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1938 **Quartz Electric Clock**

by

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1. Introduction

In recent years, application of quartz crystal as stable oscillation sources has become highly important. For precise measurement of oscillation frequency of transmitters, it is convenient to compare frequencies with the time of standard clock which is calibrated by astronomical observation. First quartz electric clocks appeared in 1928 in the United States<sup>(8)-(11)</sup> and continued by Germany in 1932<sup>(12)(13)</sup> and recently by United Kindom<sup>(14)</sup>.

2. Comparison of Quartz electric clocks with Pendulum clocks

Quartz clocks and pendulum clocks are used for standard time machine. They must be placed in a constant temperature room. However, needed space for thermostats is smaller for quartz clocks. This may be a merit of quartz clocks among many advantages.

3. Development of quartz electric clocks in Japan and design of clock systems.

In order to realize precision quartz clocks, it is dispensable to develop highly stable quartz oscillator and effective frequency demultiplier. Fortunately we could already get a temperature-insensitive quartz oscillation plate in 1933 (R1-cut). We succeeded the development of frequency demultiplier in 1926<sup>(1)-(3)</sup> prior to Vecchiacchi<sup>(4)(5)</sup> in Italy and van del Pol<sup>(6)(7)</sup> in Netherland. Furthermore we succeeded the development of quartz oscillators which were suitable for quartz clocks<sup>(15)(16)</sup>. We started the design of our first quartz electric clock which we called model KQ-1 from the beginning of 1936 and completed in the mid of same year. This model was exhibited at 1937 PARIS Exposition. Improved model of KQ-1 has been used in Tokyo Observatory since July 1937.

Design details of KQ-1 clock are as follows:

1) Frequency of quartz oscillator was chosen as 1 MHz (most of existing quartz clocks are 0.1 MHz). This resulted in a smaller size of quartz oscillation plate and easier cutting out of plates. It also provided higher stability of frequency.

2) We used an oscillation circuit shown in Fig 2 instead of normal Pierce circuit shown in Fig 1. This circuit used two quartz elements but no inductor in plate load. As the results, both of higher stability and compact size were realized. Multivibrator-type demultiplier circuit (Fig 3) down of applied frequency. 5 stages of this circuit were used for

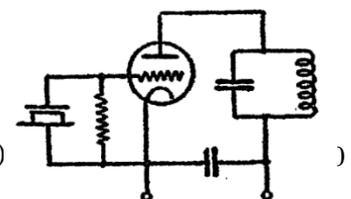


Figure 1

getting 10 Hz signal to drive synchronous motor.

3) Applied DC source voltage was chosen as 200 V instead of normal 250 V rating voltage for long life operation.

4. Operation report of cooperation with Tokyo Observatory;

Since the installation in Tokyo Observatory, there have been twenty times of noticeable earthquakes. However the quartz clock worked without any trouble.

Continuous operation has been done except a disconnection of a resistor and three times of operation errors.

In order to stabilize the oscillation frequency without using a thermostat, we installed the clock in an underground room. In this room deviation of room temperature was about 2°C. Average daily accuracies of the clock were about 2.67 seconds delay in the beginning of November, 2.69 seconds in late November, 2.58 seconds in December 1937 and 2.43 seconds in January 1938.

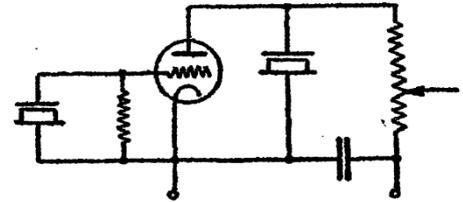


Figure 2

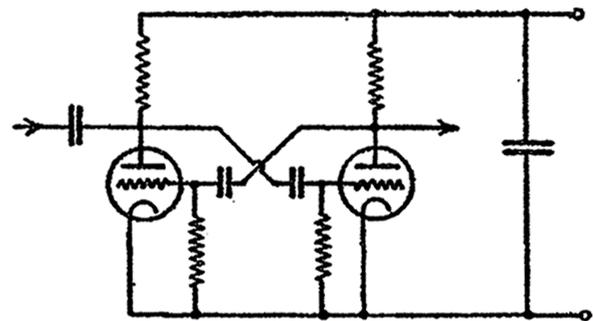


Figure 3

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