THESIS

SLIP METER

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SLIP METER.

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INTRODUCTION.

It is frequently desirable to obtain the slip of an induction motor to a greater degree of accuracy than can be obtained by the comparison of two speed indicators. The slip of an induction motor is the difference between load speed and synchronous speed as a decimal of synchronous speed.

When Syn. r.p.m. = $\frac{120f}{p}$

It is necessary to obtain the slip accurately in order to show the true performance of an induction motor.

The following discussion will show why two speed indicators are very inaccurate. If the speed of a motor is taken with an ordinary speed counter, an error of one-half of one percent is not unusual. With a machine operating at 900 r.p.m. this would mean an error of 4.5 r.p.m. Expressed in terms of slip, this error would become 10% and usually the error would be greater. Tachometers, especially the hand type, if constructed for any great range, are difficult to read and usually unreliable for precision work. Therefore, it may be seen that some special method is required to obtain the slip accurately.

AVAILABLE METHODS.

After making a study of references and devising many methods for measuring slip, the one presented in this paper was chosen.

Methods Reviewed:

1. Various stroboscopic methods.
2. Devices imploying a vibrating reed.
3. An escapement wheel which counts the cycles slip.
4. Wound rotor induction motor with voltmeter attached to field windings the generated voltage indicating the slip.
5. Cone and a disc with an arc light to indicate synchronous speed.
6. Two similar shunt D. C. machines one on a synchronous motor the other on the motor in question, with their voltages bucking each other, any difference in voltages indicating slip.
7. Two series D. C. machines arranged as in (6), but the voltage of the one indicating the syn.r.p.m. and the voltage of the other indicating the motor r.p.m.

DIFFICULTIES ENCOUNTERED IN AVAILABLE METHODS.

Any method which depends on the human element to count the slip or any which must be read over a period of time will have inacuracy of time, or if the slip is too great it cannot be counted accurately. Therefore, the following methods are eliminated 1, 2, 3, and 5. No. 4 is not accurate because the wave form of the impressed voltage would effect the voltmeter readings. Where relative high speeds are used, the differences of which indicate a relatively small slip the results are inherently inaccurate because a small error on a large number when shifted to the small one causes a much larger error. Hence 6 and 7 are eliminated. Compact devices have been placed on the market by means of which the slip can be measured. One device consists of a rotating commutator having the same number of segments as the motor has poles. This commutator is pressed against the end of the motor shaft and thus rotates at the same speed. An ammeter is connected in series with the commutator and a resistor to one phase of the power supply. As the rotor lags behind the revolving field the pointer of the ammeter oscillates at a frequency proportional to the slip. This again depends upon time and a person to count the oscillations. Another slip meter consists of a conical cylinder which rotates with the shaft of the motor in question and at the

same speed. On an axis parallel to the conical cylinder and pressing against it is a wheel of the same diameter or slightly larger than the small end of the cylinder. This wheel carries a rotating commutator as described above. The connections are as above described. In operation the speed of the wheel is increased by moving it towards the large end of the cylinder until the ammeter ceases to oscillate. The distance that it has been moved is graduated directly in terms of slip. This last method seems to be the most likely and is the one adopted with slight variations.

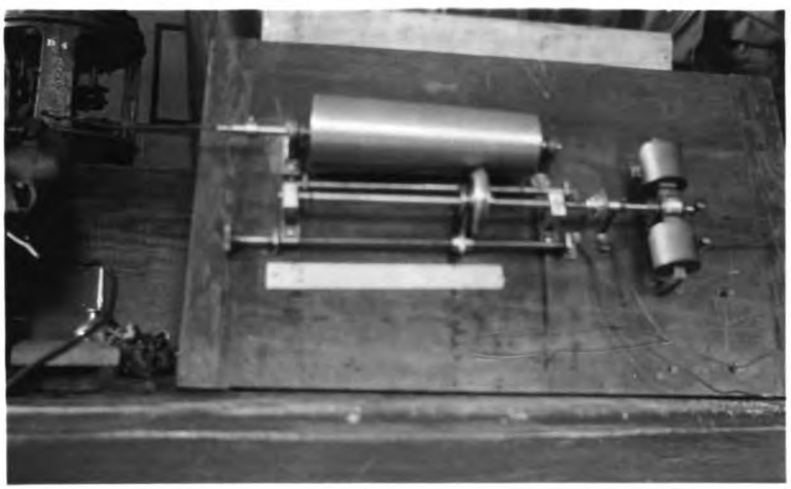
COMPLETE DISCUSSION OF APPARATUS DESIGNED AND BUILT IN THE SHOPS.

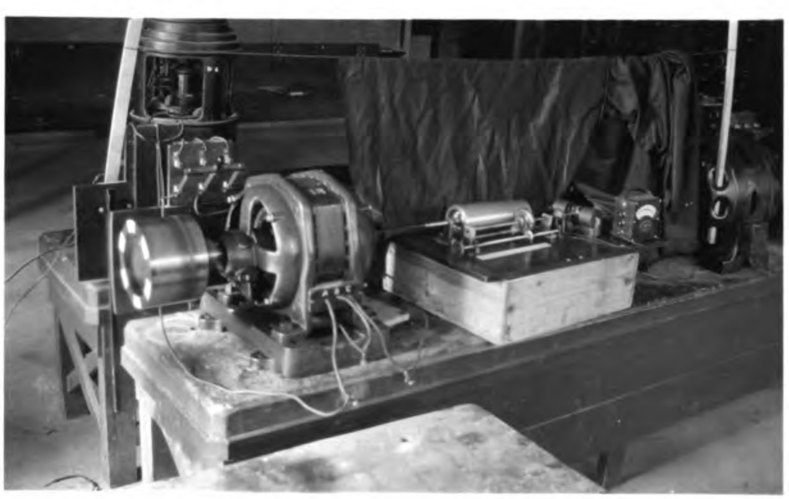
The slip meter consists of a conical cylinder which drives the counter-shaft through a movable disc. The size of the disc is such that at one end of the counter-shaft the disc revolves at the same speed as the conical cylinder while at the other end its speed is about 200 r.p.m. greater. Thus it is seen that when the cylinder is connected to the motor under test the disc may be so placed along the conical cylinder that the speed of the counter-shaft will be the synchronous r.p.m. of the motor under test. On the end of the counter-shaft is placed a commutator having four contacts. Placed opposite this commutator and in contact with it is placed a double contact brush which is driven by a 6 pole synchronous motor. This commutator, through the necessary brushes, closes the circuit of a two volt storage battery and voltmeter. When synchronous speed of the counter-shaft is obtained the voltmeter indication remains constant. The position of the disc indicates the per cent slip on a scale placed under it. As made, the meter may be used only on 6 pole 60 cycle motors. For a different number of poles, gears would be necessary to change to equivalent 6 pole speed. An attachment for measuring the period of hunting of a synchronous motor is described under "Suggestions for Further Work."

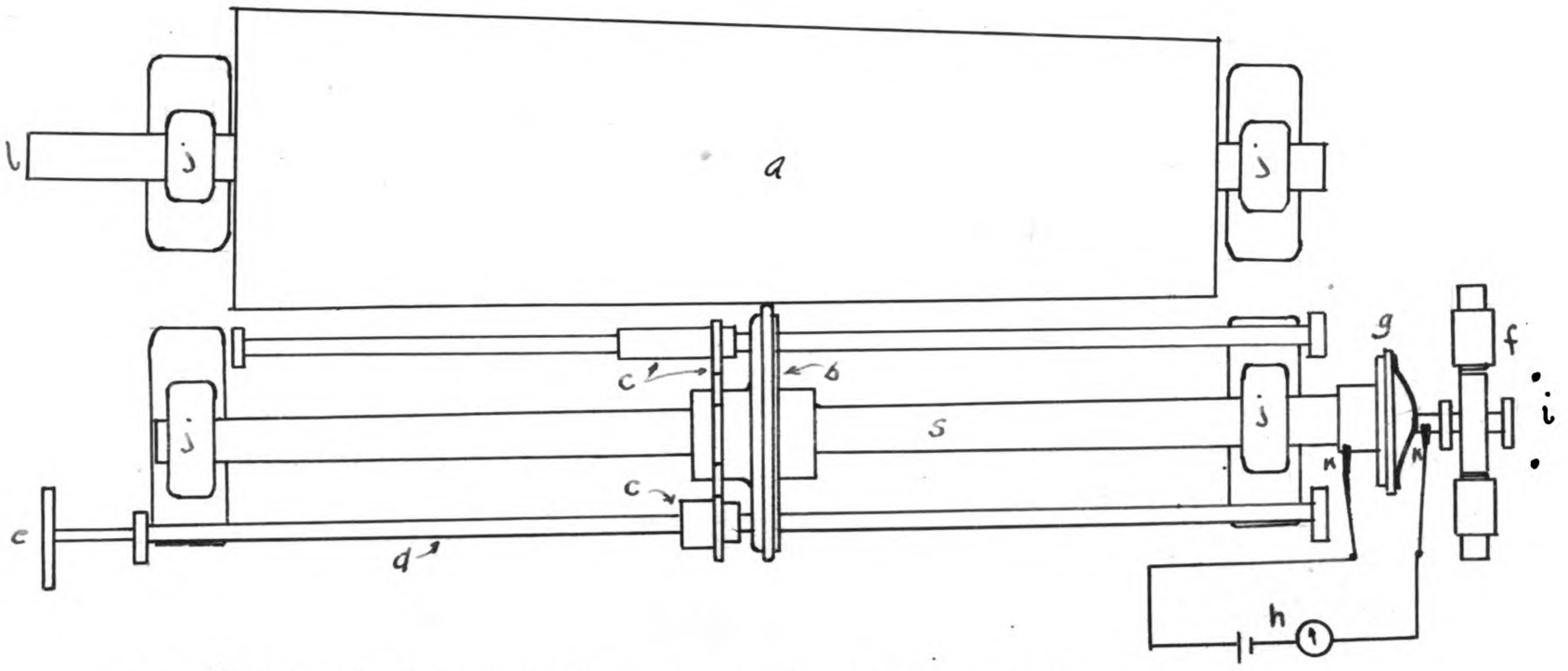
The slip meter is shown and described in detail in the accompaning diagrams and pictures.

It is desirable when measuring the slip to have synchronous speed at a standard value, so a frequency meter is a desirable adjunct for the slip meter.

Photographic Views of Slip Meter







a - Tapered brass cylinder ; b - Fiber disc
c - Yoke for moving disc along its shaft "s"
d - Rod threaded to carry the yoke back and forth.
e - Handle to turn screw or threaded rod.
f - Synchronous motor
g - contactors to determine when there is no relative motion between (S) and (f) by completing a circuit (h).
i - Synchronous motor connections.
j - bearings
K - brushes. L - connect to induction motor

ADJUSTMENTS.

The main adjustment is to keep the scale set so that when the disc sets against the cylinder at the point of the same diameter as the disc that the pointer will read zero slip. As the disc wears off it will be necessary to change the position of the scale. This may be done by connecting the conical cylinder to a 6 pole synchronous motor and setting as described for testing motor. Then move scale to zero reading on pointer. The taper on the cylinder remaining constant the readings or divisions will remain the same with respect to the zero point.

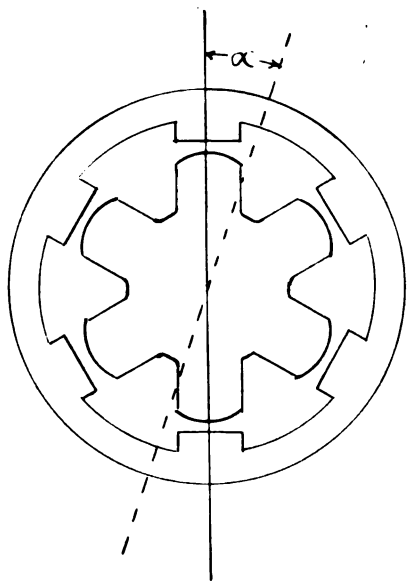
PRECAUTIONS.

Do not attempt to move the disc along the cylinder when it is standing still as doing so will produce a flat place on the disc which will cause a pound and also interfere with accuracy.

SUGGESTIONS FOR FURTHER WORK.

For measuring the period of hunting of a synchronous motor a method has been devised and is offered as a suggestion. It is as follows: On the shaft of the synchronous motor which runs the contactor place a definite poled stator excited from the A. C. line. Inside of this place a rotor of the same number of poles, this is rotated by the counter-shaft.

By transformer action there will be a voltage induced in the rotor windings. The rotor and stator rotating at the same speed in the same direction the poles will remain stationary with respect to each other, as in diagram.



A constant e.m.f. will be induced in the rotor windings, and with a voltmeter it is possible to read the e.m.f. induced. As soon as the synchronous motor in question begines to hunt and the rotor deflects by an angle α the reluctance of the flux path is increased and the induced e.m.f. changed. By

noting the oscillations of the voltmeter needle one can determine the period of hunting.

Another suggestion is that the cylinder be put in a cradle and balanced at speeds between 1000 and 1200 r.p.m. or obtain a fiber or composition cylinder which could be turned down to suitable dimensions. This would be the most desirable, as the fiber is lighter. It would also be desirable to have a ball-bearing thrust to move the disc along the cylinder.

RESULT OF TEST.

Slip as measured by Stroboscopic Method. R.P.M.	Slip as measured by Slip Meter. R.P.M.
28	30
19	21
12	11.5
8.2	8

The stroboscopic method was used in checking the accuracy of the slip meter. Sectors were painted on the end of the pulley of the motor under test and an arclight, connected to the same generator as the motor, was used to illuminate the revolving sectors. By this method the slip was easily found for low values.

The motor was loaded by means of a Pony Brake which did not give a very constant load. For this reason the slip varied some during the time of reading, and this accounts for most of the discrepancy in the results.

BIBLIOGRAPHY.

I. Accurate Method of Measuring Motor Slip.
Electrical World - Aug. 25, 1917.

II. Stroboscopic Method of Measuring Induction Motor Slip.
Electric Journal - July, 1913.

III. A New Slip Indicator.
London Electrician - July 22, 1911.

IV. Measuring the Slip and Speed of Induction Motors,
by Charles A. Perkins.
Electrical World - Oct. 31, 1908.

V. The Slip of An Induction Motor, by B. F. Bartey.
Electrical World - April 22, 1905.

VI. Measuring the Slip of Induction Motors.
Electrical World - June 10, 1905.

VII. A Simple Device for Finding the Slip of An Induction Motor,
by Charles A. Perkins.
American Institute of Electrical Engineers - June, 22, '05.

VIII. Slip Meters.
E.M.F. Electrical Year Book, 1923 - page 816.
Measurement of Slip
E.M.F. Electrical Year Book, 1923 - page 573.

BIBLIOGRAPHY - (Continued)

IX. Slip Measurement

Electrical Measurements in Practice, by Farmer - pp. 289-293