MAGNETIC CONTACTOR RC 3631 SERIES

I. INTRODUCTION

Magnetic contactors are used not only for line starting of cage motors but also for starting and speed controlling of wound motors, and further are used for switching of illumination and heating circuits and so on.

Being operated by a electro-magnet, the magnetic contactor can be controlled lightly and even freely controlled from remote points by simple operation of the magnet circuit. In addition to above merit, complicated interlockings are simplified by auxiliary contacts and because of this merit they are used in every controlling equipment and are serving to automation and rationalization in the industrial fields.

Today because of the remarkable development of automatic controls many strict conditions are being required to magnetic contactors. Namely ① long life, ② large switching cycles per hour, ③ large making and breaking capacity, ④ easy maintenance and inspection, and the interchangeability.

These conditions contradict each other, but magnetic contactors must meet these requirements in the same time.

It can be safely said that the ability of the control equipment largely depends on that of the magnetic contactors, and they assume great responsibility.

We are in technical co-operation with Siemens Schuckeltwerke A. G. in Germany, and with their technical assistance we were able to develop hereinunder introduced magnetic contactors to meet all the above requirements.

Table 1 shows magnetic contactors of this series have higher abilities than the highest class of JEM 1038, Class A, Number 1, Grade 1.

In the next articles we wish to give an outline of construction and a performance of the magnetic contactor for your reference.

II. OUTLINE OF CONSTRUCTION AND FEATURES

1. Frame

Fig 1 shows an outer appearance of this series magnetic contactors. In every type, phenol resin mold parts are mostly used in the construction.

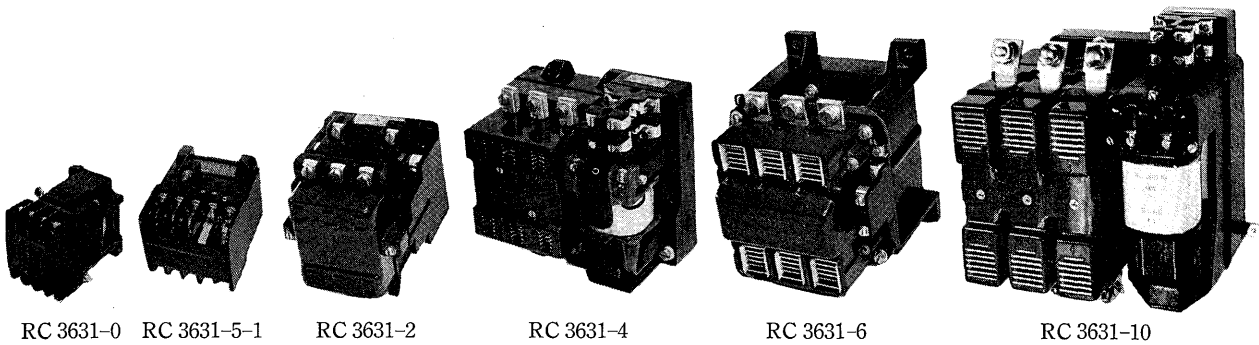
Fig 2 shows the construction of type RC 3631–2. The construction is adopted also to type RC 3631–0 and RC 3631–5–1. On the interior of this phenol resin mold frame, all parts, i. e, magnets, magnetic coil, contacts etc., are to be equipped.

Fig 3 shows the inner construction of type RC 3631–4, and in larger ones the silumin die-casting frame is adopted to inclease the mechanical strength and phenol resin bases, spool, levers and all parts are to be equipped on it.

In all cases molded and or die-casting parts become complex, but saving the space is possible so a fitting area is able to be very small.

Being high accurate, the molded and pressed parts are being interchangeable and altered easily by spare ones, too.

In general, magnetic contactors have many frictional and sliding parts sach as shafts, contacting



RC 3631–0 RC 3631–5–1 RC 3631–2 RC 3631–4 RC 3631–6 RC 3631–10

Fig. 1. Fuji magnetic contactors

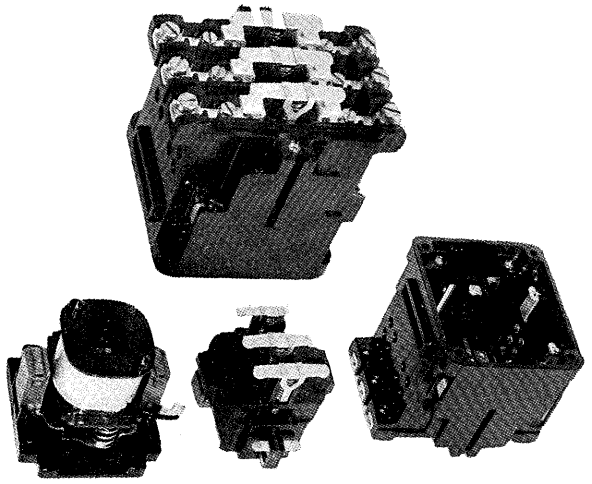


Fig. 2. Construction of type RC 3631-2

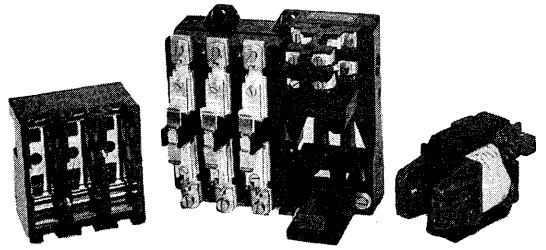


Fig. 3. Inner costruction of type RC 3631-4

parts and so forth. Because of wearing of these parts there is a tendency to shorten the mechanical life, and it was necessary to oil the parts.

Frictionol parts of Fuji magnetic contactor are composed by molded and metallic parts, which therefore is to reduce wearing even if no oil is supplied and extend mechanical life of the contactor. Oil-less frictions between metals come to remarkable wearing, but between metal and mold almost no wearing.

This is a reasen why Fuji magnetic contactors have a long life and Fig. 4 shows the test result of the wearing-off test of them.

This test was exercised so that a weight 1 kg was being put upon many kinds of metallic and molded pieces placing on the steel shafts which were rolling alternatively 180 degrees. Fig 4 shows the wearing volume per 1000 m of the frictional sliding test.

The drawing plainly shows B group metal pieces are worn off 200 times to A group molded plastic pieces.

The magnetic contactors are to be distributed on so many places that piece by piece regular oiling must be troublesome for user. No oiling is an ideal for using magnetic contactors and adopting molded one is realization of this ideal.

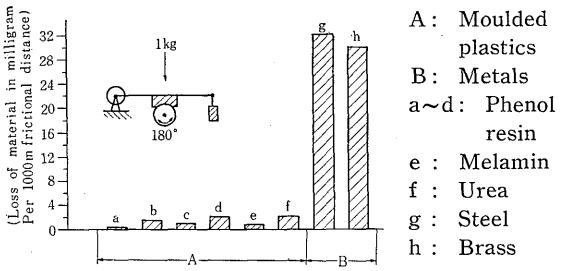


Fig. 4. Continuous frictional test of various materials

2. Material of contact

Selection of the contact material is greatly depending on closing and opening circuit capacity, and also it's important for a electrical life. This series has pure silver contacts to extend the electrical life.

Even if oxidized or sulphurated, a silver seldom formes harmful coat. Therefore sliding action which is surely necessary in case of a copper contact is needless and this results nothing of the mechanical wearing-off.

In case of a copper contact the oxidized coat is strong and a high grade insulator, so rubbing action between fixed and moving contact is necessary to eliminate this coat on every switching. In addition to the wearing by arc, the mechanical wearing off is unavoidable.

As to the wearing by arc, the silver contact is excellent than the copper contact. Moreover the silver vapour generated by the arcing will not scatter all, but a part of them will recondence on the contact and will become a part of silver contact on the time of next breaking.

On the other hand the copper vapour will not be used again but all scatter into the air.

As Fig 5-1 shows this reuse will be efficiently done in case of a larger contact area and smaller gap.

Fig 5-2 shows specific consumption of a silver contact corresponding to any diameter of it, and in this drawing it's plainly understood that larger the diameter smaller the consumption.

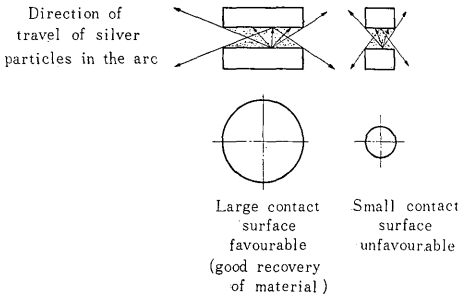


Fig. 5-1. Surface of contact

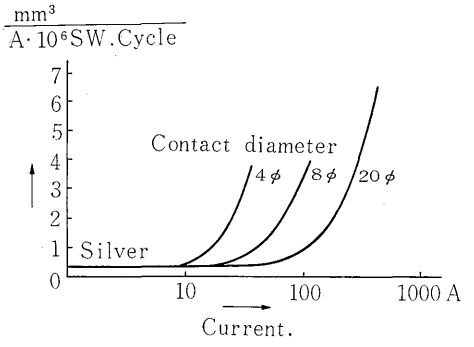


Fig. 5-2. Specific consumption of Silver contact

3. Arc quenching devices

To reduce the arcing time and to avoid the partial wear due to shifting of arc on the contacting surface must be taken into consideration for extending the life.

A double break system is adopted in this series to increase the breaking capacity. On the large type (above type RC 3631-4) arc quenching plates are attached to them as shown in Fig 6 for the purpose of the quick arc-quenching.

In the ordinary switches the contact has such a construction that current passing surface were protected from damage by shifting the arc from contacting points to arc horns.

But providing arc horns on the moving contact resulted in the increasing of the weight and the bouncing of the contact.

In this series the arc horn is eliminated or extremely small one by adopting following principles.

Fig 6 shows the principle. When the contact is opened, the arc (A) will be generated from the contacting point. This arc will shift from (B) to (C) the arc horn by electro-magnetic force, and at last will enter the gaps between arc-quenching plates.

In the meantime the arc from the moving contact will expand to the plate g_1 and g_2 and will be shifted to the plate (D) from the contact.

Because g_1 and g_2 are contacting each other and the arc will be shifted to the plates by being short circuited.

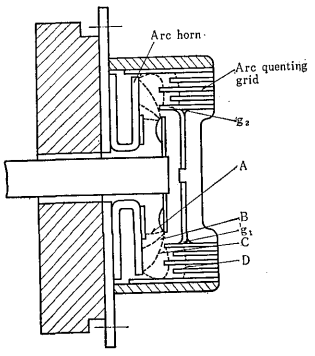


Fig. 6. Arc Quenching process (RC 3631-4)

This is the reason why it is not necessary to attatch large arc horn on the moving contact.

As to the small type contactors (under type RC 3631-2), it is too small to consider the arc quenching devices especially.

4. Countermeasure for bouncing of contact

In the ordinary magnetic contactors, the wearing was more remarkable on making than on breaking.

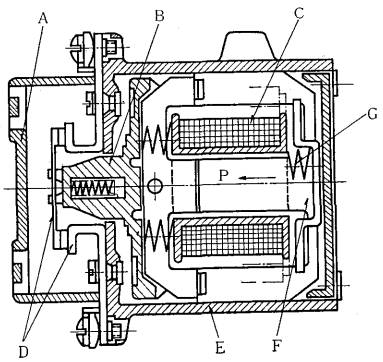
The above mentioned fact is due to bouncing of contacts rise on making and their wearing is especially remarkable when the contactor is used for starting motor.

At the start of the motor rush current several times that of the rated current flows, and if the contacts bounce, the contacts and to switch in and off this large current repeatedly.

Therefore the preventing of the bouncing is effective to maintain the long life of contacts, and in this series this countermeasure is taken into consideration especially.

By making a moving contact lighter as possible, of cource, the bouncing is reduced and moreover the electro-magnet has special construction itself to reduce the shock to a electro-magnet and the subsidualy bouncing.

As Fig 7 shows a stationaly magnetic core F is not fixed so strongly on the frame, but by the cushion spring G it is pressed on the bottom of the frame. When the electro-magnet is excited the spring G will act to the core with strong pressure and the core F will shift arrow P-direction a little up to the point of some far from the bottom of the frame. And on the status of the floating condition of the stationaly core from the frame, the moving core will strike against it. Therefore the



A: Arc chamber
B: Contact holder
C: Magnetic coil
D: Contacts (Double break)
E: Frame
F: Magnet
G: Cushion spring

Fig. 7. Cross-section of air-breake contactor RC 3631-2

Table 1. Rated capacity of Fuji AC magnetic contactors

Type	Max. permissible continuous current (A)	Max. permissible rated out put of 3 phase induction motor (kW)							
		for cage rotor				for wound rotor			
		110V	220V	440V	550V	110V	220V	440V	550V
RC 3631-0	6	0.55	1.1	—	—	0.55	1.1	—	—
RC 3631-5-1	18	1.9	3.7	3	2.2	1.9	3.7	3	2.2
RC 3631-2	28	3	5.5	7.5	7.5	3	5.5	11	13
RC 3631-4	55	5.5	11	22	28	5.5	11	22	28
RC 3631-6	83	10	20	30	37	10	20	40	50
RC 3631-10	220	20	40	80	100	25	50	100	120

shock of strike is smaller than that in case of strictly fixed stationaly core, and no shock conducted to the contact from stationary core will cause little bouncing phenomena.

By above considerations, a bouncing time of this series is 3 ms or shorter and the life of the contacts can be extended considerably.

III. RATING AND CAUTION ON USE

1. Rating of main contacts

This series was manufactured to guarantee the highest performance of rule " JEM 1038-A-1-1 ".

In this rule " Class A " indicates the ability of switching on and off the current 10 times the moter rated current for line starting of a cage motor, and " No. 1 " indicates the temperature does not rise so much even at 1,200 times/hour switching cycle, and " Grade 1 " indicates the contactor is able to be used on condition that the electrical life is above 500,000 switching cycles and the mechanical life is above 5 million. (This electrical life means number of switching untill the replacement of contact is required under condition of closing of 5 times the rated motor current and opening of the rated current.)

Applications of the main contacts are shown in the Table 1.

2. Special usage

The wearing-off of the main contact is approximately inversely propotional to the square of the current. Therefore, it is necessary to call for attention to the fact that the switching of large current will shorten the life of contact remarkably. More than anything else in case of using for frequent inching or plugging of motors the contact will wear off very much.

In this usage, the motor out put must be reduced less than the value shown in table 1.

How much is the suitable output is difficult to say in one word, for it is depending on each condition of usage. However, for your reference Table 2 shows applicable capacities of the motor using for 200 V circuits and expecting 100,000 times switching on the electrical life. Especially in case of the plugging use, please note there are two kinds of usage and their applications are different.

The first usage is to use as a reversible magnetic contactor, i. e., the rotation of the motor will be changed to a reverse direction without stopping the motor.

In this case the reverse rotation will start immediately after the motor stops. In this usage the rush current only will be switched on and no opening circuit will be done.

On the other hand when using the plugging relay and stopping the motor suddenly (not reverse operation), the switching off of the rush current at this time will shorten the life of the contactor.

In the latter case the output of the motor must be reduced suitably.

Table 2. Examples of applicable motor output in case of plugging and inching operation

Type	Normal operation kW (IP)	Inching operation kW (IP)	Plugging operation	
			Reversing operation	Plugging stop
RC 3631-0	1.1 (1.5)	0.55 (0.75)	1.1 (1.5)	0.55 (0.75)
RC 3631-5-1	3.7 (5)	1.6 (2.1)	3.7 (5)	1.6 (2.1)
RC 3631-2	5.5 (7.5)	2.8 (3.7)	5.5 (7.5)	2.8 (3.7)
RC 3631-4	11 (15)	8.6 (1.2)	11 (15)	8.6 (12)
RC 3631-6	20 (27)	11 (15)	17 (23)	11 (15)
RC 3631-10	40 (54)	17 (23)	34 (46)	17 (23)

(at 200 V~220 V)

In the actual way the motor which has an output for no plugging and no inching usage as table 1 shows will be used for some inching operation. There are of cource no trouble to such a usage if shortening of the life has been considered beforehand.

Following formula shows the life calculation of the contacts in this usage.

$$x=\frac{A}{1+\frac{C}{100}\left(\frac{A}{B}-1\right)}$$

here

x : Contact life in case of normal operation with some inching.

A : Contactor life only switching off rated current.

B : Contactor life in case of inching operation, i. e., only switching off rush current.

C : Ratio (%) of number of inching operation to total number of operation.

Fig. 8 shows the calculation example using for cage motor. In this example it is calculated as one million ordinary operation, 28,000 inching operation whoes rush current is 6 times of rated current.

By this drawing, it is plainly understood the life will be shortened 25% in spite of only 10% inchings.

3. Auxiliary Contact

Silver contacts are used and the double breaking system is adopted in our contactor. Contact pressure also so large that their reliabilities are very high. Table 3 shows number of the auxiliary contacts to be attached and Table 4 shows the rating of them.

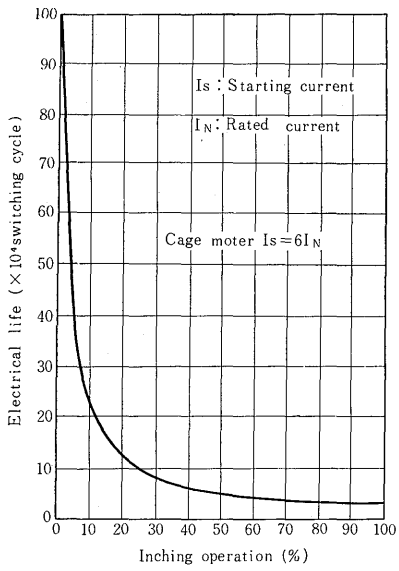


Fig. 8. Effect of inching Operation on electrical life of contact

Table 3. Number of Auxiliary Contact

Type	Number of Aux. Contact	
	A-Contact	B-Contact
RC 3631-0	1	0
RC 3631-5-1	1	1
RC 3631-2	2	2
RC 3631-4	2	2
RC 3631-6	2	2
RC 3631-10	2	2

Table 4. Auxiliary Contact Rating

Max. permissible continuous current (A)	Voltage (V)	AC (50~60 c/s, cos φ=0.3~1)		DC	
		Making Capacity (VA)	Breaking Capacity (VA)	Breaking Capacity	
				Resistive	Inductive
10	24	350	150	150	50
	110	1,600	460	200	50
	220	3,400	800	200	60
	440	5,200	1,300	150	70
	550	8,500	1,600	130	80

4. Electro-magnet Capacity

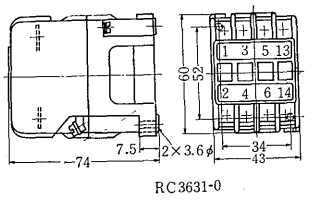
In case of AC electro-magnets, rush current will flow at the moment of excitation, so the switching contact must be fit for this rush current.

For the selection of these switch Table 5 shows the capacity of the electro-magnet of every type.

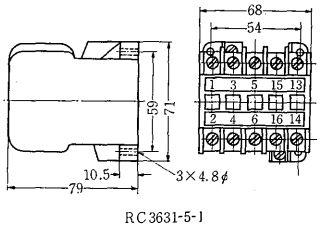
Table 5. Magnet Rating

Type	Magnetic Coil VA		Magnetic Coil Loss (W)
	Before Closing (VA)	After Closing (VA)	
RC 3631-0	60	9	4
RC 3631-5-1	85	8	3
RC 3631-2	180	20	8
RC 3631-4	320	40	10
RC 3631-6	710	80	20
RC 3631-10	1,200	100	40

(at 200 V, 50 c/s)

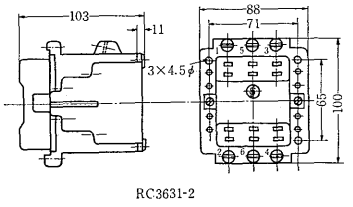


RC3631-0

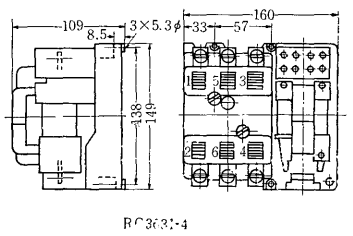


RC3631-5-1

Fig. 9-1. Outline drawing of RC 3631-0 and RC 3631-5-1

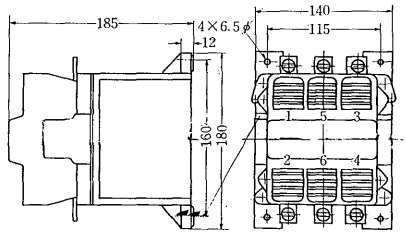


RC3631-2

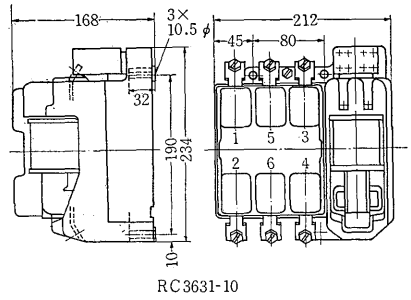


RC3631-4

Fig. 9-2. Outline drawing of RC 3631-2 and RC 3631-4



RC3631-6



RC3631-10

Fig. 9-3. Outline drawing of RC 3631-6 and RC 3631-10

IV. PROTECTING CONSTRUCTION

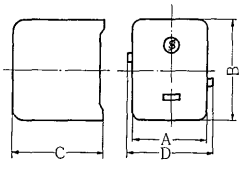
Fig 9 and 10 show the standard type of the open type and the closed type ones, and every type shall be used in a place of little dust or covered by another case and cover.

Depending on the condition of the circumstance, needless to say, suitable protecting constructions must be adopted. We are able to comply with all requesting of various types of protecting construction.

Dust proof type will be used in the dusty place as shown Fig 11. In these types rubber packings are attached on the conjunction parts to cover and inlets of wire so that dusts may not enter from outside.

In a chemical factory where corrosive gas is present the corrosion proof type may be used as shown in Fig 12. In this case the magnetic contactor is equipped in a robust cast iron case and by complete packing external gas can not enter inside of the case.

In a chemical factory and a coal mine where explosive gas is present the explosion proof type that magnetic contactor is equipped in a robust explosion proof box must be used as shown in Fig



Type	Dimension				
	A	B	C	D	Fitting hole
RC 3631-5-1C	82.5	115.5	95	—	2×7φ
RC 3631-2C	100	162	127	112	2×7φ
RC 3631-4C	164	203	131	187	3×5.3φ
RC 3631-6C	170	270	200	195	4×7φ
RC 3631-10C	223	360	210	246	3×10.5φ

Fig. 10. Outline drawing of RC 3631 series magnetic contactor with cover

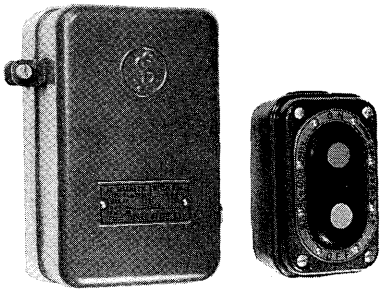


Fig. 11. Dust proof type

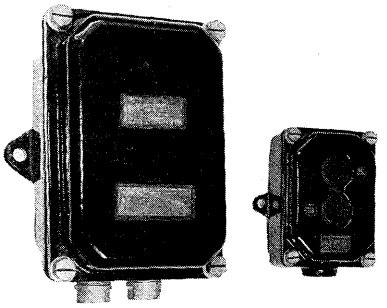


Fig. 12. Gas proof type

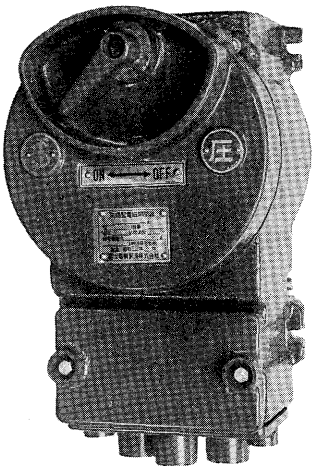


Fig. 13. Explosion proof type mag. sw. box

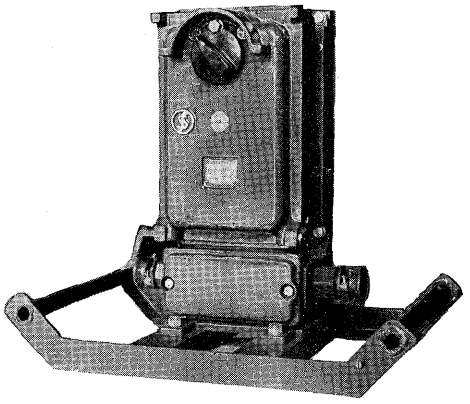


Fig. 14. Explosion proof type mag. Switch for mine use

13 and Fig 14.

Fig 13 shows for chemical factory and Fig 14 shows for coal mine.

V. MAINTENANCE OF CONTACT

1. Time of maintenance

Hitherto the maintenance was necessary immediately after contact became black or uneven and by a file they were cleaned up. This maintenance is for copper contacts oxydized easily, but RC 3631 series in which silver contacts are used does not need such a maintenance and further to clean up by a file will wear down soft silver contacts and reduce the life. Blackening of silver will be generated by oxidization or sulphuration, and this phenomenon will not cause bad contacting, because this coat is weak for thermal or mechanical actions.

Therefore cleaning up of the contact only for it's blackening is absolutely prohibited.

In this series if ordinary usage is kept such as closing of starting currents of a motor and opening of rated currents, it seldom needs maintenance.

However ordinary usage will not be expected always. Some breaking of the large current or abnormal switching due to variation of the power source voltages will cause partialy irregularity or fins.

In this case the maintenance is surely necessary.

2. Method of contact maintenance

As a rule maintenance of contact must be only to take off the fins and the irregularity, and must not be to polish or to trimm off.

In case of the ordinary usage the contact will wear off along A–B–C as shown in Fig 15. In other words the fitting part and the central part are not worn out so much, but the top is most worn out. This means it is convenience for the magnetic contactor and this is merit that the wipe is not reduced and the contact pressure is kept enough. Therefore on the maintenance polishing to the root is uneconomical and taking off the fins and large irregularity only must be done as shown in Fig 16.

As shown in Fig 17, for instance, polishing of the irregularity of B–plane shall be done until B′–plane maximum, and B″–plane is too much polishing.

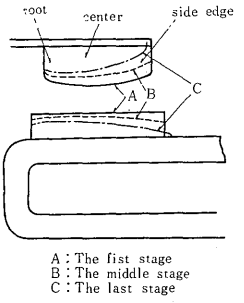


Fig. 15. Deformation of contact

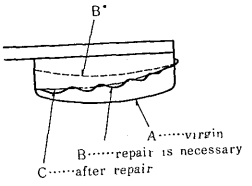


Fig. 16. Repair of contact

3. Example of irregularity of contact surface

Illustration of the irregularity is difficult, so by the photo it is shown for one example.

Fig 17 shows the fixed contact of RC 3631–4 used one million times under ordinary condition.

Irregularity of the contacting surface was very small and worn out also very little, of course, the maintenance is not necessary.

Fig 18 shows the case of including some abnormal using. In this case comparing to Fig 17 irregularity was rather large and the fins appear on the surround of the contact. But in this case also the maintenance is not necessary.

Fig 19 shows the status of the contact when a terrible inching was done. In this case irregularity of the surface was large and the silver powder flyed out.

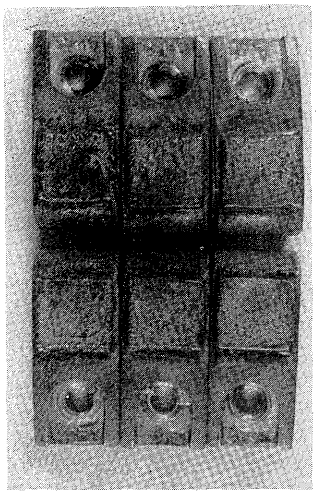


Fig. 17. Deformation of contact (Normal operation)

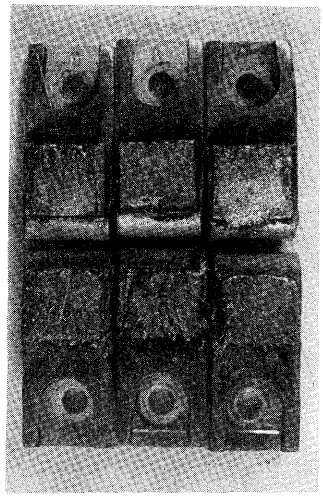


Fig. 18. Deformation of contact (Operation with some abnormal operation)

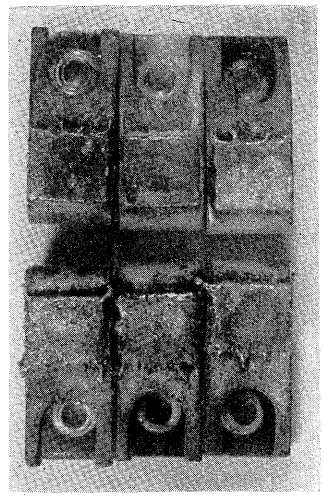


Fig. 19. Deformation of contact (Abnormal operation)

On the surface of the contact a blue sulphurated silver can be seen, but a silver brightened part is also seen. This phenomenon means the abnormal usage and the maintenance is of course necessary and the reason which caused such phenomenon must be found out.

VI. CONCLUSION

The above was the outline of the RC 3631-series magnetic contactors.

We are doing our best for the progress of the performance and we are expecting your patronage for our contactor which is being manufactured under perfect quality control.

By your opinion we will do our endevour for our further improvement of the contactor.

(By Satoru Iwata, Designing Sect., Fukiage Factory)

Outline of Our Products

(I) Heavy Current Equipment

a) Generators :
Synchronous generators up to 100,000kVA.
Direct current generators up to 10,000 kW.
Other all kinds of generators.

b) Synchronous condenser up to 75,000kVA.

c) Motors :
3–phase synchronous motors up to 10,000 kW.
3–phase induction motors up to 10,000 kW.
3–phase commutator motors up to 300 kW.
Direct current motors up to 10,000 kW.
Other all kinds of motors.

d) Standard motors (for general use):
3–phase squirrel cage motor from 0.4 kW to 75 kW.
3–phase wound motor from 20 kW to 75 kW.
1-phase split phase start ind. motor, 100 & 200 W.
1-phase repulsion start ind. motor, 200 & 750 W.

e) Special motors :
Loom, card, mule, ring-motor and pot-motor for textile industries.
All other kinds of special use motors.

f) Transformers :
Power transformers up to 300MVA, 287 kV.
Furnace transformers with on-load tap changer up to 60 MVA, 140 kV.
Measuring transformers up to 287 kV.
Other all kinds of transformers.

g) Standard transformers (for general use):
1–phase & 3–phase distribution transformers from 3 kVA to 1,000 kVA.

h) Induction voltage regulators up to 1,000 kVA.

i) Mercury arc rectifiers :
Single-anode or multi-anode type, water cool or air cool type and with pump or without pump type up to 6,000 A.

j) Contact converters up to 20,000 A.

k) Selenium rectifiers and silicon rectifiers.

l) Regulating apparatuses :
Motor starters, controllers, speed regulators, voltage regulators and other regulating apparatus for all kinds of service.

m) Circuit breakers :
Expansion circuit breakers up to 287 kV.
Oil circuit breakers up to 154 kV.
Air circuit breakers up to 3,000 V.
High speed air circuit breakers up to 3,000V.

n) Switch equipments :
Disconnecting switches up to 287 kV.
Knife switches, magnetic switches and other all kinds of switch equipment.

o) Switchboards :
Sheet iron made switchboard for all kinds of service.

p) Relays :
All kinds of relays for power and industry use.

(II) Machines

a) Water turbines :
Francis type, Pelton type and Kaplan type turbines up to 100,000 kW.

b) Steam turbines up to 150,000 kW.

c) Gas turbines :
Closed circuit type up to 50,000 kW.

d) Ventilating fan for radial and axial type.

e) Mine winder set for vertical shaft and inclined shaft.

(III) Railway and Ship Equipment

a) Traction motors of all kinds.

b) Electric locomotives of all kinds.

c) Winches for cargo ship use.

d) Steering engines for ship use.

(IV) Atomic Energy Applying Equipment and Nucleus Testing Equipment

a) Atomic reactor

b) Nucleus accelerators of all kinds.

(V) Weak Current Equipment

a) Integrating watt-meters (watt-hour meters):
1–phase W.H.M. for low tension circuit use.
3–phase W.H.M. for low tension and high tension circuit use.

b) Electric measuring instruments :
Switchboard meters, portable type meters, precision meters, recording meters, tele-metering equipment.

c) Industrial measuring instruments :
Electric thermometers, pyrometers, psychrometers, flow meters for water, steam, gas and air gas analysers, pressure gauges, vacuum meters, pH meters, level meters, electronic recorders, salinometers, etc.

d) Automatic controlling equipment :
Automatic combustion controlling equipment for steam boilers and various furnaces.
Pneumatic controllers, electro-pneumatic controllers, electrical indicating controllers for temperature, pressure, flow and liquid level, etc.

(VI) Domestic Equipment

a) Electric table and pedestal fans of all kinds.

b) Electric room heaters of all kinds.

c) Electric washers of all kinds.

d) Electric refrigerators of all kinds.

e) Centrifugal dehydrator.

f) Dry batteries & flash lights of all kinds.

g) Juicer and toaster.

h) Electric iron of all kinds.

i) Electric bulbs & fluorescent lamps & illuminating apparatus of all kinds.

j) Television sets and Transistor radios.

k) Room coolers.