UDC 621. 313. 333. 1-573

NEW TYPE AC MOTOR OPERATED STARTING CONTROLLER

By Katsuro Matsutani

Kawasaki Factory

I. PREFACE

The dc motor operated stating controller, with a starting resistor and other equipment installed separately, is used to start wound-rotor type induction motors.

The dc motor operated starting controller has various applications such as remote-control and automatic-start up of water supply and sewage pumps, as well as air blowers for factories and office buildings. It is also used for remote-control and automatic-starting of a wide range of other machines.

Drawing on its long experience in the manufacture of starting-controllers, Fuji Electric succeeded in producing a new series of extremely compact and light weight controllers. This new series of Ac Motor Operated Starting Controllers are briefly introduced here.

II. SPECIFICATIONS

Table 1 lists standard specifications and *Fig. 1* gives the range of motors with which the starting controller can be used. *Table 2* gives dimensions of the motor.

The ac Motor Operated Starting Controller is of 4 different types. As shown in *Table 1,* two ratings are given: maximum permissible voltage and current and maximum permissible output.

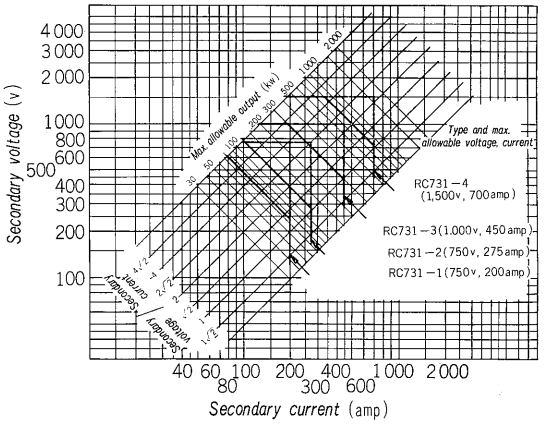


Fig. 1 Application range of motors for use with starting controller

It is not recommended that the specifications be divided into two sections, as this will only increase the complexity in handling the controller and thus cause mistakes. This division is made only from the viewpoint of economics and freedom of selection.

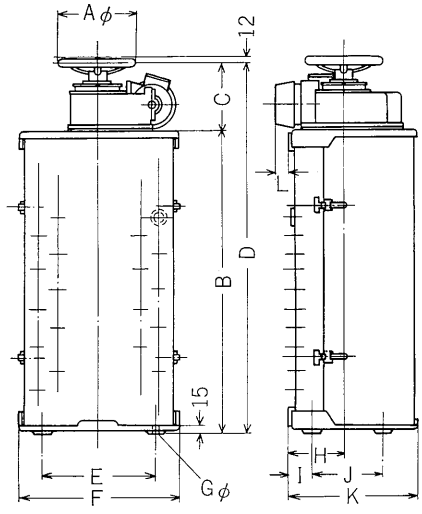
The maximum voltage and current ratings are the most popular, since these ratings are obviously the most economical and rational basis on which to select the starting controller. However, there are many times when these ratings may not be practical, since it is often impossible to select the proper controller knowing only the output, without any data concerning the secondary voltage and current.

***Table 1* Standard Specifications**

Type	Rating (I) Max. permissible voltage (v)	Rating (I) Max. permissible current (amp)	Rating (I) * Output limit (kw)	Rating (II) Maxp. Permissible output (kw)	Coasting Time ** (sec) 50 cps	Coasting Time ** (sec) 60 cps	Notch Numbers Balance	Notch Numbers Unbalance	Notch Numbers Total	Main Cam Switch Types & Numbers	Aux. Cam Switch Types & Numbers	Controller Circuit Voltage	Weight (kg)
RC 731-1	750	200	240	75	37	31	8	1	9	13×K7110-12S 2×K7110-13S	5×K267R	3 phase 200/220 v 50/60 cps	Approx. 56
RC 731-2	750	275	320	120	17	14				13×K7110-12S 4×K7110-13S			Approx. 65
RC 731-3	1000	450	700	300						13×K7110-13S 3×K7110-34			Approx. 80
RC 731-4	1500	700	1,500	800						17×K7110-34			Approx. 110

Note: * Output limit is the output when the secondary voltage and current of the motor reach the maximum.
** Coasting time is the time required for the notch to move from 0 to 8 when the current limit relay is not used.

Table 2 **Dimensions**



Units : mm

Type	A	B	C	D	E	F	G	H	I	J	K	L
RC 731-1	165	650	167	817	240	340	13	115	40	175	265	60
RC 731-2	210	704	172	876	240	340	13	130	40	205	295	41
RC 731-3	210	759	172	931	300	420	15	140	50	190	330	31
RC 731-4	210	866	172	1038	300	420	15	140	50	190	330	31

If the maximum permissible output is given, however, the secondary voltage and current can be determined easily. Although it appears simple and rational to indicate the maximum permissible output, the fact is that the ratio of the secondary voltage and current of wound-rotor type induction motors with the same output will differ considerably, if the number of poles and other factors vary. Accordingly, when selecting the permissible output, it is essential to allow for these differences.

Therefore, the economic aspects deteriorate when comparing voltage and current ratings.

For this reason, two different ratings are used. The details will be explained later.

1. Maximum Permissible Voltage and Current

As the name implies, the maximum permissible voltage is the maximum secondary voltage which the motor can accept.

The maximum permissible current is the amount of continuous carrying capacity. When selecting the maximum permissible current, take the starting surge current into consideration, and decide the current rating by the total making current of the resistance short-circuiting cam switch.

To be more precise, after taking the rating slip into consideration, the load torque when the motor is operating should be less than 100% of the rating. Accordingly, if there are variations in the load torque when the motor is operating, the maximum allowable current will increase or decrease in accordance with these variations, although the fluctuations will be small.

2. Maximum Allowable Output

The ratings of starting resistors are stated in Section #10 of JEM 1023. These are applicable mostly in the $1\sqrt{2} \sim 4\sqrt{2}$ range which is the quotient when the secondary voltage is divided by the secondary current, and the load torque is less than 100% of the rating when the motor is operating.

This range has been obtained from data gathered over a period of years and most motors can be used in this range.

In *Fig. 1* the permissible range obtained by the method mentioned above is indicated by the solid lines and the permissible range obtained by the maximum permissible voltage and current methods is indicated by the broken lines. The agreement of the two ranges obtained by different methods indicates the validity of the range.

3. Applications Outside the Specification Range

Fluctuations in the permissible output when the load torque differs from the standard specifications, or an increase in permissible output when there is short-circuiting in the motor slip ring are special cases and must be considered separately from the standard specifications.

III. FEATURES

1. High Durability of the Cam Switch and Easy Handling

The K7110 (of the K7110 series) is used as a cam switch for short-circuiting the starting resistance. It has gained wide praise for its excellent performance. The K 267R, an auxiliary control cam switch, has been altered and developed to a considerable extent. Both of these cam switches are of the cam open type. Silver-alloy contact tips well known for durability and ease of handling are used.

2. No Deposition

The geneva gear used to operate the mechanism allows for an increase in the speed of the main cam switch, and also enables proper positioning of the notch. This gear decreases wear on the contact tip considerably and prevents any deposition.

Therefore, the special circuit formerly needed to start the motor is no longer required.

3. Electromagnetic Motor Contactor

An electromagnetic motor contactor, an essential attachment, is already installed in the controller, for ease of handling.

4. Auxiliary Cam Switch

This switch is used to indicate whether the con-

troller is operating or not, as well as for the circuit of the device used to raise the brush of the main motor. It is now required only for zero interlock, protection against interruptions, stopping the device used to correct the operating position, and CT secondary short-circuiting. For this purpose, an auxiliary relay also is needed.

5. Simple Changeover from Manual to Automatic Control

The development of the transfer mechanism, has done away with the need for a special lever and changeover between automatic and manual operation can be accomplished merely by pushing a manual handle up or down.

This switch also enables a simplification in the installation of this part. Therefore, there will be few mechanical troubles in this section of the machine.

6. Most RC 731-1 Types Do Not Require a Current Limit Relay

As *Fig. 1* indicates coasting time of this type is very long compared with other types of controllers. As indication in *Fig, 2*, by making the notch interval long at the beginning and then gradually shortening it, the starting resistance is short-circuited along with the main motor. This entirely new method never used before means that the 75 kw type controller whose standard starting time [t (sec)$=4+2\sqrt{p}$ (kw)] is less than 22 seconds, does not require a current limiting relay and will start smoothly with no trouble.

Most small motors of less than 75 kw do not need a current limiting relay, and they can be used in conjunction with the standard primary switch. Because a current limit relay is not used, there are no difficulties concerning motor acceleration due to installation, and no damage can result because of the starting resistance.

7. Compact and Lightweight

This controller has less than 2/3 the volume and 1/2 the weight of conventional devices.

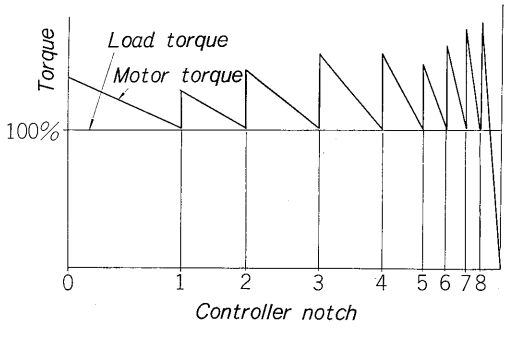


Fig. 2 Relation between controller notch and motor torque

IV. STRUCTURE AND OPERATION

As *Fig. 3* (external view of the starter) and *Fig. 4* (structure) indicate, this device is of the upright-enclosed type. It consists of two sections—one operated by a handle and the other by a switch. The section operated by a handle consists of a manually operated handle, a notch indicator, a reduction gear and a drive motor with permanent braking.

In the switch section, there is a central camshaft which is connected to the handle operated section, an electromagnetic contactor and auxiliary control cam switches, and resistance short-circuiting main cam switches on the left and right of the camshaft. There is also a control circuit terminal assembly, manually operated notching device, etc., a joint terminal assembly, manually operated notching device, etc. A joint terminal to the secondary resistance is installed in the main camswitch.

During operation by the drive motor, the manual-operating handle is kept in the down position and the drive motor is connected to the camshaft via the reduction gear. The geneva gear used with in conjunction with the reduction gear, supplies interrupted rotary motion to the camshaft, increases the closing speed, and holds the notch in the proper position.

During manual operation, the drive motor is cut off by keeping the handle in the up position. When the handle is turned, the cam moves and the cam switch operates.

The notch is positioned by means of a notching device installed on the lower part of the machine. This machine is operated by turning the handle in one direction (0→8), the same process as when the handle is turned from the operating to the starting position.

As is shown is *Fig. 5* (external view of cam switches) the cam switch is a multipurpose type designed for mass production. As mentioned previously, this multipurpose switch consists of a shearing type cam and the contact tip is made of a silver alloy.

Overhaul and assembly are possible with a single screwdriver, and the switch is an independent unit attached by a single bolt.

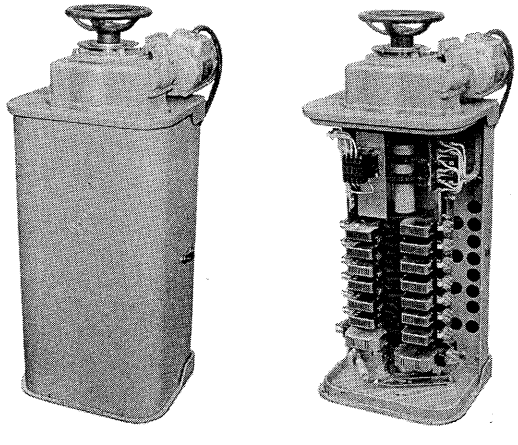
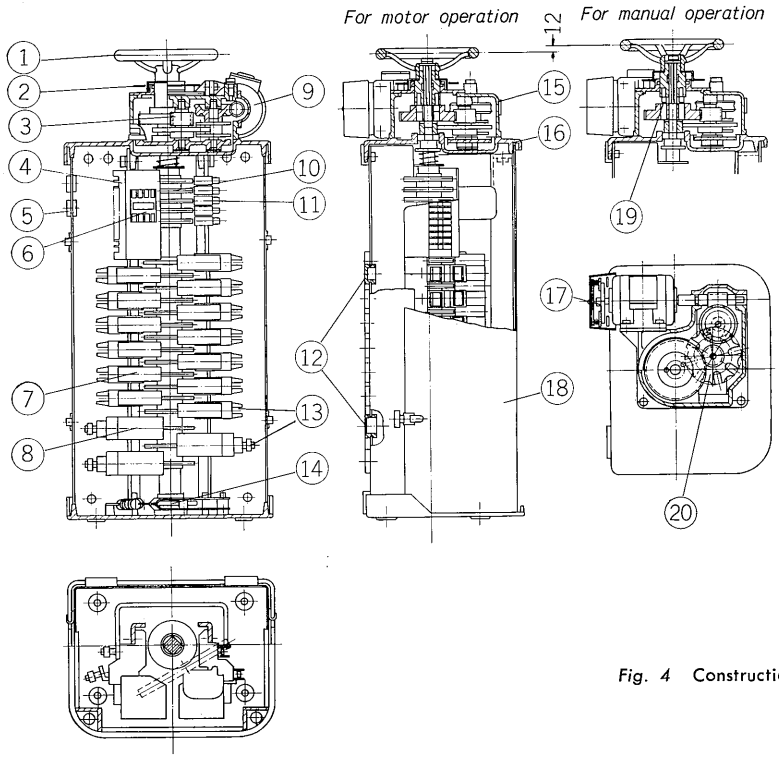


Fig. 3 External view of starter



1. Manually operated handle
2. Notch indicator
3. Reduction gear
4. Control circuit terminal
5. Electric cable bushing for control circuit
6. Electromagnetic contactor for drive motor
7. Cam switch for starting motor
8. Cam switch for running
9. Drive motor
10. Camshaft
11. Auxiliary cam switch for control circuit
12. Electric cable bushing for main circuit
13. Main circuit terminal
14. Notching device
15. Gear casing
16. Frame
17. Permanent braking-type dise brake
18. Cover
19. Clutch
20. Geneva gear

Fig. 4 Construction

The main cam switch (K 7110 series), except for the auxiliary cam switch, has an arc chute.

V. PERFORMANCE

1. Frequency of Operation

Frequency of operation is decided in the secondary in conjunction with the heat rise in the starting resistor used with the controller. When the resistor temperature returns to normal, operation is possible at any time, with no limits.

However, the starting resistor can only be used 3 times in succession with a motor of less than 40 kw and 2 times in succession if the motor is more than 40 kw; within this range it can be used continuously at any time.

2. Durability

The starter has a service life of more than 20,000 times (electrical) and more than 100,000 times (mechanical).

Electrical durability depends on the service life of the connector used when the machine starts operation. Each cam switch has a making capacity as indicated in *Table 3*.

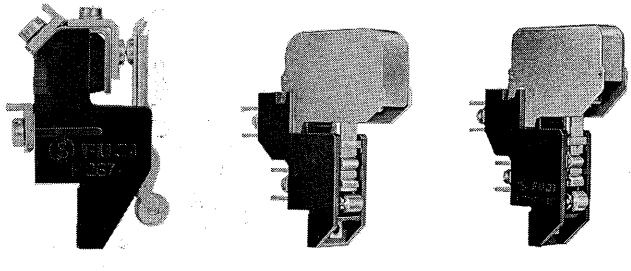


Fig. 5 External view of cam switch

Table 3 **Making Capacity of Cam Switches**

Type	Voltage (v)	Current (amp)
K7110-12S	200	500
K7110-13S	200	1000
K7110-34	4000	2000

VI. CAM SEQUENCE AND CONNECTIONS

Fig. 6 is a cam sequence and wiring diagram, explained in detail in the following.

1. Starting

1) In the RC 731-1 type, a current limit relay is not used; when the controller indicates the "O" notch, the main switch can be operated. By operating the main switch, the main motor shifts the total resistance to the secondary side. It is then connected to the power source and starts operation.

The auxiliary contact ("a" contact) of the main switch is closed and the drive motor starts operation, turning the camshaft. Now all the main cam switches are in the operating position and the main motor is accelerated.

When the conroller indicates the "8" notch, all resistances are short-circuited and the controller starts operation. At the same time the auxiliary contact ("a 3") of the controller is cut off and the