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# NEW SERIES STANDARD INDUCTION MOTOR WITH CLASS E INSULATION


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## I. PREFACE

The demand of the 3-phase induction motor, being widely utilized in the industrial fields, is still expanding due to its solidity and simplicity; and at the same time the customers are requesting that it is to be made smaller and lighter in weight than previously. The possibility of making the motor more compact in size can be realized from the viewpoint of the recent progress being made in both the materials and the techniques for designing and manufacturing. There has been a tendency in recent years to make the 3-phase induction motor smaller because of the adoption of Class E insulation by the JEC standard several years ago.

Taking into consideration the above appearances, several years ago our company proceeded with arrangements for the adoption of Class E insulation and at that time we announced the introduction of the line of small sized motor products in Japan. In this report we will present an outline.

Since we believe that this new Class E standard electric motor, which conforms to the dimensions of IEC standard, will take the place of the general purpose motor in the near future, it is significant to relate the history on the minimization of the electric motor.

## II. HISTORY OF MINIMIZATION OF ELECTRIC MOTOR

The effects to reduce the size and weight of the electric motor are being studied continuously since the induction motor were put on the market at the end of the 19th century. *Fig. 1* shows the tendency of the decreasing dimensions and weight of the induction motor arranged chronologically. Points which come into question when minimizing the motors are the improvement in designing technique, cooling technique, insulation material, core material, progress in construction material, preciseness in manufacturing and appropriateness of charcteristic values.

In the process of development over the last 70 years, it may fairly be said that the progress in the above

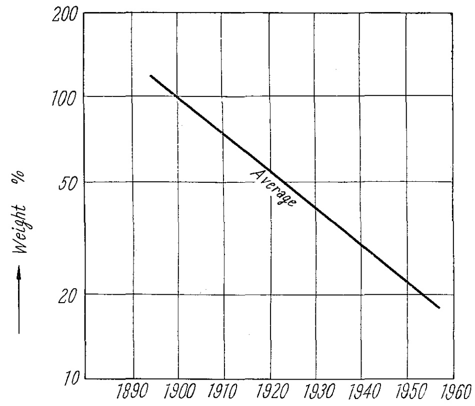



*Fig. 1* Weight of induction motors
(Cage rotor type 1～100 kw, 1500～750 rpm)

areas is attained mixing up those results mutually.

At the outset of the 20th century, each manufacturer changed the model freely according to his own researchers. However, for electric apparatus which is mass produced and is utilized in many industrial fields as the electric motor, it is more profitable for the manufacturer and the customer to adopt a standardizaıion in dimentions. Therefore, efforts for standardization have been in effect in Japan among respective manufacturers since World War II.

Concerning the dimensional standardization, it was thought sometimes to prevent the development of the electric motor but standard dimensions are not changed permanently. Periodically researches express the viewpoint of changing the dimensions along with accumulated results and the comprehension that this cannot prevent its development should be intensified. The period for changing the model is thought to be about every 10 years based on the part showings.

From the viewpoint mentioned above, it is impossible to talk about the recent dimensional minimization without paying heed to the standard dimensions.

In Japan, a dimentional agreement was established for 1/2～15 hp motors on JEM Electric 4202 in 1947 but only a few companies put it into practice due to the confused period after World War II. (Our company's open-type R-6 series was made under this agreement.) In accordance with the entrance of the synthetic resin enameled wire and new insulation materials, our company announced a series of minimized ones compared with the dimensional agreement. (Our company's R-7 series.) In America, the dimentional agreement of NEMA was established in 1929 but new NEMA having extremely minimized standards at that time was published in 1953 to replace the former one. After that our country also established a JEM standard based on this new NEMA in 1956 and the manufacturers in Japan adopted this standard (Present JIS C 4209) and conform to it at the present.

On the other hand, efforts to establish international standardization have been exerted by IEC since 1950 and a report which has NEMA's dimensions as a basis was published in 1954 and then in 1959 it was announced as an IEC recommendation, Pub. 72-1, 72.-2. This standard defines the following:

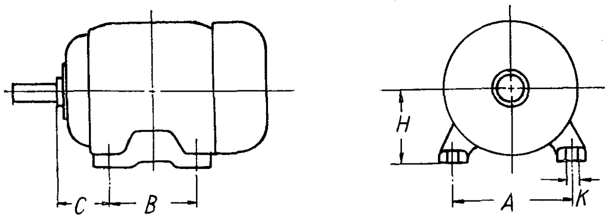
(1) Standard output ratings.
(2) Standard fixing dimensions for frame numbers.
(3) Shaft extension dimensions corresponding to output.

Concerning (1), conventional horsepower has the preference. The standard output ratings are converted to kw and the values of horsepower are stipulated. In (2), as shown in *Table 1*, there are two kinds of length according to the shaft height of 90, 100 mm and three to that of above 112 mm. Each country can select within these three kinds according to the actual conditions, and in addition, relations between frame number and output are left to the actual condition of each country. Regarding (3), the standard value of the shaft dimensions is stipulated and the highest rated torque allowed; each dimensions is also determined.

Based on the above mentioned IEC standard, adding the relation between frame number and output was discussed by each country and at first Germany announced the totally enclosed, external fan, squirrel cage type motor in DIN 42673 in 1960. After that, some European countries disclosed their standards almost similar to DIN standard.

Considering the above, renewal of the standard was discussed in Japan for the minimization based on the IEC dimensions instead of the 7 year old standard for general use motors, and last year we had a provisional plan in relation to frame number and output. *Table 2* shows the comparison of the present JIS standard and the provisional plan based on IEC dimensions for Class E electric motor frame. The reason for the enumeration of JIS dimensions and IEC frame number is that the standard of the IEC

**Table 1 Standard dimensions due to IEC Pub. 72-1**




Dimension in mm

| IEC frame No. | H | A | B | C | K |
|---|---|---|---|---|---|
| 56 | 56 | 90 | 71 | 36 | 6 |
| 63 | 63 | 100 | 80 | 40 | 7 |
| 71 | 71 | 112 | 90 | 45 | 7 |
| 80 | 80 | 125 | 100 | 50 | 9 |
| 90 S<br>L | 90 | 140 | 100<br>125 | 56 | 9 |
| 100 S<br>L | 100 | 160 | 112<br>140 | 63 | 12 |
| S<br>112 M<br>L | 112 | 190 | 114<br>140<br>159 | 70 | 12 |
| S<br>132 M<br>L | 132 | 216 | 140<br>178<br>203 | 89 | 12 |
| S<br>160 M<br>L | 160 | 254 | 178<br>210<br>254 | 103 | 14 |
| S<br>180 M<br>L | 180 | 279 | 203<br>241<br>279 | 121 | 14 |
| S<br>200 M<br>L | 200 | 318 | 228<br>267<br>305 | 133 | 18 |
| S<br>225 M<br>L | 225 | 356 | 286<br>311<br>356 | 149 | 18 |
| S<br>250 M<br>L | 250 | 406 | 311<br>349<br>406 | 168 | 22 |
| S<br>280 M<br>L | 280 | 457 | 368<br>419<br>457 | 190 | 22 |
| S<br>315 M<br>L | 315 | 508 | 406<br>457<br>508 | 216 | 27 |

**Table 2 Output comparison between Class E and Class A motors**

| Frame No. | | 1500/1800 rpm out put (kw) | | Class E/A insul. ratio of output |
|---|---|---|---|---|
| IEC | JIS C 4209 | Class E motor | Class A motor JIS C 4209 | |
| 63 | — | 0.2 | — | — |
| 71 | — | 0.4 | — | — |
| 80 | — | 0.75 | — | — |
| 90 L | — | 1.5 | — | — |
| 100 L | — | 2.2 | — | — |
| 112 M | 1114 | 3.7 | 1.5 | 2.66 |
| 132 S | 1314 | 5.5 | 2.2 | 2.5 |
| 132 M | 1318 | 7.5 | 3.7 | 2.03 |
| 160 M | 1621 | 11 | 5.5 | 2.0 |
| 160 L | 1625 | 15 | 7.5 | 1.72 |

dimensions adopted the new NEMA system and there were no substantial differences in both figures. As you will well understand from this table, minimization is remarkable with the scope of small output—output reached almost 2～3 times with the same size. The Class E electric motor series which is introduced now for the first time in Japan by our company is manufactured entirely based on IEC standards, therefore, these are the forerunners which will be for general use especially on the machinetool that necessitates small size and light weight.

## III. ADOPTION OF CLASS E INSULATION STANDARD

As mentioned above, Class E insulation was regulated by JEC in 1960 but it was put into effect considerably earlier. The typical material for insulation is polyethylen terephthalete film and for wire, polyester enameled magnet wire. These were put on the market in 1955 in Japan. Our company utilized these materials from that time for such small size motors to be used for the machine-tool, flat motor and special electric motor. To manufacture the motor of Class E insulation, it is necessary to use grease having high heat-proof nature for bearing. Grease of the lithium group which uses lithium soap as a base is a competent material. This bears the high temperature rise of 55°C, which is higher than 40°C, the limit of soda or calcium soap base grease. We have had the experience of using this grease for over five years.

## IV. PROBLEMS OF CLASS E ELECTRIC MOTOR

The first point which comes into question when promoting the adoption of the minimization of dimensions is the electric source cycle. In Europe and the American Continent, there is only one cycle but in Japan we have two kinds, 50 and 60 cycles and therefore, the motors for general use must have both cycles in common. Namely, worse characteristics at 50 cycles running (especially in the power factor and the temperature-rise) must be recovered in anticipation of the torque characteristics at 60 cycles. Due to these reasons it is necessary to make the motor able to withstand the considerable overloading in contrast to the motor which uses the simple cycle as in other countries.

Secondary, motor characteristics are hardly regulated in Europe and American Continent but in Japan motor efficiency, power factor, stating current, etc., are defined in JIS standard resulting in better characteristics than the motor in other countries.

Next is the problem of the temperature-rise. The general purpose motor has had Class A insulation (maximum tolerable temperature, 105°C; maximum limit of rising temperature as a motor, 60°C), but for the small output motor it has been considerably lower than the defined value. This comes from the vestiges of the past age having a sense of uneasiness for high temperature due to paper, silk, cotton, etc., of the winding insulation. At present, as mentioned above, high heat-proof materials are employed so the conventional base of judgment must be changed for Class E insulated motor.

## V. CONTENTS AND CHARACTERISTICS OF CLASS E MOTOR

### 1. Dimensions and Output Application

As mentioned above, our Class E electric motor is manufactured based on IEC dimensions and at first we are supplying 4-pole, 200 w to 15 kw motors for the primary stage. However, our company now has completed the design of the totally enclosed fan-cooled type motors for the frames corresponding to the output up to 30 kw 2-pole, 4-pole, 6-pole, 8-pole, and flange type motor and we are beginning to manufacture.

*Table 3* shows our standard design for the application of output to the totally enclosed, fan-cooled type motors.

*Table 3* **Frame number and output**

| IEC frame No. | FUJI frame No. | JEM frame No. (Class A motor) | Out put (kw) | | | |
|---|---|---|---|---|---|---|
| | | | 3000/3600 rpm | 1500/1800 rpm | 1000/1200 rpm | 750/900 rpm |
| 63 | 61 L | — | 0.2 | 0.2 | — | — |
| 71 | 71 L | — | 0.4 | 0.4 | 0.2 | — |
| 80 | 81 L | — | 0.75 | 0.75 | 0.4 | 0.2 |
| 90 | 91 L | — | 2.2 | 1.5 | 1.1 | 0.4 |
| 100 | 112 | — | — | 2.2 | 1.5 | 0.75 |
| 112 | 312 | 1114 | 3.7 | 3.7 | 2.2 | 1.5 |
| 132 S | 411 | 1314 | 5.5 | 5.5 | 3.7 | 2.2 |
| 132 M | 412 | 1318 | 7.5 | 7.5 | 5.5 | 3.7 |
| 160 M | 611 | 1621 | 11 | 11 | 7.5 | 5.5 |
| 160 L | 612 | 1625 | 15 | 15 | 11 | 7.5 |
| 180 M | 811 | 1824 | 19 | 19 | 13 | 9 |
| 180 L | 812 | 1828 | 22 | 22 | 15 | 11 |
| 200 L | 1012 | 2031 | 30 | 30 | 19 | 15 |

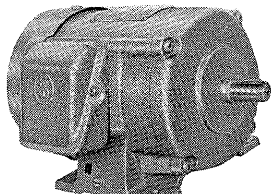


*Fig. 2* New standard induction motor with Class E insulation (0.4 kw 1500/1800 rpm)

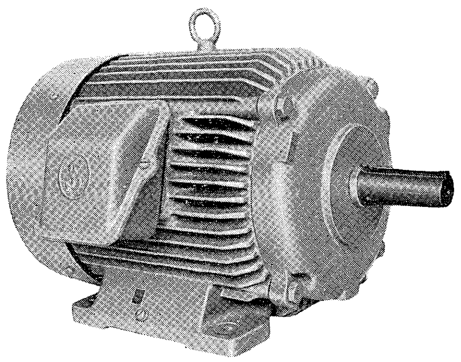


*Fig. 3* New standard induction motor with Class E insulation (7.5 kw 1500/1800 rpm)

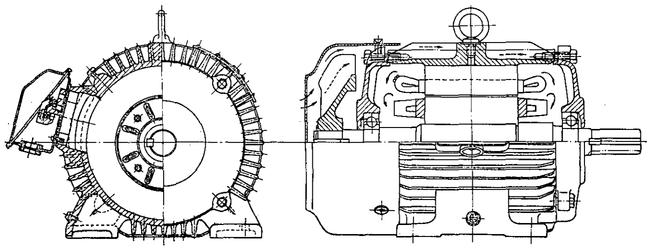


*Fig. 4* Section drawing

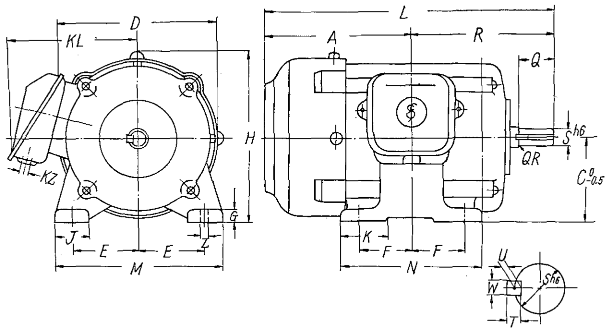



*Fig. 5* Outline dimensions (Frame No. 61 L∼71 L)

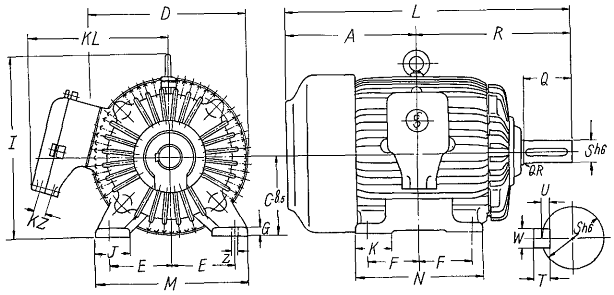



*Fig. 6* Outline dimensions (Frame No. 81 L∼1012)

**Dimension table for *Fig. 5***

Dimension in mm

| FUJI frame No. | IEC frame No. | A | C | D | E | F | G | H | J | K | KL | KZ | L | M | N | R | Z | Q | QR | S | T | U | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 L | 63 | 110 | 63 | 124 | 50 | 40 | 6 | 125 | 30 | 37 | 102 | 15 | 213 | 130 | 110 | 103 | 7.2 | 23 | 0.5 | 11 | 4 | 2.5 | 4 |
| 71 L | 71 | 123 | 71 | 139 | 56 | 45 | 8 | 141 | 30 | 40 | 110 | 15 | 243 | 142 | 120 | 120 | 7.2 | 30 | 0.5 | 14 | 5 | 3 | 5 |

**Dimension table for *Fig. 6***

Dimension in mm

| FUJI frame No. | IEC frame No. | A | C | D | E | F | G | I | J | K | KL | KZ | L | M | N | R | Z | Q | QR | S | T | U | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 L | 80 | 146 | 80 | 164 | 62.5 | 50 | 12 | — | 45 | 40 | 140 | 20 | 286 | 155 | 135 | 140 | 9.5 | 40 | — | 19 | 5 | 3 | 5 |
| 91 L | 90 L | 165 | 90 | 174 | 70 | 62.5 | 13 | — | 50 | 40 | 155 | 20 | 333.5 | 180 | 155 | 168.5 | 9.5 | 50 | — | 24 | 7 | 4 | 7 |
| 112 | 100 L | 174 | 100 | 194 | 80 | 70 | 14 | 230 | 50 | 45 | 167 | 20 | 357 | 200 | 170 | 183 | 11 | 50 | — | 24 | 7 | 4 | 7 |
| 312 | 112M | 194 | 112 | 236 | 95 | 70 | 15 | 271 | 60 | 50 | 185 | 20 | 394 | 230 | 175 | 200 | 11 | 60 | 0.5 | 28 | 7 | 4 | 7 |
| 411 | 132 S | 210 | 132 | 260 | 108 | 70 | 17 | 302 | 64 | 54 | 210 | 26 | 449 | 256 | 180 | 239 | 11 | 80 | 1.5 | 32 | 8 | 4.5 | 10 |
| 412 | 132M | 230 | 132 | 260 | 108 | 89 | 17 | 302 | 64 | 54 | 210 | 26 | 488 | 256 | 218 | 258 | 11 | 80 | 1.5 | 32 | 8 | 4.5 | 10 |
| 611 | 160M | 286 | 160 | 307 | 127 | 105 | 20 | 359 | 70 | 65 | 250 | 40 | 609 | 306 | 256 | 323 | 15 | 110 | 1 | 42 | 8 | 4.5 | 12 |
| 612 | 160 L | 310 | 160 | 307 | 127 | 127 | 20 | 359 | 70 | 65 | 250 | 40 | 655 | 306 | 300 | 345 | 15 | 110 | 1 | 42 | 8 | 4.5 | 12 |
| 811 | 180M | 301 | 180 | 350 | 139.5 | 120.5 | 22 | 412 | 80 | 83 | 275 | 40 | 652.5 | 350 | 292 | 351.5 | 15 | 110 | 1.5 | 48 | 8 | 4.5 | 12 |
| 812 | 180 L | 320 | 180 | 350 | 139.5 | 139.5 | 22 | 412 | 80 | 83 | 275 | 40 | 690.5 | 350 | 330 | 370.5 | 15 | 110 | 1.5 | 48 | 8 | 4.5 | 12 |
| 1012 | 200 L | 390 | 200 | 385 | 159 | 152.5 | 25 | 450 | 80 | 85 | 340 | 40 | 785.5 | 390 | 360 | 395.5 | 19 | 110 | 2 | 55 | 10 | 5 | 15 |

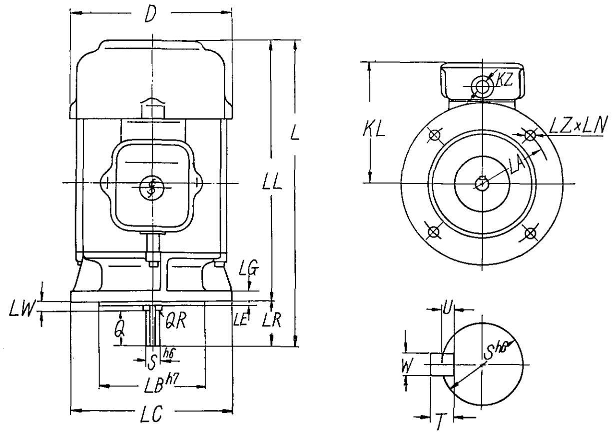



*Fig. 7* Outline dimensions of flange type motor (Frame No. 61 L～71 L)

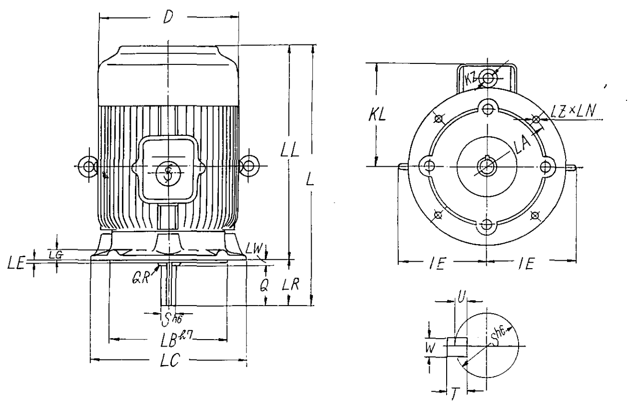



*Fig. 8* Outline dimensions of flange type motor (Frame No. 81 L～1012)

**Dimension Table for *Fig. 7***

Dimension in mm

| FUJI frame No. | D | L | KL | KZ | LA | LB | LC | LE | LG | LL | LN | LR | LW | LZ | Q | QR | S | T | U | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 L | 125 | 236 | 95 | 15 | 115 | 95 | 140 | 3 | 10 | 205 | 4 | 31 | 8 | 9.5 | 23 | 0.5 | 11 | 4 | 2.5 | 4 |
| 71 L | 145 | 268 | 100 | 15 | 130 | 110 | 160 | 3.5 | 10 | 230 | 4 | 38 | 8 | 9.5 | 30 | 0.5 | 14 | 5 | 3 | 5 |

**Dimension table for *Fig. 8***

Dimension in mm

| FUJI frame No. | D | IE | L | KL | KZ | LA | LB | LC | LE | LG | LL | LR | LW | LZ | LN | Q | QR | S | T | U | W |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 81 L | 165 | — | 315 | 127 | 20 | 165 | 130 | 200 | 3.5 | 12 | 267 | 48 | 8 | 11 | 4 | 40 | — | 19 | 5 | 3 | 5 |
| 91 L | 175 | — | 348 | 135 | | 165 | 130 | 200 | 3.5 | 12 | 290 | 58 | 8 | 11 | 4 | 50 | — | 24 | 7 | 4 | 7 |
| 112 | 195 | 115 | 365 | 155 | 20 | 215 | 180 | 250 | 4 | 16 | 307 | 58 | 8 | 15 | 4 | 50 | — | 24 | 7 | 4 | 7 |
| 312 | 236 | 120 | 412 | 175 | | 215 | 180 | 250 | 4 | 16 | 344 | 68 | 8 | 15 | 4 | 60 | 0.5 | 28 | 7 | 4 | 7 |
| 411 | 260 | 170 | 457 | 200 | 26 | 265 | 230 | 300 | 4 | 20 | 368 | 88 | 8 | 15 | 4 | 80 | 1.5 | 32 | 8 | 4.5 | 10 |
| 412 | 260 | 170 | 495 | 200 | | 265 | 230 | 300 | 4 | 20 | 407 | 88 | 8 | 15 | 4 | 80 | 1.5 | 32 | 8 | 4.5 | 10 |
| 611 | 310 | 200 | 617 | 230 | 40 | 300 | 250 | 350 | 5 | 20 | 499 | 118 | 8 | 19 | 4 | 110 | 1 | 42 | 8 | 4.5 | 12 |
| 612 | 310 | 200 | 663 | 230 | 40 | 300 | 250 | 350 | 5 | 20 | 545 | 118 | 8 | 19 | 4 | 110 | 1 | 42 | 8 | 4.5 | 12 |
| 811 | 350 | 232 | 661 | 255 | 40 | 300 | 250 | 350 | 5 | 20 | 543 | 118 | 8 | 19 | 4 | 110 | 1.5 | 48 | 8 | 4.5 | 12 |
| 812 | 350 | 232 | 700 | 255 | 40 | 300 | 250 | 350 | 5 | 20 | 582 | 118 | 8 | 19 | 4 | 110 | 1.5 | 48 | 8 | 4.5 | 12 |
| 1012 | 385 | 250 | 794 | 310 | 40 | 350 | 300 | 400 | 5 | 20 | 676 | 118 | 8 | 19 | 4 | 110 | 2 | 55 | 10 | 5 | 15 |

## 2. Construction

*Figs. 2* and *3* show the apperance of the motor and *Fig. 4* illustrates a section of it.

To produce an efficient cooling effect against the drastic minimization of the motor size, numbers of the cooling rib on the frame are increased instead of decreasing their height motors in order to give them sufficient radiation surface. Also cast iron is used for the frame and the braket to increase their mechanical strength. The bearing shield is made as one body with a part of the bearing end cover, therefore, the construction of the bearing part is very simple and the breakdown and assemblage are easily operated.

Polypropylene resin is used for the external cooling fan under the type of 81 L (4-pole, 750w) and for the larger type aluminum alloy is utilized, the surface of which is very smooth and has small air-resistance.

This in turn means smooth ventilation and light weight which are compensations for the vibration during operation. The fan cover has been determined after many experiments against ventilation noise and sufficient effect for ventilation, and since the air entrance part has ample distance to the fan blade and it is protruded by the deep wringing, and in addition, the exhaust part is over-spread to the rib part around the frame to exhibit the guide effect of the fan cover. As a result of this, sufficient ventilation can be obtained with a small diameter compared with the conventional fan and the fan cools many radiation ribs on the frame effectively. The rotor conductor is made of aluminum dicast and the interior fan is also case at the same time which stirs inside air for effective radiation action and plans to average the temperature-rise.

The totally sealed ball bearing which our company adopted first in Japan, is used with lithium grease having high heat-proof characteristics, therefore, a grease change is not necessary and the maintenance is very easy.

The terminal box is installed in the middle part of the frame in a slanted position with ample clearance from the floor level so as to facilitate the wiring operation and the terminal position can be changed according to the frame interchange. Moreover, the external lead wire part is also changeable to the light or left of the box.

The construction of the terminal box consist of a wringed steel plate for the type number 412 and synthetic rubber packing is used between the box and lead. Bushing is provided for the lead wire to protect it. The terminal stand is made of mould and employs a unique inserting and tightening system using the special type washer of our company, thus special end treatment for tne external lead wire is not necessary. Above the type 611 has a cast iron one and can be clamped on the external lead wire.

Windings for the stator of Class E insulation are worked with the newest material according to the kind of insulation. As for the characteristics, much consideration is given to the aforementioned 50～60 cycles and many experiments are conducted with the starting torque and then is determined the number of slots, therefore, starting, maximum and accelerating torques are equivalent or above the characteristics of conventional motors. The types and dimentions of foot-mounted and flange-mounted motors are shown in *Figs. 5～8*, and the dimensions for the flange-mounted motor are made in due to IEC Pub. 72–2.

### 3. Characteristics

Our company's Class E electric motor having the properties mentioned above is especially minimized compared with the conventional and other companies' produdts, thus various characteristics are listed spontaneously. The following is a list of these characteristics :

1) Compact and light weight

As mentioned above the properties are almost the same as those regulated in DIN, and output is double that of the present electric motor for general use. Dimensions are minimized 2～3 types. As shown in *Fig. 9*, by comparing the motor have the same output and weight volume ratio [(height of axial center)$^2$ × motor length] it is approximately 50% at under 7.5 kw, approximately 70% at around 15 kw. The weight is 55～85%. These figures will prove applicable for all purposes which require compact size and light weight.

2) Small inertia

Inertia of the rotor is naturally small due to the minimized size and light weight so from this phase acceleration and deceleration characteristics are extremely advantageous. When comparing the $GD^2$ of the rotor with that of the conventional motor having the same output it becomes 40～75% as shown in *Fig.*

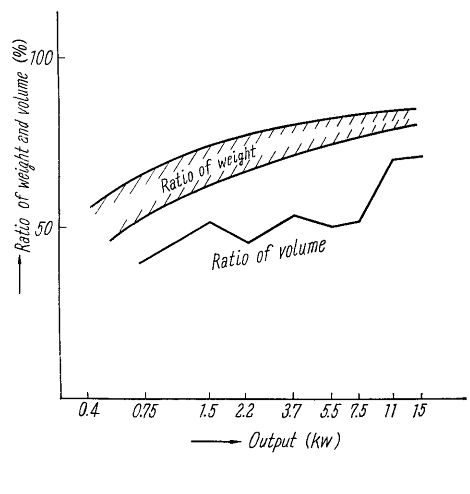



*Fig. 9* Comparison between Class E and A motor (Weight and volume)

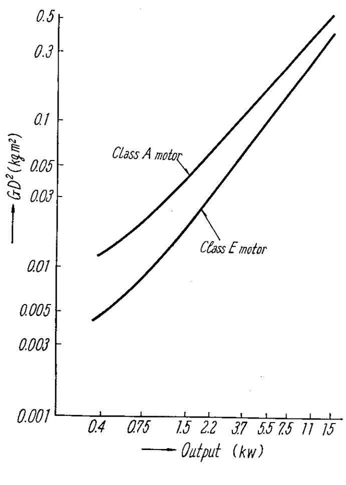
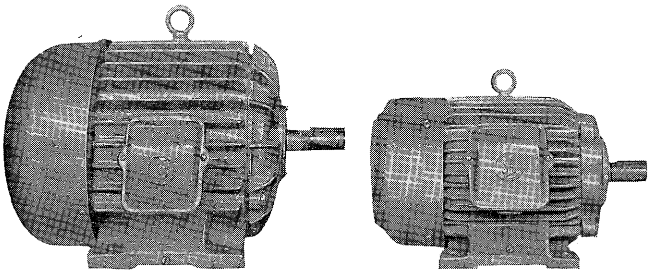



*Fig. 10* Comparison of $GD^2$ between Class E and A motor

*10*, therefore, this is chiefly for cases which necessitate acute acceleration or deceleration or frequent starting, stopping or reversing.

3) Little vibration and noise

Effective cooling ventilation above the conventional motor must be carried out for the minimized one. Namely, sufficient consideration is necessary in order not to reduce the cooling surface. As shown in *Fig. 11*, as the cooling ribs on the frame are increased compared with the conventional motor, the frame has a higher rigidity than the ordinary one and the vibration-proof capacity is increased. Due to the minimized rotation parts such as the rotor and cooling fan, it is adventageous for the eccentricity of the rotation center of gravity; moreover, the precision of the manufacturing process for each part results in lessening of vibration and the small diameter of the cooling fan reduces the noise. Noise level of the Class E motor is lower 3～4 phone than the ordinary motor value.



(A Class) (E Class)

*Fig. 11* Comparison between Class E and A motor (2.2 kw 1500 rpm)

## VI. PURPOSE OF CLASS E ELECTRIC MOTOR

Since the Class E electric motor is designed for general use it can be used in all industrial fields just as the conventional motor has been used. Furthermore, due to its reduced size it is possible to install it in a narrow space. In case the machine to be driven has a surplus capacity the motor can be replaced with the conventional motor by which the increase in output is produced which in turn results in the efficient utilization of the existing machine. Installation is very easy due to its light weight, and in addition, energy and time are saved when accelerating or decelerating the motor due to its small inertia. Thus it is suitable for machine tools which necessitate frequent starting, stopping or reverse rotation.

This motor can be designed to increase the rated output for the purpose of intermittent driving or short time rotation and in this case the completely small size will be used.

## VII. CONCLUSION

Ours was the first company in Japan to put the Class E insulation minimized motor based on the IEC international standard on the market. Our motor has excellent torque characteristics due to the cycle adoption for 50 and 60 cycles, thus this motor can bear the fluctuation of voltage and also has excellent efficiency and power factor. It also has various characteristics which contribute to easy handling and maintenance. These, then, are the reasons why this motor is received with open arms by various countries in the world.