

# Intrinsic safety principle and phenomenon which influence the intrinsic safety of the circuitry involved

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**INTRINSIC SAFETY**  
**PRINCIPLE AND PHENOMENON WHICH INFLUENCE**  
**THE INTRINSIC SAFETY**  
**OF THE CIRCUITRY INVOLVED**

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1 - PRINCIPLE OF INTRINSIC SAFETY

When an electric circuit is getting opening by a switch, we notice of course that the current stop<sub>s</sub> to flow but we can also observe a very brief flash more or less bright depending on circumstances between the metallic separating parts of the switch.

This flash, called spark, is the result of a complex phenomenon in which take place simultaneously the burning of metallic particules pulled away from the switch and the ionization of gases situated at this spot and being induced by the electric field existing between the poles of the switch.

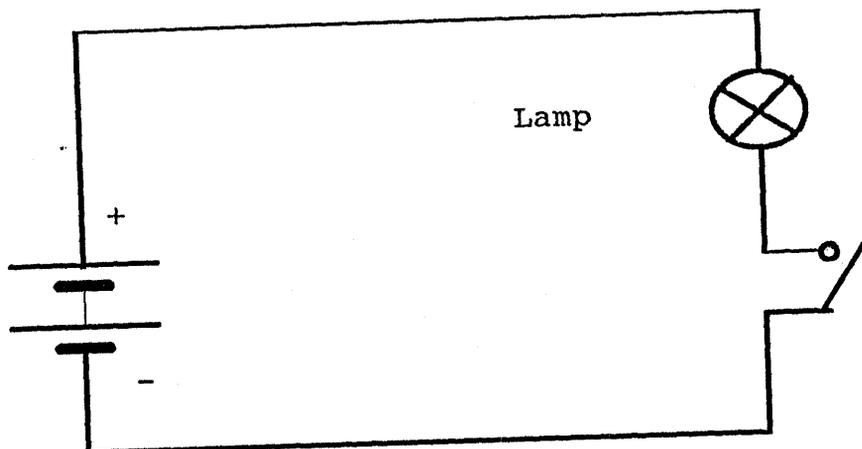


Figure 1

This spark, which is very hot, can be sometimes able to ignite an atmosphere become flammable by pollution of combustible gas, vapour or dust.

The idea to reduce the energy dissipated in this spark, to avoid to ignite the atmosphere, is very old, because at the beginning of the century, it was applied in coal mines in United Kingdom to a sounding signal device, made of a bell and an electric operating hammer.

Studies carried out on the igniting capability of these sparks have shown the influence of the main following parameters :

- Value of the open circuit voltage
- Value of the current flowing through the closed circuit
- Stored energy in the inductances and the capacitances
- Nature of materials located in the circuit between which sparks are created
- Pressure of contact
- Nature of the atmosphere

Besides, it is also well know since a long time, that objects or parts of object being brought up to high temperature, are able to ignite a flammable atmosphere without any spark being necessary.

From Joule effect, an electric circuit is capable to ignite such an atmosphere.

The parameters which ignition hazard by hot surfaces depend on are :

- the temperature of hot parts
- the surface of these parts
- the nature of the atmosphere

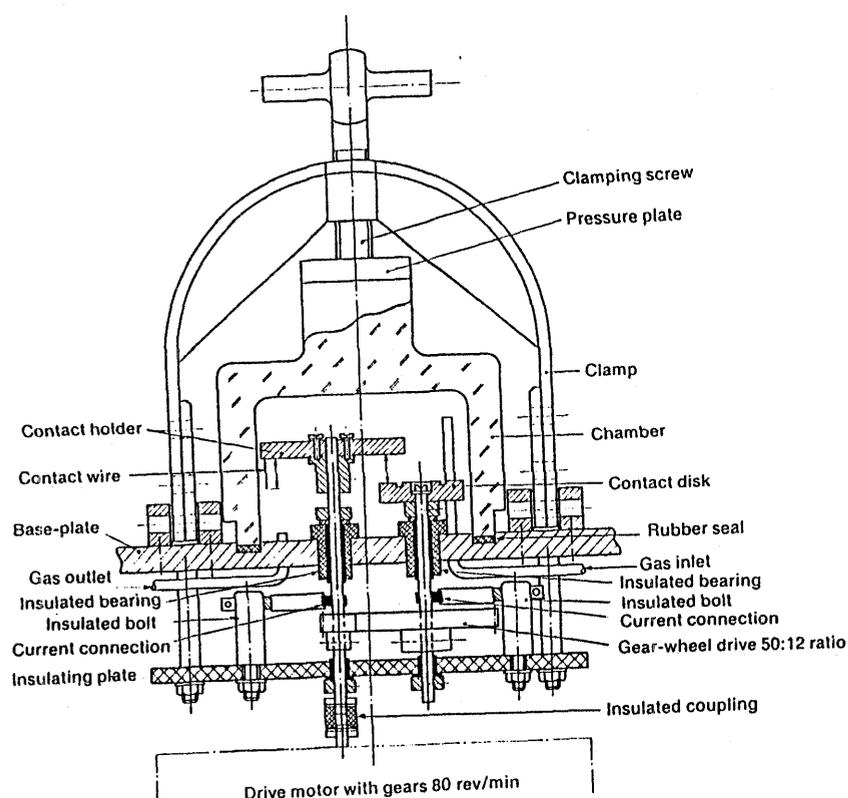
An intrinsic ally safe circuit will be then by principle a circuit in which all the parameters, mentioned above, will have such values that the ignition hazard will be excluded.

The works carried out by International Electrotechnical Commission (IEC) and the European Committee for Electrotechnical Standardization (CENELEC) have allowed the edition of standards which reduce the study of these parameters.

## 2 - STANDARDIZED SPARK TEST APPARATUS

To study ignition hazard of an electric circuit, it is necessary to use a device producing opening and closing of this circuit, in a reproducible manner during the time, simulating realistic cases, not over or insufficiently severe.

This device, called "spark test apparatus for testing intrinsically safe circuits" is described in IEC publication 79-3 and in European Standard EN 50 020.



— Example of a practical design of test apparatus.

FIGURE 2

FROM PUBLICATION 79-3 . IEC Recommendation

This apparatus had allowed to study the ignition limits obtained by different types of circuits and for different gases from which are here a few examples taken from EN 50 020 standard.

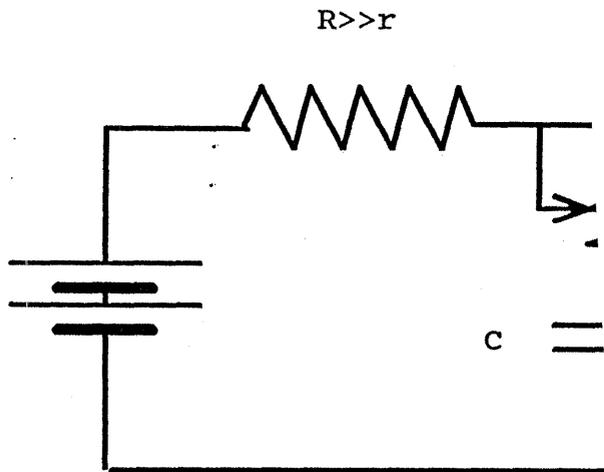


Figure 7

### 3 - CLASSIFICATION OF ELECTRICAL APPARATUS

As we have exposed above, the ignition hazard of an atmosphere depends on the nature of this atmosphere.

To simplify the use of safety apparatus which the intrinsic ally safe apparatus are part from, the apparatus have been classified in two groups.

Group I contains apparatus used in gassy mines.

Group II contains apparatus used in industries other than mines.

The variety of atmosphere found in these industries require the classification in 3 subdivisions.

The meaning of this subdivision is exposed in EN 50 014 european standard - Electrical apparatus for potentially explosive atmospheres - General rules -

For intrinsically safe apparatus, gases and vapours are classified according to the ratio of their minimum igniting currents (MIC) to that of laboratory methane.

The MIC are determined with the spark test apparatus described above.

The atmospheres are so classified in 3 subdivisions :

- Subdivision A : MIC ratio above 0.8
- Subdivision B : MIC ratio between 0.45 and 0.8
- Subdivision C : MIC ratio below 0.45

A second classification of apparatus of group II is done according to maximum surface temperature that they can have got.

The table below taken from EN 50 014 presents this classification.

EN 50014

Table 1. Classification of maximum surface temperatures for Group II electrical apparatus

Temperature class	Maximum surface temperature (°C)
T1	450
T2	300
T3	200
T4	135
T5	100
T6	85

The maximum ambient temperature is conventionnally fixed to 40°C except opposite requirements.

For components which the total surface area does not exeed 100 cm<sup>2</sup>, their surface temperature can exceed those of the class of apparatus if special tests show that the igniting hazard is not possible.

#### 4 - INFLUENCE OF CONSTRUCTIONAL QUALITY OF APPARATUS

##### 4.1 - Infallible components and infallible assemblies of components

Let us devise the circuit below which can be, for example, those of a remote control for a ring or a relay.

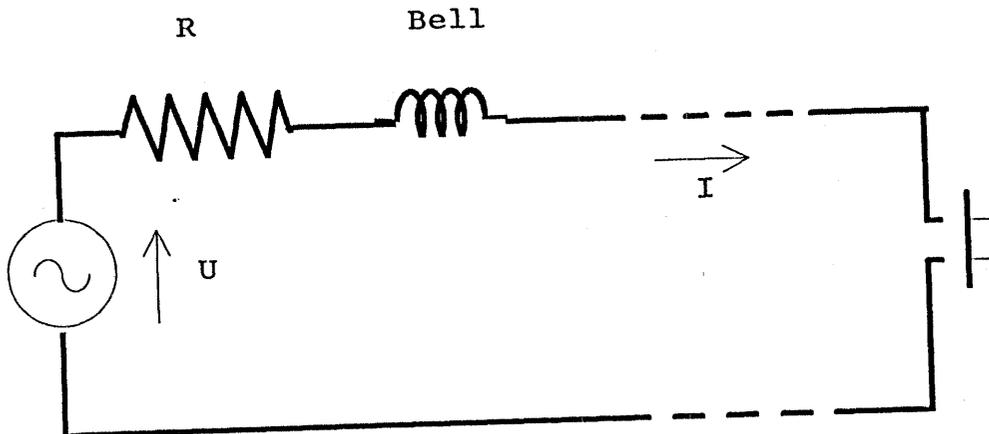


Figure 9

The presence of the resistor  $R$  limits the current of the circuit at such a value that the spark produced in the switch, is unable to ignite the atmosphere around the switch.

Where the apparatus is not designed in such a way that the short circuit of the resistor  $R$  is impossible during the time, the circuit can become hazardous. The resistor  $R$  shall be infallible.

Let us devise now a modification at this circuit.

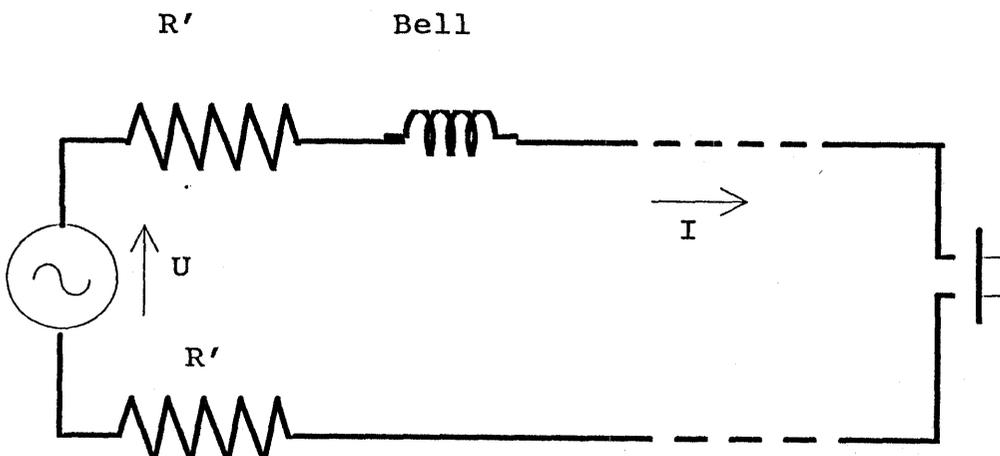


Figure 10

The short circuit of the resistor R' does not compromise the safety of the circuit, but the short circuit of the two resistors R' is hazardous.

It is not necessary that each resistor be infallible. It becomes only necessary that the assembly of two resistors should be infallible.

The infallibility of a component or an assembly of components complies to definite requirements based under circumstances on :

- the nature of components. For example, a single semiconductor cannot be infallible by its own. The EN 50 020 standard precises what kind of components can be accepted as infallible (Resistor, transformer),
- the characteristics of components (minimum voltage, rating, ...)
- the special heating and voltages tests (transformer)
- the respect of a proper isolation between bare live parts under voltage from the circuit which the component or the ensemble of components belongs.

A table shows the values to comply of clearance, creepage distances and distances through casting compound.

- The category of the wished safety

There are two categories of intrinsic safety.

The first requires from apparatus a reliability higher than the second. The two categories are described below.

#### 4.2 - Categories of intrinsic safety apparatus

In the above example, the fault of one of the two resistor R' did not induce the production of an explosive hazard.

However, in order that the apparatus should be effectively safe, it must evidently be that the short circuit of R' be the result of very low likely circumstances and over all, it must not be the result of a normal aging or a normally foreseeable damage.

As a matter of fact in the opposite situation, the second resistor could thoroughly, for the same reasons than the preceding ones, be the subject of a second short circuit and then the apparatus should be hazardous.

The number of faults, acceptable before the production of a hazard, depends on the category of the apparatus.

The standard prescribes two categories which, in order to simplify, are the followings : the category "ia" in which the apparatus remains safe even when two simultaneous faults are considered and the category "ib" in which the apparatus shall remain safe with one fault.

To consider that an event be really a fault and not a normal circumstance, the following requirements shall be complied :

- the rating of component is limited to 2/3 of the nominal rating defined by the manufacturer (U,I,P.)
- some components are excluded (tantalum capacitor for example)
- the segregation of bare live parts of circuits in which they belong shall also comply accurate prescriptions. The values of clearances, creepage distances and distances through casting compound cannot be below the third of those prescribed for infallible insulation.

#### 5 - ASSOCIATED APPARATUS AND INTRINSICALLY SAFE APPARATUS

In the two preceding examples, the power supply of the ring was not safe to ignition hazard, only the switch and the conductors up to the switch make up the intrinsic safety circuit.

On the scheme below, the apparatus framed by a dotted line, compose on elementary device of what the EN 50 020 standard calls an associated apparatus.

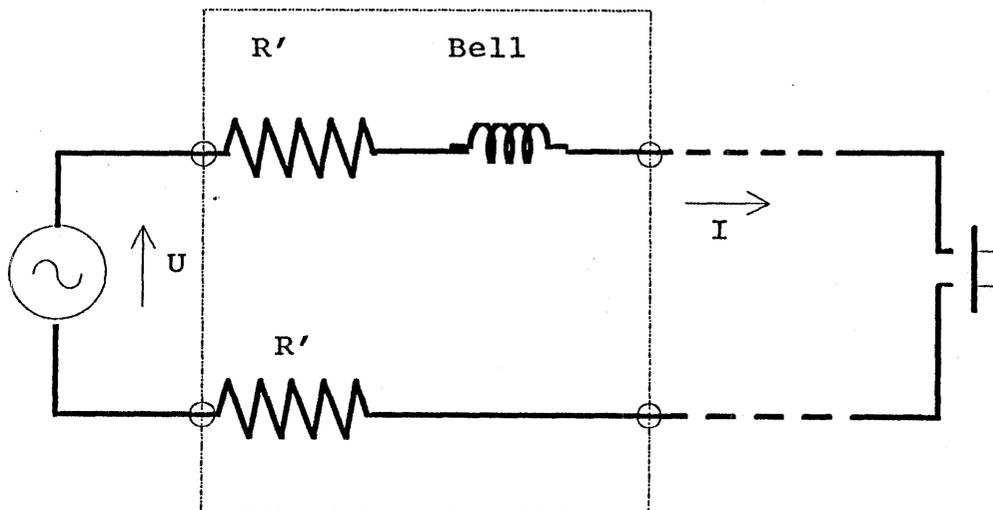


Figure 11

In opposition to an intrinsically safe apparatus in which all circuits are intrinsically safe, an associated apparatus cannot be in potentially explosive atmosphere without including any other type of protection such as flameproof enclosure, pressurized enclosure, encapsulation, ...

6 - LOOPS OR CIRCUITS BEING ABLE TO BE NON-IDENTIFIED

6.1 - Loop closed by a ground circuit

Let us keep the preceding example but let us connect the associated apparatus to a very low voltage electric network having a terminal (neutral for example) connected to ground.

The two possible connections are the following :

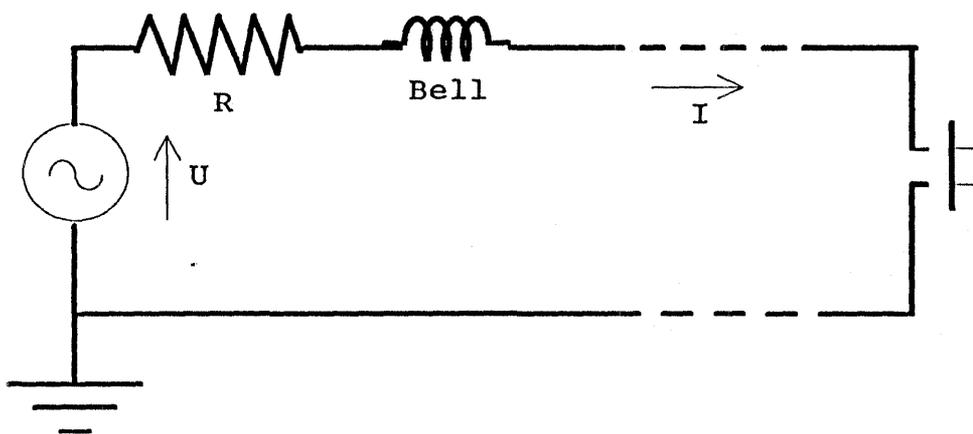


Figure 12

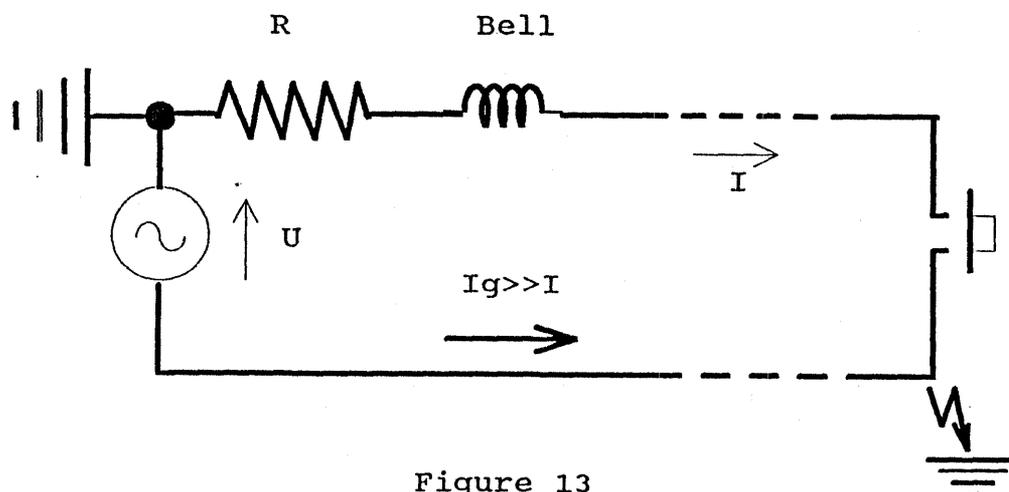


Figure 13

In the case of connection 2, it appears clearly that a fault between the intrinsically safe circuit and the ground can be particularly hazardous because no impedance other than those of the circuit will only limit the fault current.

In one case, as in the other, the circuit, chosen to be an example, could not be recognized as intrinsically safe.

In the fact, an infallible transformer in the way previously prescribed shall be a part of associated apparatus.

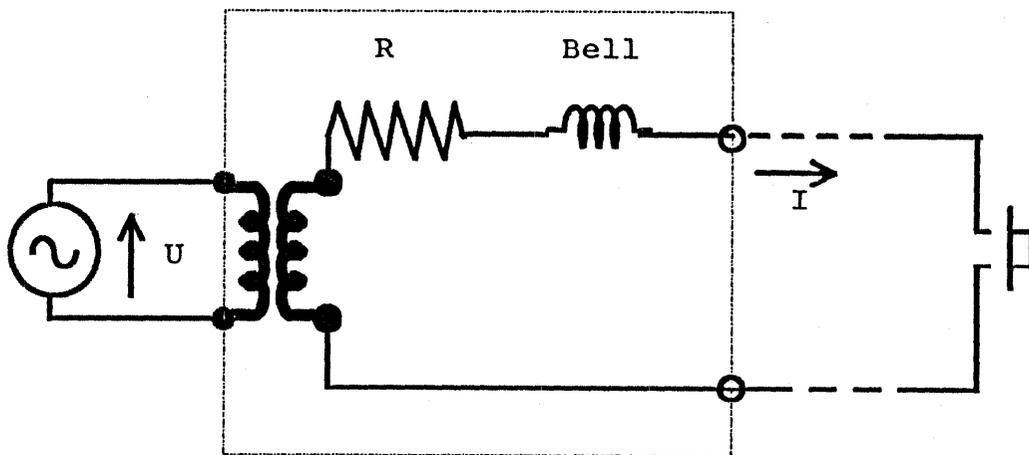


Figure 14

This example sums up a great number of conditions frequently being met especially in barriers use.

The diode safety barrier lies on the following principle :

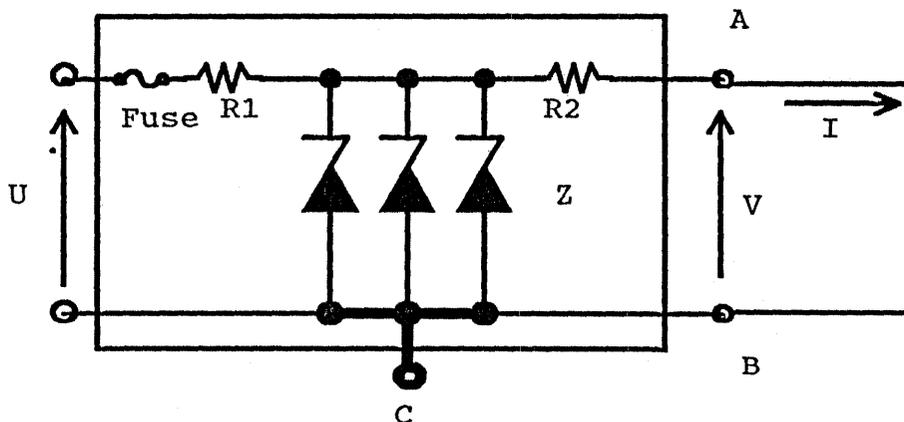


Figure 15

It is composed of an encapsulated unit having a voltage limitation  $V$  being able to appear between the terminals generally obtained by the use of Zener diodes, a limitation of the current being able to flow in the intrinsically safe circuit obtained by the resistor  $R_2$ , a protection of Zener diodes by a fuse and a resistor  $R_1$ .

Typically barriers are used to connect intrinsically safe transducers to electronic apparatus which are not itself intrinsically safe.

The hazard from a power supply connected to ground is the same than those previously studied and the use of a barrier showed above can only be accepted if its terminal C is permanently connected to ground.

## 6.2 - Loop closed by a common return

When a same elementary circuit is recurring, a trouble can appear at the level of an eventual common return.

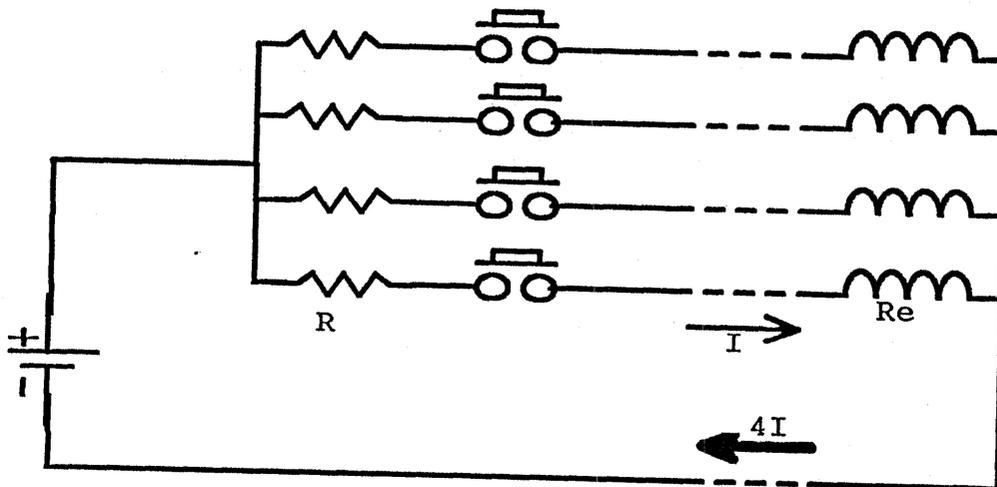


Figure 16

The circuit drawn shows a control circuit of 4 relays situated in series in a circuit composed of a push-button BP, a resistor  $R$  and a voltage supply  $U$ .

Each elementary circuit is intrinsically safe, but the current in the common return conductor is not safe.

To avoid that, it is necessary :

- to install the same number of return conductors than the way out conductors
- to keep an eye at the segregation of return circuits in spite of being connected to the same potential mode.

### 6.3 - Induction hazard by an external supply

Let us take again the over-simple preceding circuit.

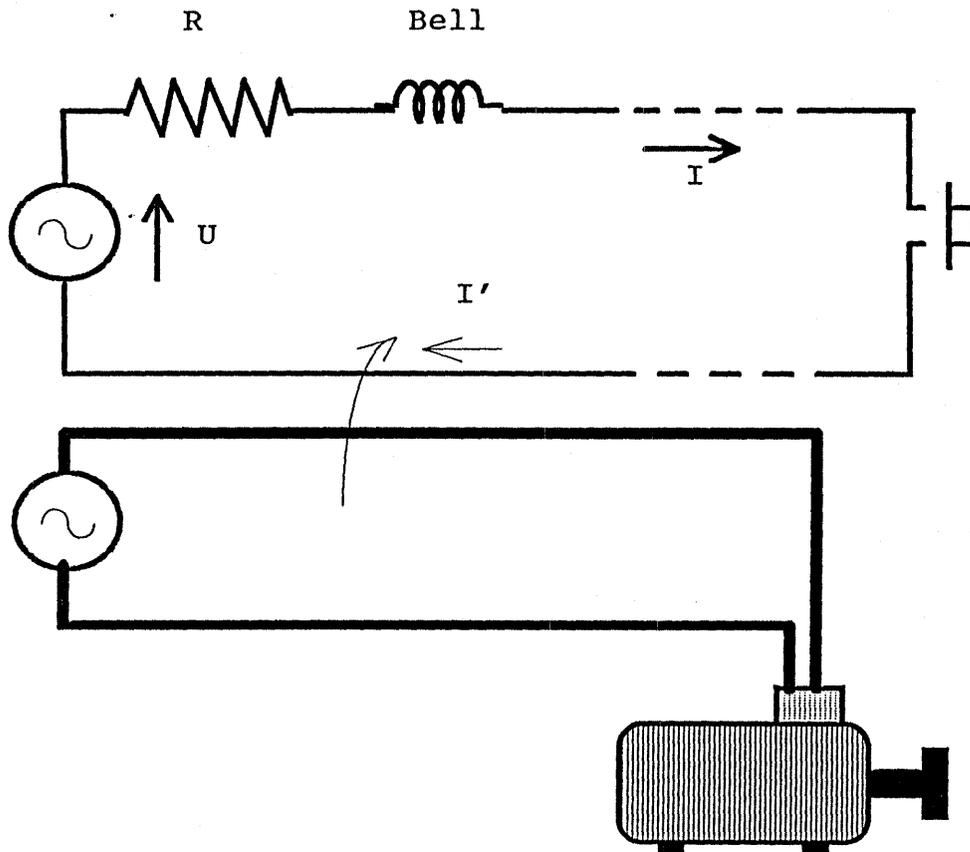


Figure 17

For economic hidden motives, the way out conductor A is separated from the return conductor R.

When an alternative magnetic field flows through this loop, an eventually hazardous induced current  $I$  can be generated.

The eventual supplies of magnetic field are, in addition to radio-emitter, the situation has been met the electric circuits of high power or those which present high unsymmetrical of their conductors such as arc-welding.

To avoid that, it is suitable :

- to see that all the conductors of a same intrinsically safe circuit are the least remote as far as possible (cable)
- to remote the conductors of electric cables. Beyond a few centimeters, the result from magnetic fields generated by symmetrical conductors is of no value.