White Paper: The KCC Scientific Model 1900S

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If you are considering the purchase of a **Model 1900GS Kit** or a **Model 1900RS rechargeable kit**, you will recognize that the kit contains two No. 6 units: the Model 1900G (or Model 1900R3) battery and the Model 1900S Synchronizer unit. They are connected in the clock exactly like an original pair of No. 6 batteries. The purpose of this White Paper is to help provide some information on what the Model 1900S Clock Synchronizer does as well as the history of Self Winding Clock synchronization. Let's start with a historic background and a general explanation of Self Winding Clock synchronization.

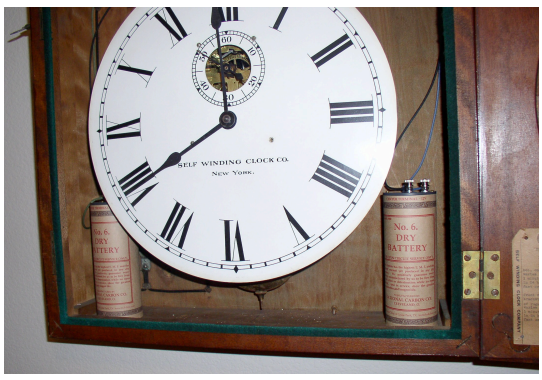
Historical Perspective. At the turn of the century (late 1890s), a developing transportation industry combined with the Industrial Revolution meant that people needed a way to know exactly what time it was across the miles in order to accurately coordinate activities. In response to this, Chester Henry Pond of the Self Winding Clock Co. working with Western Union devised an innovative system for precise time synchronization for clocks all over the US. Clocks were produced that ran on a pair of the new No. 6 Dry Cells. A Seth Thomas mechanical movement was equipped with a special rotary or vibratory motor, using the batteries to wind it hourly. This eliminated the need to wind these clocks on a regular basis.

Synchronization involved sending out a signal to clocks around the country simultaneously, at exactly the top of the hour. The Western Union Telegraph system had already established a network of wires interconnecting businesses, railroads, etc. for communication purposes. These same wires were adapted to synchronize clocks at these locations. Within a few minutes of the hour, telegraph activity was ceased and a series of synchronization signals were sent out. Inside the Self Winding Clock Co. models, a mechanism connected to an electromagnetic coil would receive this Western Union signal and "pull" the hands to exactly the hour. This method provided the nation with synchronized, precise time for a good part of 60 years!

In the early 1960's, most of these self-winding clocks were decommissioned and the Western Union service was discontinued, obsoleted by newer methods. Collectors began to recognize the historic contribution and value of these clocks. These clocks were (and still are) procured at Marts, antique stores, Ebay, and other sources. Savvy collectors recognize the significant value of resurrecting the synchronizing mechanisms on these clocks for improved timekeeping—and of course the historic accuracy and nostalgia.

The Model 1900S. The Model 1900S provides what the Western Union signal did for decades. Instead of relying on an outside signal brought in with telegraph wires, the Model 1900S acts as an internal timepiece with the ability to send the proper signal to the synchronizer coils at exactly the top of every hour. The device is connected to the synchronizer coils with the supplied wires. A button on the top of the 1900S is depressed and released at exactly the top of the hour. Thereafter, the 1900S will supply this signal on its own, every hour thereafter. This corrects any deviation in the clock's timekeeping to accuracy levels that are unachievable in a mechanical clock by itself.

The **Model 1900GS Kit or Model 1900RS Kit** (either composed of a special battery to power the clock and the Model 1900S) looks exactly like a pair of vintage No. 6 batteries. You can power the clock and synchronize it with a pair of batteries that look like they belong in the vintage clock. It is the first automatic, electronic, commercially available version in a vintage No. 6 package with accuracy far exceeding that of a quartz watch!



Technical Discussion. Here is a brief Q and A on the highly technical aspects of the Model 1900S.

1. How does a 1900S work?

Inside the 1900S is a microprocessor, a precise watch crystal, and calibration software that work together to create a super-accurate timepiece, all hidden inside of a beautifully-crafted No. 6 battery unit. This timepiece controls circuitry that connects a voltage source to the terminals at the exact time so that the synchronizer coils located in the clock can be driven at that exact time. The unit runs on three AA cells, and they will last for over 5 years. At that time they can be easily changed.

2. How do you achieve "super accuracy"?

The practical issues in designing an accurate quartz-based timepiece (synchronizer, clock, watch, etc.) are related to:

- Crystal initial calibration
- Crystal loading
- Temperature Drift
- Stability of Quartz Crystal Circuit Power
- Time Drift

The biggest problem by far is crystal initial calibration. Most crystals are cut to 20ppm accuracy. This is equivalent to 10 minutes per year. Many manufacturers of watches and other timepieces use crystals with this specification in their devices, directly, with the accompanying inaccuracy. Others hand pick and sort the best ones to use in their products using a test fixture. This is difficult because when the crystal is installed in the actual timepiece, parameters are different than they were in the test fixture. Crystals are very sensitive to this "loading" change and behave differently as a result. Further, the soldering processes involved in assembling the crystal into the product subjects the delicate crystal to extreme temperature related stresses, causing further shifts. These factors, in combination, result in less than ideal timekeeping.

3. So what do you do differently?

We first optimize crystal "loading" with a microprocessor which is programmed to load the crystal optimally. We then calibrate the crystal after it is in-circuit, where it will spend the rest of its life. To do this, we developed a software algorithm that allows initial calibration to 0.2ppm (parts per million)—the equivalent of a fraction of a minute per year.

Here's how the program works. The buffered crystal output from the microprocessor-based crystal oscillator is measured against a precision-stabilized Agilent reference counter which uses internal OCXO accurate to under 50 parts per billion. Once the actual frequency is precisely known, the software algorithm calculates the calibration constants which are stored on board the 1900S microprocessor. These constants are used to correct the timekeeping error of the individual crystal, in-circuit. The result is better accuracy than most quartz watches available today. It takes extra time to calibrate it up front, and every unit must be calibrated and verified individually. But if accurate timekeeping is important, this is the way to do it.

4. Does battery state have an affect on accuracy?

It certainly does. In fact, in a standard quartz watch, the battery state-of-charge influences the timekeeping of the watch noticeably. As the internal battery is depleted, the battery voltage naturally decreases, especially with alkaline battery technology. A feature of our design is electronic voltage regulation. To avoid errors caused by a constantly changing battery voltage, there is a special circuit on board to regulate the voltage applied to the crystal circuit itself. This keeps power to the crystal circuitry virtually unchanged over the life of the battery.

4. Do you offer a TCXO option?

Yes, we do.

A TCXO is a Temperature Compensated Xtal Oscillator. Its claim to fame is that it is internally compensated for temperature drift over a very wide temperature range. The fact is most watch crystals are designed to be amazingly stable around room temperature (about 30 seconds per year from 65°F to 83°F) which is where we operate most of our clocks. However for various reasons, some people need to operate clocks in unconditioned space such as vacation homes (where temperature might fluctuate substantially), observatories, or in outside workshops or additions. For these applications, we offer the **Model 1900STC** (Model 1900S with Temperature Compensation). It is slightly more in price, but very stable even if operated in freezing temperatures.

5. How does the 1900S hold over time?

The last crystal characteristic to deal with is time drift. Our experience, having provided these devices for over 10 years now, is that the time stability is outstanding. We use devices that have a maximum specification of around 3ppm per year (90 seconds). We have observed that they actually perform better than that. A crystal oscillator typically becomes more stable as it ages. For that reason, if after many years you decide you want your Model 1900S recalibrated, our standard charge is $40 for a recalibration—but only if needed, which is not very likely.

6. How do you verify your synchronizer's accuracy and calibration?

Each 1900S is test run for minimum 1 week. They are referenced to an "atomic" timepiece synchronized to NIST Boulder via WWVB to validate accuracy. Only those units achieving under 0.5 seconds per week are shipped (which is practically all of them, after calibration).

In the end, we routinely see accuracy levels on the order of 1 to 2 seconds per month with this approach. If you own a quartz watch, you will find yourself setting your watch to your self-winding clock synchronized with the 1900S. Come to think of it, that's the way Western Union intended it back in the day when the Self Winding Clock Co. ran the railroads!

7. Can you program your device to be used in any Self Winding Clock Co. model?

We packaged the 1900S to optimize its fit and function for all Self Winding Clock Co. models. The vast majority of the clocks are 3-volt clocks, and the 1900S works in all of these. Some Telco models are equipped with 24-volt coils. For these units, we offer the Model 1900S-UNV which can drive any clock coil up to 24 volts. It's universal. There are very few of the Telco clocks remaining in circulation. If you are a fortunate owner of a Telco and you wish to revitalize the synchronization, contact us at ken@kensclockclinic.com.

8. Do you offer a WWVB or GPS-based synchronizer?

We have thought about this extensively. The problem is that these will tend to be MUCH more expensive, and unfortunately won't offer much improvement. Outside antennas would probably be required for GPS based solutions. WWVB would only work in the USA and there are restrictions on placement of the clock so that it is on a wall near a window facing Boulder, Co. to receive the WWVB signal. This is complicated greatly by the metal cases in many clocks, which would block any radio or satellite signal, making it impossible to receive the time synchronization without special outside antennas. **For these reasons, we have designed our Model 1900S to operate super-accurately without the need for any of these services.**