Problem

Investigate the effects of adding a capacitor to a direct current circuit. Pay particular attention to the moment when the switch is turned on and off.

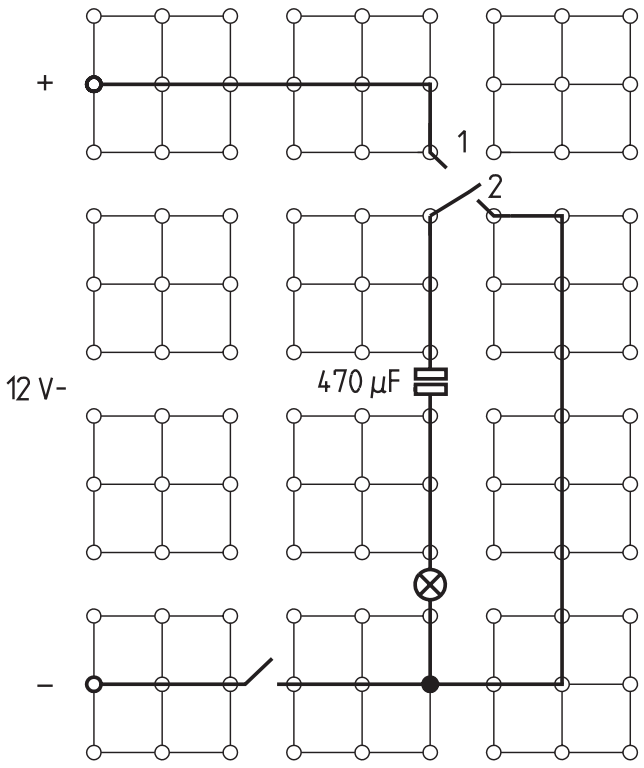
Equipment

Plug-in board	06033.00	1
On/off switch	39139.00	1
Changeover switch	39169.00	1
Lamp holder E10	17049.00	1
Filament lamp, 4 V/0.04 A, E10, 1 pc.	06154.03	(1)
Electrolytic capacitor, 47 μF, bipolar	39105.45	1
Electrolytic capacitor, 470 μF, bipolar	39105.47	1
Wire building block	39120.00	4
Connecting cables, 25 cm, red	07360.01	1
Connecting cables, 25 cm, blue	07360.04	1
Connecting cables, 50 cm, red	07361.01	1
Connecting cables, 50 cm, blue	07361.04	1
Multi-range meter	07028.01	1
Power supply, 0...12 V-, 6 V~, 12 V~	13505.93	1

Set-Up and Procedure

— Set up experiment as shown in Fig. 1 using the 470 μF capacitor initially. Set on/off switch to off position and flip changeover switch to position 1.
— Switch on power supply unit and set direct voltage to 12 V.
— Turn on/off switch on and observe filament lamp.
— Turn on/off switch off and on and observe filament lamp. Note observations under (1).
— With the on/off switch in the on position, flip changeover switch to position 2 and observe filament lamp.
— Turn on/off switch on and off several times. Note observations under (2).
— Flip changeover switch to position 1 then interrupt the circuit by turning the on/off switch to the off position.
— After 1 to 2 seconds, flip changeover switch to position 2 and observe filament lamp. Note observations under (3).
— Replace 470 μF capacitor in the circuit with 47 μF capacitor. Turn the on/off switch to on position and flip the changeover switch back and forth several times. Observe filament lamp and note observations under (4).
— Set measurement range on multi-range meter to 30 mA- and add it as a current meter to the circuit in place of the filament lamp.
— Flip changeover switch back and forth several times and observe the current. Note observation under (5).
— Switch power supply unit off.

Fig. 1



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Observations

(1)

(2)

(3)

(4)

(5)

Evaluation

1. What conclusions can you draw from the observations you noted under (1) and (2)?

2. What conclusions can you draw from the observations made under (3)?

3. What is apparent from observations (4) and (5)?
   (Note: The capacity (C) of a capacitor for electrical charges is measured in Farads (F). One microfarad (1 μF) is a millionth of a Farad.; $C = Q / U$; $1\ F = 1\ A \cdot s/V$.)

(How does a capacitor act in a direct current circuit?)

The students have a general idea of what capacitors are and, based on the graphical symbol, probably think of them as pairs of plates. Even though the capacitors used in this experiment do not correspond with this preconception of theirs, they will still not expect current to flow when a capacitor is included in a direct current circuit. This makes the results of this experiment even more surprising for them.

Notes on Set-Up and Procedure

In the last part of the experiment, they must prove the presence of charge and discharge current with the current meter because the filament lamp does not react to minimal surges in current. Make absolutely sure the students select the 30 mA measurement range (no smaller), because the pointer will deflect out of the scale range to the left during the experiment. The indicator must not deflect too far, and it won't as long as the 30 mA measurement range is selected.

The 3 short-circuit plugs in the right part of the circuit may be replaced by a single connecting cable. Fig. 1 does not show this possibility for the sake of clarity in the circuit.

Observations

(1) When the circuit is switched on for the first time, the filament lamp shines for a brief moment and then goes out. Nothing happens when the circuit is turned on and off subsequently.

(2) The filament lamp shines for a brief moment each time the changeover switch is flipped back and forth.

(3) When the changeover switch is flipped to position 2, the filament lamp shines even a bit longer (several seconds) after the left circuit is turned off.

(4) The filament lamp does not shine at all with a 47 μF capacitor in the circuit.

(5) A minimal amount of current flows with a 47 μF capacitor when the changeover switch is flipped back and forth.

Evaluation

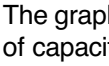
1. The capacitor is charged as soon as the circuit is switched on. This requires a one-time brief charging current, as indicated by the filament lamp.
   Switching the changeover switch from position 1 to 2 and back causes the capacitor to be charged and discharged respectively.
2. The capacitor is capable of storing an electrical charge and, therefore, of briefly functioning as a source of current.
3. The smaller the capacity of a capacitor, the less charge it can store and the faster its charging and discharging currents subside. That is why the filament lamp does not light up.

Notes

Since the recommended capacitor is unpoled or bipolar (both terms are commonly used), the students do not need to pay attention to correct polarity. The graphical symbols in circuit diagrams designate the kind of capacitor being used:

Electrolytic capacitor, poled, or

Electrolytic capacitor, unpoled (bipolar).

The graphical symbol  generally stands for the kind of capacitor with which the students are familiar.

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(How does a capacitor act in a direct current circuit?)

Room for notes