THE MASTER CLOCKS OF THE MANILA OBSERVATORY

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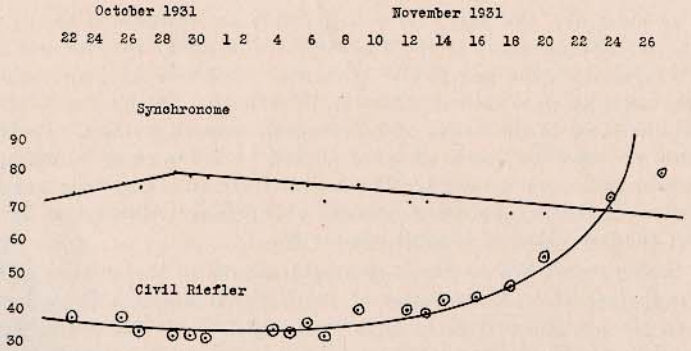
As already stated in another issue of the Bulletin, the Observatory possesses three astronomical master clocks, one Synchronome and two Rieflers. These were all placed on one massive adobe pier, the pendula being about two feet from each other, and all swinging in different planes, though on the same face of the pier. The rates of the clocks were far from satisfactory, but the true cause could not for a long time be even suspected. The key to the situation was provided by a perusal of the excellent articles by Loomis and Dr. Brown in "Monthly Notices of the Royal Astron. Society" (March 1931), concerning the rates and possible mutual interference of rates between Synchronome clocks even on different piers. If this could happen even in the extreme case mentioned, what might be expected in my case, with all clocks fairly close together on the same pier.

Upon examination and careful plotting of the rates of the three clocks of the Observatory, it was found that a good case could be made out for mutual interference as follows: a) Whenever there was a difference of phase of 0.30 sec. between the Synchronome (Civil Time) and the Civil Time Riefler clocks there was a perceptable change of rate in **all three** clocks. b) The curve of clock rate between the rate changes often showed a complete sine wave.



How explain change of rate for all three clocks? The only reason I can see is this: Resonance between the Synchronome and the Civil Time Riefler was set up violently at a definite phase difference between the two, enough probably to widen a possible crack in the adobe pier (other adobe walls in the Observatory show cracks with age). This in turn tilted the side of the pier enough to cause a change in rate of all three clocks. Whatever may be said about the crack, the simultaneous change of rate of all three clocks seems a fact; this change of rate may be traced through at least ten periods.

The plots with explanation were sent to Dr. Brown of Yale for examination, and just lately his reply was received. In brief, he replied: a) there were evident signs of interference between the clocks; b) due to other imperfections of clock rate, however, the plots did not warrant extended mathematical treatment (my own opinion already expressed to Dr. Brown) c) change of rate may occur for other reasons than the one given; d) best proof would be to set clocks up on different piers and note the change. Lick Observatory had similar difficulties lately, and got rid of them by putting the clocks in different buildings.

In the meantime, I had already been changing my clocks to separate piers. Two massive piers in a new clock vault were built, one pier for the Synchronome and one for the Civil Time Riefler; the Sidereal Time Riefler was kept on the old adobe pier, but on a different face of the same. Due to the fact that the change had to be made slowly, during the rainy season, it took time to get the clocks into any sort of shape. Besides, we had two accidents with the Synchronome. Two of the bell-jar tops caved in during the middle of the night, right on top of the works. The force was enough to imbed some of the glass in the brass of the mounting of the clock works! The breaks were due to poor annealing combined with too flat a top for the bell-jars; since only the tops of the bell-jars caved in, leaving the lower portions even uncracked, there could be no question of any carelessness on our part, allowing grit to come in between the bottom of the bell-jars and the top of the vacuum case. The main damage to the clocks was the following: a) thermometer and vacuum gauges broken; b) impulse wheel dented; c) main suspension spring very considerably bent; d) cores of magnets permanently magnetised due to continuous run of current through them until the accidents were discovered. A temporary vacuum gauge was home-made, the impulse wheel was provisionally straightened out, as was also the delicate and important suspension- spring, leads of the magnet reversed and a little slip of paper put at end of the iron cores and lo! the synchronome was put to work again!

I know of no better encomium for the Synchronome than its straight line rate curve for the past month, in spite of the fact that the impulse wheel and spring are not in the best of condition. I send a diagram of its rate on a separate sheet, each little square being a hundredth of a second. The little deviations of the crosses (marking clock error as observed from star transits) from the straight line are not due, I think, to the clock, but rather to the transits, for we have been having quite cloudy weather, and some of the transits were taken through thin clouds and otherwise poor sky. The kink in the curve on October 28th is quite interesting. On that day at 2 P. M. there was a quake at the upper end of Luzon, not enough to be sensibly felt at Manila, but still enough to give a very large record on our Weichert seismograph. Now the Slave clock of the Synchronome faces north, so that the pendulum got the full brunt of the transverse waves; the Master Synchronome was perpendicular thereto and got little. Two to three hours after the quake, I dis-