A New Revolution Counter for Ultracentrifuge

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A type of revolution counter for ultracentrifuges was devised and constructed. The output of a tacho, which is coupled to a rotor axis of centrifuge and generates an a. c. current synchronized to the rotor speed, is converted to a sharp pulse wave and these pulses are counted in a certain time interval by a scaler possessing a good resolving power. This counter can indicate an integrated revolution number within the time interval, *i. e.*, an exact average revolution number per minute.

It is of utmost importance in the experiments for sedimentation studies that the rotor should be kept to rotate constantly with a set speed throughout a whole run of centrifuging. In order to ascertain the constancy of the strength of centrifugal field, the revolution number of the rotor should be measured exactly. In the commercial ultracentrifuges as recently constructed the a. c. power frequency is referred to as a standard for automatic drive-speed control or exact measurement of rotor speed. In this country, however, it happens occasionally that the power frequency fluctuates within a range of about 2 per cent. This results in an error of the field strength of sedimentation, which amounts to 4 per cent. It is necessary, therefore, to consider the influence of frequency change upon the accuracy of results of sedimentation studies.

The SPINCO** Ultracentrifuge Model-E is an example in which the power frequency is applied to the automatic speed control unit[1] ; the rotor speed is automatically kept constant by means of a gear box containing a differential transmission device where one of the legs is driven by a synchronous reference motor. Hence an occasional change in the power frequency will bring about a change in revolution number of the reference motor, and this disturbs the function of the drive-speed control unit.

Reference will be made here to the PHYWE*** Ultracentrifuge as another example, where the power frequency is made standard for reference for the measurement of rotor speed. The shaft of the rotor is coupled to a tacho consisting of a rotating magnet piece and two coils whose phases differ from each other by 90 degrees. The output voltages generated in each coil are fed respectively to vertical and horizontal plates of a cathode-ray tube ; a spot on the tube should rotate with

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the same angular speed as that of the rotor, describing a circular trajectory. By modulating the trajectory with the pulse wave synchronized to the a. c. power frequency, the pattern on the tube can be degenerated to the still standing spots, whose configurations are characteristic to the respective speed, as shown in Fig. 1.

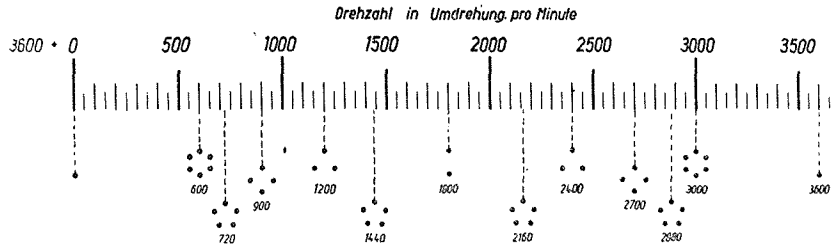

Fig. 1. Chart for rotor-speed determination.

Thus, if the rough number of revolution is known, the exact speed can be evaluated by help of the chart of the patterns.

As can be deduced from the above description, the revolution numbers which can be given by any counters of this type are not only conditioned by the fluctuation of the power frequency but also confined to such multiple numbers of 60 as shown in Fig. 1 so long as the power frequency is 60. Therefore, we can neither make the exact measurement nor set the rotor speed at will, although the set speed can be continuously and arbitarily chosen.* In order to eliminate these inconveniencies, a new revolution counter has been constructed which, differing from any other kinds in principle, indicates the integrated number of revolution within a certain time interval. Therefore, the rpm-number thus obtained represents the average speed in that time interval, This newly constructed counter is attached to the PHYWE Ultracentrifuge. The outline of the principle is as follows.

The PHYWE Ultracentrifuge has a tacho which generates an a. c. current synchronized to the rotor speed. The output of the a. c. sine wave from this tacho is converted to the sharp pulse wave having the same frequency, and these pulses are

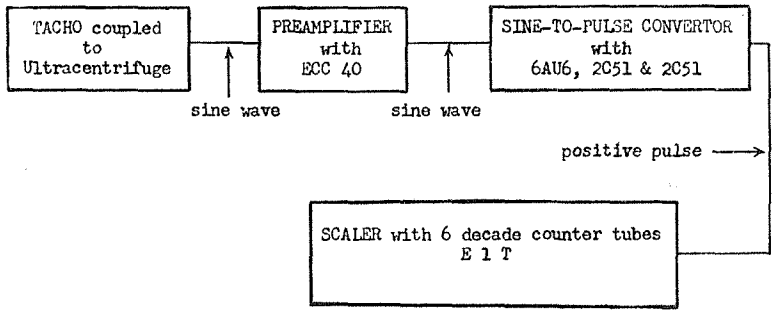

Fig. 2. Block diagram of revolucion counter.

* Neither in the case of the SPINCO Ultracentrifuge Model-E the set speed can be chosen continuously at will. (See REFERENCE 1)

counted by a scaler possessing a good resolving power. A block diagram of the arrangement is given in Fig. 2.

Fig. 3. shows a circuit used as the sine-to-pulse convertor. In the first stage of

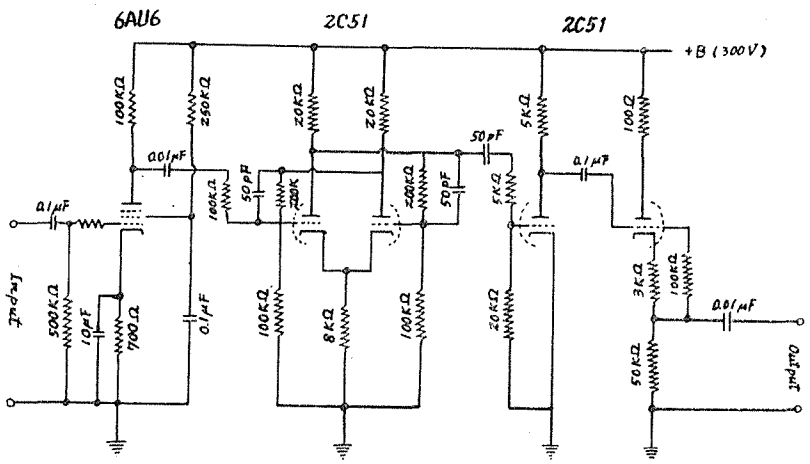

Fig. 3. Circuit of sine-to-pulse convertor.

the circuit an input sine wave is clipped and amplified by a type 6AU6. The signal obtained in this stage is fed to a flip-flop circuit consisting of a type 2C51, by means of which the signal is converted to a square wave. This square wave is differentiated by a circuit involving another 2C51, and only the positive pulses of the differentiated wave are picked up at a lower impedance by means of the cathode follower. The pulse thus obtained is supplied to a scaler which is constructed using six decade counter tubes, E1T, and has a circuit of discriminating bias. The resolving power of the scaler is about 3×10^4/sec., and is sufficiently large to cover the whole frequencies under the test. By way of example the following table shows the revolution numbers which were obtained by the use of this counter during a run of

Table : Example of speed-measurement.

Set rotor speed ; 50,000 rpm.

Time, (p. m.)	Time interval	Total revolution numbers	rpm
6.45	6.48 – 6.58 (10 min.)	500862	50086
7.00	7.03 – 7.13 (10 min.)	500805	50081
7.15	7.18 – 7.28 (10 min.)	500524	50052
7.30	7.33 – 7.38 (5 min.)	250307	50061
7.45	7.48 – 7.58 (10 min.)	500681	50068
8.00	8.03 – 8.05 (2 min.)	100104	50050

centrifuging. This result made it possible to ascertain that the rpm-numbers in each time interval, 10 minutes, fluctuate only within less than $\pm$ 0.05 per cent.

This new counter enables us to conduct the sedimentation studies with the PHYWE Ultracentrifuge at any desired rotor speed, and further the utilization of the integrated number of revolution diminishes the error caused by an occasional change in the input power. The development of this type of counters, as well as the improvements of the optical system, will result in a further enhancement of the accuracy of the sedimentation study.

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REFERENCE

(1) E. G. Pickels, *Machine Design*, **22**, 102 (1950).