Plug-in Type Safety Signal Relays

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L M Ericsson's Signalaktiebolag has developed a series of plug-in type safety signal relays. The aim has been to design relays having the same high sensitivity and reliability as the safety signal relays now in general use, but of smaller size and having the added advantage of the plug-in feature, which eliminates the risk of making wrong connections when the relay is inserted.

Among the demands considered in the design of the new relay series the following may be mentioned:

1) The contacts shall be forcibly guided in order to ensure that all circuits actuated by the relay shall receive indications having the same signification.

2) The relay shall be enclosed in a sealed case to prevent the adjustment from being disturbed and the relay from being improperly acted upon. The contacts shall be visible through the case.

3) The relay shall be of the plug-in type, *i. e.* the relay terminals shall be automatically connected to the wiring terminals of the relay rack when the relay is inserted in its proper place in the rack.

4) It shall not be possible to connect a relay in a relay position where it will not function properly.

5) The electrical apparatus shall be built to allow a normal working voltage of 220 V. The apparatus shall have the necessary air gaps and surface leakage distances and shall also withstand the dielectric and insulation tests required for this working voltage.

6) The relays shall have a low power demand, as many safety signal circuits are normally closed circuits.

7) The relay shall be of small size and weight.

The track relays, which are the measuring apparatus for the track circuits, shall also fulfil the following demands:

8) The relay shall have a low ratio of operating voltage to drop-away voltage. The power required for the track circuit is largely dependent upon this ratio and may be many times greater than the power consumed by the relay.

9) When the relay voltage is gradually changing, the moving system shall remain in the starting position until the voltage has reached the change-over value. Thereafter the relay shall move to the opposite position without any tendency to stop in an intermediate position. This will ensure that all the working contacts are closed and receiving full contact pressure, thus preventing the contacts from becoming heated and at the same time ensuring that all the connected circuits will receive co-significant indications.

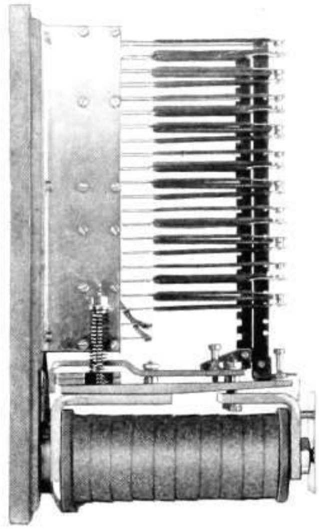
The new relay series consists of the following types:

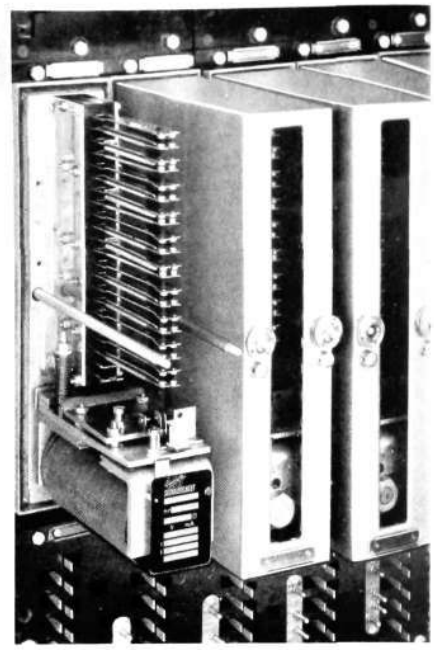
Relay type	Supply system	Power demand W	Number of contacts	Width mm	Height mm	Depth mm	Weight kg
JRJ 11	2 phase {local track	15.0 0.300	12	125	250	170	6.2
JRK 10	D.C.	0.065	10	62	250	170	3.6
JRK 11	D.C.	0.140	22	125	250	170	6.6
JRK 12	D.C.	0.350	54	125	525	170	0.2

Fig. 1 X 6552

D.C. relay JRK 10

On the left: the relay with the case removed. At the bottom the driving system is visible, the contact system with the contact spring is seen above; the left end of each spring is fixed in the contact spring block, the right end being guided by one of the strips on the right. The left strip is attached to the magnet frame and the right strip to the armature. The winding is connected to terminals at the bottom of the contact spring block.
On the right: relays inserted in a relay rack.





Design

The relays, see Fig. 1, consist of a cast aluminum frame plate carrying the contact spring system with the connecting jacks, the driving system, the case and the registering code plate. The relays are inserted and connected to bakelite panels mounted on relay racks. The wiring is located at the back of the panels.

The main parts of the different relay types are very similar with the exception of the driving systems. Thus, a description is first given of the parts common to all types, and is followed by a description of the different driving systems.

The Contact Spring System

The contact springs are flat springs of german silver, see Fig. 3. The front ends carry solid silver contacts. The rear ends are enclosed and rigidly held by slotted bakelite blocks. Onto the rear end of each contact spring eight forked thin plates are spot-welded and form a multiple prong having sixteen contact points for connecting the contact spring to the corresponding rack panel terminal. During manufacture the quality of each spot-weld is tested by subjecting the weld to a shearing force of 15 kilograms.

In the front end of the contact springs oblong holes are punched for the spring-supporting and actuating strips. These strips are made from phenolic laminate.

The lower end of the front strip, the actuating strip, is attached to the driving system. The upper end is guided by the movable spring of the upper contact spring pair, Fig. 1. In the front edge of this strip slots engage the movable spring of each contact spring pair. The lower end of the rear strip — the supporting strip — is fastened to the relay frame and is thus stationary. Its upper end is guided by the upper stationary spring. The rear edge of this strip has slots for supporting the stationary contact springs.

The edges of the contact springs are bent up in order to stiffen the springs, so that the contacts are positively guided by the motion of the strip, see Fig. 3. The rear ends of the springs are left flat and are recessed in order to make them flexible. The »front» contact springs carry twin contact studs, the stationary contact spring being slotted at the front end to give individual alignment to each twin contact stud.

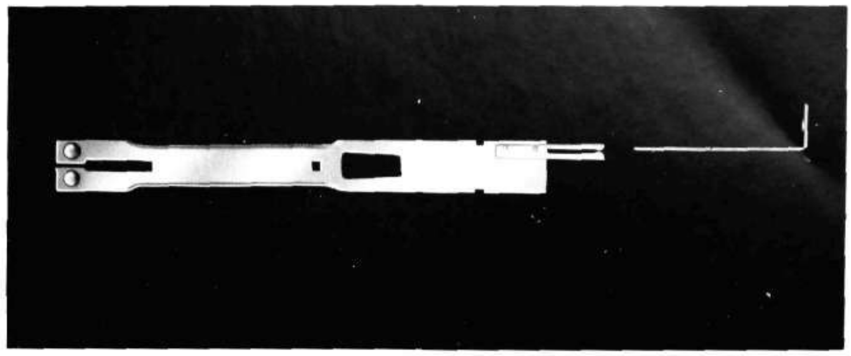
Fig. 2 X 4711

D.C. relay JRK 11

Fig. 3 X 6549

Contact spring

On the left: twin contacts with silver contact studs. At the right end of the contact spring a multiple forked prong for connection to the rack panel terminal plate which may be seen on the right.



The front ends of the stationary contact springs are supported by stiff springs, resting with their front ends in the slots of the supporting strip and having their rear ends fastened to the contact springs. During the closing of a contact, the movable spring moves towards the stationary spring until the contact studs engage each other. The motion continues until the stationary spring has left its support. The contact pressure will then have attained the full value for which adjustment has been made by the preliminary bending of the stationary spring.

Independent front and back contacts are built up from stationary and movable springs, following each other in proper sequence when the contact spring group is being assembled. A special movable spring with contact studs on both faces is also made. This is used together with the ordinary stationary contact spring for building up dependent contacts. Thus, any desired contact combination may be built up with a few elements.

The contact spring system also contains the terminal plates for the relay windings. These terminal plates carry multiple connecting prongs of the same type as the contact springs.

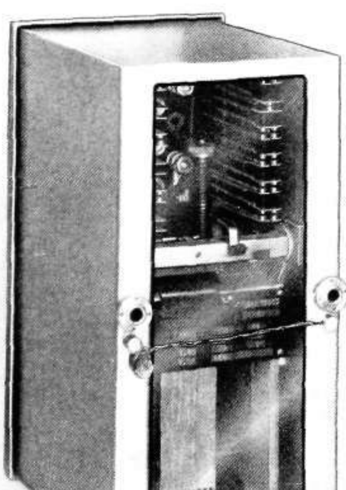


Fig. 4 X 4705

A.C. relay JRJ 11

On the front of the cover to the right and left of the window are the heads of the tubular screws sealed with a lead seal.

Relay Cases

Each relay is enclosed in an aluminum-laquered sheet brass case, see Fig. 4. A window of transparent plastic material is fitted in the front through which the contacts and the data plate of the relay are visible. The case fits into a felt-packed groove which runs along the edge of the relay frame. It is retained by tubular screws, which also serve as guides when the relay is inserted in the rack.

Relay Racks

The relays are plugged into moulded bakelite panels, mounted on racks. The relay rack consists of a supporting framework, constructed of aluminum-laquered sheet steel profiles, at the same time forming a dustproof, fire-resistant cover for the wiring, see Fig. 5. The wiring is connected to the rack panel terminal plates by screws with hexagonal nuts. The terminal plates pass through the panels and project on the relay side of the latter.

Guide rods are mounted on the rack panels, which pass through holes in the relay frame and the tubular screws, see Fig. 6, and serve as supports for the relays. When the relay is inserted, the rack panel terminals enter the forked prongs of the contact springs and terminals of the relay windings, thus ensuring reliable electrical contact.

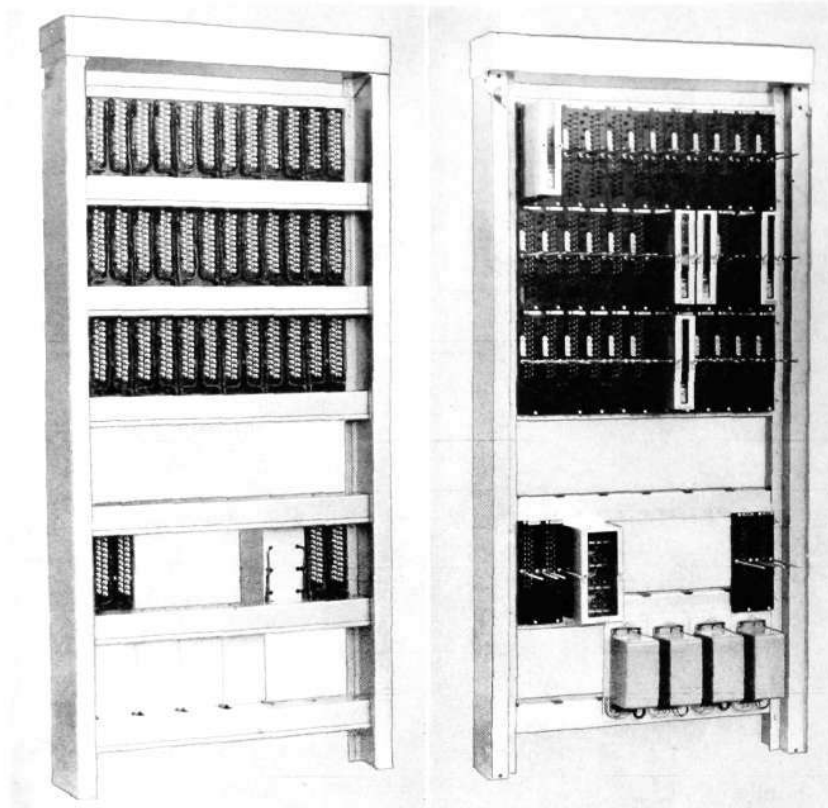


Fig. 5 X 6553

Relay rack

Left: the wiring side with three filled panel rows. The cables connected to the terminal screws run in horizontal and vertical channels formed by the sheet steel profiles of the rack frame. Right: the relay side with only five relays inserted.

In order to prevent a relay from being plugged into a panel intended for a different relay, each relay position on the panels carries a registering code plate with four pins. The location of these pins is determined by the type number of the relay, according to a certain code giving 3 240 possible combinations. A similar code plate with four holes is provided in the relay frame. Each hole must fit a corresponding pin in order to allow the relay to be connected to the rack panel.

If the arresting screw has not been removed before the relay is inserted, the connection of the relay is prevented by a projection on the panel which comes up against the head of the arresting screw.

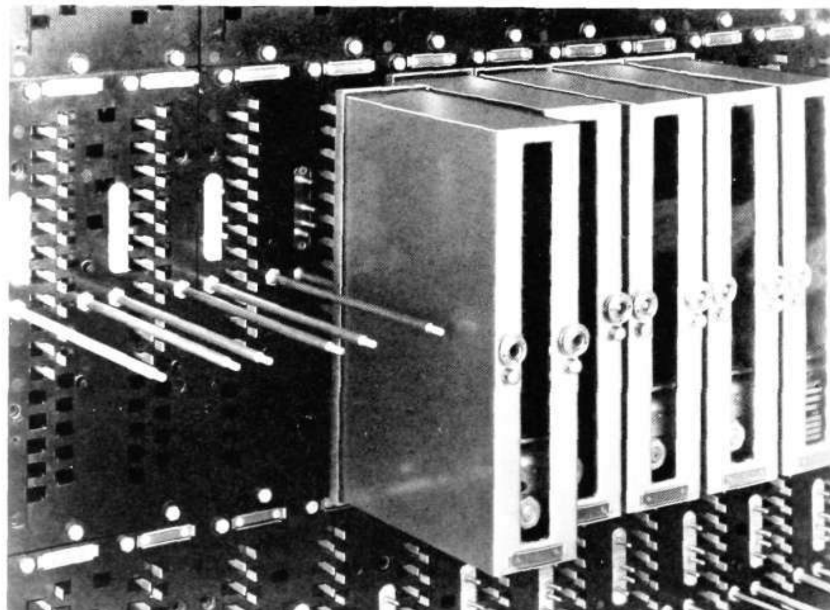


Fig. 6 X 6551

Panel row in relay rack with JRK 10 type relays

On the bakelite panels to the left the terminals and guiding pins may be seen. Above the latter are the registering code plates, each with four code pins. The *lefthand* relay is not fully inserted. The relays and relay positions on the panels are provided with a designation strip which indicates the function of the relay.

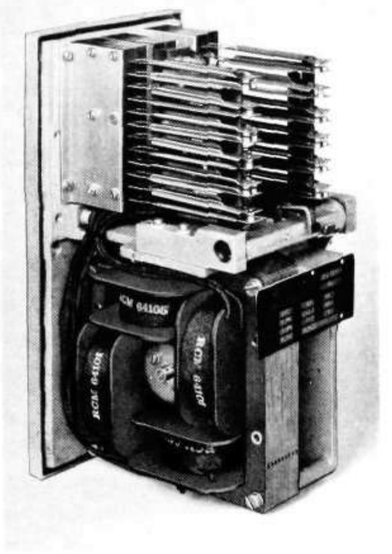


Fig. 7 X 4703

A.C. relay JRJ 11

with the case removed, seen from the motor side

The bakelite panels are made in one size only which can take one relay *JRJ 11* or *JRK 11*. Two relays *JRK 10* can be mounted on each panel, whilst the relay size *JRK 12* requires two panels located one above the other.

The rack panels as well as all other bakelite parts of the relays are injection-moulded from mineral-filled bakelite, and have an exceedingly low water absorption and electric surface leakage.

The A.C. Relay Driving System

The Motor

The A.C. relay is driven by a two-phase induction motor, see Fig. 7. The stator has a laminated iron core. This takes the form of a square frame with four legs projecting inwards through the coils. The ends of the legs form arc-shaped pole-pieces surrounding the cylindrical air gap in which the rotor revolves. The rotor consists of a cylindrical brass drum, surrounding an iron core with a shaft running in ball bearings.

Each opposite pair of coils are connected in series, thus forming one phase winding. The winding which surrounds the horizontal legs constitutes the local phase winding and is fed with a constant alternating current.

The track phase winding surrounds the vertical legs and is connected to the track circuit protected by the relay. The power required in the track phase winding for operating the relay amounts to 300—500 mW, depending on the frequency of the current and on the contact combination.

The voltage in a phase winding drives a current through this winding. The current produces an alternating magnetic flux which passes diametrically through the rotor. Around the flux a voltage is induced which drives an alternating current through the rotor drum. This current circulates around the generating poles, and passes under the other pole faces. When this current is acted upon by the flux from these other pole faces, the resulting force produces a torque on the rotor.

On account of the symmetry of the rotor and the magnetic system, no voltage is induced by one phase winding in the other when the rotor is at rest. For the same reason, the rotor torque is independent of the rotor position.

Transmission

The load from the contact springs varies during the relay movement. In order to make the relay follow up the motion during the operating- as well as during the return movement, it is necessary to transform the driving torque in a suitable manner. This transformation must also be such, that the ratio between the operating and the drop-away voltages will have a minimum value.

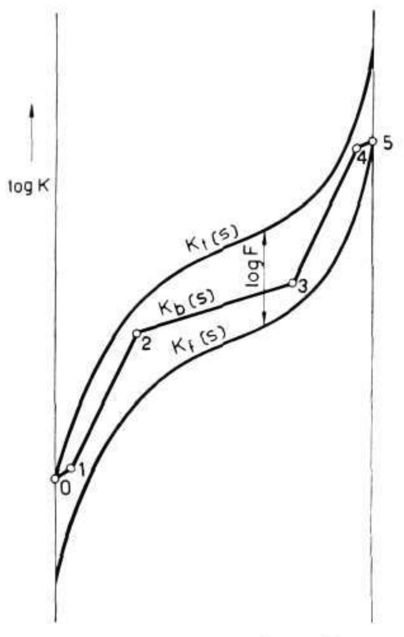


Fig. 8 X 4697

Load and driving forces shown as functions of the contact spring movement

- F operating voltage/drop-away voltage
- K_b load from the contact spring system
- K_t driving force at operating voltage
- K_f driving force at drop-away voltage
- S movement
- 0 resting position
- 5 operating position

Load Characteristic

The actuating strip carries the load from the movable springs at both the front and back contacts. In the resting position (*0* in Fig. 8), the back contacts are closed and the stationary springs, which are raised from their supports, take up the contact pressure and thus partly relieve the load on the actuating strip. When the operating movement starts, the tension in the moving springs increases while he back-contact stationary springs relax. The load on the actuating strip increases accordingly. When the back-contact stationary springs touch their supporting strip, position *1*, the contact pressure rapidly decreases and a corresponding part of the tension in the back contacts' movable springs must therefore be taken up by the actuating strip. In the position *2* the back contacts open after which only the movable springs move until in position *3* the front contacts

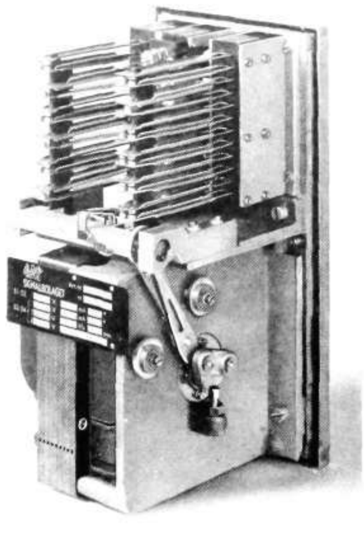


Fig. 9 X 4704

A.C. relay JRJ 11

with the case removed, seen from the linkage side. Above are the contact spring groups actuated by a horizontal intermediate shaft carrying a crank which is connected by a link to a crank on the rotor shaft.

close. The front contact pressure then increases rapidly thus raising the load on the actuating strip. When in position *4* the front contact stationary springs leave their supports, the front contact pressure increases more slowly and finally, the working position, 5, is attained. Thus, the load increases according to the broken curve *0—1—2—3—4—5*, shown in Fig. 8, which is plotted in accordance with a logarithmic scale.

To enable the relay to follow up the motion, the driving force must exceed the load during the whole operating movement. Under such conditions the relay will not exhibit any tendency to stop in an intermediate position. Similarly, the load must exceed the driving force during the whole drop-away movement.

The torque at the rotor shaft is proportional to the track phase voltage if the local phase voltage is maintained constant. In the logarithmic diagram, Fig. 8, the driving forces at different voltages are represented by congruent curves situated at different heights. The difference in height represents the logarithm of ratio between the voltages. The shape of the desired driving force curves may then be determined in the following way:

Two parallel, congruent driving force curves should be drawn, the one through point *0* and running entirely above the load curve, the other through point 5 and running entirely below the load curve. The difference in height between the curves should be as small as possible.

When the desired function has been determined, the next step is to construct a mechanical transmission which will transform the constant rotor torque into a driving force proportional to the given function. The transmission chosen takes the form of a simple link mechanism: a crank on the rotor shaft is connected by a link to a crank on an intermediate shaft. This latter shaft moves the actuating strip of the contact spring system, Fig. 9. This combination of two cranks and a link offers a very wide range of transmission possibilities. By choosing suitable lengths for the two cranks and the link in relation to the distance between the shafts and by determining the limiting angles of the rotor crank movement a fairly close approximation to the desired driving force function can be obtained. The mechanism is simple, strong and stable, and there is very little friction as the shafts run in ball bearings.

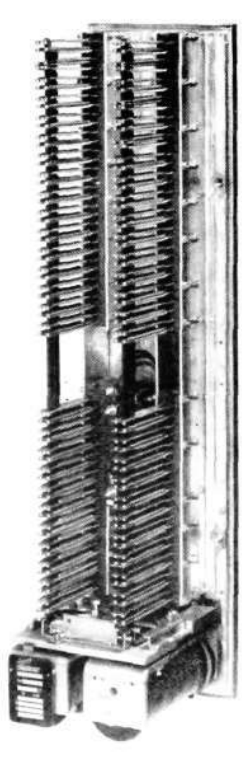


Fig. 10 X 4712

D.C. relay JRK 12

with the case removed

The D.C. Relay Driving Systems

The driving systems of the D.C. relays are electromagnets. In the relay type *JRK 10*, the magnet consists of a coil with a cylindrical iron core and two pole pieces, bent at right angles so that they form two parallel pole faces above the coil, Fig. 1. The armature moves above the pole pieces. The relay types *JRK 11—12* have magnets with two coils, at the rear united by a yoke and are provided at the front end with pole-pieces. The armature is located across the two pole faces, Fig. 10.

In both types of magnets the armatures are balanced to eliminate the influence of mechanichal vibrations. The armatures move downwards during the operating movement. The actuating strips of the contact spring systems are directly attached to the armatures.

The driving force characteristic has been adapted to the load characteristic by suitable dimensioning of the air-gap area.