Introduction of Products

ON NEW TYPE MAGNETIC SWITCHES RC 3931 SERIES

I. INTRODUCTION

Today because of the remarkable development of automatic control equipment and remote control equipment many different conditions are being required of magnetic switches (including magnetic contactors) and for the some usages many types of magnetic switches hitherto used cannot meet the requirements. Among the conditions are ....

1. Should be of long life

This, needless to say, is the most important point in which to judge the switch. For no matter how superior the operating character or the breaking character may be, it must be proven durable and safe during the period of operation. And for the switch to have long life is the most economical.

2. Switching cycle per hour should be large

With the rise in production speed this condition is being put more and more into demand.

3. Should be compact in size and light in weight

For instance, when built in a tooling machine the switch must be compact and light. Also with a similar performance it would be easier to operate. In Germany this compactness and lightness is being shown in the ratio between the rated current and weight. It is called by the term "Weight per Current."

4. Should be easy to maintain

The putting up of the switch, wiring, inspection and the changing of parts should be easy and except for special cases the assembling and detaching of the switch should be possible with only the use of a screw driver.

Besides, in case there are many small switches or the switch is assembled inside a machine, the inspection of each switch is difficult and it should require little maintenance.

5. Shonld possess large combined performance

When it can be put to many uses by the simple change of parts, it will prove of immense value to the user.

This RC 3931 Series magnetic switches are the first to be completed by our Company since we reformed technical ties with the Siemens Company in the post war period. And having met the above conditions it has been greatly welcomed in industrial circles. This Series which required a high technical degree in both construction and material was completed after much difficulty. And thus in the following article we wish to give an outline of this magnetic switch and the results of the tests.

II. OUTLINE OF CONSTRUCTION AND THE RATING

While the portions in which there is a special relation to the performance will be explained in detail later, in all it can be said that molded parts were mostly used in the construction. Because of this, though the shapes of the molded parts have become more complex, the number of parts has been greatly reduced making for a decrease in weight. Fig. 1, 2 and 3 show the outer appearance of the magnetic switches and the dimensions. Magnetic switches of this Series were manufactured to fit the standard of JIS C 8325 (hereafter referred to as standard) and the performance is of Class A, Number 1, Grade 1. Here Class A means the ability to switch on or switch off 10 times as large as the maximum permissible load current. Number

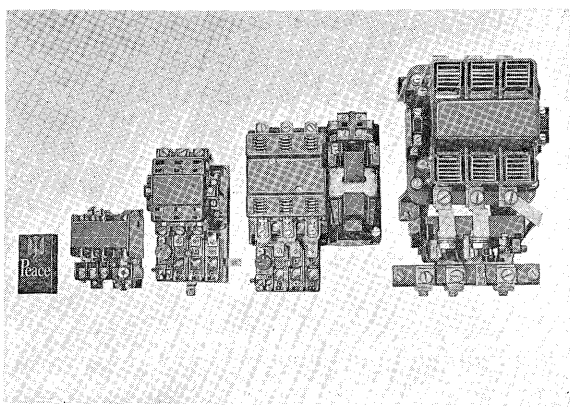
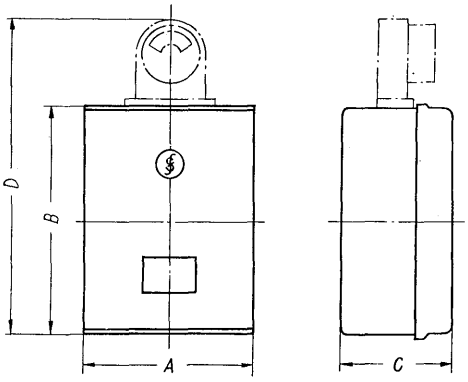
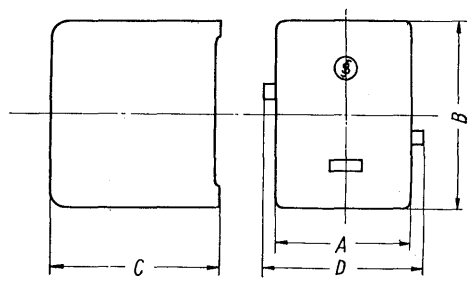


Fig. 1. Inner view of new type magnetic switch



Type	Dimensions				
	A	B	C	D	Fixing hole
RC 3931-1	84	134	94	206	2 × 7 ϕ
RC 3931-2	145	249	131	353	4 × 7 ϕ
RC 3931-4	219	308	140	414	7 × 7 ϕ
RC 3931x-6	213	405	211	526	4 × 9 ϕ

Fig. 2. Outline drawing of RC 3931



Type	Dimensions				
	A	B	C	D	Fixing hole
RC 3631-1c	84	134	94	—	2 × 7 ϕ
RC 3631-2c	100	162	127	112	2 × 7 ϕ
RC 3631-4e	164	203	131	187	3 × 5.3 ϕ
RC 3631x-6c	170	270	200	195	4 × 7 ϕ

Fig. 3. Outline drawing of RC 3631

Table 1. Details of new type magnetic switch

Type	Max. applying motor				Max. continuous cur.	Thermal relay and it's regulating range to RC 3931	Auxiliary contact	Capacity of magnet	Weight	JIS Character
	Voltage	Cage type	Wound type	Plugging type						
	V	HP	HP	HP	A	A		VA	kg	
RC 3631-1 RC 3931-1	110	2.5	2.5	2	16	RC 3737-1 Regulating range 0.125–0.25 0.25–0.5 1–2 2–4 4–8 8–16	Standard 1A 1B	85/8	0.5	A–1–1
	220	5	5	4						
	440	4	4	3			Standard 1A on demand 2A or 1A 1B		1	
	550	—	—	—						
RC 3631-2 RC 3931-2	110	4	4	3	25	RC 3737-4 Regulating range 0.125–0.25 0.5–1 1–2 2–4 4–8 8–16 15–30 30–50	Standard 2A 2B	180/20	1	A–1–1 *(B–1–1)
	220	7.5	7.5	6						
	440	10	15	8			Standard 2A on demand 2A 2B		2.4	
	550	10	18	8						
RC 3631-4 RC 3931-4	110	7.5	7.5	6	50		Standard 2A 2B	320/40	3.5	A–1–1
	220	15	15	12						
	440	30	30	24			Standard 2A on demand 2A 2B		6.7	
	550	37	37	30						
RC 3631x-6 RC 3931x-6	110	12	12	10	75	RC 3737-II Regulating range 70, 60, 50, 40, 30, 20, 16, 12.5, 10 E.T.C.±20%	Standard 2A 2B	710/80	5.4	A–1–1 *(B–1–1)
	220	25	25	20						
	440	40	50	33			Standard 2A on demand 2A 2B		12	
	550	50	65	40						

* It's only for wound type used over cage type's capacity.

Table 2. Rating of auxiliary contact

Max. continuous cur.	Voltage	A. C.		D. C.		
		Switch-in capacity	Breaking capacity	Switch-in capacity	Breaking capacity	
					Resistance load	Inductive load
A	V	VA	VA	W	W	W
10	24	350	150	150	150	50
	110	1,600	460	500	200	50
	220	3,400	800	500	200	60
	440	5,200	1,300	500	150	70
	550	8,500	1,600	500	730	80

Table 3. Rating of contact of thermal relay

Type	No. of contact	Voltage	A. C.		D. C.		Continuous cur.
			Switch-in capacity	Breaking capacity	Switch-in capacity	Breaking capacity	
		V	VA	VA	W	W	A
RC 3737-1	1B	24	50	7	—	—	0.3
		110	150	34	—	—	
		220	260	65	—	—	
		440	580	130	—	—	
RC 3737-4	1C	24	150	35	35	35	4
		110	650	160	165	30	
		220	1,300	330	330	45	
		440	2,600	660	660	25	
		550	3,000	825	825	15	

1 means the operation of 1200 times an hour at an operational time ratio of 40%. Grade 1 means to be able to operate 5 million times mechanically and 500 thousand times electrically. Table 1 shows the varicus details of the types of magnetic switches, table 2 the capacity of the auxiliary contact and table 3 the contact capacity of the thermal over load relay.

III. RESULTS OF VARIOUS TESTS

1. Life tests

The biggest advantage of this Series may be termed the long life of the magnetic switches. Magnetic switches are ordinary used in the 3 phase induction motors and the life of the switches must take into consideration the character of the motors. At the start of the motor a rush current several times that of the rated current flows and the switch must close on this currrent. However in a switch that is just closing, a bouncing or chattering phenomenon always rises and before the switch completely closes several switchings are repeated. During this process the contact material is worn off by the arc energy that rises. In the ordinary switches this chattering was from 10 to 50 msec. and the wearing off process was highest during the closing period, and not during the opening period. In other words this means that during the switching-off the current was weak and the arc time was small too (in most cases less than 10 msec.).

To show the largeness of this chattering process Dr. Wilhelm came up with the following formula for the double break type ....

$$Q=\frac{2m^2v_0^3}{3F^2}\cdot\frac{\eta^3}{1-\eta^3}$$

here m: Mass of moving contact
v_0: First velocity of moving contact at switching stationary contact
F: Strength of contact spring
η: Repulsion coefficient of moving contact and stationary contact

Though this formula does not show the process of chattering in minute detail, the qualitative points can be gained. For instance

1. To make the mass of moving contact as light as possible
2. To make the contact spring as strong as possible
3. The switching speed should not be too fast
4. To pick a small repulsion figure

Though the above mentioned qualitative points cannot all be utilized due to problems of design, it can be solved by picking special material and construction methods.

Especially in regards to clause 3 there is the patent Number 214055 and as shown in Fig. 4 the stationary iron core is made movable by a cushion spring. By exciting the coil the stationary iron core is moved up a bit where the shock is absorbed and lessened. It is so made that chattering will not appear on the surface of the contact point. Thus we have succeeded in this Series to cut the chattering time to less than 3 msec.

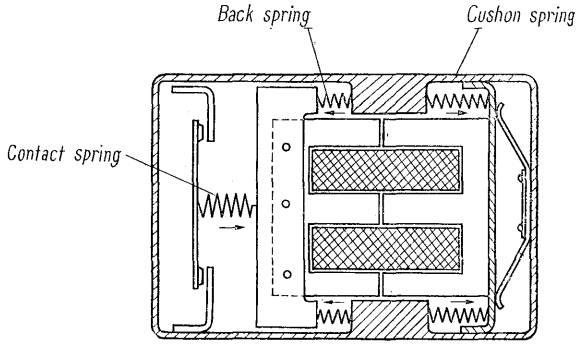


Fig. 4. Mechanism for bouncing-less

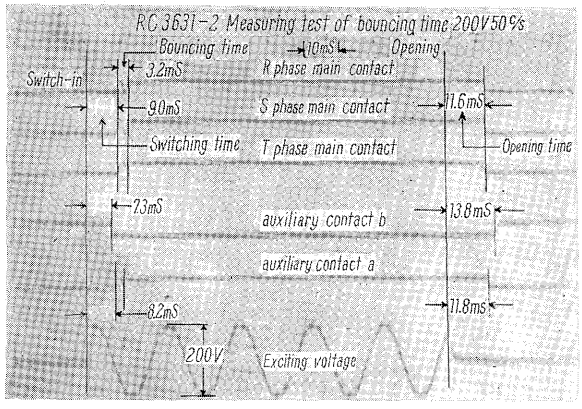


Fig. 5. Oscillogram of bouncing

Fig. 5 shows the oscillogram of this. Through this it can be seen that wear volume has been greatly reduced and there is a definite characteristic in the wear state. The surface state is of small pattern and there are no sharp uneveness. Fig. 6 shows the variation with the increase in number of times. This advantage can be plainly seen by comparing this with the switch in which bouncing time is long and there is a large state of wear in the central section of the point of contact.

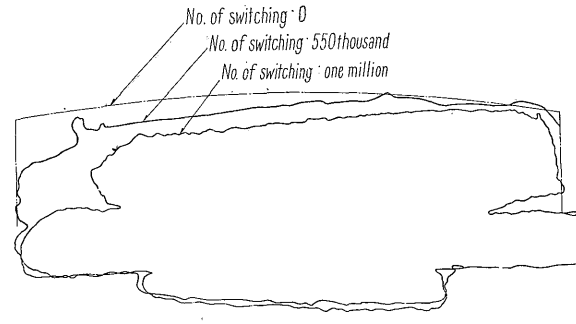


Fig. 6. Wear state of moving contact

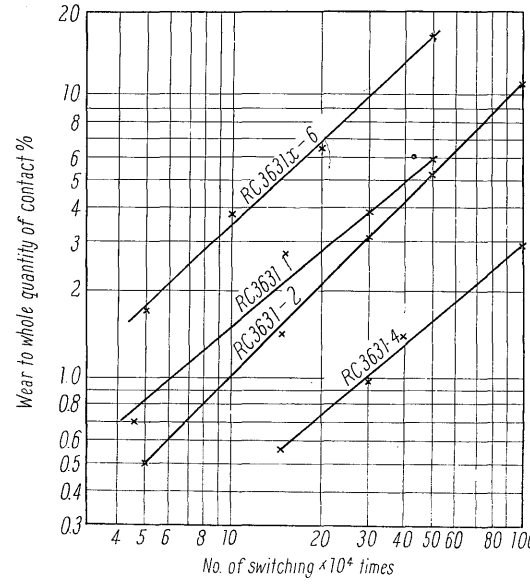


Fig. 7. Relation of switching number and wear

Fig. 7 shows the percentage of the wear weight against the total weight of the contact point.

This test was carried out in accordance with the standards under the test conditions as shown in Fig. 10. For contact point material pure silver was used. As the melting point of silver is low and the switch-in capacity is small, this metal was not used very much before but as noted previously due to the small quantity of chattering it has been found that it can be utilized in large currents. Also the use of silver contact point lessens the mechanical wear. This is due to the fact that the chemical feature of silver is stable and no other substances will appear on the surface. Even if other substances do appear, they are very weak mechanically and towards heat and given rise to butt contact. By this, nearly all of the mechanical friction is abolished. In case of copper contact point which has been largely used the oxidation copper film developed on the surface was strong mechanically and strengthened further by the heat. This meant that the oxide film was erased upon contact by the wipe proces and contact was made with a new metal surface.

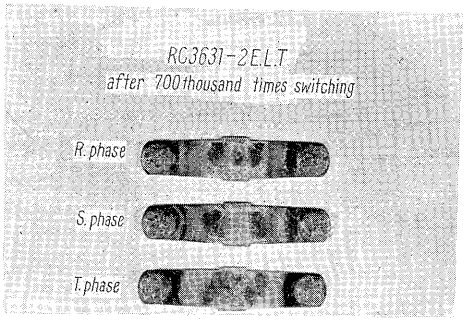


Fig. 8. Wearing state of moving contact, type RC 3631-2

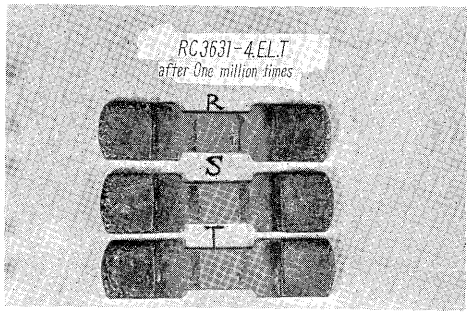


Fig. 9. Wearing state of moving contact, type RC 3631-4

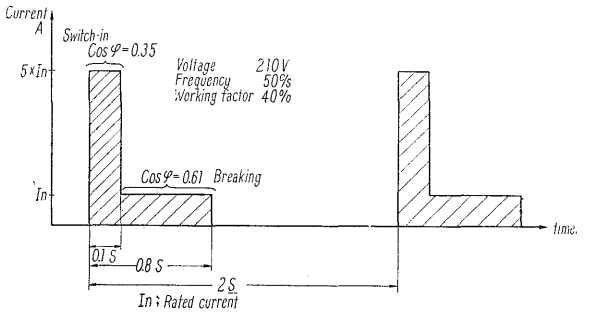


Fig. 10. Test condition of life test

In other words, it was the same as filing off the life term at each contact.

In the case of this new switch, as the standard of the mechanical life is 10 times that of the electrical life, the contact point can be changed after wearing off and used for long periods again. Thus the wheel and axle parts of the movable section is so constructed to withstand long life. Ordinarily these parts are protectively oiled but as stated in phase 4, many parts cannot be oiled as, in this Series, the friction parts have been changed from metal to plastics. By this, tests shown that these parts have passed the mechanical life of 5 million times.

2. Breaking and switch-in capacity

A–c breaking differs from d–c breaking in the fact that it possess a zero point passage in current and to lengthen the breaking distance does not necessarily mean to increase the breaking capacity. In this Series the breaking distance is from 3–6 mm

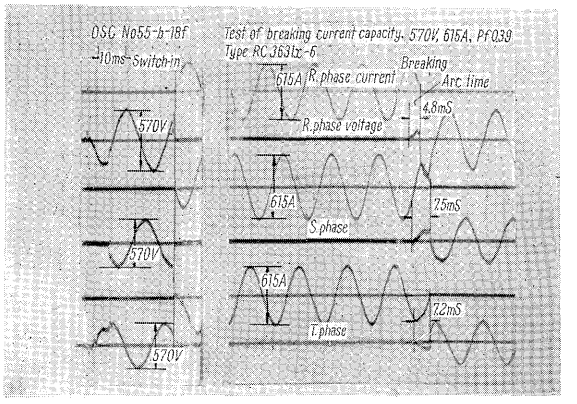


Fig. 11. Oscillogram of breaking test

Table 4. Arc time

Type	Test condition			Arc time m/sec.		
	Voltage V	Current A	Power factor	Max.	Min.	Mean
RC 3631-1	220	178	0.4	7.4	4.5	5.8
	440	69	0.38	7.0	4.1	5.6
RC 3631-2	220	250	0.35	7.6	2.8	4.7
	440	170	0.4	27	4.7	8.7
	550	136	0.35	25	5.2	9.1
RC 3631-4	220	500	0.40	13.5	5.7	9.7
	440	610	0.37	20	4.6	10.5
	550	515	0.40	17	8.5	13.2
RC 3631x-6	220	779	0.40	14	2.5	8.4
	440	610	0.36	17.5	3.0	9.5
	550	600	0.39	19	2.5	7.8

but the production of arc energy is less than the other types. The use of butt contact is from the construction standpoint of double break, thus increasing the capacity of breakage. Also in the forms 4 and 6 the Deion grid formula is being used. Fig. 11 shows the oscillogram of the breaking tests while table 4 the arc time.

According to the standards it is enough to hold 5 operation tests as CO–15–CO–15, but in our Company it is a rule to hold 30 such tests. This is because we believe that the worst condition of breaking cannot be obtained in only 5 tests. Again this test was conducted in a circuit with resistance and inductance as the conditions were much more severe than under a loaded motor. This shows that special case is being taken in these tests.

The chattering as noted in the life tests is also a large factor in determining closing capacity. When chattering occurs during closing, the current is switched off several times because the occurance of arc energy resulting in fusion. In other swiches during closing tests the occurance of arc and sound was permitted, however, in this Series there was very little apparently or hardly any at all.

According to the standards the closing tests must be made 100 times but to further safety alowance we made 200 tests. While in the wearing state of contact, switch must further close on starting current of motor and it is prescribed that the tests should be carried out at 3/4 of the wearing thickness of the contact point. However, as shown in Fig. 6 the points contact pressure which decides the thickness of the contact shows but little change. Thus even at a life of over 5 million times the closing capacity shows little change.

3. Operation tests

To test proper operation, the standards requires switching 600 times/hour at 90–105% of rated current. This Series sets its mark at 1200 times/hour at 90–105% and as shown in Table 5 the minimum attracting voltage is less than 85%. Thus

Table 5. Attract and release voltage

Type	Coil rating	Min. attract voltage V	Max. releasing voltage V
RC 3631-1	200 V 50 c/s	135	106
	200-220 V 60 c/s	159	123
RC 3631-2	200 V 50 c/s	146	114
	200-220 V 60 c/s	164	120
RC 3631-4	200 V 50 c/s	160	121
RC 3631x-6	200 V 50 c/s	153	119

Table 6. Switch-in and switch-off time of contact action (Unit: m/sec.)

Type	Items	Switch-in time			Switch-off time		
		Max.	Average	Min.	Max.	Average	Min.
RC 3631-1	a. Contact	14.7	12	9.0	13	10.7	5.3
	b. Contact	12.5	9.8	7.4	17.2	12.3	10.7
RC 3631-2	Main contact	16.5	11.5	8	18.3	13.3	6.0
	Auxiliary a. contact	15.0	11.0	8	20.0	14.6	7.2
	Auxiliary b. contact	14.2	10.4	6	22.5	15.7	8.3
KC 3631-2	Main contact	44	26.8	20	20.5	14.8	7.0
	Auxiliary a. contact	34.0	29.1	19	24	17.6	9.0
	Auxiliary b. contact	20	14.5	11	30	21	12.5
RC 3631x-6	Main contact	31.5	19.5	13.5	21.0	16.9	9.0
	Auxiliary a. contact	27	16.5	12	22	14.3	8.5
	Auxiliary b. contact	15.0	11.8	8.5	27	24.4	13

Table 7. Temperature rise test (Unit: °C)

		RC 3931-1	RC 3931-2	RC 3931-4	RC 3931x-6	Gauge
Test condition	Voltage V	50 c/s 220 V	50 c/s 220 V	60 c/s 242 V	50 c/s 220 V	—
	Current A	17.6	27.5	55	77	—
Contact		42	55	39	46	75
Coil	Thermometer method	41	51	25	56	65
	Resistance method	63	62	57	73	85
Terminal	Power source side	39	43	30	40	50
	Load side	48	33	42	30	50

it can operate freely at spots of much current variation. Also we might add that when the starting current flows from the motor the coil voltage takes a large drop causing troubles.

Table 6. shows the operational time of the switch.

4. Noise

In other switches it was the practice to fit magnet core to abolish the humming but in the Series this is not necessary. Even after several assembling or detaching the switch is practically noiseless.

5. Temperature tests

Table 7 shows the rise in temperature of this Series.

IV. THERMAL OVERLOAD RELAY

The magnetic switch combined with the thermal overload relay should protect against overload of the motor. As the thermal overload relay possess a similar character to the a-c motor overload character, it is adopted as a motor protecter. As the RC 3737-1,11 used in this Series is already well known, we will here outline the features of the RC 3737-4 used in the RC 3931-2, 4 type.

1. Temperature compensation equipped

Though the heat capacity of the motor increases during the winter and decreases during the summer, the switch and motor are not necessarily set in the same room. And considering the capacity output of the accompaning machine to be constant a temperature compensation equipment is necessary.

2. Both self reset and manual reset possible

In most cases a manual reset is used to figure whether power stoppage or overload is responsible for stoppage of motor. Recently, however, automatic control equipment is being used and, for instance, when set in tool machine or used for explosion proof machine, a self reset is being put to use to ease the difficulty of resetting.

3. Contact is change over (1C)

As the contact of the over-load relay it is generally enough to be 1B to do by breaking the exciting current of the magnetic coil of the switch, however by using 1C the over load can be indicated as well as, in self reset, the reason for motor stoppage can be determined.

4. 2 or 3 poles heat element can be put on

In case of 3 phase 3 wire system the over-load of the motor can be protected by 2 poles. 2 poles thermal relay is standard type in our Company. However, in case of 3 phase 4 wire system 3 poles thermal relay must be used.

5. Large adjusting range

To use the thermal over-load relay for a motor, it is only necessary to adjust to the rated current of the motor but if the adjusting range is small, the different ratings of the motors must all use different heat elements. This makes trouble in use. In this Series the adjusting range is large, for instance, for 200 V 5 HP and 7.5 HP heat elements 15–30 A are used, and for 200 V 10 HP and 15 HP heat elements 30–50 A.

Thus this relay has many advantages over previous ones and it is easy to assemble or detatch the relay with a contactor.

V. SPECIAL USAGE

When the magnetic switch is used to control the motor, there are special operations, possible in character with the accompaning machine.

1. Inching

Can be widely used in a tool machine or lifting machine. In this case as the operation time of the motor is very short the switch will open before the starting current of motor has put down. This means that wear off of the contact point will be much larger than under ordinary conditions. When less

Table 8. Applying capacity for inching

Type	Applying capacity for inching	
	1 time/sec.	2~3 time s/sec.
RC 3931-1	2 HP	1 HP
RC 3931-2	3 HP	3 HP
RC 3931-4	10 HP	7.5 HP
RC 3931x-6	25 HP	15 HP

than the rated current, wearing volume will be proportional to the current, and when more than rated current it will be proportional to the sudden increase. Table 8 shows the applying capacity for this inching.

2. Plugging

Used often when the motor is suddenly stopped. The rush current at this time will be 20% increase over the starting current. Thus the motor must be so chosen. Also the switching-off of the rush current at this time will shorten the life of the switch. When plugging, it is necessary to use a plugging relay—and one must be careful in choosing this plugging relay, for a wrong one can cause a phonomena similar to chattering in the switch.

3. Continuous operation

Magnetic switches are generally considered to be switched on and off at least one time a day.

When the switch is operated continuously for a week, the current is lowered to keep down the oxidation of the copper contact point when copper is used. However as silver contact point is used in this Series, this is not necessary.

VI. CONCLUSION

The above was the outline of the new type magnetic switches and the results of the tests. Though there are many advantages compared to other switchs, we find that there is still room for improvement.

In closing I wish to thank my colleagues in the Fukiage Works for their help in gathering material for this article. Also to Mr. Abe for advising me on the paper.

(By Isao Honma, Designing Div., Fukiage Works)