Designs for Mounting Reed Switches Inside Complete Conductors

Mark Kletsel
dept. Electrical Power Engineering
Toraighyrov University
Pavlodar, Kazakhstan
mkletsel@mail.ru

Alexandr Barukin
dept. Electrical Power Engineering
Toraighyrov University
Pavlodar, Kazakhstan
alexbarukin@mail.ru

Bauyrzhan Mashrapov
dept. Electrical Power Engineering
Toraighyrov University
Pavlodar, Kazakhstan
bokamashapov@mail.ru

Abstract—**The use of reed switches is shown to be one of the ways of solution of the well-known problem of designing relay protection devices without current transformers. Four patented designs for mounting reed switches inside complete conductors are considered. In the first design, a bar with reed switches is passing through slots of two separating plates of three-phase complete conductors. In the second design, a bent bar connects a plate with reed switches with the separating plate of the conductor. In the third design, the housing with a cover is used instead of the plate, inside which there are a bar with reed switches, a time relay, and an output protection relay. The fourth design is attached to the inner side of the hole cover of a single-phase complete conductor by means of an adjustable rod with a plate and a disk with a reed switch attached.**

Keywords—protection; reed switch; design; mounting; complete conductors

I. Introduction

Resource conservation is of special importance in today's society. The amount of copper, steel, and high-voltage materials can be reduced by tens and even hundreds of times in relay protections designed without current transformers. We have chosen reed switches – reed contacts for such a design, since they have advantages important for relay protection in comparison with other magnetically sensitive elements: they do not require amplifiers for signal transmission; this transmission is carried out through control but not measuring circuits; they can simultaneously function as an analog transducer and a responder. Reed switches are widely used in engineering technology. Studies of their properties [1-12] have shown their sufficient speed and sensitivity and long-term stable operation, which allow their use in relay protection. We have already created the foundations for designing several protections [13] and are developing more complex ones [14, 15]. In all protections, reed switches are mounted (Fig. 1) at a safe distances from the phases of an electrical installation l_A (l_B, l_C) in the plane of their cross-section at an angle γ in the plane parallel to the busbars. The total magnetic flux with the induction

$$B_{long} = \frac{\mu_0}{2\pi}\left(I_A \frac{\cos\alpha_1}{l_A} + I_B \frac{\cos\alpha_2}{l_B} + I_C \frac{\cos\alpha_3}{l_C} \right) = \mu_0\left(g_A I_A + g_B I_B + g_C I_C\right) \quad (1)$$

acts along the longitudinal axis of a reed switch. Here, α_1 (α_2, α_3) is the angle between the magnetic flux induction vector B_A (B_B, B_C) produced by the current I_A (I_B, I_C) of the phase A (B, C) and the reed switch axis; g_A, g_B, and g_C are the coefficients represented in terms of x, h, d, and γ; μ_0 is the air permeability.

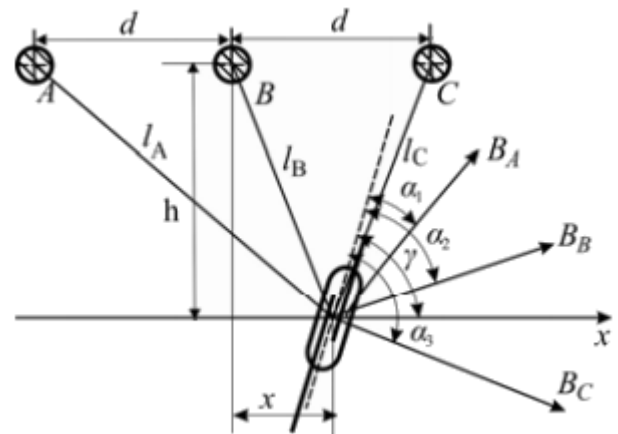Each term in parentheses in (1) is written in accordance with the Biot–Savart law.

Fig. 1. Reed switch munted under the phases of an electrical installation

A reed switch actuates (switch contacts) under the induction

$$B_{act} = \mu_0 H_{act} = \frac{\mu_0 F_c}{l_c} = \frac{\mu_0 w_c I_c}{l_c} = B_{long}, \quad (2)$$

where $F_c = F_{act}$ is the magnetomotive force required for the actuation, it measures for each reed switch in an induction coil with the number of turns w_c and the length l_c.

To perform any reed switch protection, special designs are required to fix them near the busbars. In this work, we present four designs developed and patented by the authors, which allows their mounting near the busbars of three-phase and single-phase complete conductors.

II. Designs for Mounting Reed Switches inside Three-phase Complete Conductors

A. The First Design

The design (Patent of the Republic of Kazakhstan no. 34421, authors: Kletsel, Barukin, Berguzinov, Kaltayev) includes: three groups of reed switches 1–3 (Fig. 2) attached to bar 4 with the help of clamp 5 (Fig. 3), fixed by lock bolts 6; guiding battens 7–10; slide 11 (Fig. 4). Reed switch groups 1 and 2 are fixed on bar 4 near its ends, while group 3, near the center. Guiding battens 7–10 are fixed at two ends of bar 4. It is attached to slide 11 throughout its length and is capable of moving along it and passing along with it through slits in separating plates and in the conductor shell (omitted in Figs. 2–4). There is handle 12 at one of the ends of bar 4. Protection set points of each reed switch group 1–3 are adjusted by means of choosing the number of reed switches used.
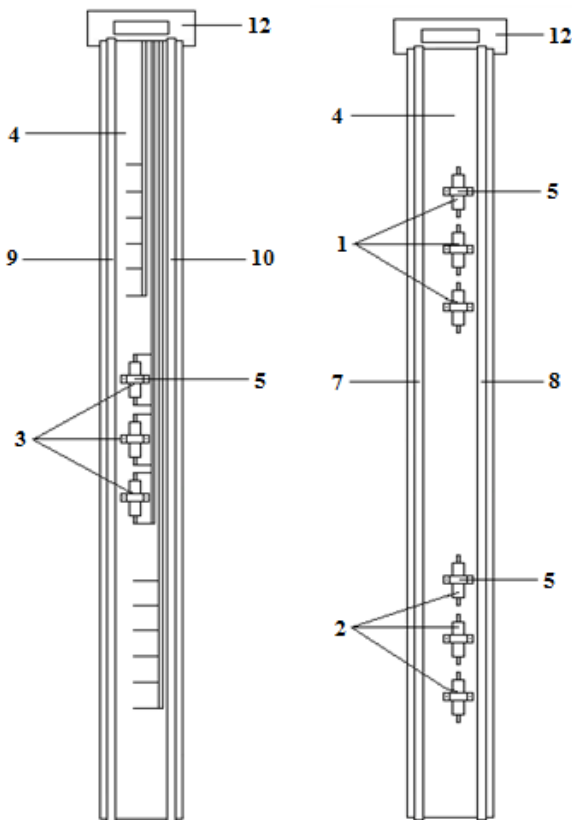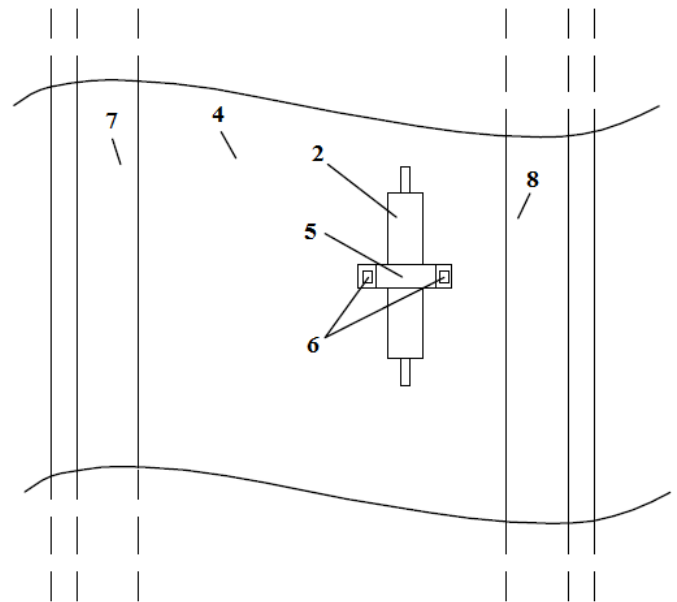

Fig. 3. Fastening reed switches to the bar (with group 2 as an example)
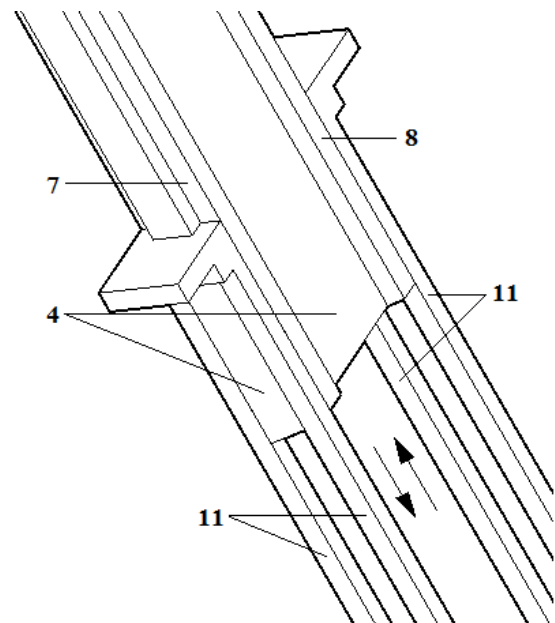

Fig. 4. Bar sliding (isometry)

B. The Second Design

The design (Patent of the Republic of Kazakhstan no. 30165, authors: Kletsel, Berguzinov) contains console 1 (Fig. 5) and reed switches 2 fixed on its first face 3 with clamps 4 (Fig. 6), located in the magnetic field of busbars 5 of the conductor for each busbar. Reed switches 2 are connected to logic block 7 with the help of insulated wires 6, the output of which is connected to actuator 8. Curved strip 9 connects console 1 with separating plate 10 inside the conductor with the use of bolts 11. Connector 12 is fixed on the second face 13 of console 1. Clamps 14 and 15 (Fig. 7) are used to fix

Fig. 2. General view of the first and second sides of the bar with reed switches
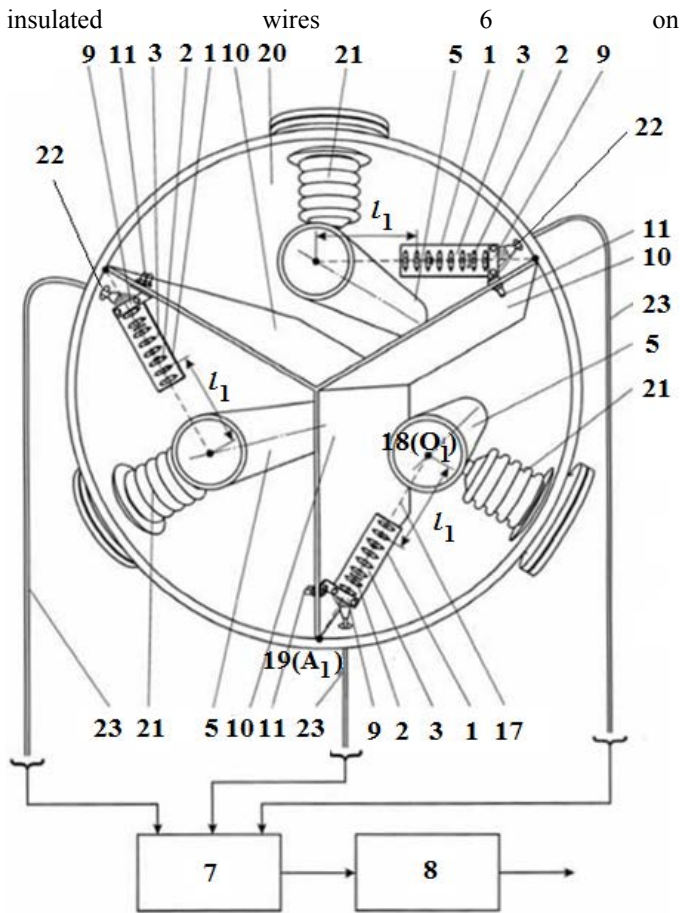
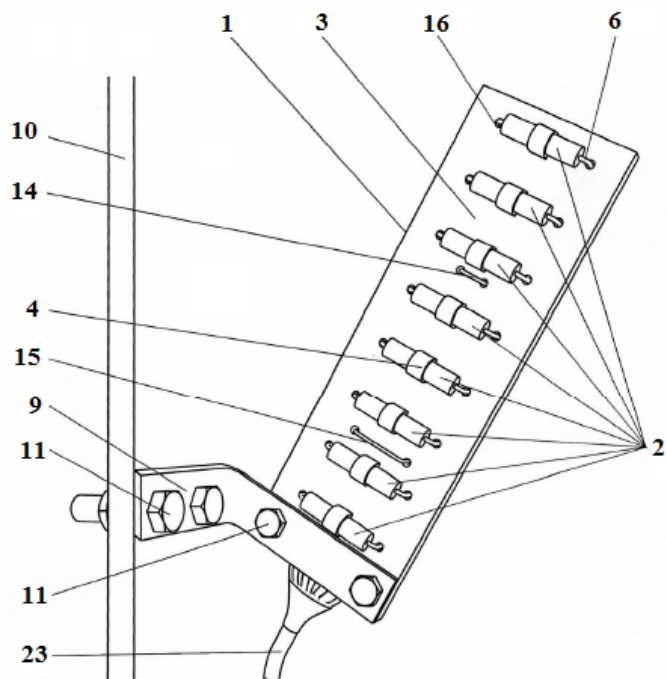Fig. 5. Mounting of the design in the conductor (general view)

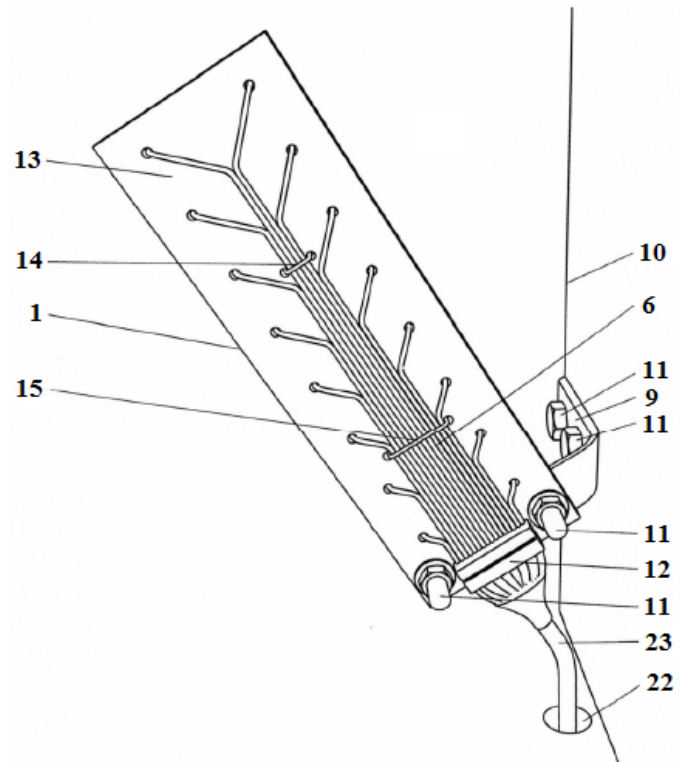Fig. 6. Console from the side where reed switches are fixed

Fig. 7. Console from the side where wires are attached

the second face 13; they pass through holes 16 in console 1, are connected to connector 12, and soldered to the ends of the contacts of reed switches 2. Console 1 is attached to strip 9 so as its face 3 coincides with the plane of cross section of busbar 5, and the centers of gravity of the reed switches are on line 17 (O_1A_1) which connects center 18 (O_1) of the busbar cross section with point 19 (A_1) of intersection of shell 20 and separating plate 10.

The design is made of dielectric material. Busbars 5 are mounted on insulators 21. There is hole 22 in shell 20 of the conductor for cable 23 with wires 6 from connector 12 to pass through it.

Reed switches 2 are a sensing element of the current protection device. The distances l_1 from their longitudinal axis to the center of the cross section of busbars 5 are known, and they all are fixed on console 1 so as they are maximally sensitive at the point of fixation. The magnetic induction B_{act} under which reed switch 2 actuates depends on the current flowing in busbar 5 and on the distance l_1.

In the case of a short circuit between the conductor phases, the magnetic induction produced by the current in busbar 5 exceeds B_{act}, reed switch 2 is actuated (closes the contacts) and transmits a signal through wires 6 to unit 7, which trips the electrical instalation protected through actuator 8.

III. DESIGNS FOR MOUNTING REED SWITCHES INSIDE SINGLE-PHASE COMPLETE CONDUCTORS
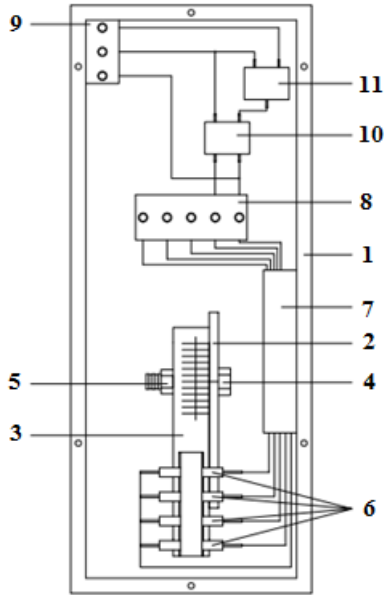
A. The First Design

Fig. 8.   General view of the design (plan view)

The design (Patent of the Russian Federation no. 2624907, authors: Kletsel, Barukin, Mashrapov, Sholokhova) has housing 1 with a cover (not shown in Fig. 8). The housing has ledge 2 with a hole and bar 3, which are fastened together by means of adjusting bolt 4 with nut 5. Four through holes are made on the side of bar 3, with reed switches 6 fixed inside. The reed switches are connected to terminal block 8 with the help of wires passing through cable channel 7. A hole is made in the side wall of housing 1, inside which terminal block 9 is fixed. One the reed switches 6 acts on output protection relay 11 through time relay 10 (one of reed switch outputs is connected to the circuit breaker of the electrical installation protected through the second negative terminal of block 9). Housing 1 is attached to the busbar by means of a clamp put on it (not shown in Fig. 8). The construction is made of plastic.

The protection set points are adjusted by moving bar 3 within the length of its groove along ledge 2 (the distance from the busbar to reed switches 6 varies and, hence, the inductions B_{act}). The accuracy of adjustment of the set points is ensured by controlling the position of the scale of bar 3 relative to the notch on ledge 2. The design allows an increase in the sensitivity in comparison with known reed switch protections due to the wide range of variation in their positions.

B. The Second Design

The design is fixed on hatch cover 1 (Figs. 9 and 10) and contains: reed switch 2 fixed with clamps 3 on disk 4 with a scale around the circumference; graduated rail 5; threaded
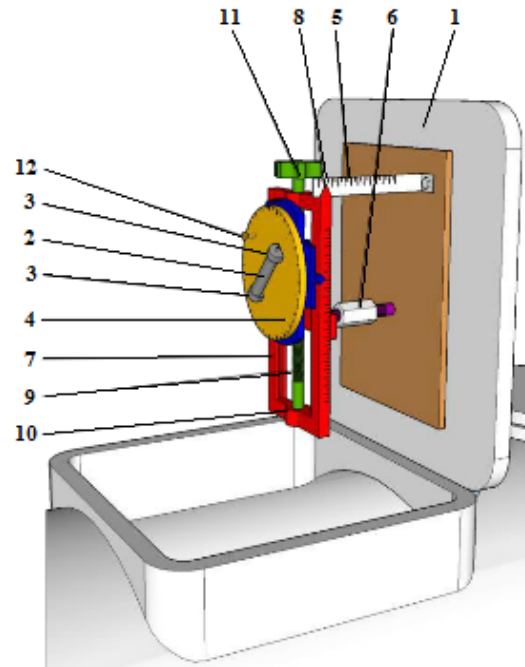

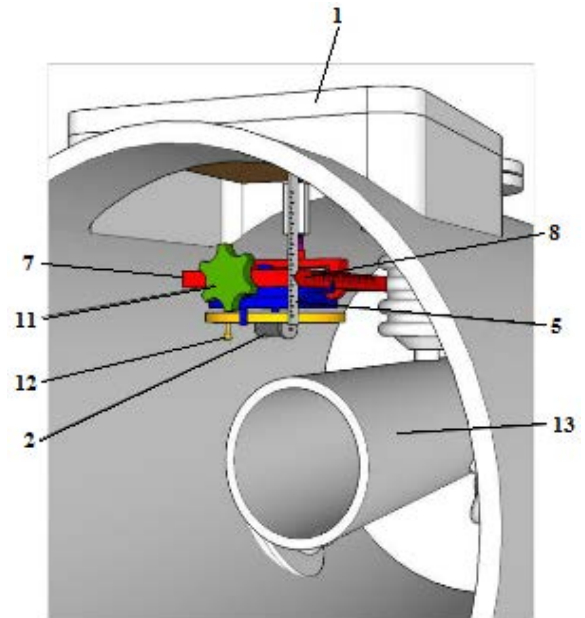Fig. 9.   Fastening the reed switch on the hatch cover when it is open

Fig. 10. Fastening the reed switch on the hatch cover when it is closed

split adjustable rod 6; plate 7 with a longitudinal slit and indicator strip 8 with risks along it glued to the end of the plate. Disk 4 is fixed in longitudinal slit 7 with a capability of moving along it with the help of bolt 9 built into hollow cylinder 10. The other end of bolt 9 with the locking knob 11, passes through the hole of the other transverse bar with a slit.

It is possible to raise and lower disc 4 with the reed switch using rod 6 and shift it to the left and to the right by turning locking knob 11. Disc 4 is rotated by handle 12. All

movements are made manually. During adjustment, the height of reed switch shift relative to busbar 13 (Fig. 10) is determined according to rail 5; the length, to the risks on plate 7, and the angle of rotation, to the scale on the disk. If it is necessary to mount several reed switches, then the corresponding number of the structures is fixed on hatch cover 1.

IV. Conclusions

The designs suggested are quite simple in perform and allow the reed switches to be fixed near the busbars of three-phase and single-phase complete conductors without serious structural changes. Adjustment of the protection set points is provided either by mounting reed switches at points required by shifting them in the horizontal and vertical planes, or by simultaneous mounting of several reed switches. All designs except for the third one allow changing the set points without shutting down the electrical installations protected.

Acknowledgment

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