin's diagonal. The off-centre hole accommodates the stripped wire. The corkscrew type wrapping needle serves for opening the joint.

Notching tools

Notching pliers are used to join a conductor with a cable eye or several conductors in a sleeve by notching or crimping. In order to be able to handle various conductor cross-sections, two adaptors are required for the notching pliers. The adaptors required for flexible copper conductors, for example, are

0.75... 1.5 mm² and

2.5... 10 mm² cross-section.

For smaller conductor cross-sections the crimping is done with a flat nose plier or adjusting plier.

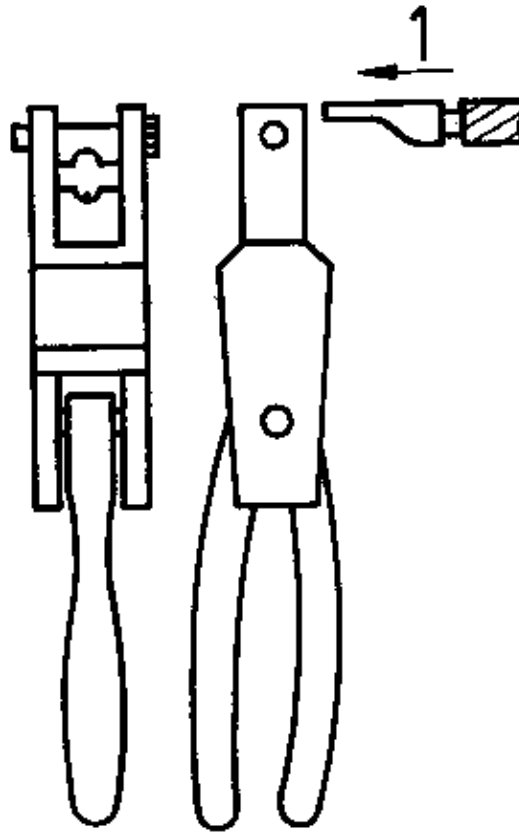


Figure 5 – Notching pliers with tool insert – 1 direction of leading in the cable eye

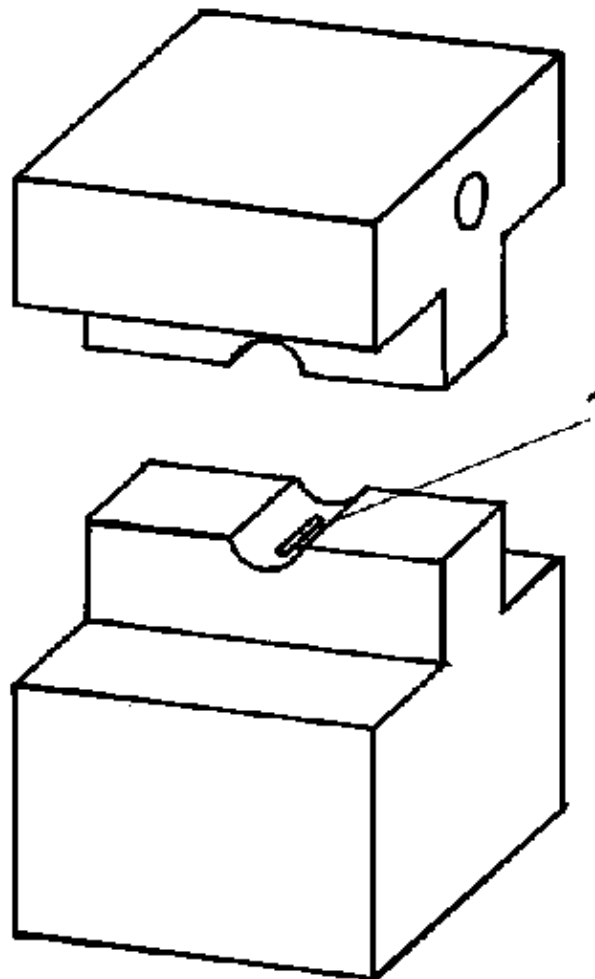


Figure 6 – Tool insert – 1 movable grooved pin

Solders are metals with a lower melting point than that of the metals to be joined. Common solders are tin and lead based.

Depending on their use, they are available in different forms:

- Bar solder for soldering baths.
- Thread type solder for manual soldering.
- Strip solder with flux for manual soldering.
- Friction solder for manual soldering of aluminium.

Cleaners

Fluxes, such as soldering tincture or soldering paste, become detrimental to the properties of soldered joints in the course of time. Therefore, it is necessary to remove flux residues after soldering. For cleaning of the soldered joints we use

- spirit or
- naphtha.

3.2. Steps of Work

In practice, there is a variety of forms of soldered joints. The preparation for soldering, however, is always the same.

The following steps are involved:

- Cutting to length and stripping of conductors

The stripping length depends on the relevant use. Stripped conductors must not be notched – risk of breakage!

Tools for stripping of conductors:

Conductor diameter/ Single-wire conductor	conductor cross-section	Tool
Single-wire conductor	0.45... 0.8 mm	
Single-wire conductor	1.0 mm, 1.5... 6 mm ²	
Conductors of more than	6 mm ²	
Wire and tinsel conductors		

- Cleaning of soldering surfaces

Soldering surfaces are stripped conductors, leads (pigtails) of components as well as connections of conductors and components. For making a proper soldered joint it is necessary to clean the surface to be joined by soldering. Depending on the soldering surface, cleaning is done by

- paint stripper (scraper) for small wire diameters and components
- cable stripper for big wire wire diameters
- wire brush
- flame cleaner for enamel-insulated wires (diameter smaller than 0.2 mm)

- Flux-treatment of soldering surfaces

Why must soldering surfaces be treated with flux prior to soldering?

- Tin-coating of soldering surfaces

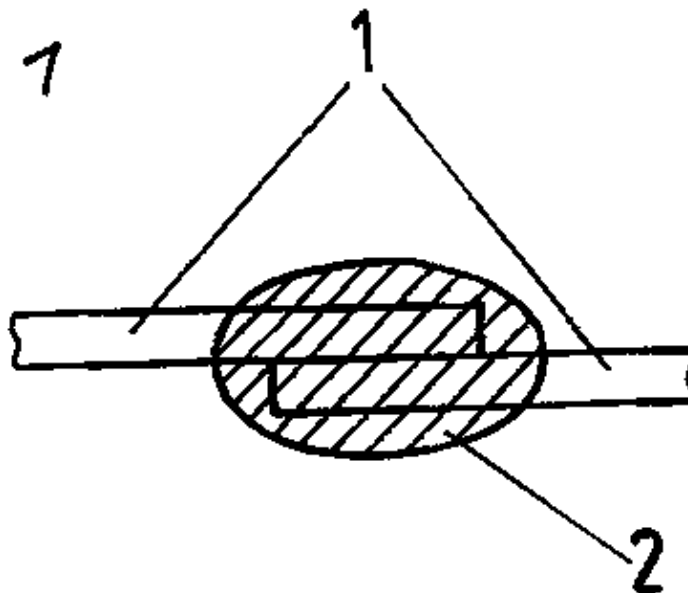
With thin-coating a material-closed joint is made by heating the soldering surface above the melting point temperature of the solder by means of a soldering device and by supplying solder on the soldering surface.

- Making soldered joints

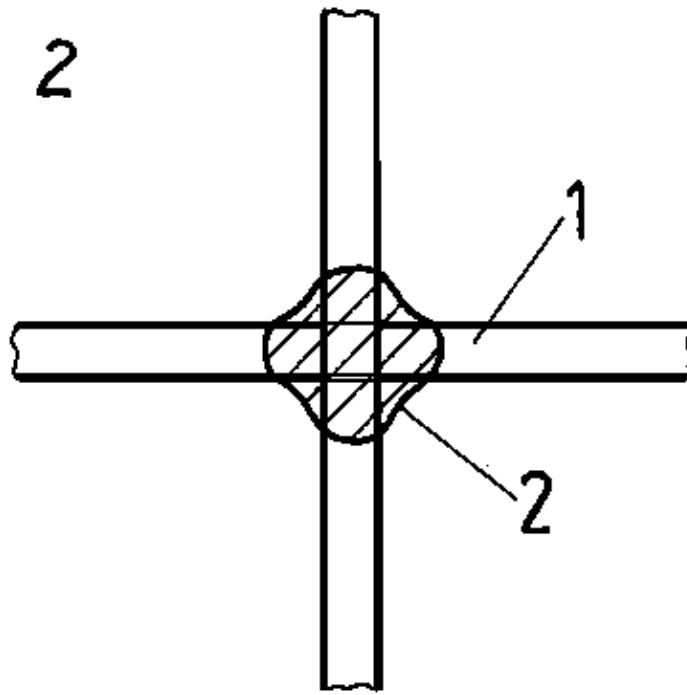
Soldered joints are material-closed joints (bonds) of two solderable metals. There are different forms of soldered joints:

– Wire-to-wire joints as parallel, cross or hook joints as well as soldered joints with twisted wires. Parallel and cross joints are mechanically connected by the solder only and, therefore, can be more easily detached. Hook joints and joints with twisted wires are mechanically stronger and more difficult to detach. The tin-coated wires are put together according to the type of joint. The joint is heated above melting-point temperature of the solder by means of the soldering iron and bonded with soldering tin added. Then the soldered joint must cool down with no displacement of the wires.

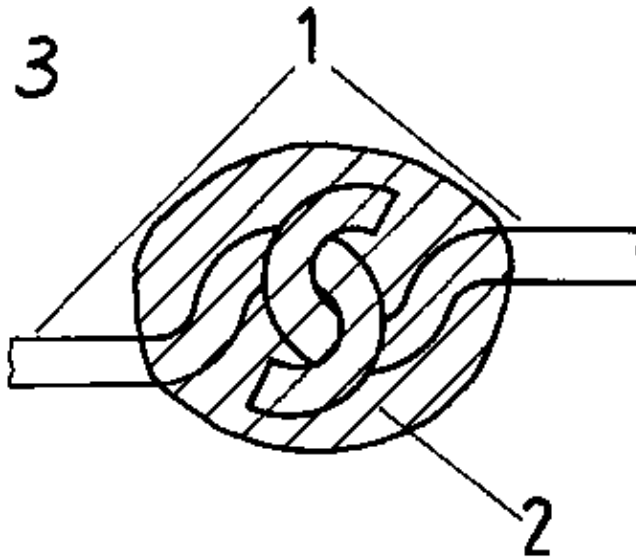
Figure 7 Soldering joints – 1 conductor, 2 soldering joint



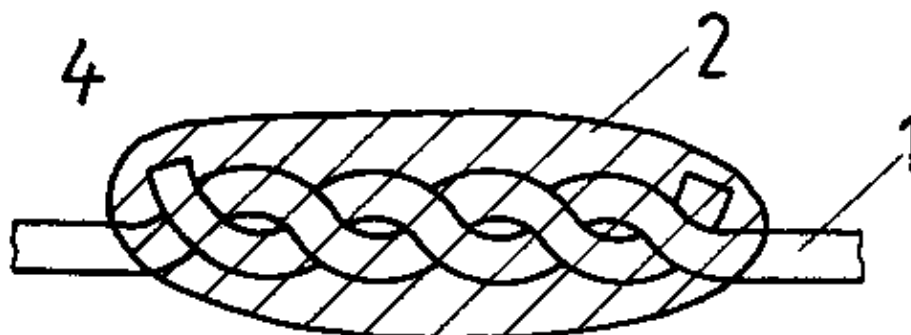
7.1. single or parallel joints



7.2. cross joint



7.3. hook joint



7.4. twisted joint

– Wire and cable eye

The cable eye is to be selected depending on the size of the conductor and to be tin-coated, if necessary. A flexible insulating tube is to be slipped over the conductor and, after soldering, over the cable eye and to be fed into the cable eye. The joint is to be heated by means of a soldering device and when adding solder the

sleeve of the cable eye is filled. It is to be made sure that the wire end and cable eye form a clear end.

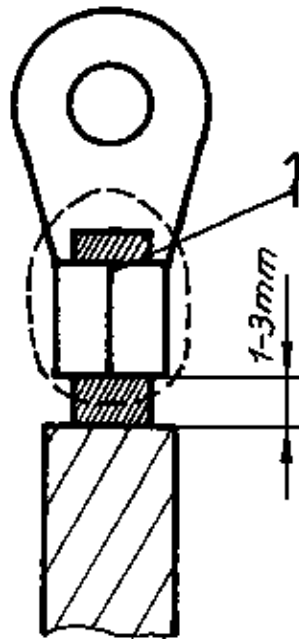
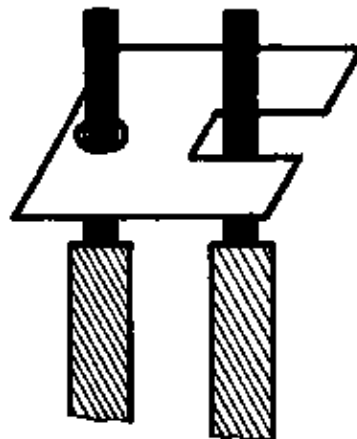


Figure 8 – Wire and cable eye – 1 point to be soldered is to be tin-coated

– Wire and soldering tags



Soldering tags are produced in various forms. The wire is to be led into the respective tag and to be clamped in place by a flat nose plier. Then the soldering tag is heated by means of the soldering iron and by adding soldering tin the joint is made.

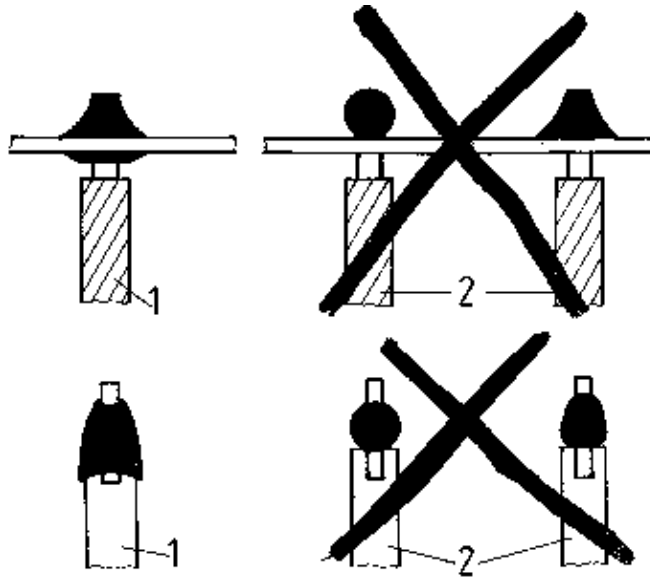


Figure 9 – Wire and soldering tags – 1 correct, 2 incorrect

– Component and soldering tag

What steps are required for joining a component and soldering tag?

– Component and wire

A component–wire–joint is made like a hook type soldered joint.

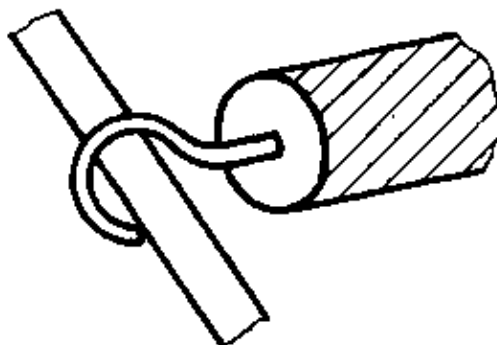


Figure 10 – Component and wire

– Components on printed circuit boards

Soldering on printed circuit boards is to be done quickly and exactly. The soldering iron's capacity should not exceed 60 W so as not to destroy the sensitive semiconductor components by high temperature. The leads of the components are to be bent and cut to length according to the hole spacing on the printed circuit board and to be tin-coated, if required. The component is to be inserted and the soldering eye and the lead are to be heated from the conductor end by means of a soldering iron adding solder.

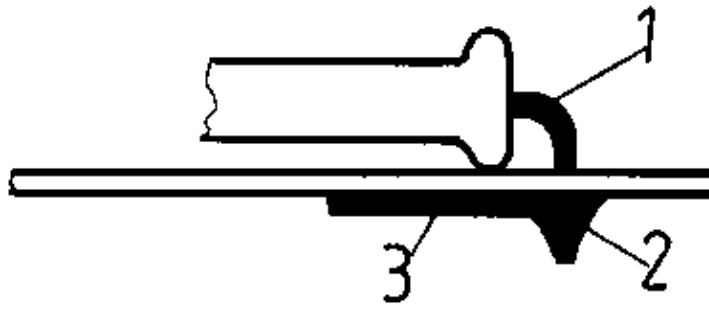


Figure 11 – Components and printed circuit boards – 1 lead, 2 soldering point, 3 printed circuit board trace

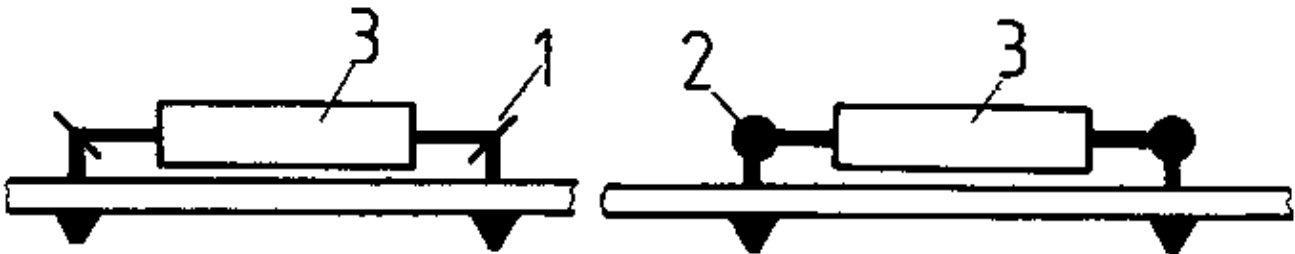


Figure 12 – Replacing a component – 1 separation point of the defect component, 2 soldering point of the new component, 3 component

What steps are required for replacing a component in Figure 12?

• Inspection of the soldered joint

A correct soldered joint features:

- a consistent, bright surface,
- perfect bond between the solder and the parts connected,
- no holes or inclusions in the surface,
- a mechanically strong connection.

What are the causes for a bad soldered joint showing the following faults?

Soldered joint	Cause
Grey surface Bad bond of solder	

4. Wire-wrap Joints

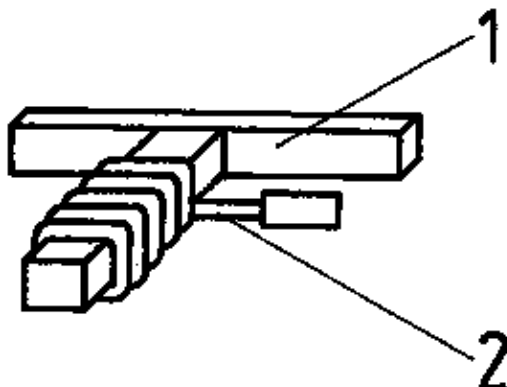


Figure 13 – Wire-wrap joints – 1 wrap pin, 2 wire to be connected

Wire-wrap joints serve to connect solid copper wires of 0.3 mm to 1.0 mm diameter with the respective connecting elements. The wire-wrap joint restricts the electric connection to the two mechanical elements absolutely necessary:

- the wire to be connected
- the wrap pin as connecting element.

Using technological properties of the wire and wrap pin, it is possible to do without solder, flux and heat. Disadvantages of soldered joints are excluded. A maximum of 7 windings is required to achieve a correct joint mechanically and electrically. The joint is generated by plastic flow in the wire at the edges of the wrap pin. The sharp edges of the wrap pin are penetrating into the wire with the oxide layers on the wire and/or wrap pin being removed by scraping and squeezing. Since 7 windings are made, several metallic, clean and gas-proof contact faces are generated. Corrosion on the contact faces is not possible.

Steps of work

- Cutting to length and stripping of conductors

The stripping length results from the number of turns multiplied by the circumference of the wrap pin. As a general rule, a stripping length of approximately 25 mm can be considered for any wire diameter.

Why must stripped wires not be notched?

- Feeding the wire into the wrapping mandrel

The wire is to be fed into the smaller off-centre hole of the wrapping mandrel, to be bent over and held in place.

- Making the wire-wrap joint

The wrapping mandrel is slipped on the wrap pin with the central hole. The wrapping process may start at any point in the wrapping area of the pin. By rotating the wrapping mandrel the wire end is drawn off the hole and firmly wrapped around the wrap pin. In order to ensure that the individual windings are closely fitting, the wrapping mandrel is to be pressed towards the base during wrapping. If several wires are to be connected to one wrap pin, the wires are to be wrapped one after another.

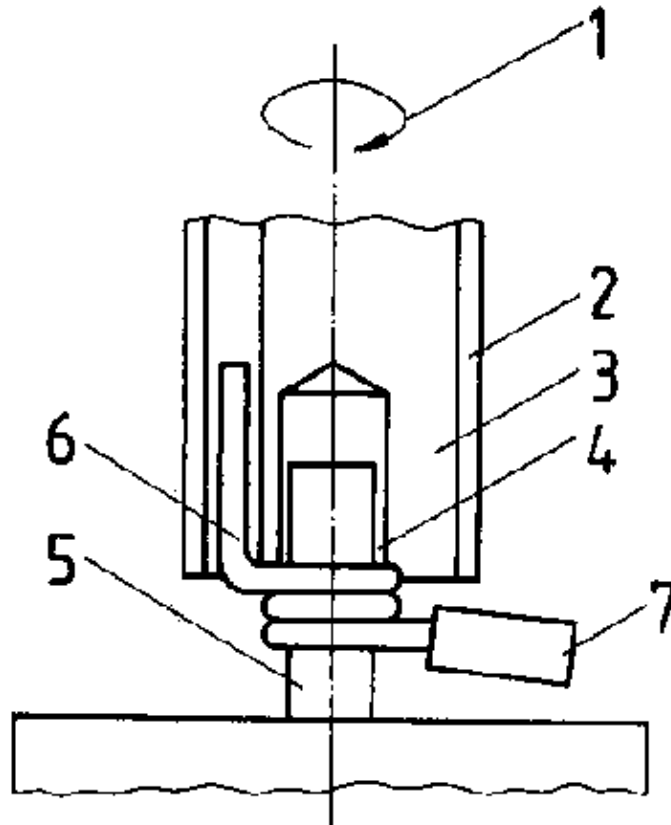


Figure 14 – Making the wire-wrap joint – 1 winding direction, 2 wrapping mandrel, 3 wrapping mandrel part for socket, 4 socket for wrap pin, 5 wrap pin, 6 wire fed into off-centre hole, 7 wire to be connected

• Inspection of the wire-wrap joint

A correct wire-wrap joint features:

- the correct number of turns (windings),
- closely fitting windings,
- no overlapping windings.

The inspection also includes strength testing.

The strength is tested by means of a drawing-off claw and a spring balance.

The joint has the correct strength is not achieved, the joint is to be re-made.

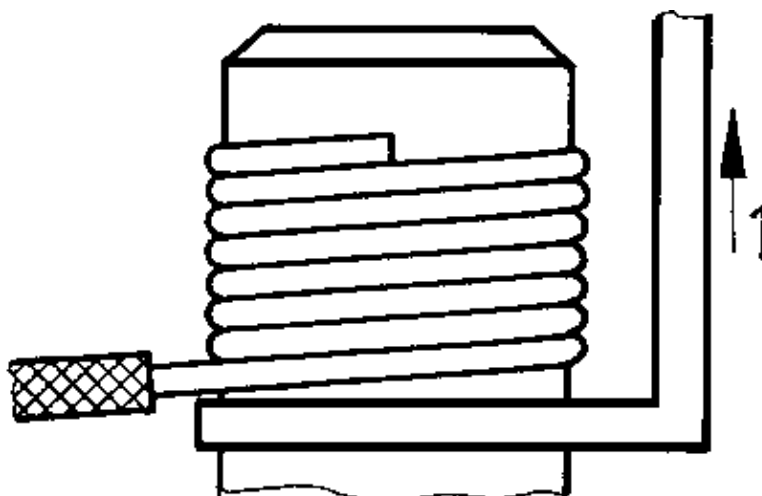


Figure 15 – Strength testing – 1 tensile force direction of the drawing-off claw

Wire diameter	0.3	0.4	0.5	0.6	0.8	1.0	mm
---------------	-----	-----	-----	-----	-----	-----	----

Required strength	2.0	2.5	3.0	3.5	4.0	4.5	kgf
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• Opening the wire-wrap joint

Any wire-wrap joint can be detached by means of the wrapping needle and then be re-made. The corkscrew type wrapping needle is put on the wrap pin with the hole. By rotation opposite to the wrapping direction of the wire, the wire is lifted and thus the joint is opened. Once used for wrapping, the piece of wire must not be used again for a wire-wrap joint since because of notches there would be a risk of breakage. The wire must be cut off and stripped again.

5. Notched Joints

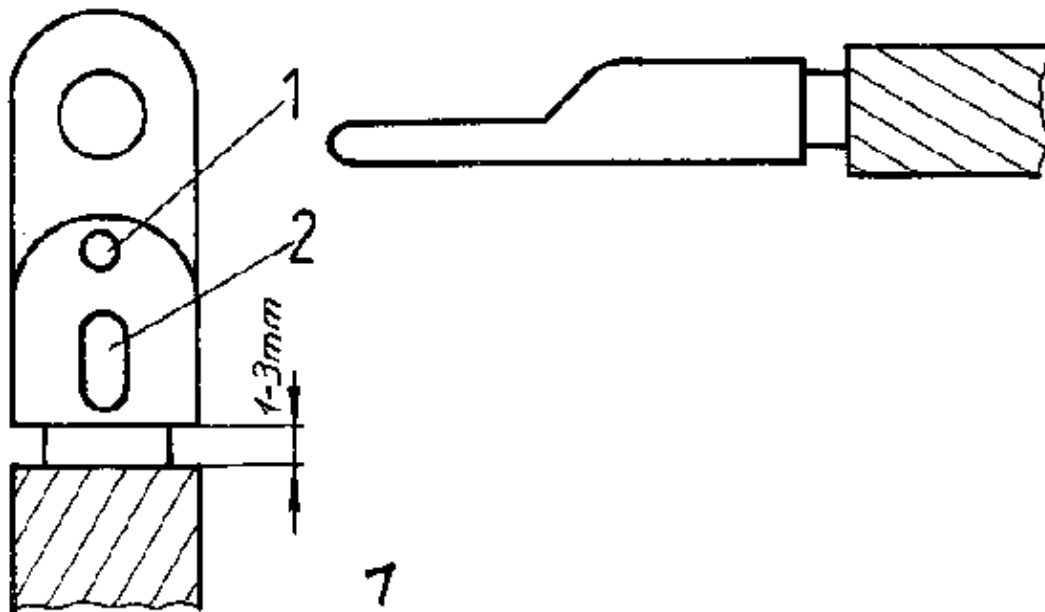
Notched joints are a way of connecting cable eyes with flexible copper conductors or rigid copper or aluminium conductors by means of a sleeve.

Flexible conductors may have a cross-section of 0.02 mm² to 10.0 mm² while for rigid conductors cross-sections of 0.2 mm² to 4.0 mm² are possible.

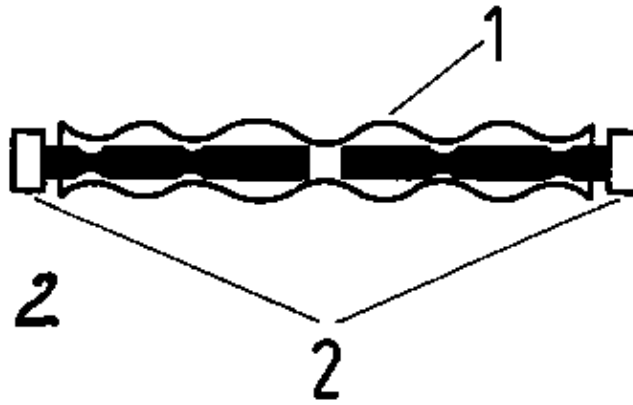
The joints are squeezed together by means of additional metal (cable eye or sleeve).

What are the advantages of notched joints over soldered joints?

Figure 16 – Notched joints



16.1. cable eyes and conductors prepared for notching, – 1 hole for conductor check, 2 pressed mark



16.2. longitudinal notched joint – 1 notch connector, 2 ends of conductor

Steps of work

- Cutting to length and stripping of the conductor The stripping length depends on the required size of the cable eye or sleeve.
- Cleaning of the conductor

In order to achieve good contact of the notched joint the conductors must be free from oxide and/ or varnish.

Which tools are required for cleaning of conductors depending on the cross-section?

- Feeding the conductor into the cable eye or sleeve

When inserting the conductor it is important that the size of the cable eye or of the sleeve is in accordance with the conductor cross-section. The space available in the cable eye or sleeve is to be fully utilized for the conductor.

In the case of flexible conductors with a small cross-section the conductor is to be bent towards the insulation and to be inserted in the cable eye together with the insulation in order to increase the strength of the joint.

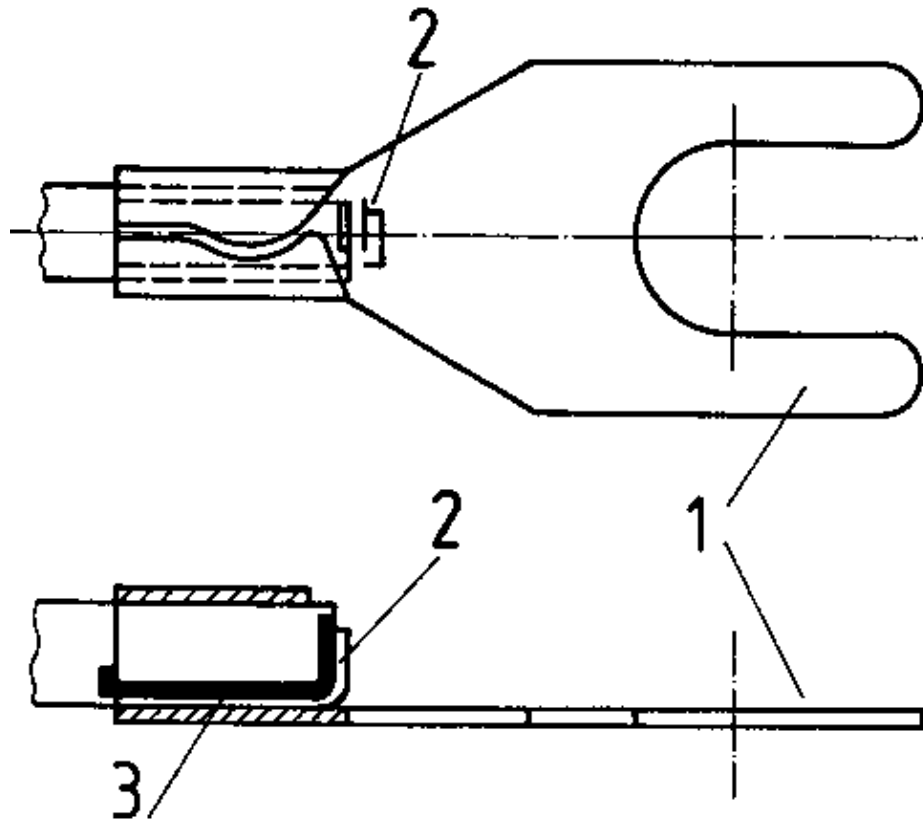


Figure 17 – Notched and crimped joints for flexible cables – 1 cable eye, 2,3 insets

- Making the notched joint

Before the cable eye or sleeve is put into the notching plier it is to be made sure that the correct adaptor is fitted. The cable eye or sleeve is to be put into the notching plier so that notching takes place in the centre. The notching plier is to be pressed down up to the stop and then removed. For joints with cable eyes of less than 0.5 mm² cross-section, flat nose pliers or adjusting pliers may be used. In this case the individual straps are bent over by the plier one after another.

- Inspection of the joint The conductor (s) must be firmly seated in the cable eye or sleeve.

How is a notched joint checked for firm seat?

6. Pressed Joints

Pressed joints are a way of connecting cable eyes with a multiple-wire or flexible conductor. The cable eyes are selected so as to suit the cross section and material of the conductor. Conductor and cable eye must be of the same material. The joint is made by means of a pressing tool.

What cross-sections of copper or aluminium conductors can be pressed?

Steps of work

- Cutting to length and stripping of the conductor
- Cleaning of the conductor
- Feeding the conductor into the cable eye or the conductors into the sleeve

The press-sleeve must be used only for aluminium conductors of 2.5 mm² cross-section.

Three conductors must always be fed into the press-sleeve.

If only two conductors are to be joined, third conductor is to be used as filler.

• Making the pressed joint

The cable eye or the sleeve is to be put into the respective tool with existing marks for fixing the position to be considered. In correct position the pressing process can be performed.

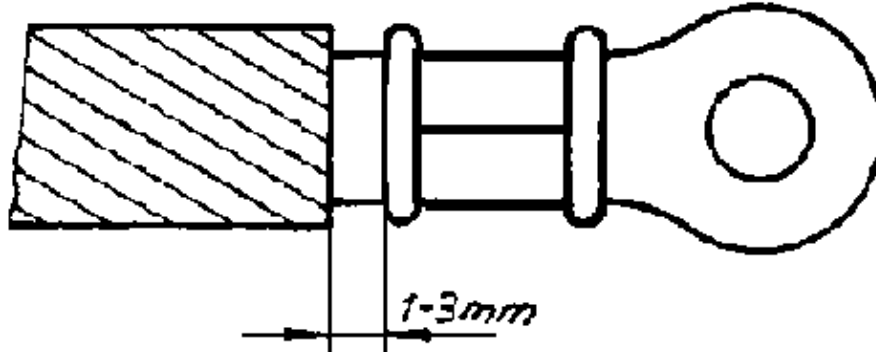


Figure 18 – Marked and fixed cable eye connections

After the pressing process the cable eye or sleeve is to be removed from the pressing tool. The flash produced at the cable eye is to be removed by a side cutting plier or by a file. The insulating sleeve is to be slipped over the press-sleeve until the conical end sticks on the press-sleeve. The pressing tools are to be cleaned after use.

Why must the flash at the cable eye be removed after pressing?

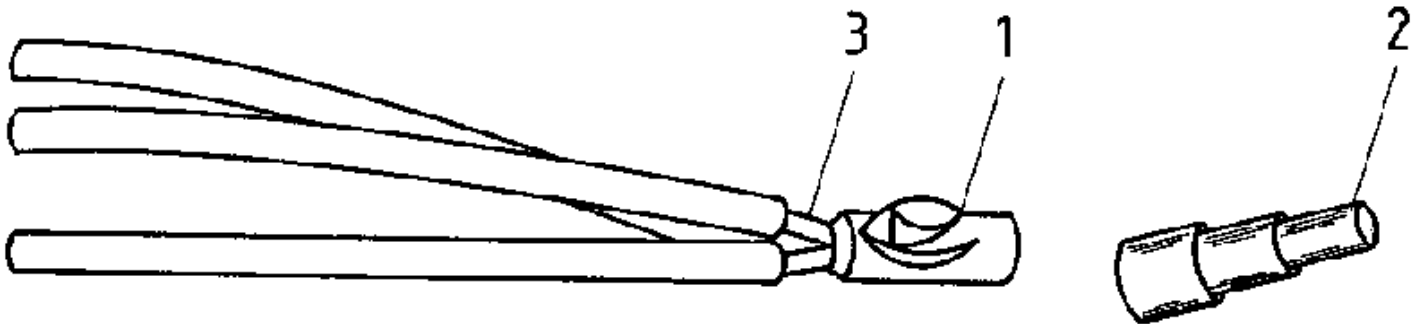


Figure 19 – Sleeve or passed joint – 1 press-sleeve, 2 insulating sleeve, 3 conductors to be connected

• Inspection of the pressed joint

Check gauges are used for checking the proper execution of the pressing

What steps are required for making the various types of joints?

soldered joint wire-wrap joint notched joint pressed joint

- 1
- 2
- 3
- 4

5

6

**Making Permanent Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Methodical Guide for Instructors**

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Making Permanent Joints – Course: Basic Skills and Knowledge of Electrical Engineering. Methodical Guide for Instructors

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1. Aims and Contents of Practical Vocational Training in the Working Techniques of "Making Permanent Joints"

After having finished their training based on this lesson, the trainees shall have achieved the following aims:

- They have the necessary knowledge and skills for making permanent joints.
- They can work with manufacturing documents, engineering drawings and working drawings.
- They are able to do the work in the quality required.
- They meet the safety requirements.

In order to achieve the above aims, the following knowledge and skills must be taught by the instructor:

Knowledge

- Design, operation and applications of the tools.
- Steps of work required for making permanent joints.
- Quality requirements for permanent joints.
- Labour safety requirements.

Skills

- Handling of tools.
- Maintenance and servicing of tools.
- Making soldering joints.
- Making notched joints.
- Making pressed joints.

2. Organizational Preparation

In order to ensure that the instructions, demonstrations and exercises go off smoothly, the training must be well prepared.

This includes:

2.1. Preparation of Labour Safety Instructions

Prior to the exercises the trainees must be instructed in brief on how to properly handle the working tools and prevent accidents.

It is recommended to prepare a book in evidence of the labour safety instructions given to note down in brief outlines all instructions given for preventing accidents and for handling the working tools properly. The trainees should then confirm by their signature that they have been instructed accordingly.

The instructions should include the following:

- Tools must be in proper condition.
- Cords and plugs of electric appliances must not be damaged.
- When leaving the room, electric appliances are to be switched off or disconnected from the power supply.
- Electric appliances must never be unattended.
- Electric soldering devices must be secured from falling down.
- Electric soldering devices are to be stored on non-inflammable supports.
- Damaged bits of soldering devices must be removed for repair.
- Tin baths should be centrally located in the room.
- Fluids must not be poured into tin baths because of the danger of explosion-like splashing of the fluid soldering tin and of the fluid.
- Soldering fluxes have caustic constituents and must not get into contact with skin. Fumes generated during soldering must not be breathed in directly.
- In case of comprehensive soldering work, fume extraction is to be provided or sufficient fresh air to be supplied.
- Inflammable fluids and gases are to be stored in prescribed containers.
- Inflammable fluids are to be stored at the place of work in small quantities only.
- Blowtorches are to be filled and put into operation outdoors.
- Blowtorches must cool down before filling.
- Adaptors of tools must not be changed unless the tools are out of operation.
- When working with rotating tools, closely fitting clothes are to be worn.
- Don't grip into pressing or notching adaptors when making the joints.
- Tools and materials are to be deposited clearly and neatly arranged.

Other labour safety instructions can be given for special local conditions.

2.2. Preparation of the Necessary Teaching Aids

- The theoretical instructions should be given at a place where the trainees are able to make notes, preferably a class-room with blackboard, desks and mains supply.

- When the instructions are given in the workshop at the workplace, the tables should be provided with clean supports for the papers etc. to be deposited.

For demonstrations during the instructions a workplace should be equipped as follows:

- For making soldered joints with conductor material: soldering device, cable eye, soldering tags, components and a printed circuit board.
- For making wire-wrap joints with conductor material: connecting element, tools for preparing the conductors, wrapping tool and testing tools.
- For making notched joints with conductor material: tools for preparing the conductors, notching tool, sleeves and cable eyes.
- For making pressed joints with conductor material: tools for preparing the conductors, pressing tools, cable eyes and sleeves.

Sufficient copies of the "Trainees' Handbook of Lessons – Making Permanent Joints" are to be made available to provide one copy to each trainee.

Tables etc. are to be written on the blackboard prior to the instructions.

All tools and accessories for making permanent joints as mentioned in section 3 are to be made available as visual aids.

2.3. Preparation of Working Tools and Materials

Sufficient copies of the "Instruction Examples for Practical Vocational Training – Making Permanent

Joints" are to be made available to provide one copy to each trainee as theoretical basis for the exercises to be done.

The initial materials necessary for the exercises as specified in the "Instruction Examples..." are to be prepared and kept ready in sufficient quantity.

Each trainee must have a workplace with a vice and mains supply connection.

The trainees' workplaces are to be checked for complete equipment with tools and accessories required for the planned exercises.

Recommended basic equipment:

- Screw drivers 2, 4, 6, 8, 10 mm
- Combination plier
- Flat nose plier
- Round nose plier
- Adjusting plier
- Side cutting plier
- Stripping plier
- Cable stripper
- Scraper
- Hand hacksaw with metal saw blade
- Wire brush
- Bastard file and smooth file 200 mm (half round)
- Hammer
- Soldering iron
- Soldering flux
- Spirit
- Folding rule
- Wrapping set

- Notching plier
- Pressing plier

2.4. Time Planning

Based on the total hours available, the times for the individual training sections of this lesson should be planned individually.

Time planning is recommended for the following sections:

- Introduction into the relevant working technique in the form of instructions including labour safety instructions.
- Necessary demonstrations.
- Job-related instructions to prepare the exercises.
- Exercises/practising.
- Recapitulations and tests.

In such time planning the following factors should also be taken into consideration:

- Level of training reached by the trainees,
- training conditions,
- future assignment of the trainees,
- level of difficulty of the relevant training section.

The emphasis in each training section should be on the acquisition of practical skills and abilities. Any waiting times occurring for the trainees in spite of good planning should be bridged by suitable preparatory work, such as preparation of conductor material.

3. Recommendations for Realizing Practical Vocational Training in the Working Techniques of "Making Permanent Joints"

The following sections contain recommendations on how to organize and implement the instructions, demonstrations of the working techniques as well as exercises and tests. The instructions for making the joints can be given regardless of the order specified.

3.1. The Introductory Instructions, Demonstrations and Exercises

The introductory instructions for each working technique can be given in a class-room. During the instructions the trainees should be advised to note down necessary additions or answers into the "Trainees' Handbook of Lessons".

The arrangement of the contents of the "Trainees' Handbook of Lessons" is adapted to the introductory instructions and the main points therein contained should be taught. The knowledge of the working techniques of treating cables and wires should be repeated and referred to since a good command of those working techniques is a pre-condition for acquiring the working techniques of "Making Permanent Joints". The subjects of "Types and Meaning of Permanent Joints" and "Tools for Making Permanent Joints" should be taught intensively using all teaching aids available.

Types and meaning of permanent joints

In order to make clear the types and meaning of permanent joints, it is recommended to show to the trainees finished joints made by welding, soldering or pressing, for example, for comparison. Such joints are then to be identified by means of the table in the "Trainees' Handbook of Lessons" and the possibilities of making and using them can be derived in a dialogue.

Tools for making permanent electrical joints

Original tools should be used to explain the basic design, operation, handling and requirements for use of the tools required for the relevant types of joints. The instructions should also contain recommendations for attendance, servicing and maintenance of the tools.

For testing the trainees' knowledge, the instructor should show tools and let the trainees repeat the designation of the parts of the tool, their functions and the mode of operation of the tools.

Then the trainees should note down in the "Trainees' Handbook of Lessons" which type of joint the relevant tools is used for. The notes are to be checked by having them read by one trainee while the other trainees are comparing and, if necessary, correcting their notes.

Making soldering joints

In this working technique the trainees shall acquire basic skills and abilities in soldering. The emphasis should be on the following main points:

- Correct preparation of the joint to be soldered.
- Proper use and handling of the soldering devices.
- Making a correct soldered joint.
- Meeting the labour safety requirements.

Before dealing with the actual sequence of operations, the trainees should be informed on the main metals that can be soldered, particularly in electrical engineering/electronics. It should be pointed out that copper can be easily soldered, but aluminium under certain conditions only.

In practice, there is a wide variety of forms of soldered joints. The preparation for soldering, however, is always the same. The following procedure is to be explained and demonstrated.

- Cutting to length and stripping of conductors.
- Cleaning of the soldering surfaces.
- Flux-treatment of the soldering surfaces.
- Tin-coating of the soldering surfaces.
- Making the soldered joint.
- Inspection of the soldered joint.

The demonstration of the steps of work involved is to be well prepared. To enable all trainees to see the demonstration, it is recommended to form groups of 6 to 8 trainees. The trainees of one group should be positioned around the place of demonstration so that they can easily watch the individual operations demonstrated. Then the instructor demonstrates how to make a soldered joint following the procedure given above. It is important

- that the instructor explains the purpose of his activities during the demonstration,
- that the trainees realize that making a soldered joint calls for great care, calmness and expertise,
- that the instructor's example is a decisive factor motivating the trainees in their work.

The demonstration may then be repeated by one trainee. The instructor must see to it that it is properly done and correct any mistakes immediately. Then the group is exchanged.

To bridge any waiting times, the trainees may answer the respective questions in the "Trainees' Handbook of Lessons" on their own. The answers are to be checked by the instructor. To develop the trainees' practical skills it is then necessary for the trainees to practise the making of soldered joints.

The exercises can be carried out on any conductor material available. The instructor should see to it that the level of difficulty of the exercises is adapted to the trainees' level of skills. It is recommended to have the exercises carried out in the following order:

- Tin-coating of different soldering surfaces.
- Joining of wires and wires.
- Joining of wires and cable eyes.
- Joining of wires and soldering tags.
- Joining of components and soldering tags.
- Joining of wires and components.
- Soldering on printed circuit boards.

The example from the "Instruction Examples for Practical Vocational Training" may also be used for practising. In this case it will be necessary to prepare and implement a "job-related instruction". For carrying out the work it is recommended to determine criteria for observation and evaluation, such as:

Cutting to length and stripping of conductors

- Did the trainee use the right tool?
- Is the stripped length in accordance with the relevant joint?
- Is the conductor undamaged?

Cleaning of the soldering surface

- Did the trainee use the right tool?
- Is the soldering surface metallic-bright?

Flux-treatment of the soldering surface

- Is the soldering surface completely moistened?

Tin-coating of the soldering surface

- Is the insulation of the conductor undamaged?
- Did the trainee use the right soldering tool?

Making the soldered joint

- Did the trainee use the right soldering tool?
- Did he use just as much soldering tin as necessary?

Inspection of the soldered joint

- Does the soldered joint meet the quality requirements?
- Is any insulation burnt?
- Are there any inclusions?
- Are any wire systems lifted off the printed circuit board?

Such criteria of evaluation should be made known to the trainees before they start with the exercises.

Making wire-wrap joints

In this working technique the trainees shall acquire basic knowledge and skills in making wire-wrap joints. The emphasis should be on the following main points:

- Preparation of the joint to be wrapped.
- Use and handling of the wrapping tools.
- Making the wire-wrap joint.
- Meeting the labour safety requirements.

Making a wire-wrap joint calls for much practice and manual skill. Therefore, great importance is to be attached to practising. At first, the instructor should explain the fundamentals, the advantages and

disadvantages of wire-wrap joints. This should also include explanations as to possible connecting forms of wrap pins and types of wire-wrap joints. After such introduction the steps of work are to be explained and demonstrated to the trainees. Knowledge already acquired should be questioned.

The trainees have to learn the following steps of work:

- Cutting to length and stripping of conductors.
- Feeding the wire into the wrapping mandrel.
- Making the wire-wrap joint.
- Inspection of the wire-wrap joint.

The demonstration of the individual steps of work is to be well prepared.

The demonstration should be implemented in groups like the demonstration of making soldered joints.

It is important:

- that all trainees can closely watch the demonstration,
- that the instructor explains all his activities,
- that the trainees realize that wire-wrap joints are to be made carefully and thoroughly,
- that the instructor's example is a decisive factor in motivating the trainees in their work.

After the demonstration of the steps of work it is recommended to have the steps repeated by the trainees so that their knowledge of the procedure of making wire-wrap joints will become more solid.

The instructor may also demonstrate the opening of a wire-wrap joint. It is to be pointed out that this also serves for testing the wrapping tools.

To bridge any waiting times, the trainees may, for example, prepare conductor material for wrapping exercises. Then the trainees can answer the questions in the "Trainees' Handbook of Lessons" on their own. The answer must be checked by the instructor.

In order to develop the trainees' practical skills, they have to practise the making of wire-wrap joints, and the exercises should be evaluated to the following criteria:

- Did the trainee use the right stripping tool?
- Does the conductor have any notches?
- Does the wire-wrap joint have a firm seat?
- Is the number of windings correct?
- Are all windings arranged one after the other?
- Is the direction of winding correct?

Making of notched joints

In this training section the trainees shall acquire the necessary knowledge and skills for making notched joints.

The emphasis should be on the following main points:

- Preparation of the notched joints.
- Use and handling of the notching tools.
- Making and inspection of the notched joints.

At first, the trainees should be made familiar with the application and advantages and disadvantages of notched joints. After such introduction the necessary steps of work are to be worked out with the trainees, such as:

- Cutting to length and stripping of the conductor.
- Cleaning of the conductor.
- Feeding the conductor into the cable eye or sleeve.
- Making the notched joint.
- Inspection of the notched joint.

After that the instructor should demonstrate how a notched joint is made. The demonstration should be carried out in the same way as for making soldered joints and wire-wrap joints.

After the demonstration the trainees can answer the respective questions in the "Trainees' Handbook of Lessons". The answers are to be checked by the instructor. To develop the trainees' practical skills, the trainees should practise the making of notched joints on various conductor cross-sections. But it is also possible to start immediately with the exercise suggested in the "Instruction Examples for Practical Vocational Training".

The following criteria of evaluation for the proper execution of a notched joint are to be announced to the trainees:

- Did the trainees use the right tool for the conductor?
- Does the cable eye or sleeve have a firm seat on the conductor?
- Does the distance between the insulation of the conductor and the neck of the cable eye have the required length?

Making pressed joints

In this working technique the trainees shall acquire the necessary knowledge and skills for making pressed joints. The points of emphasis in training, the steps of work for making pressed joints and the criteria for evaluation are similar to those for making notched joints.

Therefore, the trainees should repeat the technological sequence for making notched joints.

The instructor has to point out special features for making pressed joints and demonstrate the use of pressing tools. Practical skills already acquired are to be consolidated by further practising.

3.2. Recommendations for Working with the Instruction Examples for Practical Vocational Training

The "Instruction Examples" describe the sequence of operations and contain a working drawing for making permanent joints between a conductor and a cable eye by soldering, notching and pressing.

Moreover, the recommended materials, a list of the necessary working, measuring and testing tools as well as accessories are included for each example.

Depending on the application of the joint to be made, the length of the conductor material should be specified by the instructor in a brief instruction.

Thus the trainees have any information required for properly doing the exercises.

The following should be considered in the organization of the work:

The trainee should do himself any work involved in the instruction example, from preparing the initial material up to completion.

This is the only way of ensuring a just evaluation.

3.3. Examples for Recapitulation and Tests

This section contains questions to strengthen and test the knowledge and skills acquired. The answers to the questions are also given. Questions, which are also contained in the "Trainees' Handbook of Lessons", are marked with the letter "A".

1. What are permanent joints?

(Joints which can be detached only by destroying the connecting elements.)

15. Why must the flash at the cable eye be removed after pressing?

"A" (To avoid injury, such as cuts or laceration)

16. What steps are required for making the various types of joints?

"A" soldered joint	wire-wrap joint	notched joint	pressed joint
1. Cutting to length and stripping of conductor			
2. Cleaning of soldering surface	Feeding the wire into the wrapping mandrel	Cleaning of conductor	
3. Flux-treatment of soldering surface	Making the wire-wrap joint	Feeding the conductor into the cable eye or sleeve	
4. Tin-coating of soldering surface	Inspection of wire-wrap joint	Making the notched joint	Making the pressed joint
5. Making the soldered joint		Inspection of the joint made	
6. Inspection of the soldered joint			

**Making Permanent Joints – Course: Basic Skills and Knowledge of
Electrical Engineering. Instruction Examples for Practical Vocational
Training**

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Making Permanent Joints – Course: Basic Skills and Knowledge of Electrical Engineering. Instruction Examples for Practical Vocational Training

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Introduction

The present booklet contains 4 selected instruction examples to practise the main techniques of making permanent joints, i.e. made by soldering, notching and pressing.

Since a good command of these working techniques calls for much practice, the instruction examples are confined to the manufacture of joints between conductors and cable eyes.

The suggested instruction examples should be interpreted in a flexible way to provide for adequate use of the products; the product as per Instruction Example 2 could be used, for example, for a bicycle lighting line.

In order to facilitate the preparation and execution of the work, the necessary materials, working, measuring and testing tools, and accessories are given for each instruction example as well as the additional knowledge required for carrying out the work.

Moreover, working drawings are attached to illustrate the sequence of operations and show more details of certain steps of work.

Instruction Example 3.1. Soldering of Cable Eyes

To practise the manufacture of a permanent joint between a conductor and cable eye by soldering.

Material

Stepped flexible rubber sheathed cable $3 \times 2.5 \text{ mm}^2$
Length: approx. 2000 mm
Stepped length: 80 mm
Cable eyes, number: 3 off
Flexible insulating tubing length: 20 mm
number: 3 off

Working tools

Cable stripper (cable stripping knife) or stripping tool, 100 W soldering iron, flat nose plier

Measuring and testing tools

Folding rule or steel rule

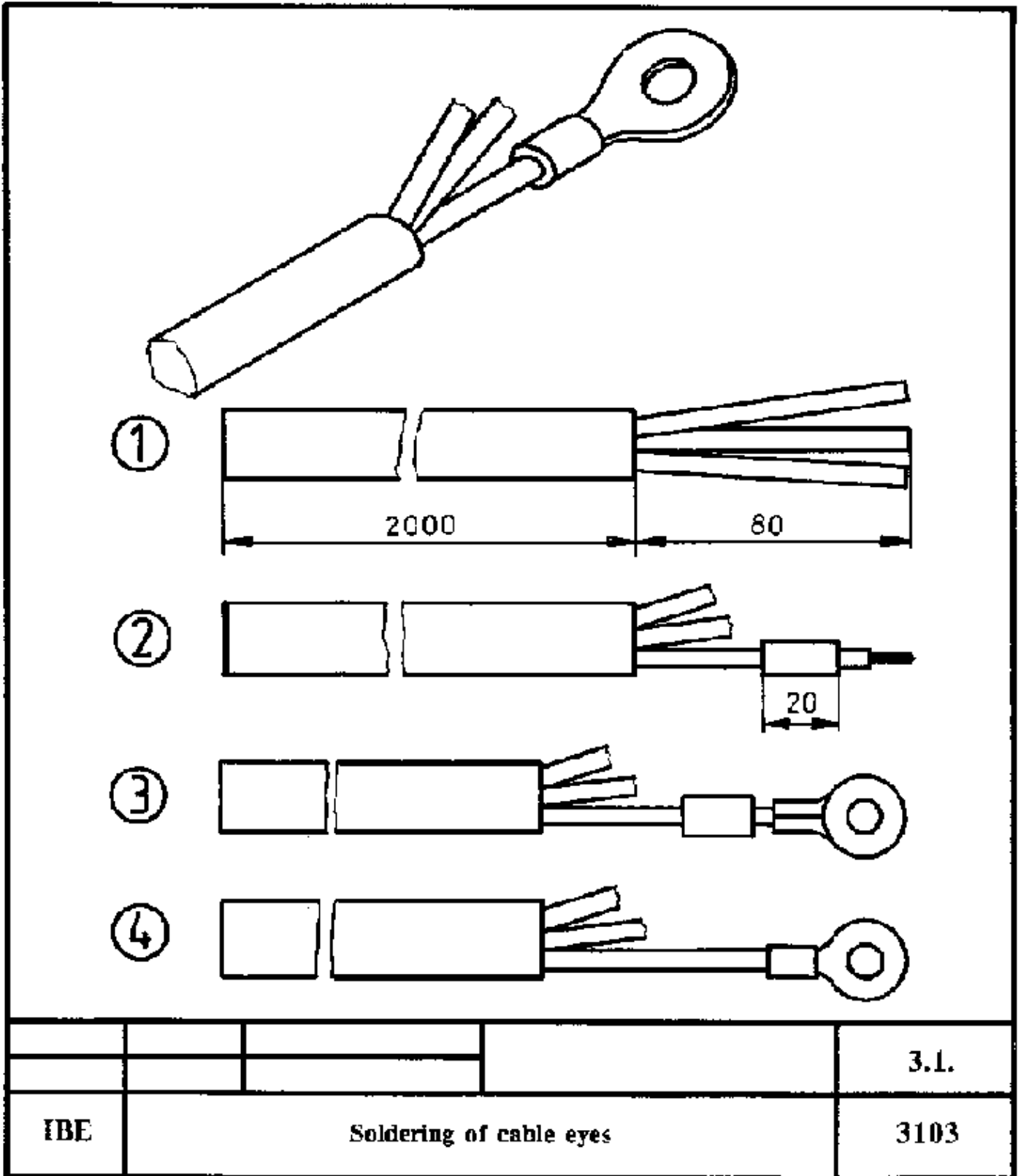
Accessories

Soldering flux, soldering tin

Necessary additional knowledge

Reading of drawings, treatment of cables and lines, measuring

Sequence of operations	Comments
1. Preparation of workplace. Making available the working materials.	Check tools and materials for completeness.
2. Checking of initial lengths.	Cut conductor to length, if necessary.
3. Stripping of conductors.	The stripping length is determined by the length of the cable eye sleeve. (1) Slip flexible insulating tubing on both ends of conductor prior to stripping. Twist stripped wire ends.
4. Bending down of stripped conductor towards insulation.	(2)
5. Feeding conductor in cable eye.	Stripped conductor must lie on base face of cable eye. (3)
6. Alternate pressing down of erect straps of cable eye on conductor by means of flat nose plier or adjusting plier.	(4)
7. Inspection of notched joint.	The conductor must be firmly seated in the cable eye.
8. Slipping flexible insulating tubing over cable eye sleeve.	



Soldering of cable eyes

Instruction Example 3.2. Notching of Cable Eyes and Conductors with Small Cross Section

To practise the manufacture of a permanent joint between a conductor and cable eye by notching.

Material

Flexible plastic-sheathed copper conductor 0.2 mm²
Length: depending on purpose of use.
Notch-type cable eyes number: 2 off
Flexible insulating tubing length: 10 mm number: 2 off

Working tools

Paint stripper (scraper), flat nose plier or adjusting plier

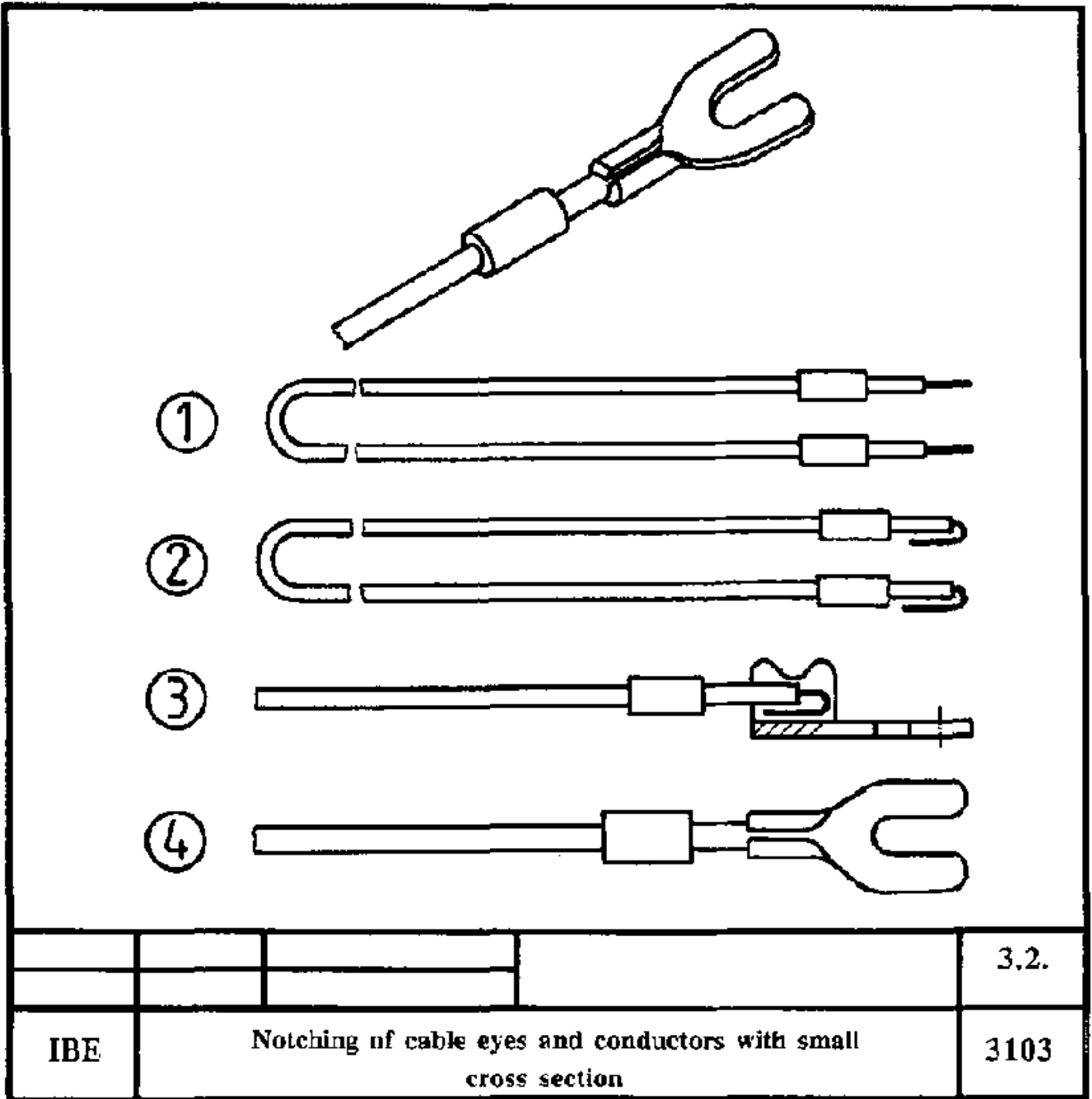
Measuring and testing tools

Folding rule or steel rule

Necessary additional knowledge

Measuring, treatment of cables and lines

Sequence of operations	Comments
1. Preparation of workplace. Making available the working materials.	Check tools and materials for completeness.
2. Checking of initial lengths.	Cut conductor to length, if necessary.
3. Stripping of conductors.	The stripping length is determined by the length of the cable eye sleeve. (1) Slip flexible insulating tubing on both ends of conductor prior to stripping. Twist stripped wire ends.
4. Bending down of stripped conductor towards insulation.	(2)
5. Feeding conductor in cable eye.	Stripped conductor must lie on base face of cable eye. (3)
6. Alternate pressing down of erect straps of cable eye on conductor by means of flat nose plier or adjusting plier.	(4)
7. Inspection of notched joint.	The conductor must be firmly seated in the cable eye.
8. Slipping flexible insulating tubing over cable eye sleeve.	



Notching of cable eyes and conductors with small cross section

Instruction Example 3.3. Notching of Cable Eyes and Conductors with a Cross Section Exceeding 0.75 mm

To practise the manufacture of a permanent joint between a conductor and cable eye by notching.

Material

Flexible plastic-sheated copper conductor 10 mm²,
 Length: depending on purpose of use,
 Notch-type cable eyes number: 2 off

Working tools

Cable stripper (cable stripping knife) or stripping tool, wire brush, notching plier with adaptor for 2.5... 10.0 mm²

Measuring and testing tools

Folding rule or steel rule

Necessary additional knowledge

Measuring, treatment of cables and lines

Sequence of operations	Comments
1. Preparation of workplace. Making available the working materials.	Check tools and materials for completeness.
2. Checking of initial lengths.	Cut conductor to length, if necessary.
3. Stripping of conductors.	The stripping length is determined by the length of the cable eye sleeve plus 1... 3 mm.
4. Cleaning of conductor by means of wire brush.	After cleaning twist wire ends.
5. Feeding conductor into sleeve of cable eye.	The conductor must fill the whole length of the sleeve. If a check hole is available, the conductor is to be fed in up to such hole.
6. Putting the cable eye into the notching plier.	Check position of the cable eye. The notching must be made in the centre of the sleeve.
7. Making the notched joint.	Press down notching plier up to the stop.
8. Inspection of proper execution.	The conductor must be firmly seated in the cable eye.

Instruction Example 3.4. Pressing of Cable Eyes and Multi-wire Conductors

To practise the manufacture of a permanent joint between a conductor and cable eye by pressing.

Material

Aluminium conductor.

Cross section and length depend on purpose of use.

Press-type cable eyes number: 2 off for Al conductors

Working tools

Cable stripper (cable stripping knife), wire brush, tube brush, pressing tool with adaptor for aluminium, flat file, side cutting plier

Measuring and testing tools

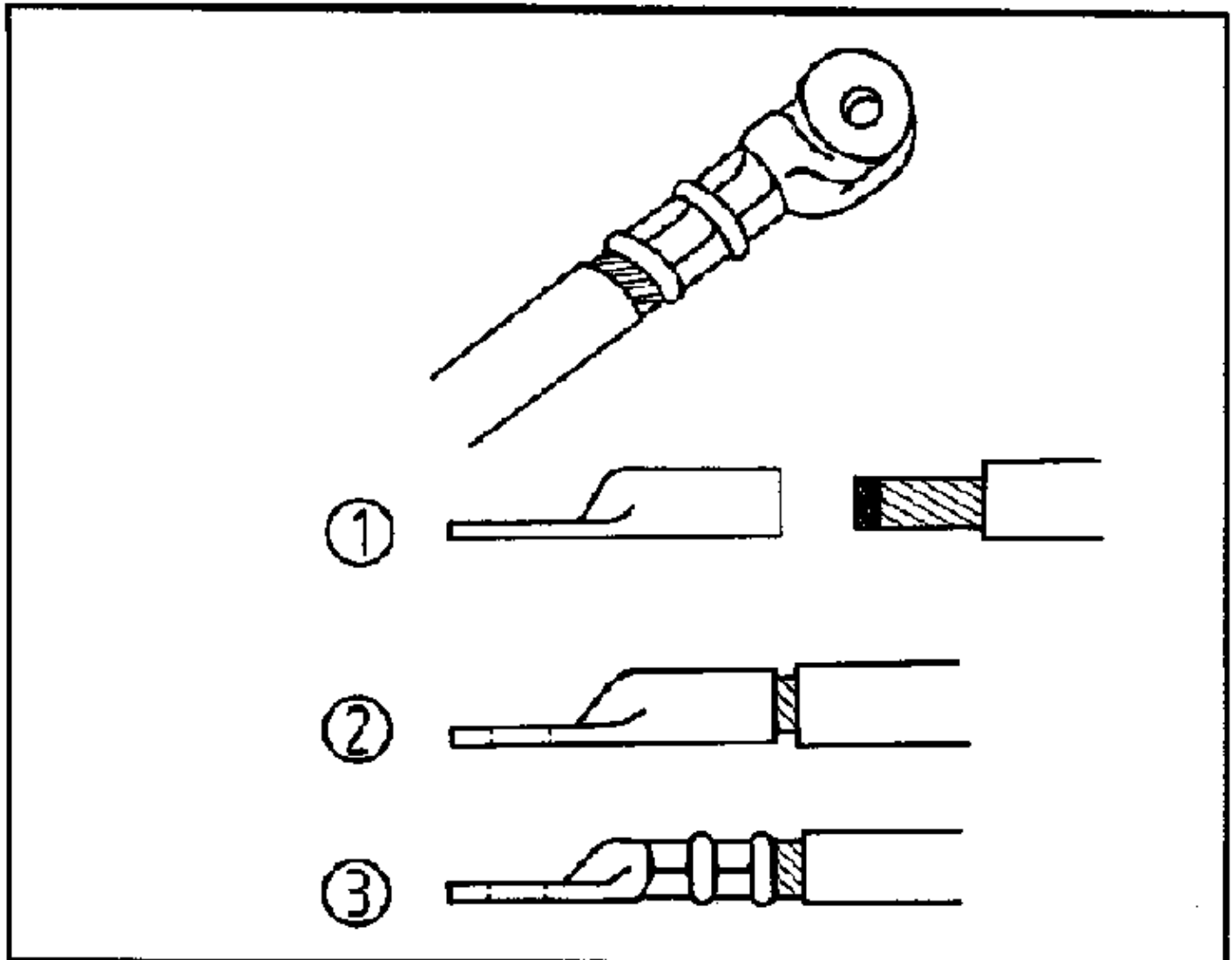
Folding rule or steel rule, reference gauges

Necessary additional knowledge

Measuring, treatment of cables and lines

Sequence of operations	Comments
------------------------	----------

1. Preparation of workplace.
Making available the working materials. Check tools and materials for completeness.
2. Checking of initial lengths. Cut conductor to length, if necessary.
3. Stripping of conductors. The stripping length is determined by the length of the cable eye sleeve plus 1 mm. (1)
4. Cleaning of conductor by means of wire brush. The time period between cleaning and pressing must not exceed 10 minutes.
5. Cleaning of cable eye sleeve by means of tube brush.
6. Feeding the conductor into the cable eye sleeve. If necessary, chamfer the conductor by means of flat file or provide wire collar next to cut point; wire collar is to be removed after feeding in. The conductor must fill the length of the sleeve. (2)
7. Pressing. The cable eye must lie in the pressing tool with the pressing mark. Start always with the pressing point next to the strap. Press only until the pressing jaws of the tool adaptor are closed. (3)
8. Removal of flash produced by means of side cutting plier or flat file.
9. Inspection of pressed joint by means of reference gauges.



				3.4.
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Pressing of cable eyes and multi-wire conductors

Basic Vocational Knowledge – Switchgear

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Basic Vocational Knowledge – Switchgear

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Preface

This textbook has been drawn up on the basis of the wide experience gained in the field of vocational training in the FRG and is intended for trainees of electrical engineering. It is based on the fundamentals of low–voltage switchgear. In a didactically edited form it contains the necessary knowledge for this field of electrical engineering.

With the help of many figures and corresponding surveys as well as a clear and comprehensible textural representation the trainees are assisted in understanding the problems dealt with. Taking into consideration the unity of theory and practice the trainees can use this textbook as a working basis in theoretical vocational training and in practical vocational training. Taking into account the corresponding IEC recommendations the low–voltage switchgear explained is taken from FRG production, represents a selection and is to be assimilated to products existing in each case.

1. General remarks

Low-voltage switchgear has to fulfil mainly the following functions in electrical energy systems:

- disconnecting
- switching (in the sense of arbitrary switching)
- protecting and
- limiting of the short-circuit current.

Since the field of application of low voltage is very extensive, there is a large variety of low-voltage switchgear.

Switches

Switches are devices for opening and closing electric circuits in which all parts necessary for connecting or disconnecting are mounted firmly on a joint base.

Relays

Relays are devices which are influenced by the change of physical magnitudes and control electrically further devices.

Trips

Trips are devices which are influenced by the change of physical magnitudes and control mechanically further devices.

Regulators

Regulators are devices provided with resistances for changing the operating state of electric operating means whose resistance remains permanently switched on in the circuit,

Plug-and-socket connectors

Plug-and-socket connectors are devices for establishing connections of current paths without additional auxiliary means, with connection for electric supply lines.

Fuses

Fuses are devices for interrupting current paths by melting of a piece of fusible metal when a current is exceeded in a given period of time. The fuse comprises all components of which the complete device consists.

2. important components of switches

2.1. Switching contacts

Definition

The electric contact is a disconnectable connection between two conductors suitable for carrying a current.

Contact fault

Contact faults cause great contact transition resistances, and it is difficult or impossible that the contacts open.

Cold welding

Adhesion between contact pieces by cohesion of metal ions.

Hot welding



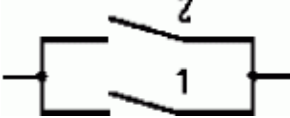
Great plastic deformation of contacts by Joule heat.

Fusion welding

Melting of the contact material due to excessive heating up (arcs, short-circuit currents). The adhesion resulting during cold and hot welding is overcome by corresponding switching forces. In case of fusion welding it is not possible any more to open the switch, and thus the switch cannot perform its function any more.

Contact arrangements

Survey 1 Contact arrangements

Contact arrangements	Examples of application	Construction	Advantages and disadvantages
Single break	ES contactors Relays	 Connection of a fixed and a movable contact member	Small contact opening, difficult to extinguish arc
Double break	Gang switches Contactors Low-voltage circuit breakers On-load switches	 Connection of two fixed contact members by a contact bridge	Arc extinction is made easier since two partial arcs are drawn on which half of the voltage is applied
Parallel connection of contacts	Low-voltage circuit breakers	 Functional principle: During the opening sequence first of all the main contact (1) is opened. The current continues flowing via the arcing contact (2). When the working contact is actuated, an arc is drawn on the working contact. During the closing sequence the working contact is closed first of all. 1 main contact 2 arcing contact	During the opening and closing sequences the main contact remains arc-free. Surface quality (silver/silver alloy) is maintained. Contact resistance is kept low. Arcing contacts can be easily replaced when worn (burn-up).

2.2. Arcs

When opening a switch, an arc is generated between the contact members. At low switching capacity this phenomenon is called switching spark, at high switching capacity it is called arc. The conductivity of the arc greatly increases with increasing temperature.

Quenching of the arc (lengthening of the arc)

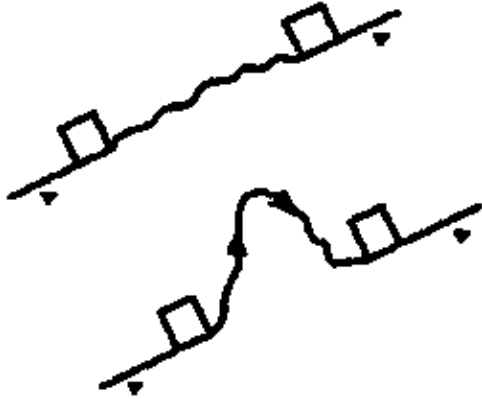
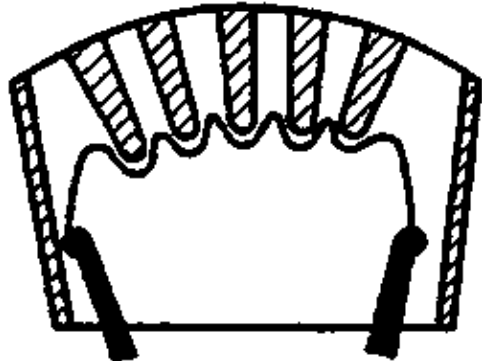
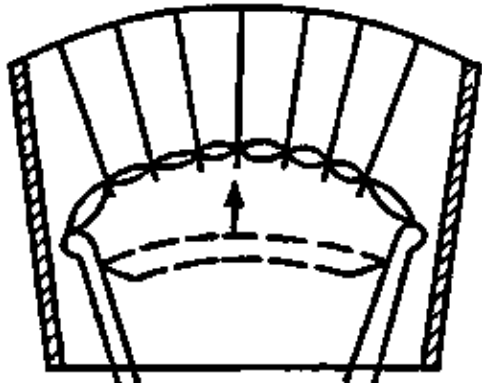
An intensive cooling of the arc by gas or oil results in the quenching of the arc. By decreasing the temperature the arc current becomes less and the cross-section of the arc is reduced. For medium-voltage and

high-voltage a.c. switches a lengthening of the arc is not recommended. When quenching the arc, the property of the latter is used that due to the zero passages of the alternating current at a frequency for example of 50 Hz, the arc is quenched one hundred times per second and ignited again the same number of times.

Arc facilities

It is the task of the arc facilities to cool the arc or to increase pressure and to make sure that after natural quenching the arc does not ignite again.

Survey 2 Arc quenching facilities

Quenching possibilities	Examples of application	Construction	Functional principle
Natural arc extinction	Low-voltage circuit breakers		Due to the thermal lifting power of the heated-up gas column the arc is lengthened. Electromagnetic forces between the two arc branches support lengthening.
Lengthening and cooling of the arc through the shape of the quenching chamber	Contactors ES contactors		When the arc cones into contact with the quenching chamber, heat extraction takes place. Due to the incorporation of webs, partial chambers are created in which a fireplace effect occurs. In the meander chamber the arc is lengthened greatly.
Deion chamber	Low-voltage circuit breakers		Copper-plated iron sheet metal plates divide the complete arc into partial arcs. Partial arc voltages are reduced below 30 V. At the same time heat is extracted from the plates, and thus the arc extinguishes.
Magnetic blowing	ES contactors		The current to be interrupted flows through the blowout coil (1). The magnetic field generated is transmitted to blow-out plates (2) arranged at the sides of the quenching chamber. The arc burns in the magnetic field between the two

			<p>plates so that an electric force (3) acts on it. Thus the arc is moved upwards, that means, it is lengthened and cooled. (4) Direction of current</p>
Vacuum chamber	Vacuum contactors (EVS)	<p>1 fixed contact member, 2 movable contact member, 3 vacuum chamber</p>	<p>Contact-break distance is in the vacuum. Atoms from the air are missing for ionisation. The arc burns only for a short time in the metal vapour of the switching contacts. The metal vapour moves quickly out of the contact-break distance.</p>

2.3. Switch mechanisms

They change the switching position of switches (CLOSED-OPEN). For this purpose a force is required. In accordance with the type of force generation the mechanisms are classified in:

- manually-operated mechanisms
- solenoid-operated mechanism
- motor-operated mechanism, and
- pneumatic-operated mechanism.

Manually-operated mechanism

Actuation elements are knob, pushbutton or lever. Rated currents up to approximately 100 A can be switched by means of these mechanisms. The manually-operated mechanism is the cheapest mechanism. Examples for these mechanisms are installation switches, gang switches, pushbutton switches.

Solenoid-operated mechanism

By switching on a control current an electromagnet is excited. The armature of a magnet actuates the contact members. Examples for solenoid-operated mechanisms are contactors, relays, installation remote switches.

Motor-operated mechanism

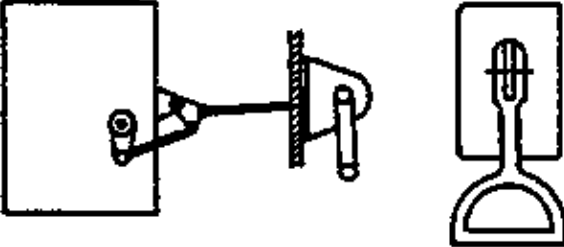
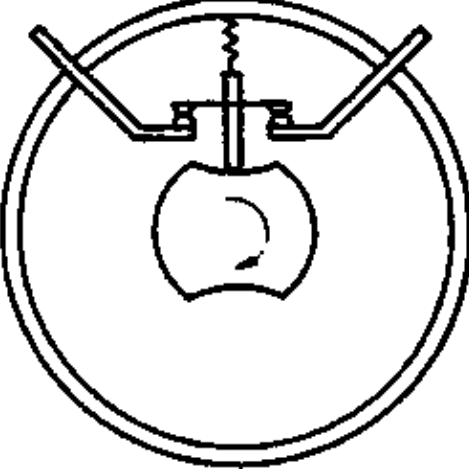
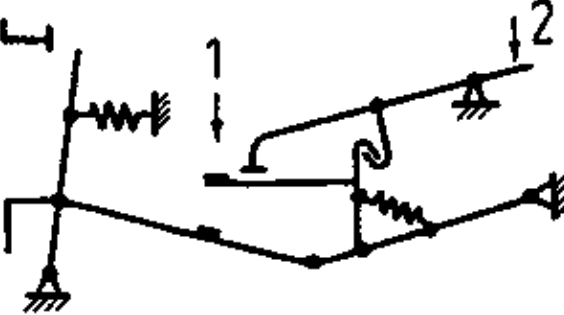
The motor either drives the interruptor shaft via a gear or the motor acts on a spring energy store.

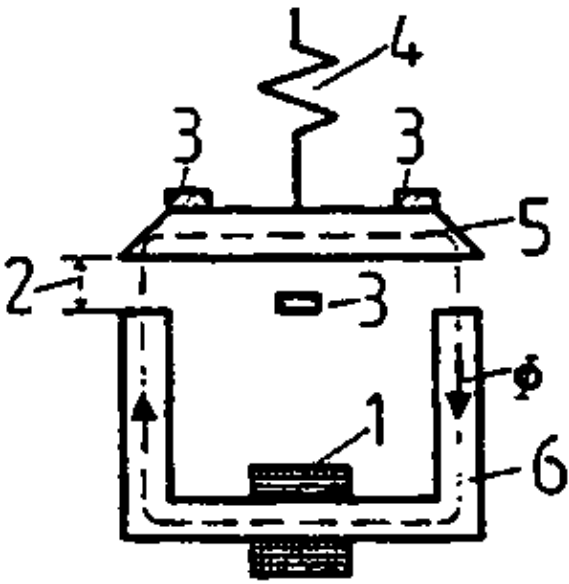
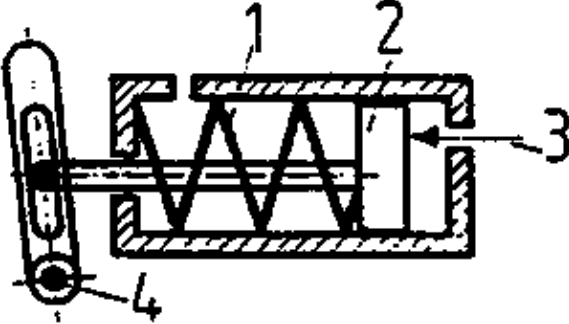
As far as the motor-operated mechanism with spring energy store is concerned, simultaneously with the closing operation a disconnection spring is tensioned and latched. When the spring is unlatched, it opens the contact members independently of the motor.

Pneumatic-operated mechanism

By means of 15 to 20 MPa compressed air the contact members are actuated via pressure piston and linkage mechanism. This type of mechanism is mostly used for high-voltage circuit breakers.

Survey 5 Summary of the most common switch mechanisms

Mechanisms	Examples of application	Functional principle	Advantages and disadvantages
Manually-operated mechanism Pushbutton and lever-operated mechanism Stirrup-operated mechanism	Low-voltage circuit breaker Load-break switch Isolating switch Earthing switch Power circuit breaker up to 30 kV	 <p>The actuation element is attached directly to the interruptor shaft. The switch linkage transmits the switching force from the front side of the cell to the switch fastened on the rear.</p>	Favourable as to costs, no high switching frequency. At rated currents above 100 A excessive switching forces required
Manually operated mechanism by means of a twist knob	Multisection cam-operated switch	 <p>The switch lever is arranged directly on the camshaft</p>	Simple design, unobjectionable switching of high currents at a speed almost independent of the operator
Snap-action connection (toggle latching mechanism)	EI circuit breaker	 <p>From a certain switching angle onwards the opening and closing sequences are taken over by incorporated springs.</p> <p>1 release force, 2 manual force</p>	Unobjectionable switching of high currents at a speed independent of the operator

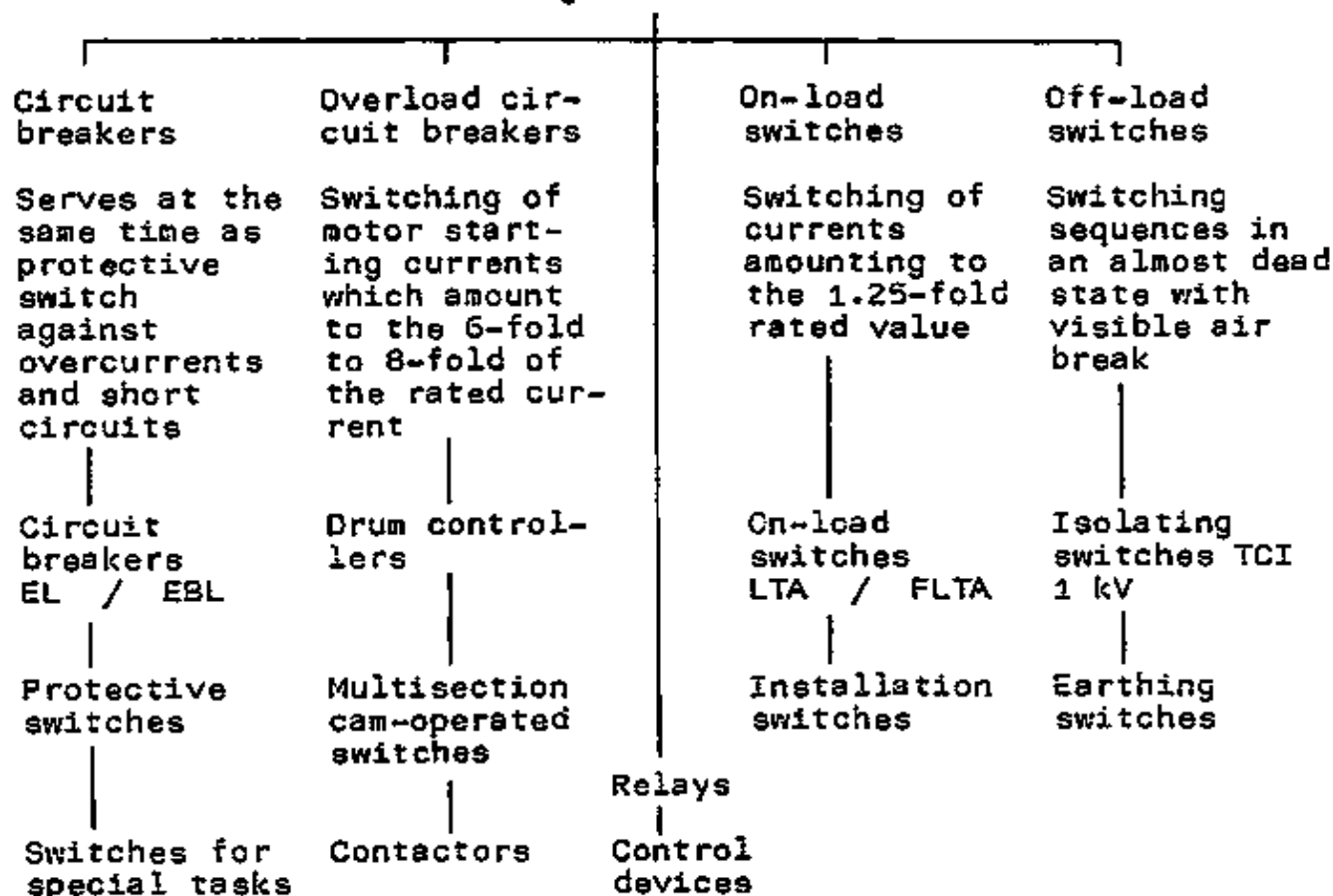
<p>Solenoid-operated mechanism</p>	<p>Contactors Relays</p>	 <p>1 excitation coil, 2 spacing between armature and magnet, 3 lifting limits, 4 return spring, 5 armature, 6 magnet</p>	<p>Relatively high power consumption by the switching magnet. A high making current can load the network.</p>
<p>Motor-operated mechanism</p>	<p>EI circuit breakers SCI circuit breakers</p>	<p>The interruptor shaft is driven directly by a motor via a worm gearing and an excentric. When an energy store is used, the motor tensions the closing spring. By unlatching this spring the switch is closed and the opening spring is pretensioned. During the opening sequence the closing spring is pretensioned.</p>	<p>Compared with the solenoid-operated mechanism, the motor-operated mechanism is more economical for high rated currents</p>
<p>Pneumatic-operated mechanism and D3AF</p>	<p>Isolating switches Circuit breakers of types DCI</p>	 <p>1 spring, 2 piston, 3 compressed-air, 4 interruptor shaft</p>	<p>Remote control possible. Simpler design compared with electric-operated mechanisms. Higher switching speed and smoother switching</p>

3. Low-voltage circuit breakers

3.1. Classification and tasks of the circuit breakers

Survey 4 Low-voltage circuit breakers

Low-voltage circuit breakers



3.2. Circuit breakers

In low-voltage switchgear installations the protection against overload and short circuits is mainly taken over by fuses. The latter have, however, the disadvantage that their rated breaking capacity is limited. Furthermore, long-term operating disturbances may occur due to the replacement of the fuses. For this reason circuit breakers are used for outgoing feeders of greater amperage and for incoming supply panels. They possess bimetal and instantaneous trips and may be equipped with undervoltage trips.

Compared with fuses a better selective protection can be reached with circuit breakers. Due to their design they are in a position to close and open high short-circuit currents and to quench objectionably arcs occurring.

Since it is not possible to meet all requirements in one circuit breaker, internationally two types are manufactured

- universal circuit breakers and
- compact circuit breakers

which in each case can be with or without current-limiting effect.

3.2.1. Universal circuit breakers

The non-current-limiting universal circuit breakers, i.e. of type EL (Figure 1) are manufactured for medium and high amperages from 250 A onwards.

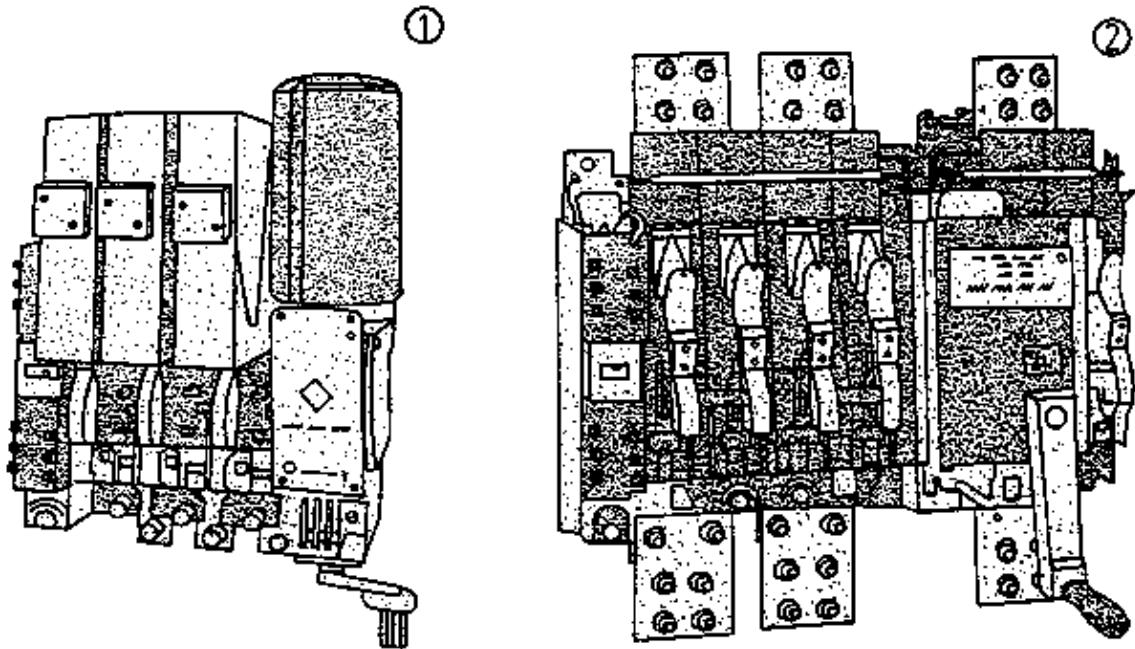


Figure 1 Universal circuit breaker of type EL

(1) 630 A, (2) 1000 A with the arc-control chamber removed

In these circuit breakers only the fixed and movable contact members as well as the latching mechanism are fastened on the base frame.

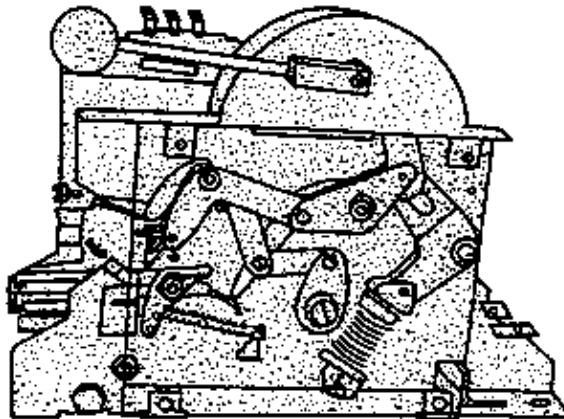


Figure 2 Latching mechanism of the universal circuit breaker

All the other components such as switch mechanism, trips and other additional devices are designed as replaceable modules. They are used in those cases where a high degree of modification is required and space requirements are not very important.

As far as the circuit breaker of type EL is concerned, the arc is led very quickly into a deion chamber (see Survey 2) so that the overall opening time is short.

3.2.2. Compact circuit breakers

As to the circuit breaker in compact construction, the individual elements of the compact circuit breaker are arranged in an insulating casing made of moulded material. In this way considerable space is saved in the low-voltage distribution board.

The disadvantage of the compact circuit breaker is its low degree of modification. Furthermore, the cooling conditions are unfavourable so that the current-carrying capacity, especially in case of short circuits, is worse than that of the universal circuit breaker.

The compact circuit breakers for small and medium amperages (25, 63, 160, 1000 A) are current-limiting switches such as type EBL for example.

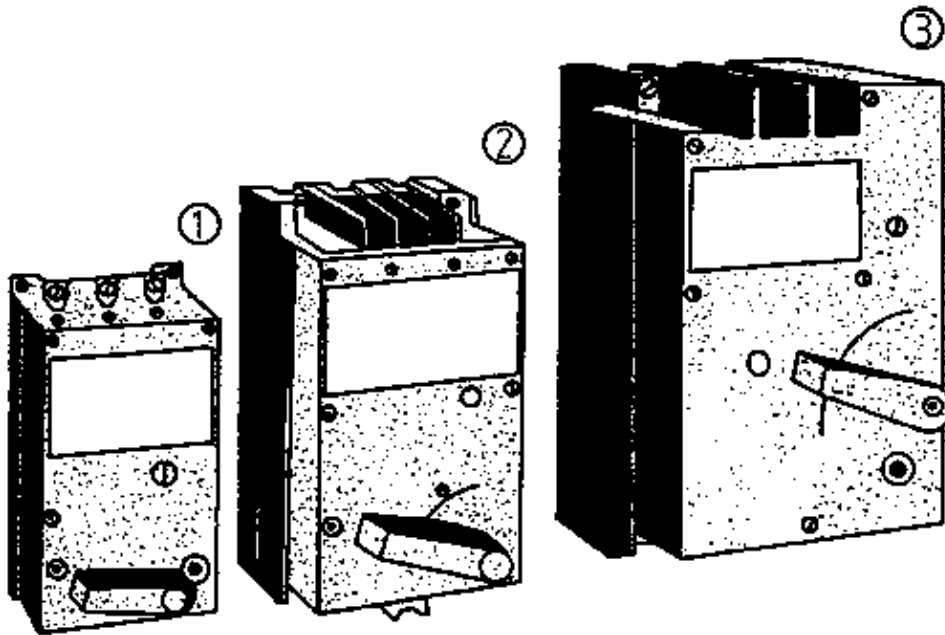


Figure 3 Compact circuit breaker of type EBL

(1) 25 A, (2) 63 A, (3) 160 A

In Figure 4 the construction and function of this circuit breaker is shown. In the following the function of the circuit breaker will be explained taking EBL 1000 as an example.

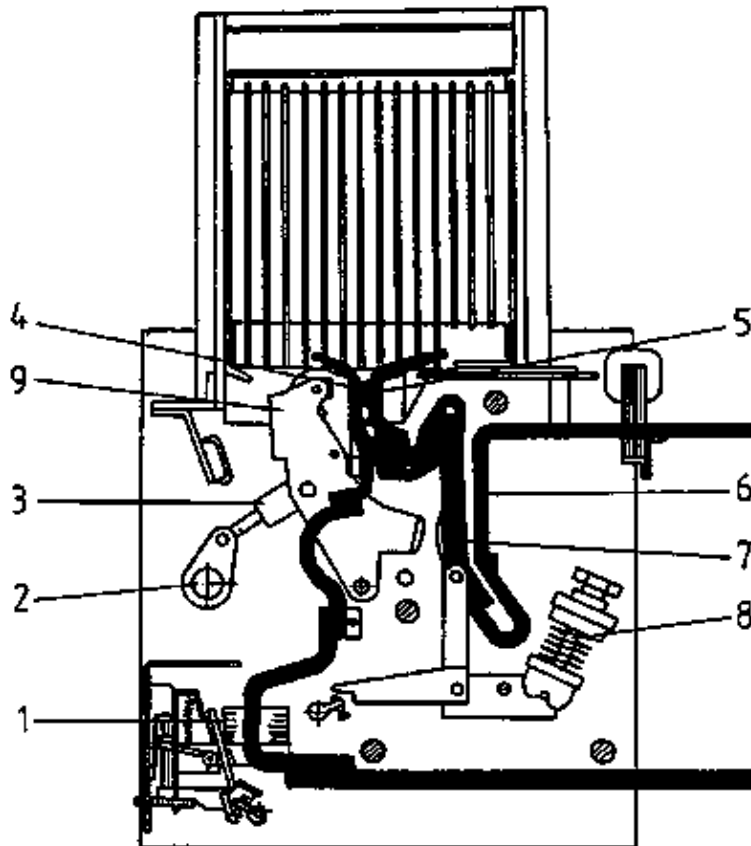


Figure 4 Sectional drawing of the compact circuit breaker of type EBL 1000 A

When the short-circuit current is less than 20 kA, the instantaneous trip 1 is actuated and its armature picks up. During this operation it turns a releasing shaft which in turn causes the latching mechanism to trip. The movable contact member is removed from the fixed contact member by spring force via interruptor shaft 2 and

linkage 3.

When the short-circuit current is greater than 25 kA, the electrodynamic force at the contact support of the main contact pair becomes so great that the force of the contact spring is overcome and the contact members are slightly lifted. Consequently, current is flowing via the arcing contacts while contact members 4 and 5 form a loop through which current flows in the opposite direction. Thus, the movable contact member 4 is pushed off at high speed and an arc with current-limiting effect is brought into the circuit. Parallel to this process electrodynamic forces also occur between current path sections 5 and 7. The latter are supported by spring 8 so that the movable loop branch 7 is thrown onto contact cage 9. Thus the opening sequence is accelerated. Contact opening occurs already before the current maximum is reached.

3.2.3. High-speed switches for d.c. installations

Direct-current arcs can only be extinguished by lengthening the arc. For this purpose high-speed switches which quickly lengthen the arc are required in d.c. installations. They should have only a short switching delay (up to 6 ms) so that the contacts open quickly. By drawing the arc early the short-circuit current can be limited.

These high-speed switches are manufactured as single-pole d.c. protective switches for all d.c. installations as a protection against overcurrents, short circuits and reverse currents. There are different designs of high-speed switches, but nowadays high-speed switches with impact armature are mostly used.

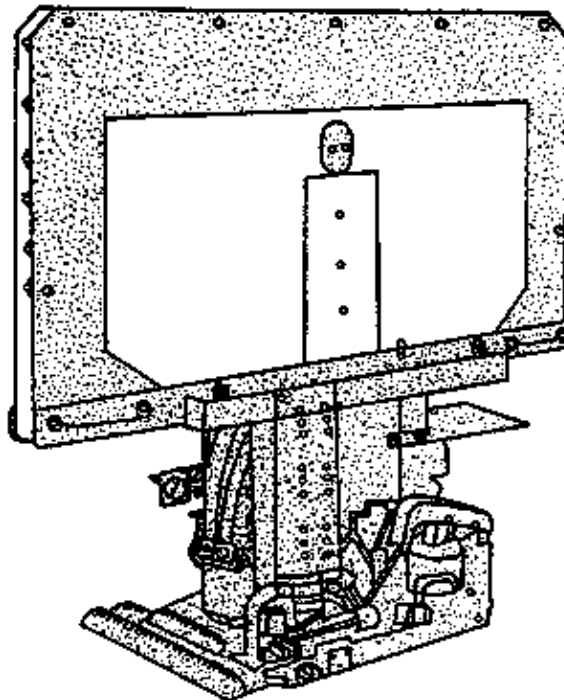


Figure 5 D.C. high-speed switch

In this switch two magnets, one release magnet and one holding magnet, are used through which the same current flows.

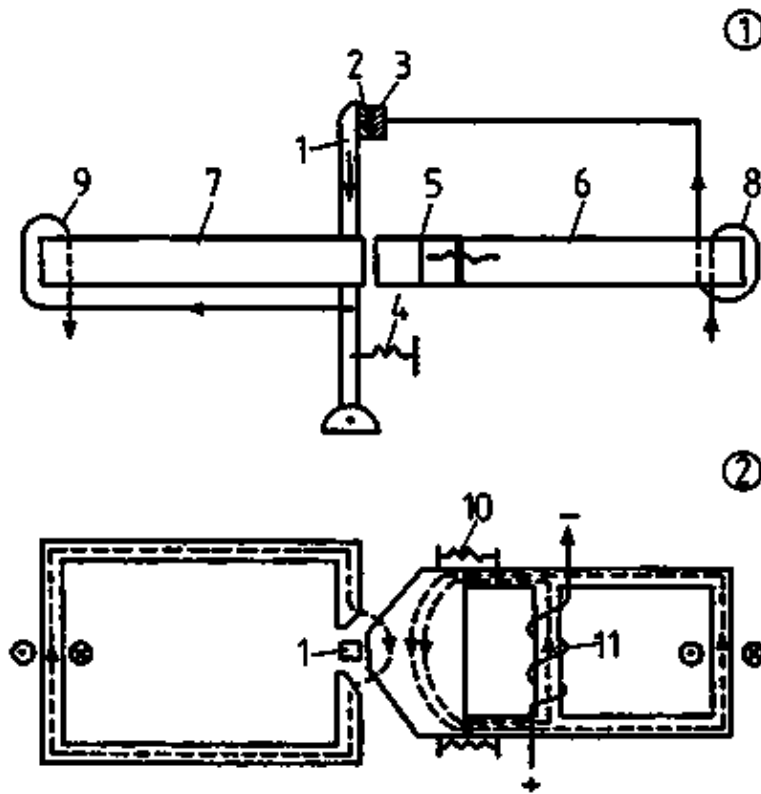


Figure 6 Principle of the highspeed switch with impact armature

- (1) Side view
 (2) Top view

1 switch lever, 2 movable contact, 3 fixed contact, 4 contact pressure spring, 5 impact armature, 6 holding magnet, 7 release magnet, 8 holding coil, 9 tripping coil, 10 restoring spring for impact armature, 11 polarisation coil

When the rated current is present the holding magnet is already saturated so that in case of overcurrent only the tripping flux can become greater and the impact armature can open the contact. The switch also trips in case of reverse current as the same current flows through both coils. Since reverse currents are smaller than overcurrents, the holding magnet is premagnetised by a polarising coil. In case of reverse current the polarising flux counteracts the magnetic flux of the holding coil so that at a lower current the release force can pull off the armature. Direct-current high-speed switches are manufactured for voltages up to 3 kV and currents of 3000 A.

3.2.4. Protective switches

It is the main task of protective switches to protect low-voltage installations and equipment against overload and short-circuit currents. At the same time they may also be used for connecting and disconnecting circuits (see motor protection switch).

The main components of protective switches are:

- Electromagnetic instantaneous trip

As protection against short circuits an electromagnetically operating instantaneous trip is provided which releases a mechanical lock. Its adjustment ranges lie between the 3-fold and the 6-fold rated current for line protection and the 3-fold to the 16-fold rated current for motor protection. With the help of the instantaneous trips arranged in each of the three switch poles the protective switch is in a position to immediately open the circuit in case of short circuits.

– Thermal trip

A thermal trip is provided for protection against overload. It is a tripping device with delay effect which in the overload range acts on a tripping pawl by heating up of one bimetal each per outer conductor.

The adjustment range of the thermal trip is adjusted to the rated current of the load (for example thermal relay as motor protection) or the release value of the rated current has been determined by the manufacturer (for example automatic cut-out).

– Undervoltage trip

The undervoltage trip operates electromagnetically and responds to the decrease in operating voltage.

Automatic cut-outs

Automatic cut-outs are used in control installations and mainly in households. They are manufactured for rated voltages up to 380 V and rated currents up to 25 A as automatic circuit breaker with thread E 27 (Figure 7) and as automatic line protection (Figure 8).

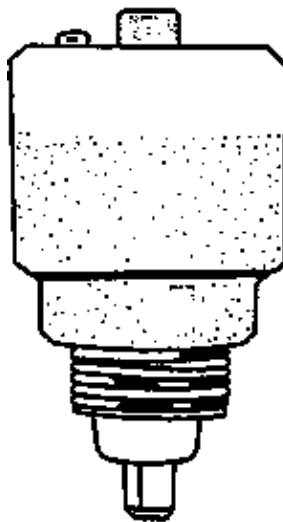


Figure 7 Automatic cut-out

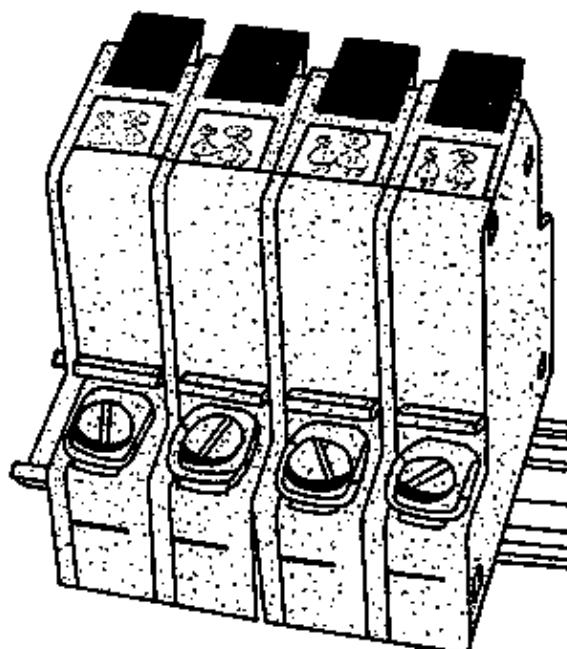


Figure 8 Automatic line protection

For each outer conductor one automatic cut–out is required as individual module. Actuation is carried out by a toggle lever. By means of a trip–free release an unhindered tripping can take place even if the control element is held fast.

The module consists of:

- thermal trip
- magnetic overcurrent trip
- latching device

Switches for special tasks

In addition to the circuit breakers for low–voltage installations explained until now, special switches for specific purposes are manufactured.

Fault–current protectives switches: Fault–current protective switches are used as a protective measure against electric shocks in low–voltage installations.

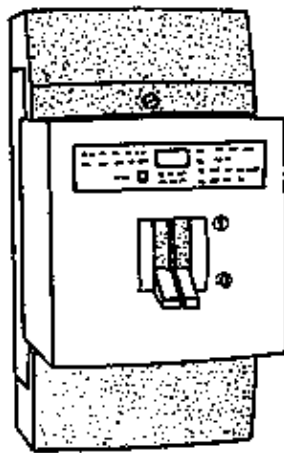


Figure 9 Fault–current protective switch

The fault–current protective switch or the fault–current facility monitors inductively with a current transformer the sum of inflowing and out–flowing currents in the system to be protected. For this purpose all conductors coming from the network, also the neutral conductor, are led through the summation current transformer. They form the primary winding. With a faultless circuit in the three–phase system or in the alternating current system the sum of all currents is zero at that moment. The current flowing against earth in case of a body contact or a line–to–earth fault disturbs the symmetry and generates in the secondary winding of the transformer a voltage which disconnects the installation when the rated fault current is exceeded.

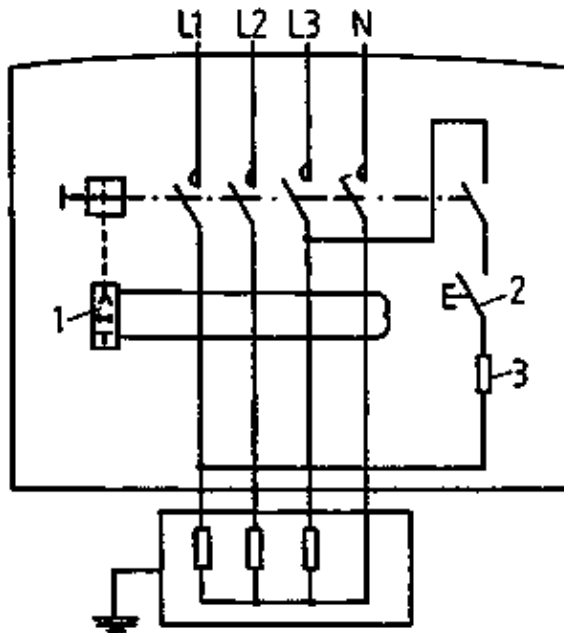


Figure 10 Principle of the fault-current protective switch

L... conductor
 N neutral conductor

1 fault-current coil
 2 test key
 3 limiting resistor

Fault-current protective switches are manufactured for the rated voltage of 380 V a.c. or three-phase and for rated currents of 25 A, 40 A, 80 A.

When installations with currents above 80 A shall be switched, the fault-current control circuit must be used.

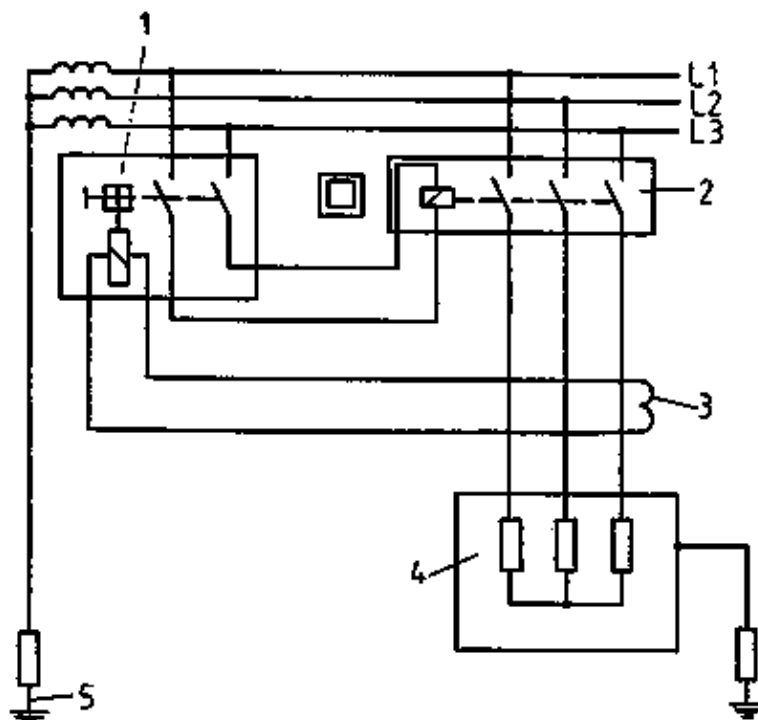


Figure 11 Fault-current control circuit

L... conductor,

1 fault-current control switch, 2 contactor, 3 summation current transformer, 4 consumption

device, 5 earthing in accordance with regulations

Fault-current protective switches are manufactured

- for rated fault currents of 30 mA for protecting human beings and productive livestock and
- for rated fault currents of 100, 200, 300 and 500 mA for protecting installations and for fire protection.

Motor protection switches: Motor protection switches are special switches which serve for switching and protecting motors. They are provided with bimetal and instantaneous trips.

Motor protection switches are manufactured for rated voltages up to 380 V and rated currents up to 25 A in open and enclosed design.

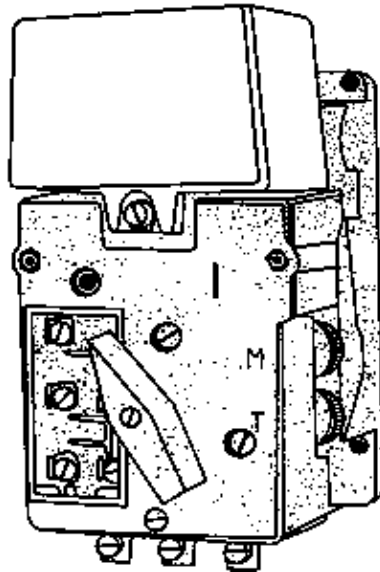


Figure 12 Motor protection switch 25 A

3.3. Overload circuit breakers

When directly switching on electric motors, especially three-phase squirrel-cage motors, the starting current may amount to the 6-fold to 8-fold value of the rated current. Since on-load switches can only switch the 1.25-fold value of the rated current (see Section 3.4.), the overload circuit breakers must be in a position to switch the starting currents.

Overload circuit breakers can be equipped with magnetic instantaneous trips and bimetal trips (see 3.2.4.) so that they serve at the same time as protective switches.

Drum switches and cam-operated switches, contactors and motor protection switches can be used as overload circuit breakers.

They must display high switching speeds (snap-action circuit, see Survey 3), and the contacts must be arc resistant. Furthermore, the overload circuit breakers must have a long mechanical service life at a high switching frequency.

Multisection cam-operated switches and contactors are mainly used as overload circuit breakers.

3.3.1. Multisection cam-operated switches

Multisection cam-operated switches are built-up in accordance with the modular construction principle. Their main components are the locking device and according to the circuit a specific number of switching plates* Up

to eight switching plates can be grouped to form a packet. Due to the different designs of the switching plates different switching operations can be carried out with one turn of the switch. Such circuit breakers are frequently used as control switches. The contacts are designed as pressure contacts. Contact bridges which cause a double interruption of the corresponding current path are moved by cam disks via switching plungers. When the camshaft turns, the plunger lifts the switching contact and thus causes a double interruption (see Survey 3).

Multisection cam-operated switches are manufactured for rated amperages of 10 to 200 A.

The breaking capacity can amount up to 960 A.

3.3.2. Contactors

Contactors are unlatched, electromagnetically actuated switches which fall back into their rest positions as soon as the control circuit is opened. The contacts are designed in such a way that for a short period of time currents can be carried which lie above the rated currents.

The most common air-break contactors work with double interruption of the contacts and a plunger armature. In addition to the main contacts the contactors are provided with several auxiliary contacts. The magnetic system has been designed in such a way that at 85 % of the rated voltage the armature is still in a position to pick up and that at 55 % of the rated voltage it drops out automatically.

Air-break contactors

Air-break contactors, for example of type series LX 00 to LX 2:

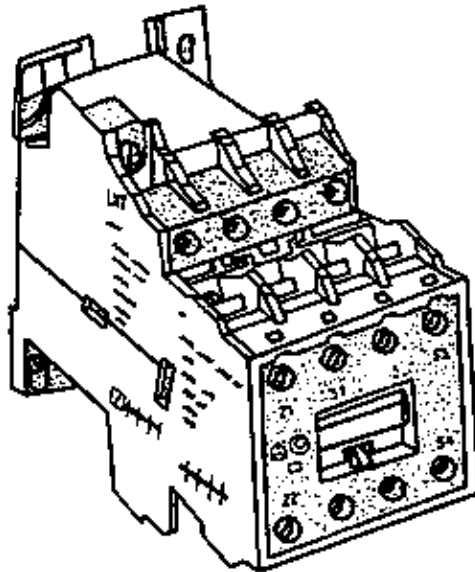


Figure 13 Air-break contactor LX 1 with auxiliary switch block HX22

Air-break contactors 'LX' consist of a basic contactor and an additionally arranged auxiliary switch block with different contact complementation and switching functions (n.c. contacts, n.o. contacts, staggered switching instants, electronic-compatible auxiliary current paths).

They consist of a casing made of moulded material and can be mounted on 35-mm support rails. They are manufactured with d.c. and a.c. drive, for the rated alternating voltage of 220 V and the rated current of 23 A up to a rated alternating voltage of 660 V and a rated current of 14 A.

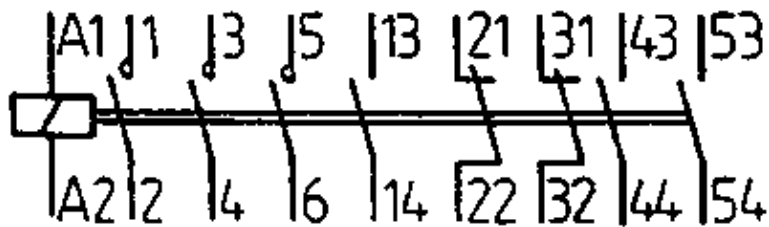


Figure 14 Circuit diagram of an LX1-32 air-break contactor

Air-break contactors, for example of type series ID 21 to ID 7: The air-break contactors 'ID' consist of a plastic casing which is resistant to tracking and has externally accessible terminals for the coil as well as the main and auxiliary contacts. The contact system consists of silver pressure contacts with double interruption (three main contacts and six auxiliary contacts).

The arc chambers are provided with arc deflectors and extinguishing sheet metals. Above 63 A they are provided with deion chambers.

ID contactors are used for

- switching operations in alternating-current circuits and three-phase circuits
- direct switching-on of squirrel-cage motors
- switching of slip-ring motors (rotor contactor).

They are manufactured for rated insulation voltages of 750 V a.c. and for rated operating currents of 32 to 250 A. An important feature of the contactors of type series ID is the modular construction principle. The individual modules can be replaced without loosening the terminals.

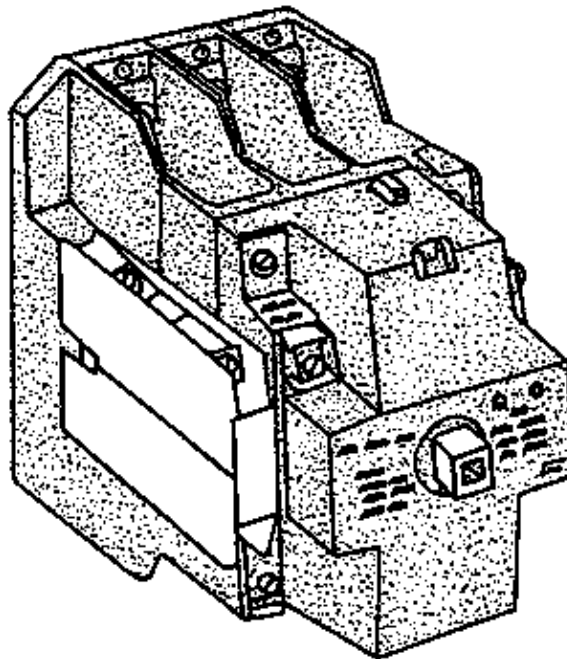


Figure 15 IDX43 air-break contactor

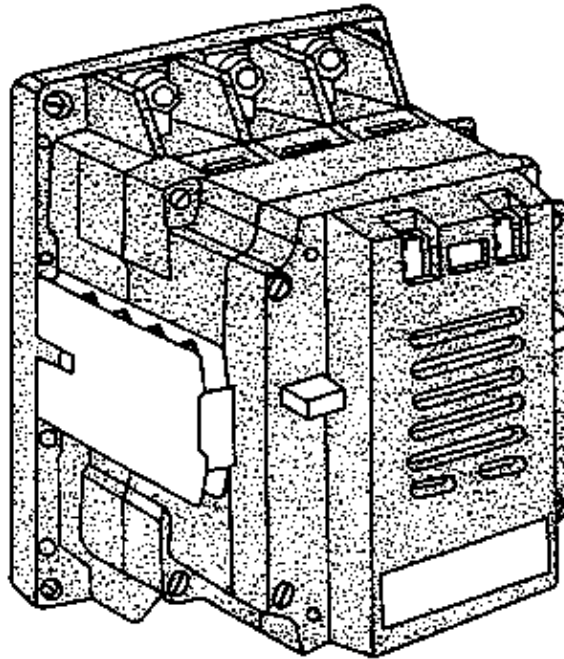


Figure 16 ID7 air-break contactor

Air-break contactors of type series LX and ID can be used with and without thermal overcurrent relays (for example type IR 1 to IR 4).

Since both type series of contactors are frequently used for switching motors, thermal overcurrent relays have been developed which can be plugged on the main contacts.

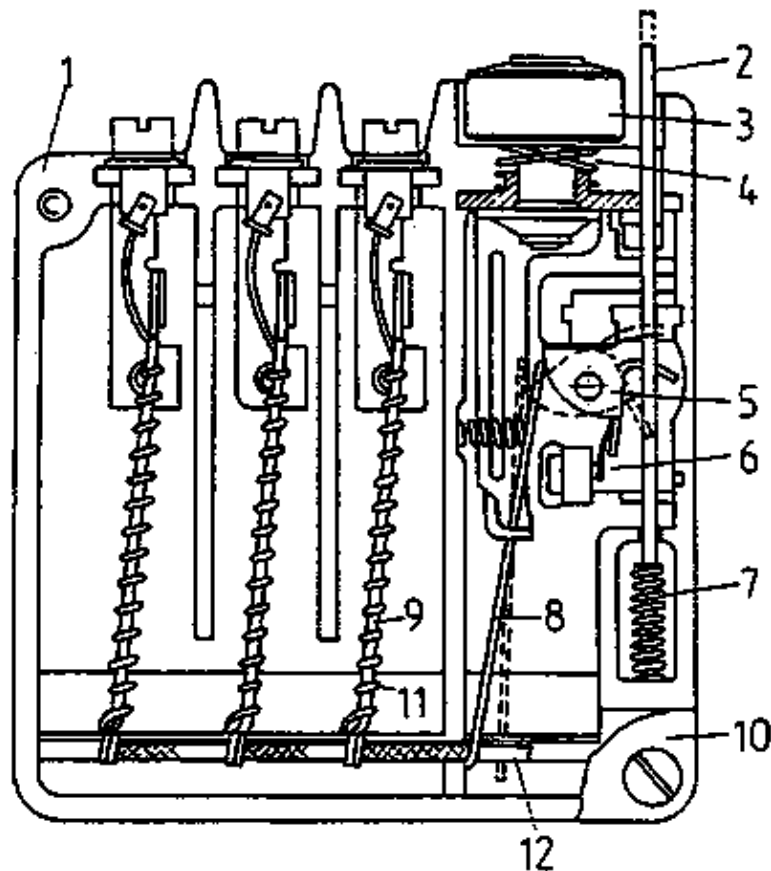


Figure 17 Thermal overcurrent relay in the open state

- 1 casing,
- 2 unblocking pushbutton,
- 3 adjustment knob,
- 4 connecting screw,

- 5 pawl,
- 6 command contact,
- 7 compression spring,
- 8 temperature compensation strip,
- 9 bimetal strip,
- 10 cover,
- 11 core conductor,
- 12 release strip

Air-break contactors, for example of type series ES:

Air-break contactors of type series ES are suitable for heavy duty conditions. For this purpose they have a special design. The magnet is fastened on rubber-metal antivibration mounting and ensures shock-free switching operations. These ES contactors display a high operational safety and can be used in rolling mills, on excavators and heavy machine tools. Their mechanical service life amounts to approximately 10 million switching cycles on an average of 3000 switching cycles per hour.

The rated voltage lies at 500 V a.c. or 600 V d.c. and a rated current up to 630 A depending on the type

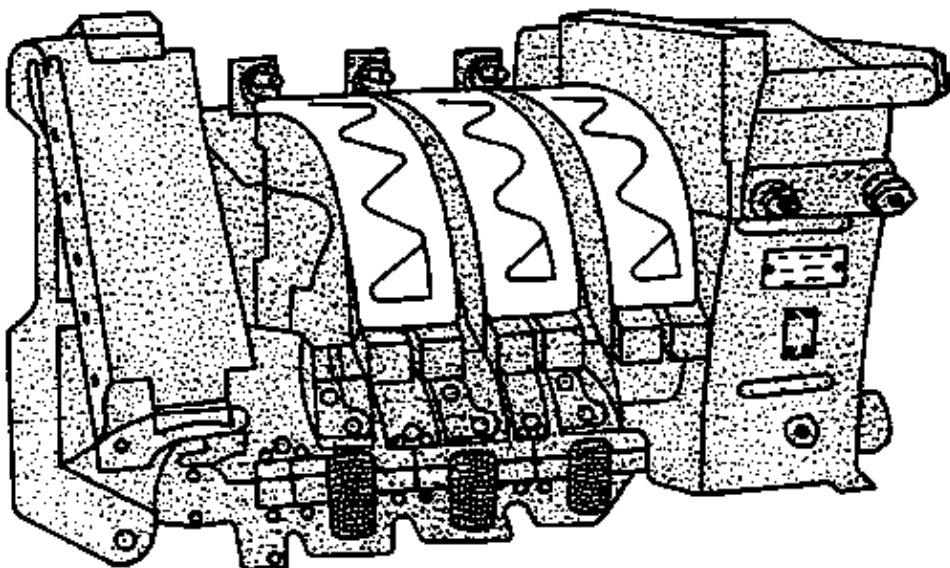


Figure 18 Air-break contactor (ES series) for heavy conditions, for example in rolling mills and on excavators

Vacuum contactors, for example of type series EVS 160 – 630: Vacuum contactors are single-pole basic devices which with the help of connecting rails can be assembled by the user to form n-pole contactors.

Each single-pole vacuum contactor possesses an auxiliary switch block with two freely available, optionally repluggable auxiliary contacts (1 n.c. contact and 1 n.o. contact). Opening and closing of the main contact members is effected with sufficient accuracy via an electric parallel connection of the individual solenoid-operated mechanisms.

Differing from the mode of action of air-break contactors, the switching operations of the main contacts take place under vacuum. Therefore they only need a short length of contact travel. The solenoid-operated mechanism has been designed for direct voltage. For alternating-current operation a rectifier module is arranged in the contactor.

Vacuum contactors have been designed for use in works of the basic industry as well as the chemical and metallurgical industries for heavy duty electric and mechanical operating conditions.

Vacuum contactors are used like ID contactors for

- switching operations in alternating-current circuits and three-phase circuits
- direct switching-on of squirrel-cage motors
- switching of slip-ring motors (rotor contactor).

Vacuum contactors are manufactured for rated voltages up to 660 V a.c. and rated currents up to 630 A. The contact members have a service life of approximately 7 million switching operations.

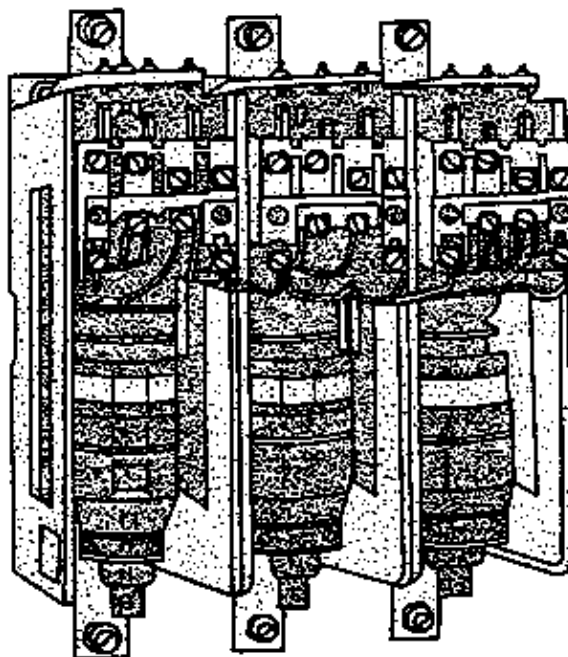


Figure 19 Vacuum contactor with three arc chambers

3.4. On-load switches

On-load switches may be overloaded for a short period of time during the closing/opening cycle with the 1.25-fold rated current. Since the amount of the overcurrents during the closing/opening cycle depends mainly on the inductance of the circuit, on-load switches are only to be used in circuits with a power factor greater than 0.7.

On-load switches are used in many fields of consumers' installations of electrical energy.

There is a variety of technical designs of on-load switches, both as far as the mode of action, for example lever switches, drum switches, cam-operated switches, gang switches and the shape of the contact, for example blade contacts, rolling contacts and pressure contacts are concerned.

In addition to the installation switches such switches which can be built into low-voltage distribution systems are important for power-current plant construction. On-load switches, mostly combined with HRC fuses, are used as incoming disconnectors, but mainly as outgoing-feeder disconnectors.

3.4.1. Load-break switches in slim design

The load-break switch in slim design (FTLA switch) has replaced the former load-break switch (LTA switch), with the exception of the switch for a rated amperage of 1000 A.

FTLA switches are manufactured both in open and encapsulated design.

The encapsulated design of the FTLA switch is especially suitable for sheet-steel-enclosed installations. The switches possess silver pressure contacts with double break.

They are manufactured in three different sizes for a rated voltage of 660 V a.c. with a power factor of 0.7 and for rated currents up to 630 A (with the exception of LTA – rated current 1000 A).

When a letter is added to the designation FTLA, for example FTLAS, that means that the load-break switch and the associated HRC fuses are arranged in a sheet-steel casing.

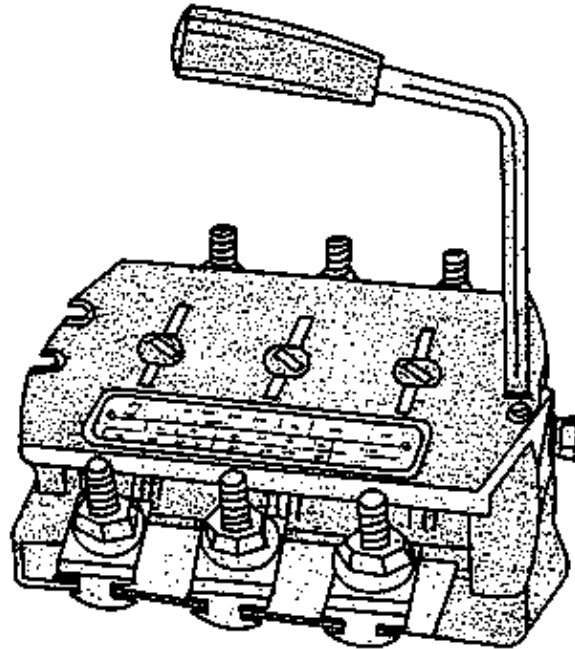


Figure 20 FTLA load-break switch 250 A in open design

3.4.2. Installation switches

Installation switches are load switches which have been designed for electrical low-voltage installations, mainly lighting systems in dwelling-houses, workshops and social buildings. They are designed for rated currents of 6 or 10 A.

Installation switches are classified in accordance with the

- type of connection, for example on-off switch, two-circuit single interruption switch, intermediate switch, on-off switch as dimmer with thyristor
- type of actuation, for example toggle switch, rocker switch, rotary switch (in most cases now only as a light controller; see Figure 21), pushbutton switch
- type of mounting, for example surface switch, flush switch, appliance switch
- use in accordance with the degree of protection.

Survey 5 Degrees of protection for installation material

Degree of protection	Application	Place of application
IP 20	Surface and flush design	Dry rooms
IB 41	Surface and flush design	Moist rooms
IP 55	Surface design	Wet rooms

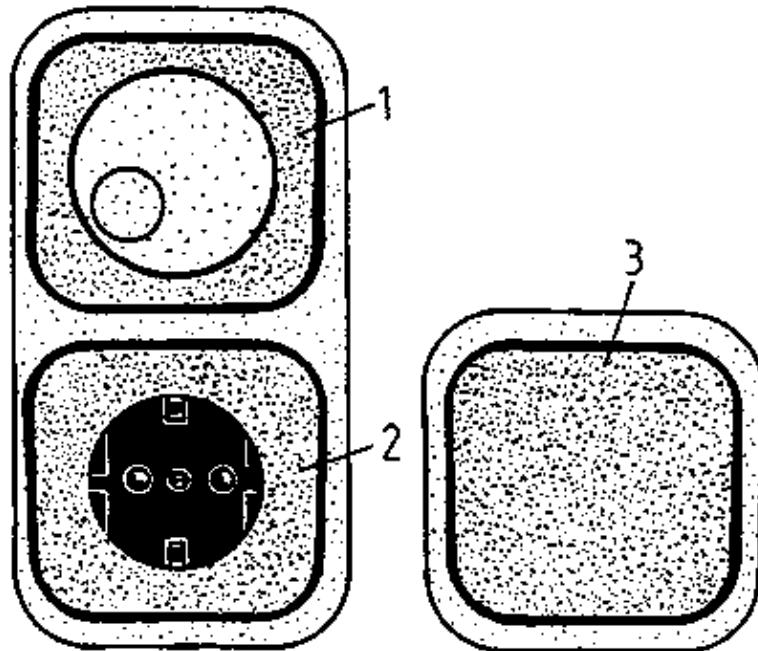


Figure 21 Installation switch (flush design IP 22)

- 1 dimmer,
- 2 socket-outlet with earthing contact,
- 3 rocker switch

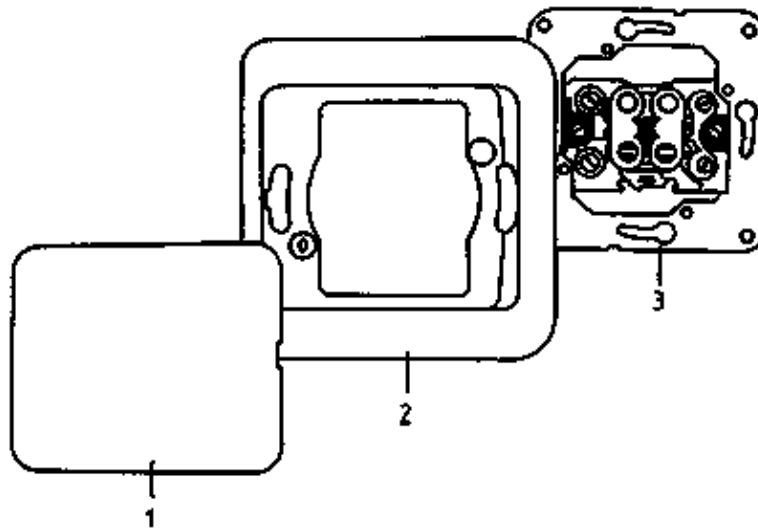


Figure 22 Installation switch, dismantled (flush design)

- 1 junction rocker, 2 covering frame, 3 switch 10 A/220 V a.c.

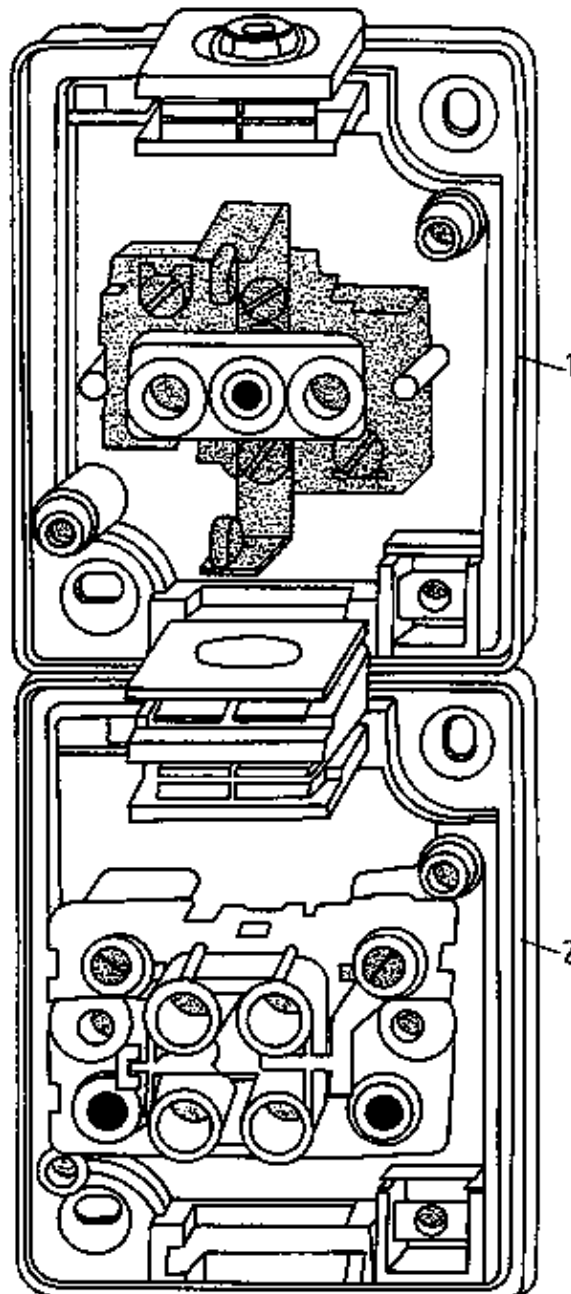


Figure 23 Moisture-proof switch and moisture-proof socket-outlet with earthing contact, open (surface design IP 41)

1 Socket-outlet with earthing contact, 2 switch

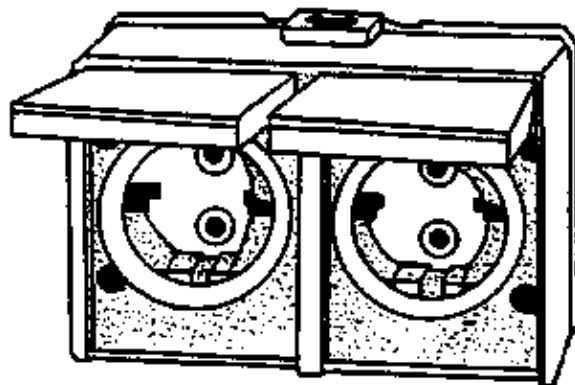


Figure 24 Moisture-proof socket-outlet with earthing contact (double) in surface design IP 41

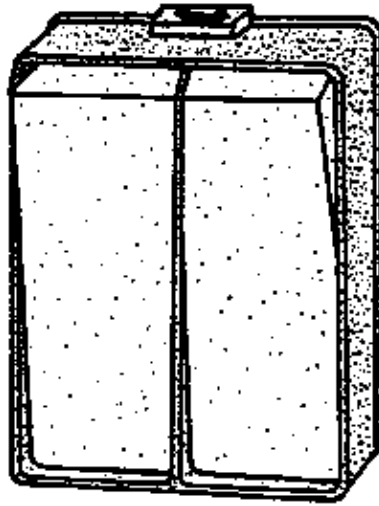


Figure 25 Moisture-proof multicircuit switch in surface design IP 41

Installation remote switches

Electromagnetic, remote-controlled, latched switches controlled with a voltage of 12 V a.c., for dwelling-houses and social buildings.

Installation remote switches with a control voltage of 220 V a.c. are used for industrial plants.

At the power-current side the switch has been designed for a rated voltage of 250 V a.c. and a rated current of 10 A.

The advantages of these switches are:

- the circuit arrangement can be switched by an optical number of pushbutton switches
- small cross-sections for the pushbutton switches
- low voltage at the pushbutton switches.

The disadvantages are:

- high material expenditure
- more expensive than conventional installation circuits.

3.5. Off-load switches

Off-load switches serve for the almost currentless switching of circuits in order to make dead, by a visible isolating position, the parts of the installation lying behind.

In most cases an off-load switch is not used for this task, but the dead state is established and secured by

- isolating links
- HRC fuses or
- carriage-type switchgear (plug-in technique).

For rated amperages from 1000 A onwards the TCI isolating switch (T = isolating switch, C = three-pole, I = indoor) which is also manufactured for 1 kV, can be used. It is produced for 1250, 2500 and 4000 A.

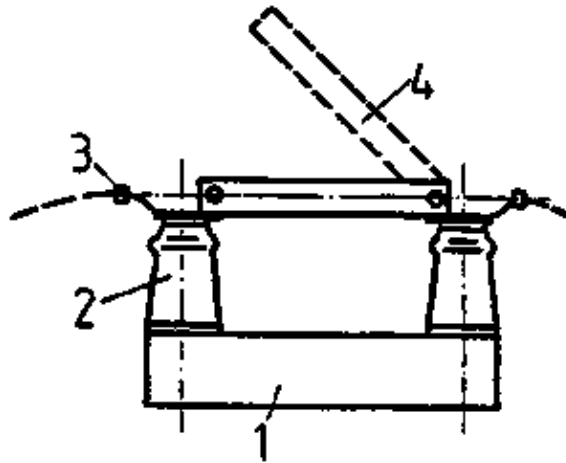


Figure 26 TCI isolating switch

- 1 frame, 2 insulator
- 3 connecting shaft
- 4 disconnecting blade

Its disadvantage is that it is relatively big and thus requires a lot of space in low-voltage switchgear installations.

Earthing switches

Earthing switches are used for earthing disconnected parts of plants.

They can be combined with on-load and load-break switches.

4. Relays and control devices

4.1. Relays

Relays are important devices in control installations. They are influenced by the change of the characteristic quantity in the operating element and actuate electrical switching elements.

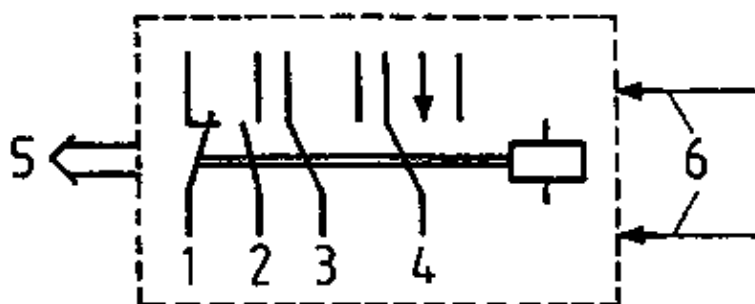


Figure 27 Types of contacts (types of switching elements) on a relay

- 1 n.c. contact,
- 2 n.o. contact,
- 3 double-throw contact,
- 4 passing contact,
- 5 manipulated variable,
- 6 measured variables

Characteristics

- Pick-up value

Actual value of the characteristic quantity at which undelayed relays and trips reach the operated condition and delay relays, time relays and delayed trips reach the starting position.

– Resetting value

Value of the characteristic quantity at which the relay and the trip leave the operated condition.

– Operate time

Time between the appearance of the characteristic quantity until reaching of the operated condition.

– Operating time

Time between the appearance of the pick-up value of the characteristic quantity in protective relays until reaching the operated condition.

– Basic time

Shortest operating time.

– Maximum operating time Longest operating time.

– Grading time

Difference of operating times of relay protective devices in series connection.

– Main protection

Time protection for response in case of disturbances in the range of a complete part of the installation to be protected, this time being less than that of the other relay protective devices of the corresponding part of the installation.

– Setting value of the protection

Rated value of the characteristic quantity or the time of disconnection between pick-up range and non-operating zone.

– False tripping

Response of a relay protective device in the absence of disturbances or abnormal operating conditions in the part of the installation to be protected.

– Erroneous tripping

Response of a relay protective device due to the wrong setting of a protective relay.

– Primary relay.

The characteristic quantity to be monitored lies directly on the operating element via the transformer.

– Secondary relay

The characteristic quantity to be monitored lies indirectly on the driving system via the transformer.

– Protective relay (general)

A combination of measuring, neutral and time relays solely for the purpose of special protective tasks. Apart from a few exceptions, currents, voltages, products, quotients, sums of differences thereof are used as characteristic quantities. Protective relays shall work in a very exact and reliable manner. The contact elements are actuated when the set values are exceeded or fallen below during monitoring of the characteristic quantities.

Abbreviations for type designations (examples)

A	display	a	drop-out-delayed
B	instruction, command (switching instruction), burden	b	limited, dependent
		c	capacitive, sine-phi circuit
D	distance measurement		
E	earth fault		
F	for overhead lines	f	fine, sensitive, exact
G	for generators	g	only for direct current
H	auxiliary relay (only for intermediate relay)	h	with intermediate relay
Io	asymmetric current	i	interval
K	for cable (on its own – terminal)	k	short
L	for locomotives	l	long
M	message		
N	shunt resistor	n	for connection to shunt resistor
O	location, position finding (fault finding)		
P	anti-hunt device		
Q	formation of quotients, quotient excitation		
R	on its own – resistor,		
R	as first letter – relay in other respects – direction		
S	current, overcurrent	s	quick, saturated
S	as first letter – control		
		t	thermal
U	voltage (undervoltage and overvoltage)		
Uo	asymmetrical voltage		
V	comparison	v	interlocked
W	transformer	w	transformer current
			tripping or alternating current
X	mixed impedance		
Z	time		
	Number as last number – design, in all other cases – number of poles		

System example and RELOG designations

URSAMAT: Universelles (universal) system of equipment and facilities for
Regelung (regulation)
Steuerung (control) and
Auto
MATisierung (automation) of technological processes

RELOG designations

First number: Dimension stipulation of the module (Multiply number by 15 = width of the module)

First letter: R for electromechanical module
T for transistorised module

Second letter: (Reference to the function of the module)
A Signal relay (colour – red)
G Neutral relay with dry–reed contact (colour –blue)
H Neutral relay with open contact elements (colour black)
S Measuring element for current (colour – light violet)
U Measuring element for voltage (colour – light violet)
Z Time relay (colour –green)

Last two numbers: Type distinction

Example: Relay with the designation 2 RH 05

30–mm wide electromechanical module as neutral relay with open contact elements of Type 05

4.1.1. Neutral or auxiliary relays

Auxiliary relays possess a magnetic system with hinged armature and a series of contacts (n.c. contacts, n.o. contacts and change–over contacts) which are actuated by the armature.

As far as the technical data of

- coil voltage
- switching current
- number of contacts and types of contacts

are concerned, there is a large variety of auxiliary relays, and in accordance with requirements a proper selection has to be made.

Examples of application:

- Switching of control circuits
- Amplification and transmission of weak control pulses (for example contact thermometer)
- Control element in electrical installations for the direct control of magnets etc.

A frequently used neutral relay is, for example, relay 2 RG 04 of the RELOG system.

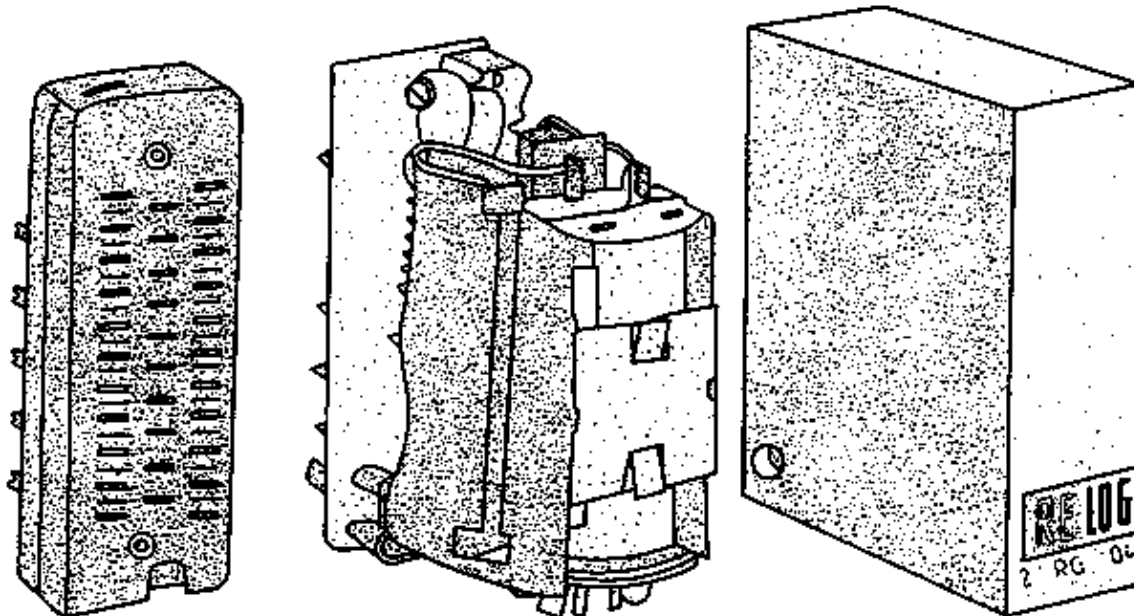


Figure 28 Neutral relay 2RG04

4.1.2. Time relays

Electronic time relay:

Time modules work in accordance with the principle of making and breaking delay. That means, the charging of a capacitor is effected via a resistor in accordance with an exponential function (see charging curve of a capacitor). At a determined magnitude of capacitor charging voltage the relay is actuated by the threshold switch (Schmitt trigger).

Electronic time relays are used:

- for making and breaking delay between 0.3 s and 6 h (protective devices with delay effect)
- for switching operations with delay effect.

Electromechanical time relays:

These relays consist of a hinged armature magnet and a mechanical time–delay element. Through the energization of the magnetic coil a contact lever is moved at constant speed which strikes against an adjustable countercontact and switches the tripping circuit. When the voltage disappears, the relay returns to its starting position without delay.

As far as the electromechanical time relays are concerned, a difference is made between short–time relay, precision–time relay and time relay with synchronous motor.

- Short–time relay, for example RZk and RZk3

These short–time relays can be used for all delayed switching operations of control engineering in which only a short adjustable time delay is required. In connection with overcurrent or undervoltage relays they can also be used for the delayed tripping of switches.

- Precision–time relays, for example RZf2

These precision–time relays possess a high time accuracy. In connection with single–pole, double–pole or three–pole overcurrent and undervoltage relays they are suitable for establishing protective facilities with delay effect. The relay possesses one undelayed and one adjustable delayed n.o. contact

each.

- Time relay with synchronous motor, for example RZw

When a voltage is applied, the synchronous motor starts. With the help of a coupling magnet the motor is engaged with a time wheel which passes through an angle proportional to the set time until contact making takes place. When the voltage disappears, the corresponding contact elements open immediately.

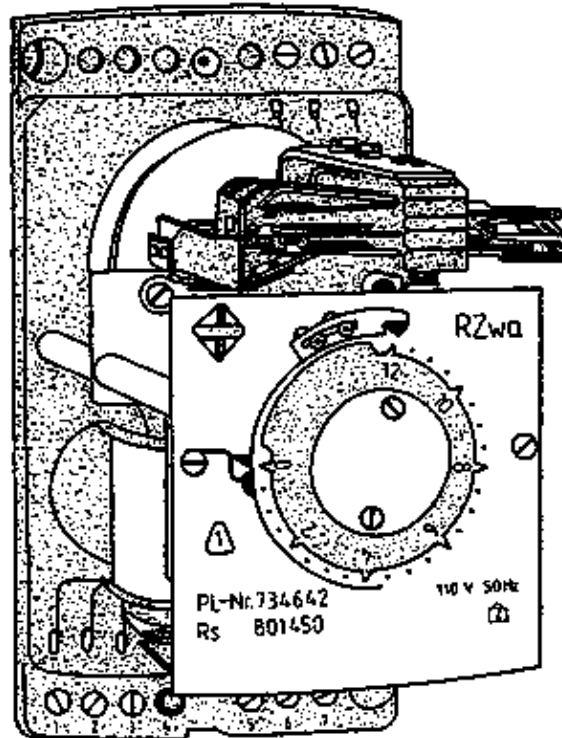


Figure 29 Time relay RZw

4.1.3. Undervoltage and overvoltage relays

These relays, for example RUf5 and RUf5F, are suitable for the undelayed tripping of switches when the mains voltage drops or fails as well as for the undelayed tripping of switches in case of occurring overvoltage.

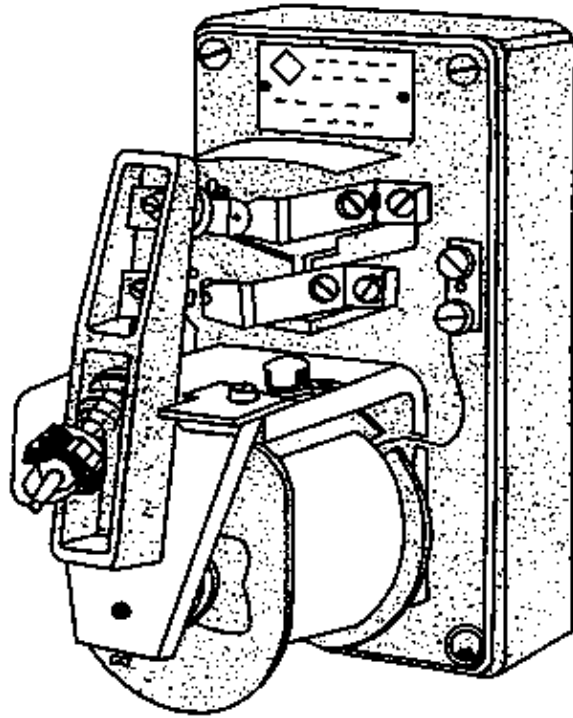


Figure 30 Undervoltage relay

4.1.4. Overcurrent relays

This relay, for example RSf5, has been designed for the undelayed tripping of switches in case of overcurrents caused by overload or short circuit. Picking-up is shown by means of a visual indicator. Thermal overcurrent relays, for example IR1 to IR4, are suitable for direct-current and alternating-current application. They are used together with air-break contactors of type series ID1 to ID4 and LX00 to LX2.

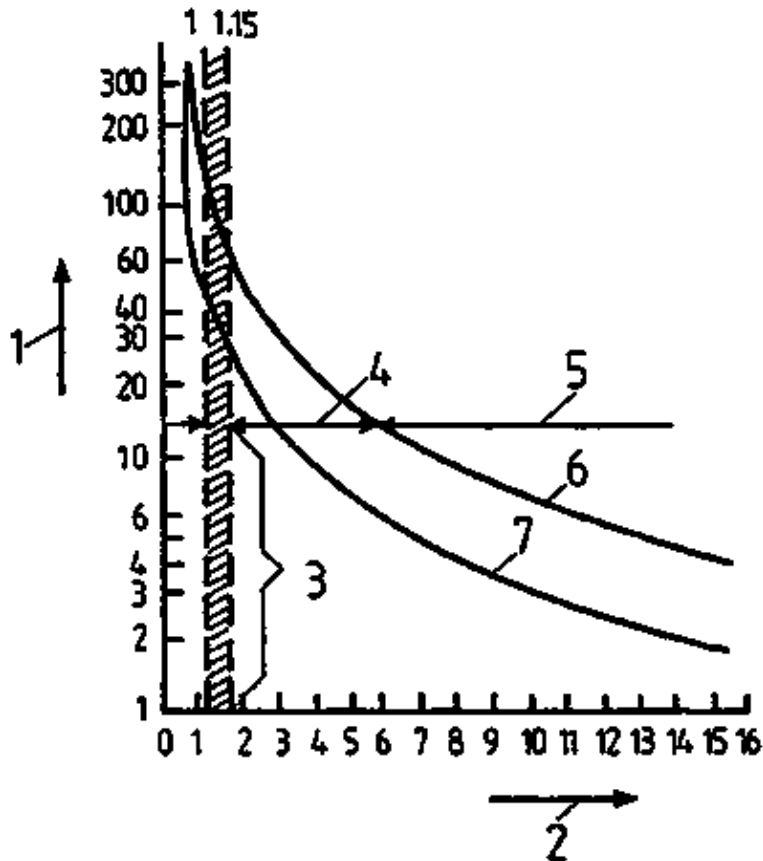


Figure 31 Release characteristic of a thermal overcurrent relay in the hot and cold states

- 1 time in seconds,
- 2 rated current,
- 3 overload range,
- 4 start,
- 5 short circuit,
- 6 characteristic (cold),
- 7 characteristic (hot)

4.1.5. Overcurrent time relays

The relay, for example RSZ3f2, serves for the current-dependent monitoring of motors (low voltage and high voltage) and transformers to protect them against overload and short circuit. The supplied auxiliary voltage serves for feeding the timing element as well as for giving the tripping command.

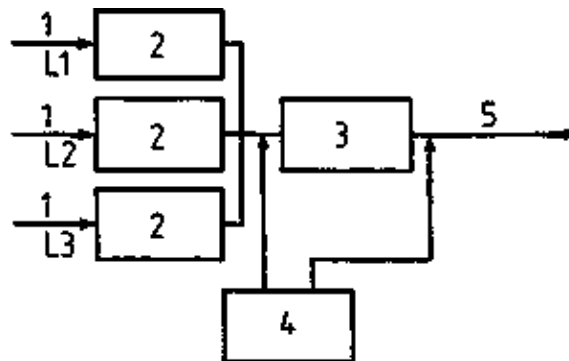


Figure 32 General wiring diagram of an overcurrent time relay

- 1 current of conductors 1...3
- 2 excitation elements
- 3 delay (time) element
- 4 auxiliary voltage source
- 5 tripping command

When an adjustable current value is reached, the excitation elements respond and via the series-connected time element they give the delayed tripping command for the associated circuit breaker.

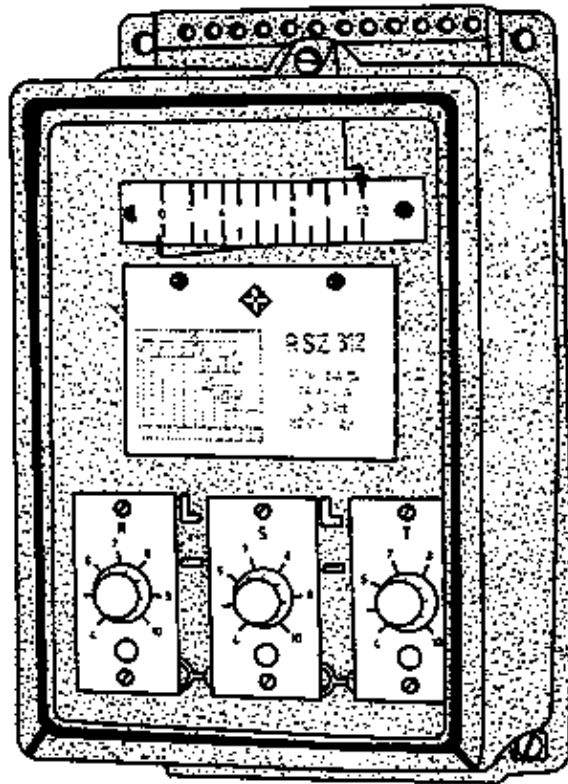


Figure 33 Overcurrent time relay RSZ3f2

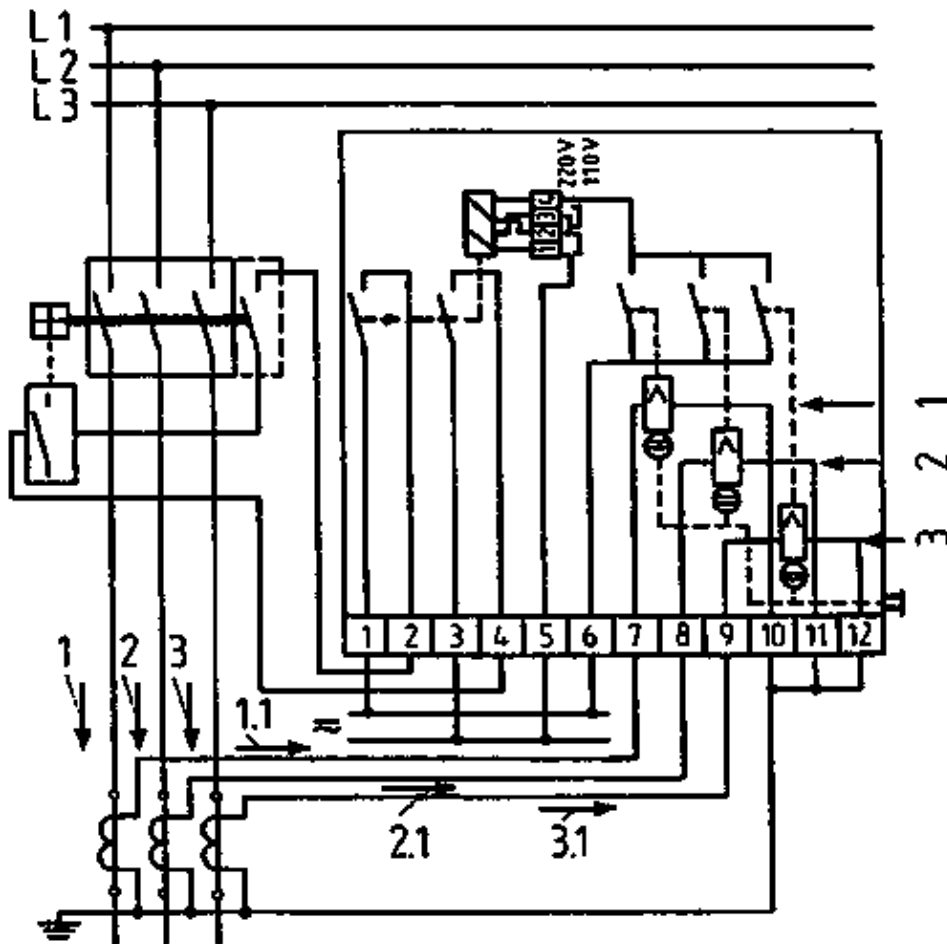


Figure 34 Circuit of the overcurrent time relay RSZ3f2

- 1 current of L1
- 2 current of L2
- 3 current of L3

- 1.1 excitation current of L1
- 2.1 excitation current of L2
- 3.1 excitation current of L3

4.1.6. Magnetic overcurrent relays

Magnetic overcurrent time relay, for example ERMv, for protecting the equipment in low-voltage installations against overload. It is an independent device and works in connection with low-voltage circuit breakers.

The time mechanism is provided with adjustment facilities and scales. When the set minimum operating current is reached, the armature of a magnet picks up and initiates the start of the time mechanism. After the delay time has run down, the armature actuates the auxiliary switch.

4.1.7. Signal relays

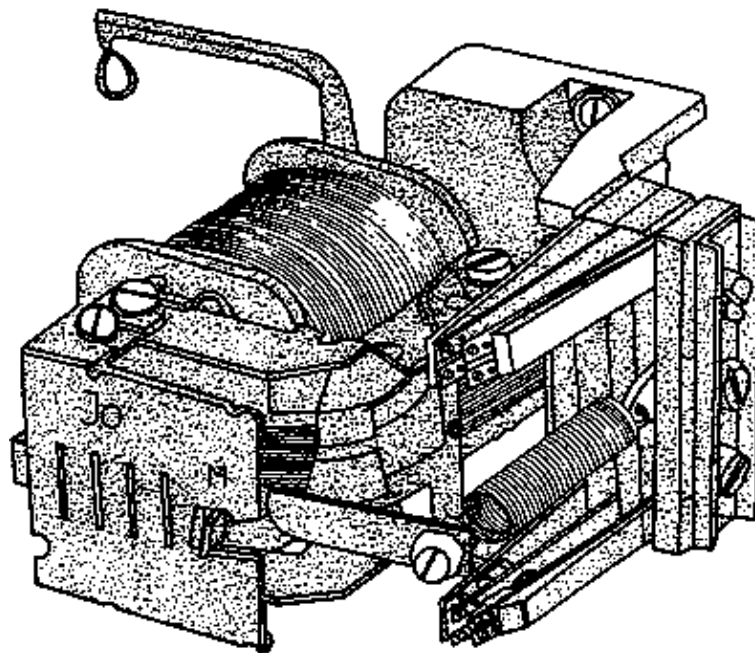


Figure 35 Signal relay RA70

The signal relay, for example RA70, serves for indicating disturbances (voltage failure), operating states (ON, OFF, full, empty). Information is stored for acknowledgement by manual actuation until the disturbance is eliminated or the initial position is restored. Built-in contacts can be used for remote display, for disconnecting disturbed installations as well as for tripping acoustic signals.

- Rated voltage: 60, 110 and 220 V d.c.
24, 220 and 380 V a.c.
- Making current: 10 A a.c./d.c.
- Continuous current: 5 A a.c./d.c.
- Contact elements: 2 double-throw contacts or
1 double-throw contact,
1 passing contact or
1 n.o. contact in middle position and
1 double-throw contact or
1 n.o. contact in middle position and
1 passing contact

4.2. Control devices

4.2.1. Discrepancy switches

The discrepancy switch, for example BM2, serves for indicating and monitoring the switch position in mimic diagrams and illuminated circuit diagrams of electrical installations, for indicating the position of valves in a piping system and indicating faults by means of visual or acoustic signs. It can also serve as command switch, for example, for controlling switches while displaying at the same time the position of the switches.

The control button is designed as graphical symbol. When the latter is lit, it is indicated that the state of the associated switch or valve does not coincide with the display.

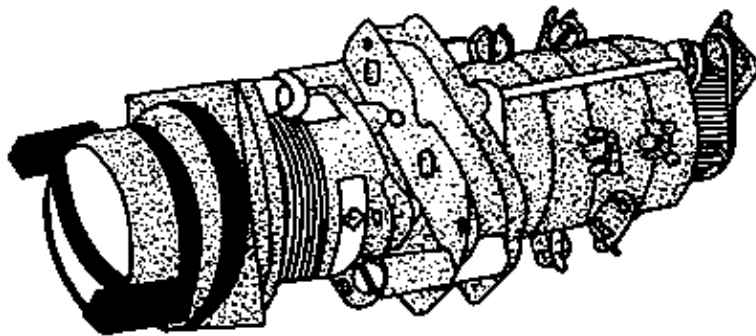
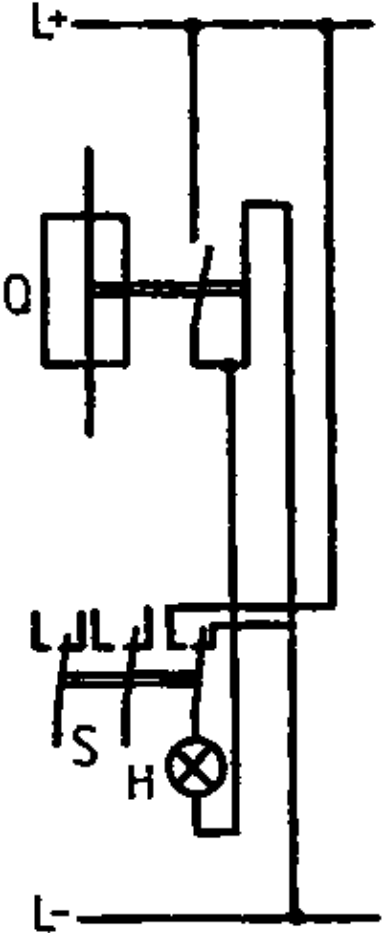

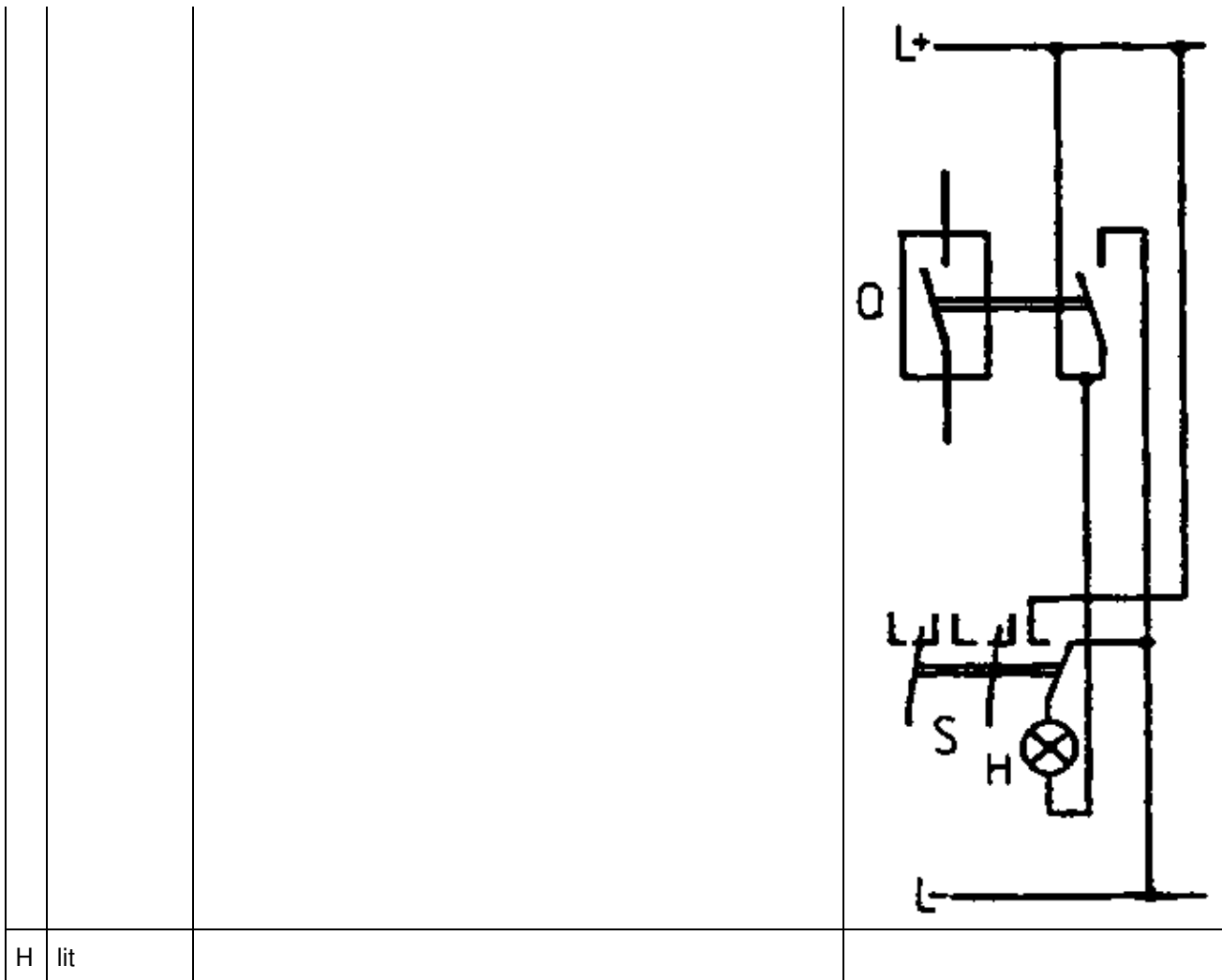


Figure 36 Discrepancy switch BM2

Survey 6 Functional principle of the discrepancy switch BM2

	Switching state	Operation	Connection
Q	OPEN	The position of the circuit breaker Q corresponds with that of the discrepancy switch S. Lamp remains off.	
S	OPEN		
H	dark		

<p>Q S</p>	<p>CLOSED CLOSED</p>	<p>See Figure</p>	
<p>H</p>	<p>dark</p>		
<p>Q S</p>	<p>OPEN CLOSED</p> 	<p>By changing the position of the circuit breaker Q the circuit of the signal lamp is closed. Acknowledgement is effected by changing the discrepancy switch S.</p>	



4.2.2. Control discrepancy switches

The control discrepancy switch, for example SM2, is used in switchgear installations for controlling circuit breakers and isolating switches as well as for displaying and monitoring their switching positions in mimic diagrams. When the switch symbol lights up, it is indicated that the position of the control discrepancy switch does not coincide with that of the associated circuit breaker or isolating switch.

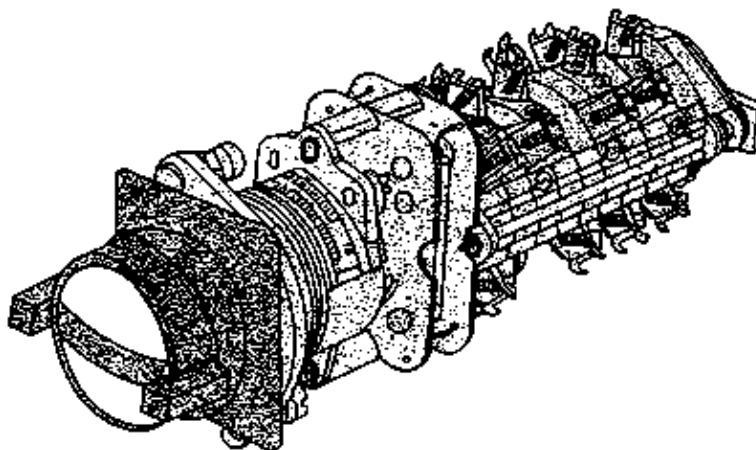

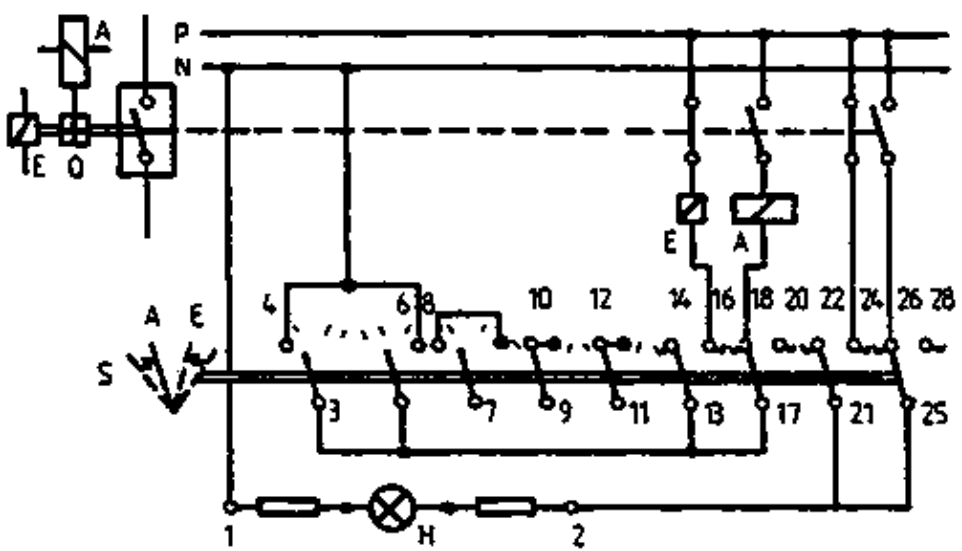

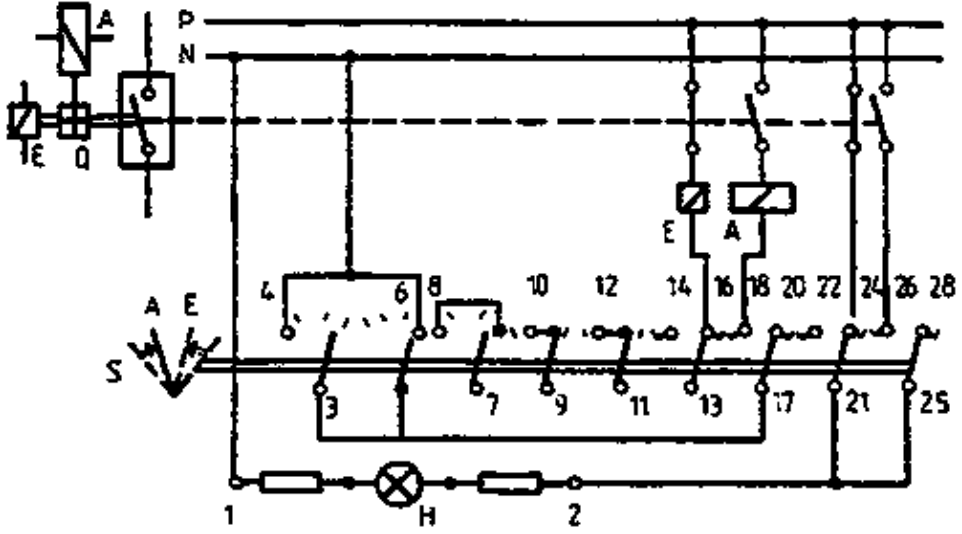

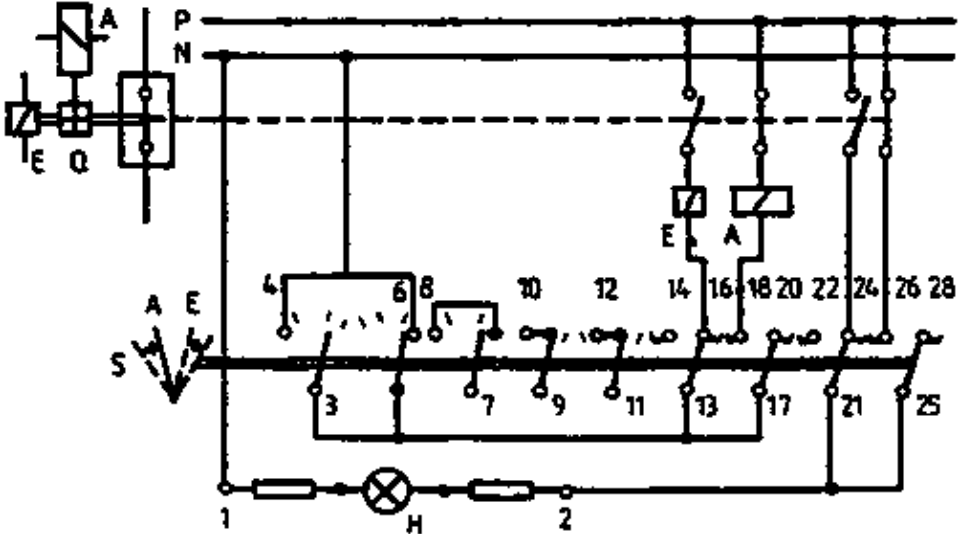

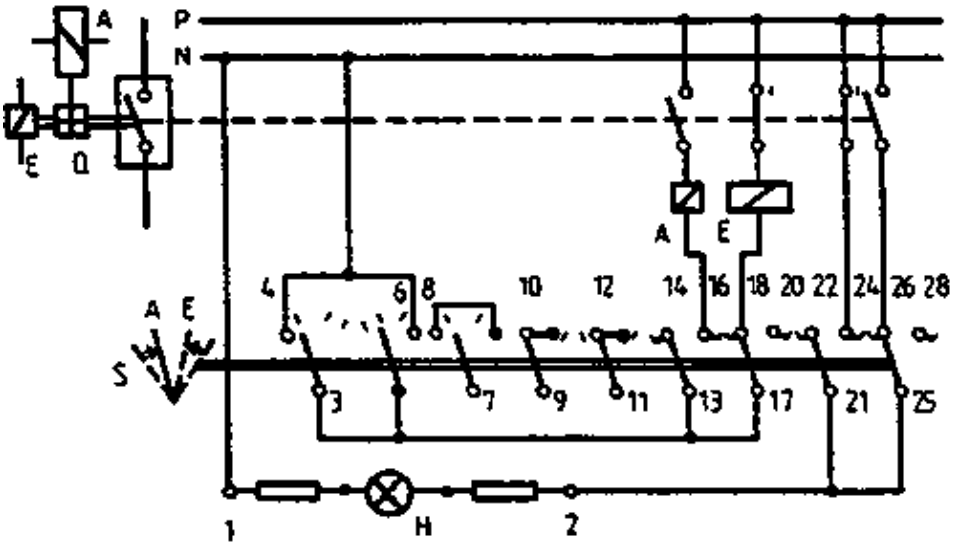


Figure 37 Discrepancy control switch SM2

Survey 7 Functional principle of the control discrepancy switch in preselection position

Switching state	Operation	Connection

Q S	OPEN OPEN 	Circuit breaker Q and control discrepancy switch S in agreement.	
H	dark		
Q S	OPEN CLOSED 	Preselection by turning control discrepancy switch S to close circuit breaker Q. No agreement between the two switches.	
H	lit		
Q S	CLOSED CLOSED 	Closing of circuit breaker Q by shortly depressing and turning control discrepancy switch S by 45 degrees. Agreement between Q and S.	
H	dark		

Q S	OPEN OPEN 	A change of the position of circuit breaker Q causes control discrepancy switch H to light up. By turning the control discrepancy switch S by 90 degrees, the message is acknowledged and lamp H goes out.	
H	dark		

H – lamp
Q – circuit breaker
S – control discrepancy switch