

High-speed ac motor including the function of a magnetic frequency tripler

メタデータ	言語: English 出版者: 公開日: 2017-10-03 キーワード (Ja): キーワード (En): 作成者: Yamada, Sotoshi, Takeuchi, A., Sudani, T., Bessho, Kazuo メールアドレス: 所属:
URL	http://hdl.handle.net/2297/48290

HIGH-SPEED AC MOTOR INCLUDING THE FUNCTION OF A MAGNETIC FREQUENCY TRIPLER

S. Yamada, A. Takeuchi, T. Sudani*, K. Bessho
 Electrical Energy Conversion Laboratory,
 Faculty of Technology, Kanazawa University,
 Kodatsuno 2-40-20, Kanazawa 920, Japan.
 * Kanazawa Technical College,
 Ogigaoka 7-1, Nonoichi, Kanazawa, 921, Japan.

The new electric motor is the magnetic combination of a magnetic frequency multiplier and a AC motor which share the common magnetic yoke. The motor operates near the synchronous speed (10,800 rpm) by applied the single-phase commercial source at 60 Hz. The new machine is called "high-speed hybrid AC motor" because the combination of a motor and a frequency converter. This paper describes the structure and the operating characteristics of the new motor.

INTRODUCTION

The authors have developed the magnetic three times frequency multiplier (frequency tripler) with series-connected reactor circuit and the 3-legged core type tripler is suited to operate an electric motor at a high speed.^{1,2} Since both the magnetic tripler and the motor have each magnetic circuit, the magnetic combination can simplify the structure. We call it "hybrid motor". In this paper we present the characteristics of the hybrid single-phase induction motor and the outline of the advanced two-phase type motor is described.

STRUCTURE OF A HIGH-SPEED INDUCTION MOTOR

The magnetic structure of the high-speed hybrid induction motor consists of a 3-legged core as shown in Fig.1.³ One of the limbs is a salient pole in which a cage rotor is installed. The poles have shading coils. The capacitor C₂ are connected to the winding N_c at the output limb. The circuit enhances the third harmonic component and reduces the fundamental component and other harmonics. The left-hand limb with a gap (L) acts as a linear reactor and the right-hand limb with small section (SR) as a saturable reactor. Two limbs have the windings N_L and N_{SR} which are connected in opposite-series. The circuit (L₁, C₁) in the input side reduces the distortion of an input current and improve the power factor.

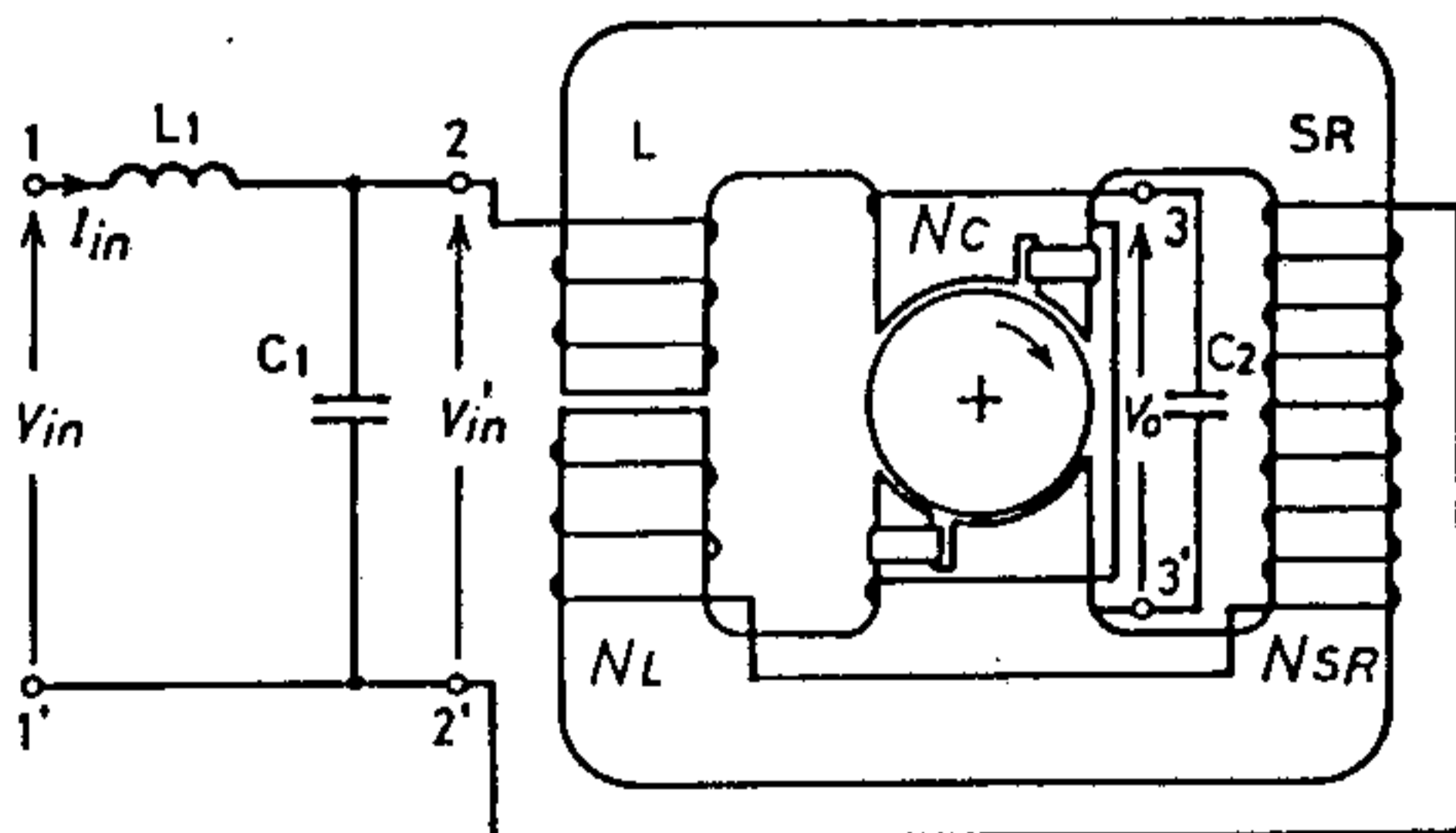


Fig.1 High-speed single-phase induction motor

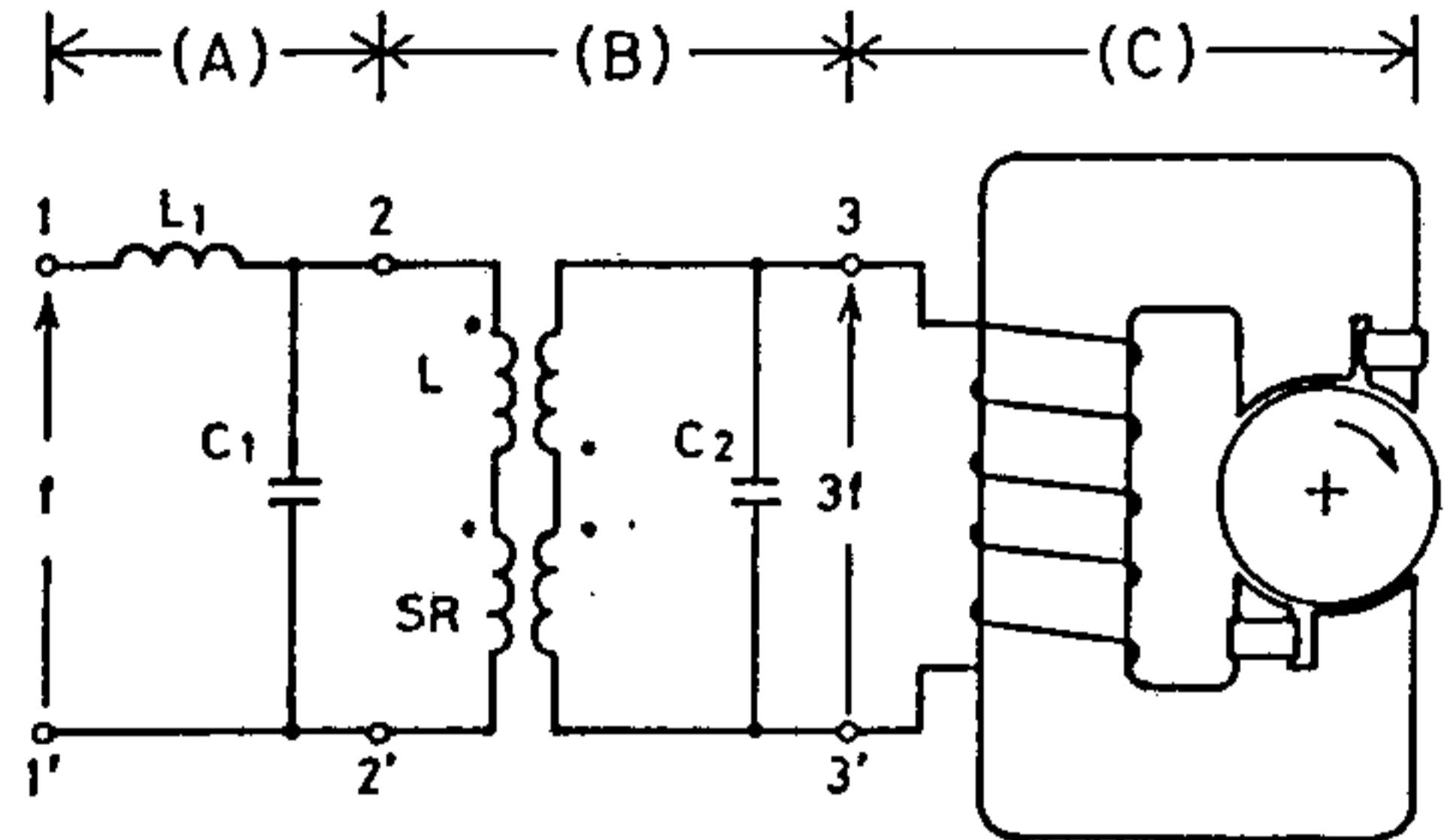


Fig.2 Equivalent circuit

FUNDAMENTAL CHARACTERISTICS

The simplified equivalent circuit of the hybrid induction motor in Fig.1 is illustrated in Fig.2. The circuit consists of three parts. The part (A) is a filter circuit, the part (B) a three-times frequency and the part (C) a single-phase induction motor. In the part (B), a linear reactor and a saturated reactor are connected in series and the secondary windings in opposite-series. We call the circuit "series-connected reactor circuit".

The basic frequency conversion of a series-connected reactor circuit can be explained by approximating the characteristics of linear and saturated reactors as shown in Fig.3(a). When a sinusoidal voltage with the rms value V_{in} and the angular frequency ω is applied, waveforms in the circuit are shown in Fig.3(b). The saturated reactor SR is saturated over the flux linkage λ_k for the periods θ_{sl} < ωt < π - θ_{sl} and π + θ_{sl} < ωt < 2π - θ_{sl}. As the waveform s₁ of the s₁ secondary s₁ voltage is represented by the Fourier series, the rms value of the fundamental and (2n+1) order harmonics are expressed as

$$V_o(f) = \frac{1}{\pi} \left\{ \frac{2}{\alpha+1} (2\theta_{sl} - \sin 2\theta_{sl}) - \pi \right\} \cdot V_{in} \quad \dots(1)$$

$$V_o(2n+1)f = \frac{2}{\pi(\alpha+1)} \left\{ \frac{\sin 2\theta_{sl}}{n} - \frac{\sin 2(n+1)\theta_{sl}}{n+1} \right\} \cdot V_{in} \quad \dots(2)$$

where the phase angle θ_{sl} is given as,

$$\theta_{sl} = \cos^{-1} \left(\frac{\omega \lambda_k}{\sqrt{2} V_{in}} \right) \quad \dots(3)$$

Equation (1) indicates that the fundamental component vanishes in the condition as,

$$\frac{2}{\alpha+1} (2\theta_{sl} - \sin 2\theta_{sl}) = \pi \quad \dots(4)$$

Then the output voltage has the odd-order harmonics including the three times frequency voltage as a prime component. Figure 4 is obtained by using Eqs.(1) and (2). The torque of the hybrid motor is calculated by the sum of torque which each harmonic component generates.

Torque-slip characteristics

Figure 7 shows the torque-slip characteristics of the single-phase induction motor. The torque-slip curve is similar to that of the conventional single-phase induction motor. But the negative torque of the fundamental component affects the torque-slip curve at 4,000 rpm and the crawling effect can be observed. The efficiency of the motor was 7.2 % as a rotational speed is 9,000 rpm.

OUTLINE OF TWO-PHASE INDUCTION MOTOR

The single-phase induction motor has unavoidable defects, starting torque and efficiency. In order to remove these defects, we propose the rotating-field type hybrid motor.

Figure 8 shows the three-phase to two-phase magnetic frequency tripler circuit. In the figure, two triplers shown in Fig.2 are connected in Scott-connection. Therefore an input voltages at each tripler is shifted at 90 degree. The three-times output voltages have the phase difference of 270 degree.

Two-phase hybrid induction motor is illustrated in Fig.9. Each pole has the magnetic frequency tripler and the third harmonic flux flows through the rotor and the yoke.

CONCLUSION

The new high-speed motor with the combination of a magnetic frequency tripler and an AC motor have been proposed. The structure of motor is simple and does not need the semiconductor device. The principle of operation have been reported briefly. And it has been indicate that the characteristics include the function both of a magnetic frequency tripler and of an AC motor.

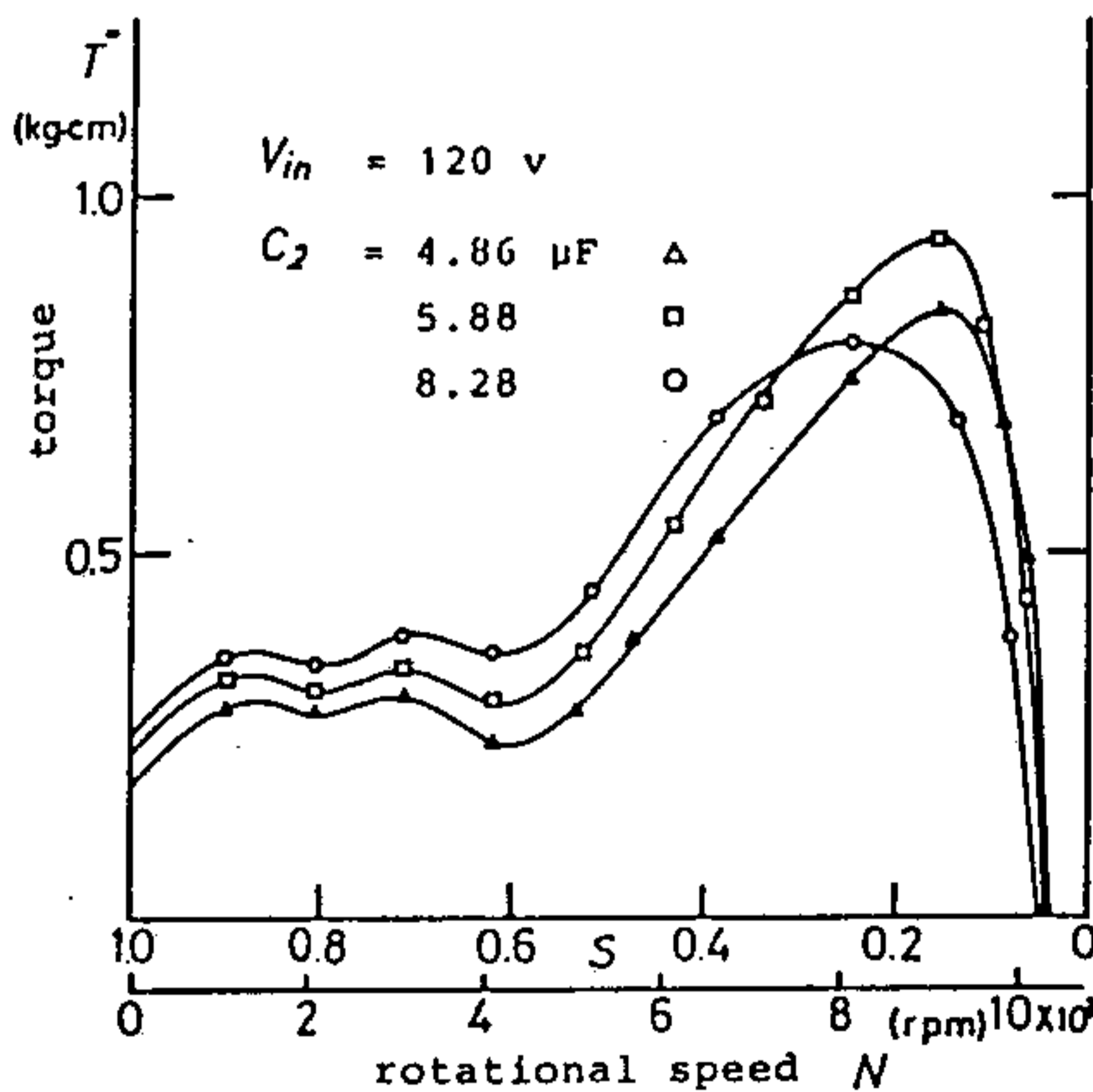


Fig.7 Torque-slip curve

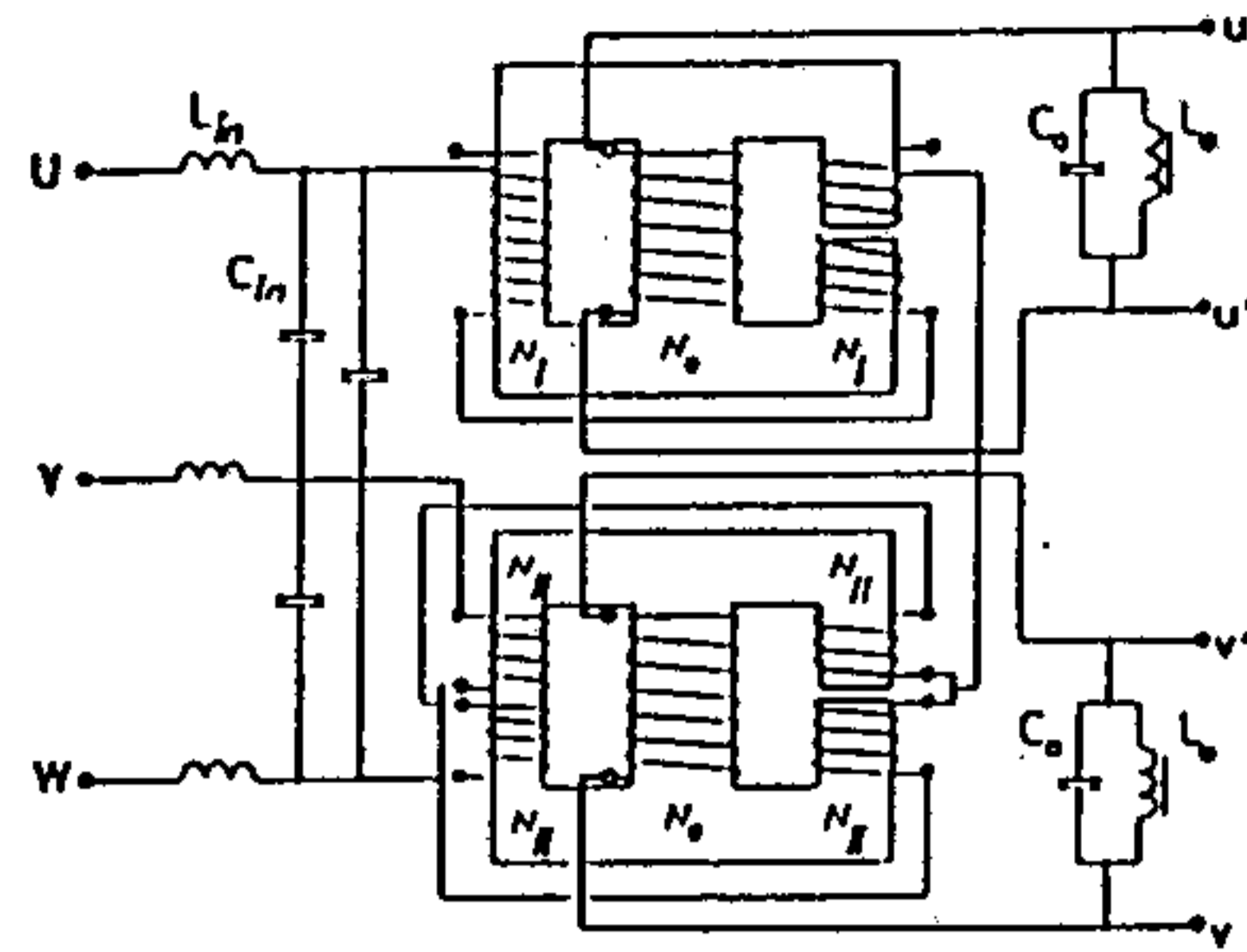
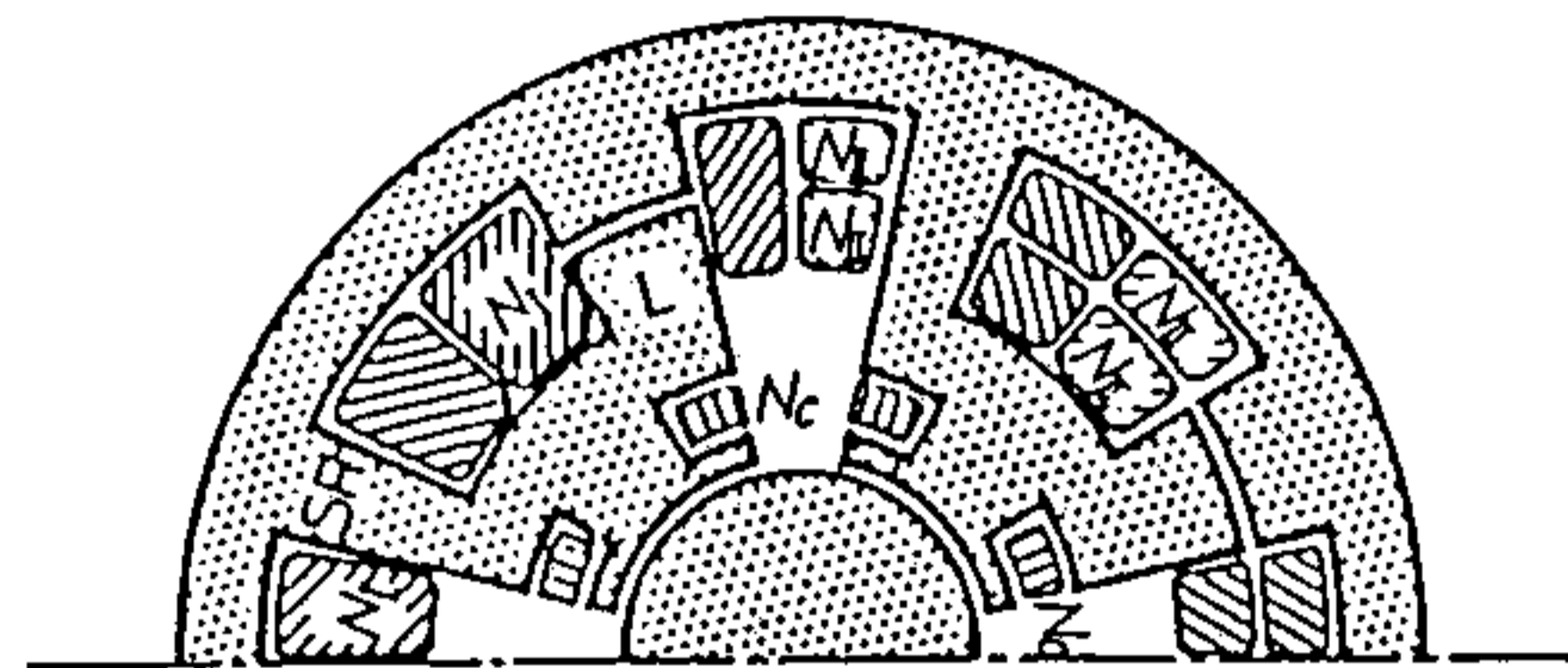
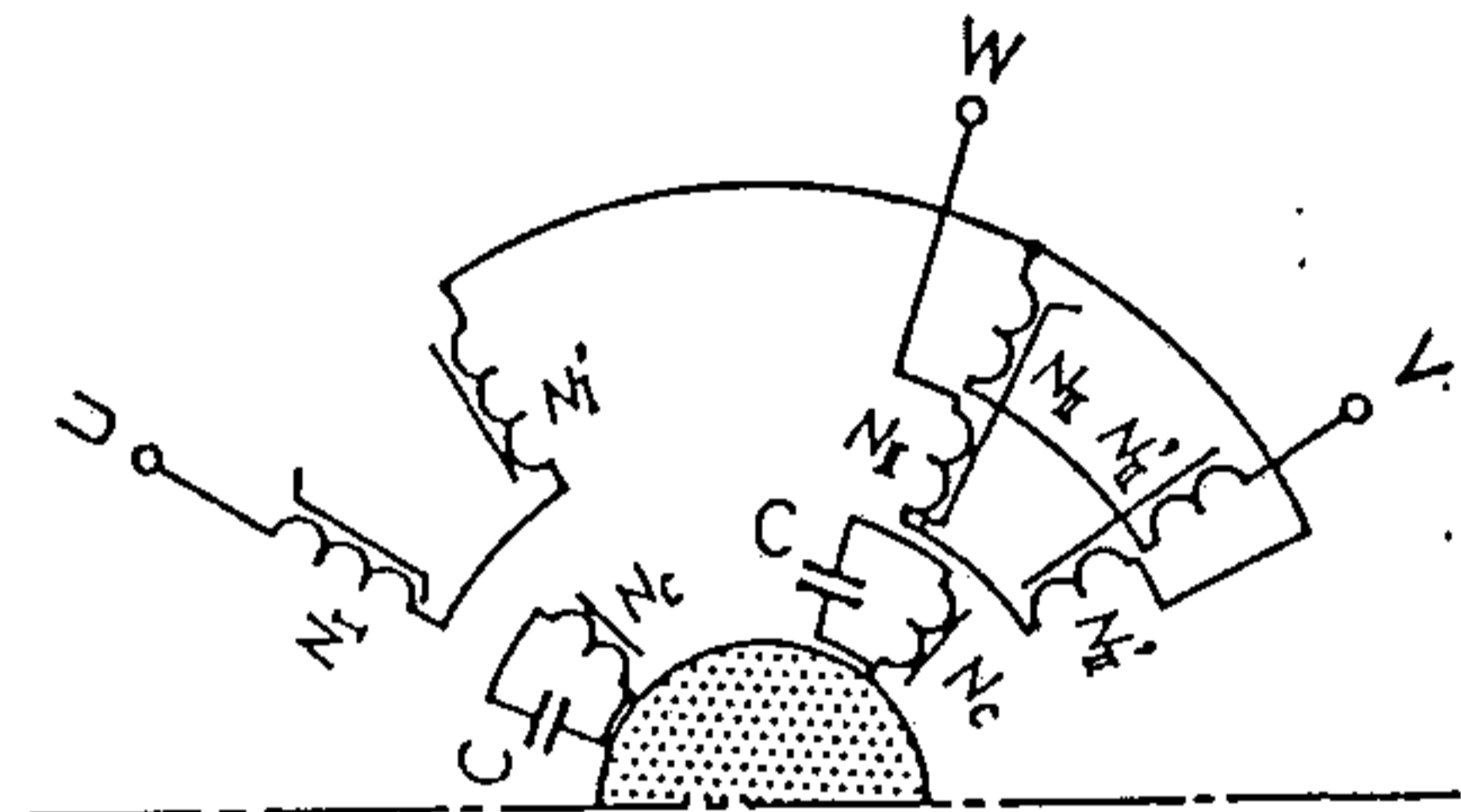


Fig.8 Two-phase frequency tripler



(a) Cross section



(b) Connection

Fig.9 Two-phase hybrid induction motor

REFERENCES

- [1] K.Bessho, S.Yamada, T.Sudani, Y.Kanamaru; "Some experiments and considerations on the behavior of a new magnetic frequency tripler with bridge connected reactor circuit", IEEE Trans. Magnetics, Vol.MAG-12, No.6, p829, '76.
- [2] K.Bessho, S.Yamada; "Delta connection type frequency tripler using series-connected reactor circuit", JIEE, Vol.B-100, No.3, p169, '79.
- [3] K.Bessho, S.Yamada; "High-speed hybrid ac motor", JIEE, Vol.104-B, No.12, '84.
- [4] A.Nafalski, K.Bessho, S.Yamada, T.Sudani; "Performance and analysis of an advanced type magnetic frequency tripler with three-legged cores", IEEE Trans. Magnetics, Vol.MAG-18, No.6, '82.