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D-C MAGNETIC CONTACTOR K916II SERIES

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I. INTRODUCTION

The use of direct current motors is becoming increasingly popular nowadays in various fields of its application as a result of the spectacular progress in automatic controls for various industrial machines. This is apparently due to the fact that direct current motors have a number of characteristics which alternate current motors do not have, such as, for instance, their ability to obtain a wide range of speed controls on a purely electrical basis with a lower rate of power consumption for these controls thereby rendering automatic controls highly efficient and easily maneuverable and the ease with which it is possible to manufacture motors having characteristics commensurate with load characteristics.

In parallel with this progress, it is also becoming necessary that the direct current controls equipment such as direct current magnetic contactors in particular be highly efficient and capable of long service.

Drawing on a rich experience and extensive research embodying the heritage of the Siemens in Germany, we started to manufacture alternate current magnetic contactor RC361 series sometime ago which has now been followed by the development of a Direct Current Magnetic Contactor K916II Series we shall speak about in the following passages.

The d-c magetic contactor in this series of an entirly new construction which is, more or less, a derivative in application of the a-c magnetic contactor RC3631 series beeing essentially different from its predecessor. Performancewise, the new type d-c magnetic contactor thoroughly guarantees Category A, No. 1, class 1 of the Standards JEM 1138 promulgated by the Japan Electric Machine Industry Association.

In this presentation, we intend to give an introduction the outline and performance of the new type d-c magnetic contactor in the hope that this information may by used to advantage by intersted parties.

II. MODELS AND RATING

The d-c magnetic contactor K916II is available in four different models of rated current 25, 50, 110 and 160 amp for d-c circuits at the rated voltage of 550 v or less. In addition to the dc-operated contactor, it is possible to manufacture ac-operated contactors. The main contact is of double-pole system and the contacts is of normally open type. With the auxiliary contact, there are two normally open and two normally closed contacts, i.e., 2A+2B contacts.

These rated values are shown in *Tables 1* and *2*.

III. CHARACTERISTICS

The present contactor, when compared with the conventional counterparts, is characterized by the following special features:

1) Small in size and light in weight

Smallness in size is an important requirement of the contactor when it is built in a machine tool or an industrial machine or arranged in a control board. Since our contactor under review is of compact design composed solely of molded parts, it is small in size and light in weight so that it requires only small space for fitting.

2) Long in service life and endurable against frequent operation

A rather demanding requirement is imposed upon a d-c magnetic contactor because of the necessity to improve stability and productivity of the machine using it. The present contactor guarantees more than 500,000 operating cycles for electrical life of contacts and over 10,000,000 operating cycles for mechanical endurance. Moreover, it has the capability to endure over 1200 operating cycles per hour and completely satisfies its requirement.

3) Easy in maintenance and inspection

Replacement of coils and contacts may be carried out with a driver alone so that it is easy to maintain or inspect this contactor in field service.

4) Superior in quality control

Thoroughgoing control of production quality in

Table 1 **Rated capacity of new type d-c magnetic contactors**

Model	Maximum capacity of motor applied (kw)				Maximum Continuous flow of current (amp)	Capaciy of closed coil current (amp) L/R=5 ms at 550v	Open coil curretnt (amp) L/R=15 ms at 220v/550	Frequency of opening and closing (times/hr)	Mechanical endurance (10,000 times)	Electrical endurance (10,000 times)	Classification by JEM
	110 v	220 v	440 v	550 v							
K 916 II-2 K 916 II-2W	1.7	3.7	6.0	5.5	25	100	100/60	1200	Exceed 1,000	Exceed 50	A-1-1 Mechanical endurance class "0"
K 916 II-4 K 916 II-4W	3.7	7.5	15.0	19.0	50	200	200/200	1200	Exceed 1,000	Exceed 50	A-1-1 Mechanical endurance class "0"
K 916 II-8 K 916 III-8W	9.0	19.0	37.0	45.0	110	440	440/440	1200	Exceed 1,000	Exceed 50	A-1-1 Mechanical endurance class "0"
K 916 II-10 K 916 II-10W	15.0	30.0	60.0	75.0	160	640	640/640	1200	Exceed 1,000	Exceed 50	A-1-1 Mechanical endurance class "0"

Notes: 1. Auxiliary contacts are all 2A+2B.

2. d-c control types are indicated as K 916 II-2, 4, 8, 10, and 10 while a-c control types are shown as K 916 II-2W, 4W, 8W and 10W.

3. When a cover is fitted, the letter "C" is added. e.g.-K 916 II-2C/W.

Table 2 **Rated capacity of auxiliary contacts**

Max. cont. flow of current (amp)	Voltage (v)	Rated making current (amp)	Rated breaking capacity		
			a-c 50/60 c/s cos ϕ 0.3~1 (va)	d-c (w)	
				Non-inductive load	Inductive load
10	24	50	240	240	240
	110		1100	550	140
	220		2200	290	120
	440		4400	220	120
	550		5500	165	110

our specialized plant ensures uniformity of quality and high reliability of performance.

IV. CONSTRUCTION

The construction of K916II d-c magnetic contactors may be largely classified into two kinds: namely, one like K916II-2 with its plunger type magnet where the movable iron core is directly linked with the movable contact support and moves the latter, and the other like K916II-4, 8 & 10 with their hinged type magnet where the movable iron core is linked with the movable contact by means of links synchronized with the former which moves the movable contact. For large capacity, the making of magnet gives rise to a "dancing phenomenon" and the neighboring apparatus are ill-effected when contactors are fitted to the board. The change in the moving directions of the movable iron core and the contact by means of links is intended to prevent this very phenomenon.

In the case of K916II-2, on the other hand, the arc-quenching system employs a permanent magnet for blow-out flux, while K916II-4, 8 and 10 use a blow-out coil in series blow-out system where load current of its own creates blow-out flux.

Connections are all of surface connection type while for operation there are both dc and ac operations. *Fig. 1* shows dc-operated d-c magnetic contactors, while *Fig. 2* represents ac-operated contactors.

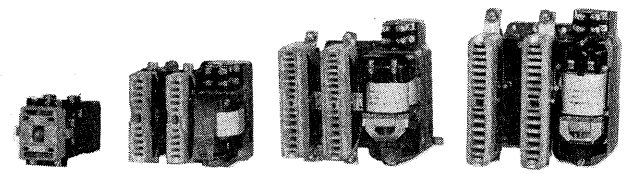

Fig. 1 Model K 916 II-2, 4, 8, 10 d-c magnetic contactors (d-c operated)

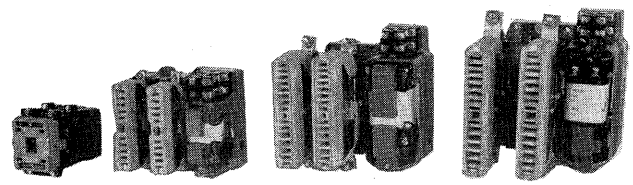

Fig. 2 Model K 916 II-2 W, 4 W, 8 W, 10 W d-c magnetic contactors (a-c operated)

1. Contacts

Contacts are made of pure silver, Pure silver is known as stable contact material. With our contactors, contacts are of two break butt contacting structure and the displacement phenomenon at the time of dc breaking is held to a minimum due to the rapid displacement of the electric arc legs by blow-out flux to arc horns. The fact that these contacts can withstand the anticipated life has been experimentalily verified.

2. Operating Magnet

This explanation concerns a d-c magnet.

As previously stated, the magnet in the case of K916II–2 is of plunger type and coil replacement may be easily out by simply removing a rear cover built in a plastic frame. K916II–4, 8 and 10 use a hinged type magnet but since the bearing of the movable core for the magnet is of knife-edge type we may dispense with worries connected with mechanical wear and lubrication as in the case of the pin bearing, thereby contributing to the long mechanical life of these contactors. The winding wire of magnet coil is of poliuretan wire (E) so that deterioration of insulation, layer short circuit, and burning or breaking of coil will not take place even when the opening and closing operations are highly frequent.

Table 3 shows standard voltage of coil, magnet capacity and time constant of coils.

3. Arc Quenching Device

The arc quenching device of d-c magnetic contactors is an important element in determining the breaking current capacity of a circuit as well as their electric life.

In the case of K916II–2 two permanents magnets are fitted to the upper section of the arc quenching chamber which create blow-out flux. As for contactors with small capacity, it will be constructionally easier to employ permanent magnets but, generally speaking, it arises a problem with regard to polarity of the magnet. However, with our construction of the arc quenching chamber, there is no necessity to worry about the polarity. With the permanent magnet, moreover, since the blow-out flux remains constant regardness of the breaking current, blow-out effect will not change as in the case of series type blow-out system. On the otherhand, when the capacity increases as with K916II–4, 8 and 10, the method of fitting permanent magnets and the matter of polarity present problems in connection with the structure of the arc quenching chamber. From this consideration, we employ a series type blow-out system wherein blow-out flux is created by giving its own current to blow-out coil. In this case, blow-out flux density becomes smaller at the time of current breaking and the blow-out effect decreases and the arc time prolongs, which in turn gives rise to the necessity to use special blow-out coils with more windings.

The conventional d-c magnetic contactors in the past used a series type blow-out system even with the contactor of the smallest capacity in the series and the blow-out effect became insufficient as stated above when load was of small capacity. To cope with this, the windings of a blow-out coil were changed to correspond to load capacity. However, in our present series a permanent magnet system is

***Table 3* Magnet coil of new d-c magnetic contactors**

Electromagnetic coil for d-c operation

Model	Standard control circuit voltage (v)	Capacity of electromagnet (w)	Coil time constant (ms)		Remarks
			T_0	T_m	
K 916II-2	DC 12 24 48	12.5	19	37	Series resistance is fitted in the case of K 91611-10
K 91I6I-4	60 80 100	19.5	30	25	
K 916II-8	110 125 150	35	50	105	
K 916II-10	200 220	65	27	60	

T_0: Time constant for magnet opening. T_m: Average time constant for Electromagnet closing.

Electromagnetic coil for a-c operation.

Model	Standard control circuit voltage	Coil capacity of electromagnet (va)		Remarks
		At time of making	After making	
K 916 II-2W	100 v 50 c/s, 100~110 v 60 c/s	180	20	Common coil
K 916 II-4W	200 v 50 c/s, 200~220 v 60 c/s	320	40	Bilateral coil
K 916 II-8W		1100	80	
K 916 II-10W	100 v 50 c/s, 110 v 60 c/s 200 v 50 c/s, 220 v 60 c/s	1200	100	Special coil

Note: Besides the above standard, the coil control voltage may go up to a-c 24~550 V.

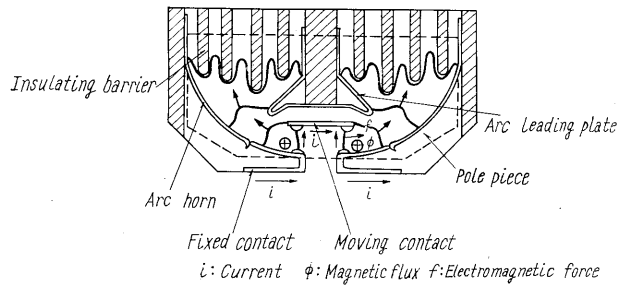

Fig. 3 Inner construction and arc-quenching mechanism of arc chamber

employed for the contactor with the smallest capacity so that these inconveniences have been removed.

It may be added that contactors with extremely large capacity will not be used for extremely small load, so that contactors outside the one with the smallest capacity may adopt a series type blow-out system without any difficulty.

Fig. 3 depicts inner construction and arc-quencning mechanism of arc chamber in the case of direct winding blow-out system. Here, the arc leading plate is so arranged as to enable the arc legs to displace promptly from the moving contact to the arc leading plate, thereby preventing wear of the moving contact.

By using this arc-quenching chamber, it has become possible to shorten arc time and to increase breaking current capacity as well as electrical life.

Fig. 4 shows a process of arc quenching in the case of K916II–4 as photographed by a high speed camera in which displacement of arc and validity of arc-quenching effect are proved.

Fig. 5 shows a relationship between breaking current and arc time in a circuit of 220 v and 550 v, respectively, with constant selfinductance, when a standard blow-out coil is used.

As is clear from this diagram, the arc time becomes shorter as the breaking current becomes smaller in the case of K916-2 since blow-out flux is created by a permanent magnet. However, in the case of K916II–4, 8 and 10, on the otherhand, there appears a portion in which in a small current range the arc time becomes longer due to the series type blow-out system employed.

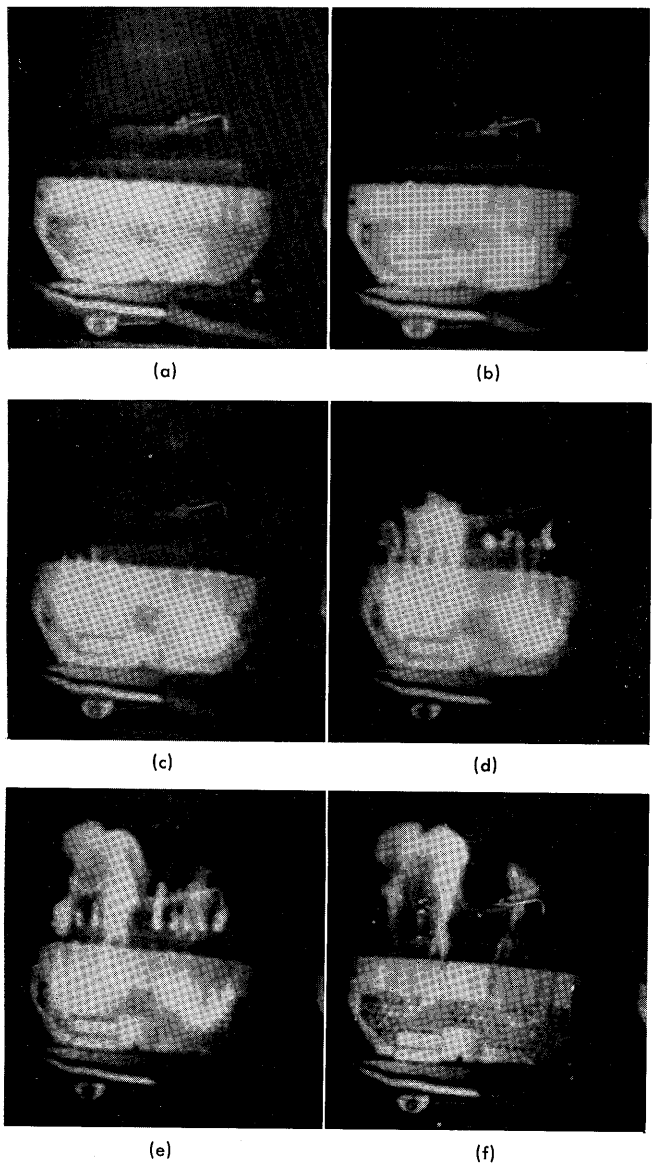

Fig. 4 Process of arc quenching photographed by high speed camera

V. Performance

New type d-c magnetic contactors K916II series are manufactured on the basis of the standards of Japan Electric Machine Industry Association covering direct current magnetic contactors, JEM1138.

1. Operation Characteristics

These contactors are made to function without any practical trouble within the range of 85～110% of the coil rated voltage for the operating voltage at the maximum ambient temperature of 40°C and after their operating magnet coils have reached to the state of thermal equilibrium.

2. Capacity for Breaking and Making Current

JEM1138 provides for classification of making and breaking currents of contactors according to several utilization categories as in *Table 4.*

The present contactors correspond all to Class A which are capable of breaking and making current capacity four times the rated current. It is stipulatted that the standard operating duty should be conducted five times at an interval of 10 sec. from CO also four times the current.

Fig. 6 (*a*) to (*d*) show each an oscillogram of breaking at 550 v. for K916II–4, 8 and 10 and at 220 v. for K916II–2.

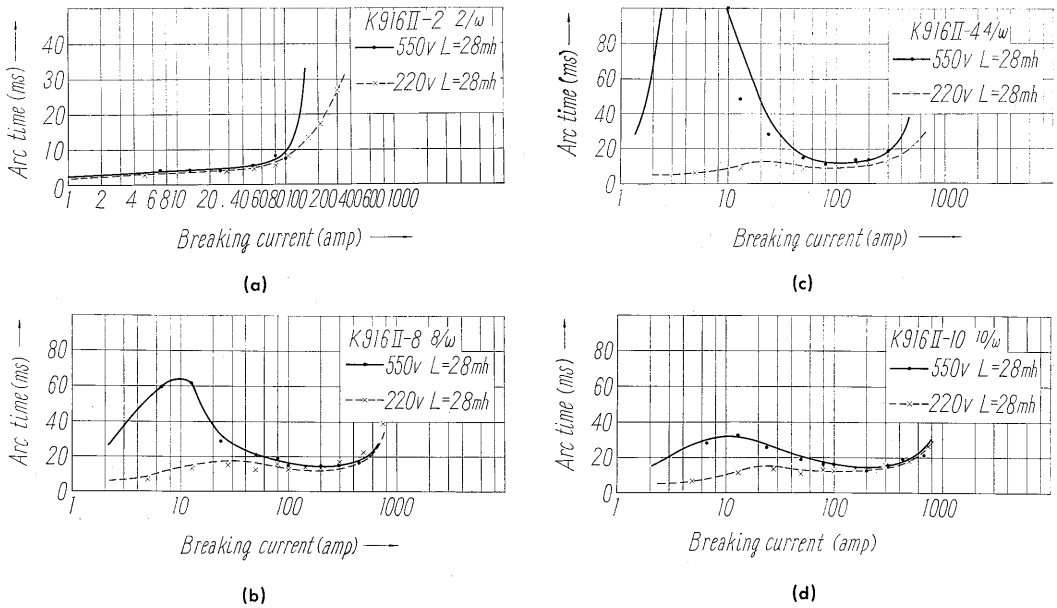

Fig. 5 Breaking characteristics of K916II d-c magnetic contactors

Table 4 **Conditions for making and breaking current corresponding to several utilization categories**

Category	Time constant (L/R) (sec)	Multiple of rated value of current		Uses
		Breaking	Closed	
A	over 0.015	over 4	over 4	For motor for current limit starting
B	under 0.005	over 1.5	over 1.5	For resistance load
C	under 0.005	—	over 4	For starting resistance short circuit

3. Endurance and Frequent Operation

Tables 5 and *6* show group number and class number of operating cycle according to endurance and according to opening cycles per hour, respectively, as per JEM standards.

The present contactors correspond to group 0 for mechanical endurance, group 1 for electrical life and class No. 1 for operation frequency.

The current in use for testing operation frequency and endurance varies according to class of contactors and is indicated in *Table 7*.

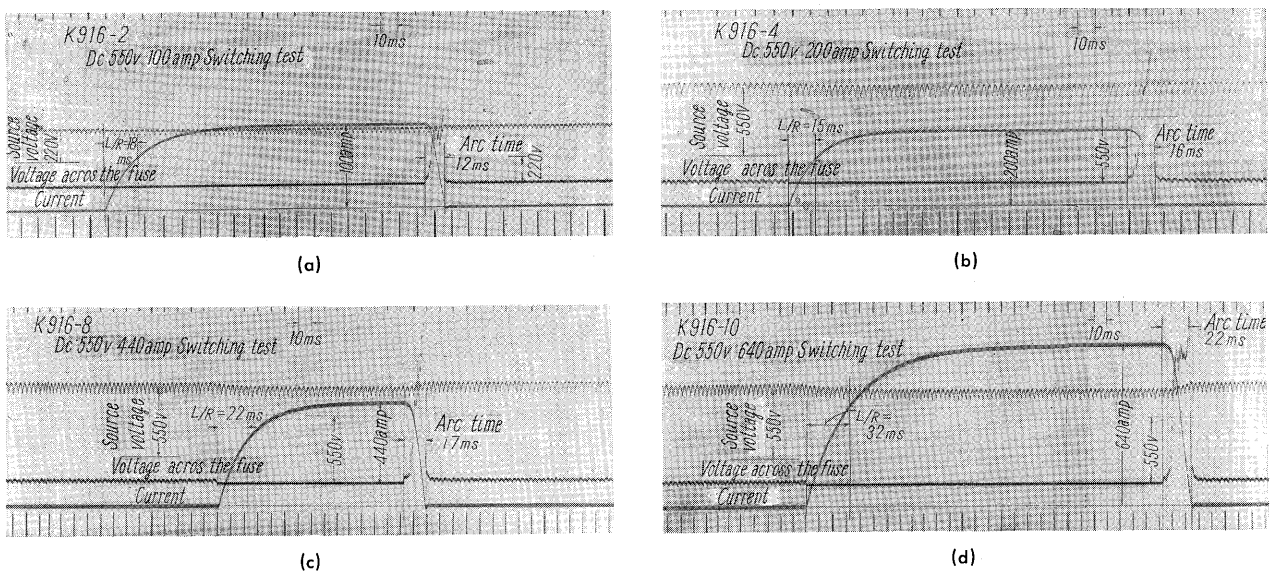

Fig. 6 Oscillogram of break capacity test

Table 5 **Group number and a number of operating cycle according to endurance**

Endurance of contactor / Group number	Mechanical life of contacts	Electrical life of contacts
0 Group	Exceed 1,000million operations	Exceed 100 million operations
1 Group	Exceed 500 million operations	Exceed 50 million operations
2 Group	Exceed 250 million operations	Exceed 25 million operations
3 Group	Exceed 100 million operations	Exceed 10 million operations
4 Group	Exceed 25 million operations	Exceed 5 million operations
5 Group	Exceed 5 million operations	Exceed 1 million operations

Table 6 **Class number of intermittent duty for contactor according to opening cycles per hour**

Class number	No. 1	N.o 2	No. 3	No. 4	No. 5	No. 6
Operating cycles (number of operation per hour)	1200	600	300	120	70	Not prescribed

Table 7 **Current in testing frequent operation and endurance**

Category	Multiple of rated value of current			
	Making		Breaking	
	Multiple	Time constant (L/R) (sec)	Multiple	Time constant (L/R) (sec)
A	2	over 0.015	1	under 0.005
B	1	under 0.005	1	under 0.005
C	2	under 0.005	—	

VI. SPECIAL USES

1. Inching and Plugging

When the contactors are used for inching and plugging, an appropriate capacity must be determined in consideration of endurance as the motor starting current is made and broken by them. Categories dc 3 and dc 5 of the IEC standards stipulate test conditions of contactors for inching and plugging. According to these standards, making and breaking at current 2.5 times the rated current is to be done in a circuit of time constant 2 ms in the case of shunt motors, and, in the case of series motors, current also 2.5 times the rated current is to be tested in a circuit of time constant of 7.5 ms.

Table 8 represents application of inching and plugging for electrical life 0.1 million determined on the basis of the foregoing stipulation.

With the contactors of series blow-out system, in passing, it must be noted that mere lowering of application capacity will not make the electrical life any longer. To do this, when the application capacity is lowered below a certain figure, blow-out coils of special specifications with a greater number of winding must be used.

2. Rapid Forward/Reverse Change-over

Rapid change-over refers to an occasion on which when one of the two contactors for reversal opens, the other contactor makes by means of one's normally closed auxiliary contact. In this case, when the arc time of the opend contactor is long or when the closed time of the closed contactor is short, the other contactor closes during the arc time to short circuit the electric source. When this happens, a time delay relay should be used to delay the closing time of the main contact.

Table 9 shows application requiring time delay relays.

3. When Using Double-pole Contactors for Single-pole Switching

The application of K916 series d-c magnetic contactors in *Table 1* is related to two poles arranged in series. When they are used with one pole, the breaking current capacity decreases. *Table 10* shows rated capacity for one pole use.

VII. CAUTIONS FOR USE

In using these contactors, the following points should be observed by way of caution :

1) Mount the contactor in a place with little humidity and vibration and at an inclination within

Table 8 **Application of inching and plugging for electrical life 0.1 million**

Model	Capacity of applied motor (kw)		
	110 V	220 V	440 V
K 916 Ⅱ-2, 2W	1.5	3.0	5.0
K 916 Ⅱ-4, 4W	3.0	6.0	13.0
K 916 Ⅱ-8, 8W	7.5	15.0	30.0
K 916 Ⅱ-10, 10 W	13.0	25.0	50.0

Table 9 **Application needed to time delay relay**

Model	Application needed to time delay relay
K 916 Ⅱ-2	550 v 1.5 kw, to over 440 v 2.2 kw
K 916 Ⅱ-4	Unnecessary
K 916 Ⅱ-8	Unnecessary
K 916 Ⅱ-10	Unnecessary

Note : A-c control d-c electromagnetic controls of K916Ⅱ-2/W 4/W 8/W 10/W all require delay relays since the closing time of main contacts is fast.

Table 10 **Rated capacity for one pole use**

Model	Capacity of applied motor			
	110 v	220 v	440 v	550 v
K 916 II-2, 2W	0.75	1.5	1.1	1.1
K 916 II-4, 4W	2.2	5.5	7.5	11
K 916 II-8, 8W	5	10	20	22
K 916 II-10, 10 W	6	12	24	30

Tbble 11 **Minimum clearance in front of arc quenching chamber**

Model	K 916 II-2, 2 W	K 916 II-4, 4 W	K 916 II-8, 8 W	K 916 II-8, 8 W
Clearance (mm)	30	50	55	70

± 15 degrees against four directions of forward, backward, left and right.

2) Set minimum clearance in front of arc quenching chamber as in *Table 11*.
3) Do not operate the contactor unless the arc chamber is properly and firmly seated on all sides and undamage.
4) Contacts should be free from grease or other oily stuff. Surfaces of contact should not be rubbed even if they have become black because the latter phenomenon does not affect the contact.
5) When using K916II-4 and K916II-8 for 440 v and 550 v under 30% of application in *Table 1* and under 60% under *Table 10*, blow-out coils will be special coils.
6) The back spring adjusting screw is locked by white paint after the making voltage adjustment in our plant after testing, so that it should not be tampered with.

VIII. CONCLUSION

So far has been the presentation in outline of new type d-c magnetic contactors which are different from conventional d-c magnetic contactors in construction. It is our belief that being small in size and superior in performance these new contactors will be used with satisfaction as sister products of a-c magnetic contactors RC3631 series.

We invite all users to send comments which might help improve these new type d-c magnetic contactors.