Seconds Pulses Generator Used at Radio Station WWV

Highly accurate seconds pulses are broadcast continuously from radio station WWV on each of the carrier frequencies along with other technical services. These pulses are so synchronized with the basic time determinations of the U.S. Naval Observatory as to constitute also an accurate time signal. The pulse for the 59th second of each minute is omitted and the pulses also are synchronized with the 1-minute breaks in tone modulation each 5 minutes to facilitate their use as time signals. Seconds intervals are accurate to 1 part in 1 million (1 microsecond); intervals of 1 minute and greater as well as the audio and radio frequencies as transmitted are accurate to 1 part in 50 million.

These seconds pulses consist of 5 cycles of a 1000-cycle per second frequency as shown in Fig. 3. This waveform was chosen to obtain a sharp pulse consistent with r-f band width assignments and of low interference to the standard audio frequencies and one easily passed by the amplifiers of ordinary radio receivers. The pulses are obtained by use of a balanced modulator and mechanical gate. Frequencies of 1000 c/s and 100 c/s, obtained by frequency dividers from the 100 kc/s primary frequency standard, are filtered and supplied to the balanced diode modulator as shown in Fig. 1. The modulator is operated in a manner to suppress all output components except the 1000 c/s and generates a continuous wave train as shown in Fig. 2. The four diodes conduct during the positive half of the 100-cycle wave and are biased beyond cut-off during the negative half cycle. The 100-cycle and 1000-cycle frequencies are in phase as conducted through the diodes at the beginning of the pulse. This is brought about by means of the phase adjuster control R_1 in the 100-cycle input circuit. In order to prevent clipping of the last negative half-cycle of the pulses the 100-cycle voltage must be at least 10 times the amplitude of the 1000-cycle voltage in the bridge arms.

Emission effects and contact potential in the diodes causes them to conduct for slightly greater than one-half cycle of the 100-cycle frequency. By means of the series resistor R_2, the conducting angle can be adjusted to 180 degrees to give exactly five cycles of 1000-cycle voltage as shown in Fig. 2. A small 100-cycle transient is eliminated by placing some of this resistance (2000 ohms) in the other side of the 100-cycle supply to the bridge thus cancelling stray electrostatic unbalance of the circuit.

For proper operation the modulation bridge is used at high impedance. Also, to reduce the pulse distortion and to preserve wave symmetry push-pull operation is desirable in all associated circuits. In addition, inverse feedback is employed in the mixer amplifiers as well as over the entire audio channels of the transmitters.

Selection of the appropriate 5-cycle pulse per second is done by the 1 c/s contact as shown in Figs. 1 and 3. This gate consists of four limit switch contacts operated in parallel which are adjusted to remain closed for 0.01 ± 0.001 second. The switching is done at low impedance to reduce leakage and, in addition, the contact capacitance is neutralized as shown in Fig. 1. These contacts are operated by a motor-actuated cam driven by standard 60-cycle power obtained by dividers from the primary frequency standard. A phase adjuster similar to the one used at T_1 on the 100-cycle input is used to phase the closing and opening time of the 1 c/s contact. Rough adjustments on this phasing when starting up the equipment are made by momentarily interrupting the motor power. Other cams and contacts omit the 59th second and control the announcement intervals by passing the proper pulses through electronic switches which control the mixer amplifiers.

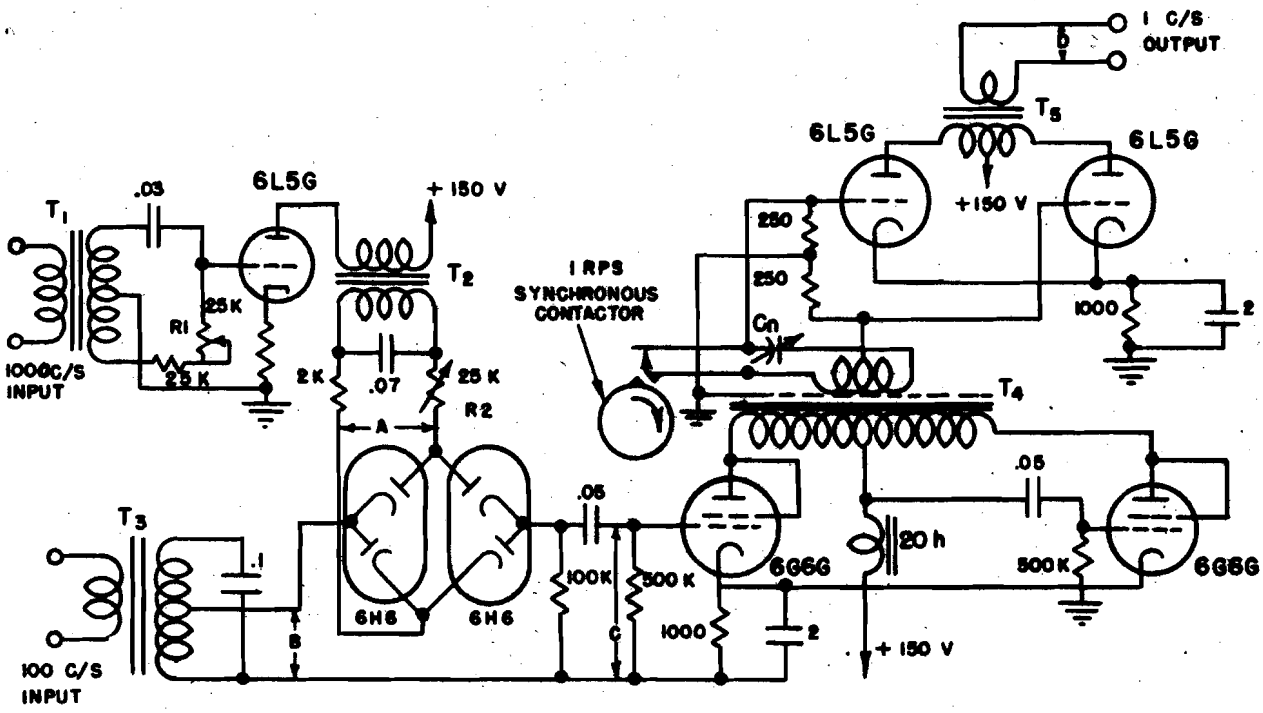


Fig. 1 SIMPLIFIED SCHEMATIC CIRCUIT DIAGRAM OF SECONDS PULSES GENERATOR USED AT RADIO STATION WWV.

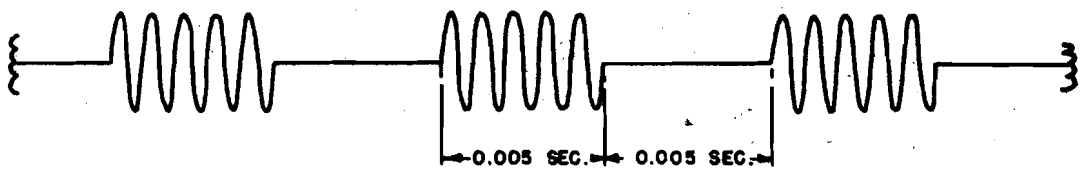


Fig 2. CONTINUOUS VOLTAGE WAVEFORM AT OUTPUT OF BRIDGE MODULATOR (POINT C)

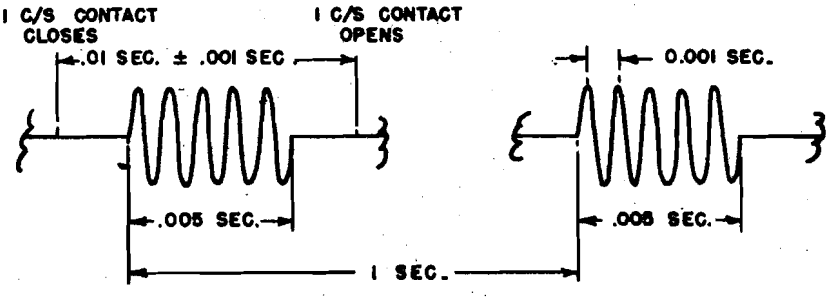
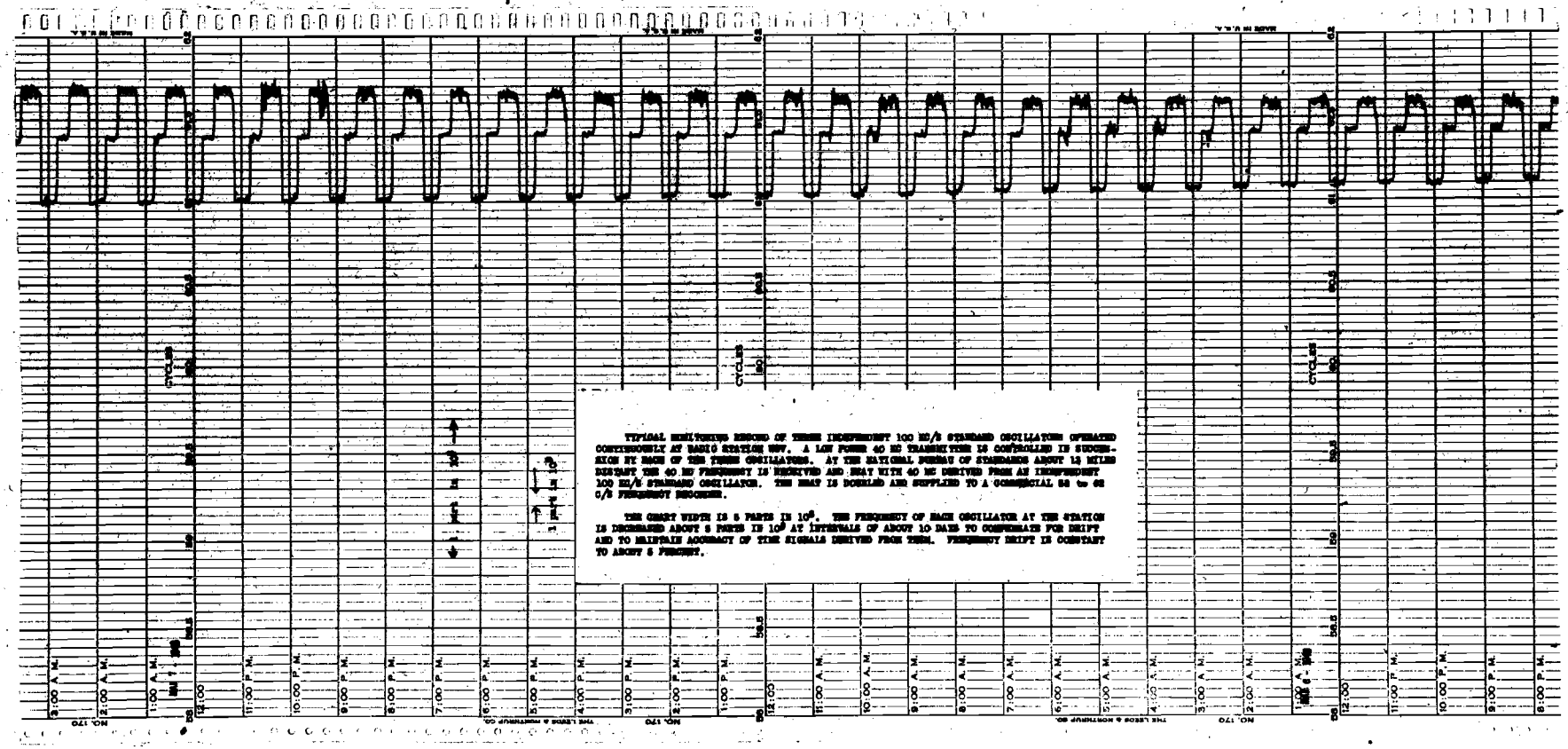
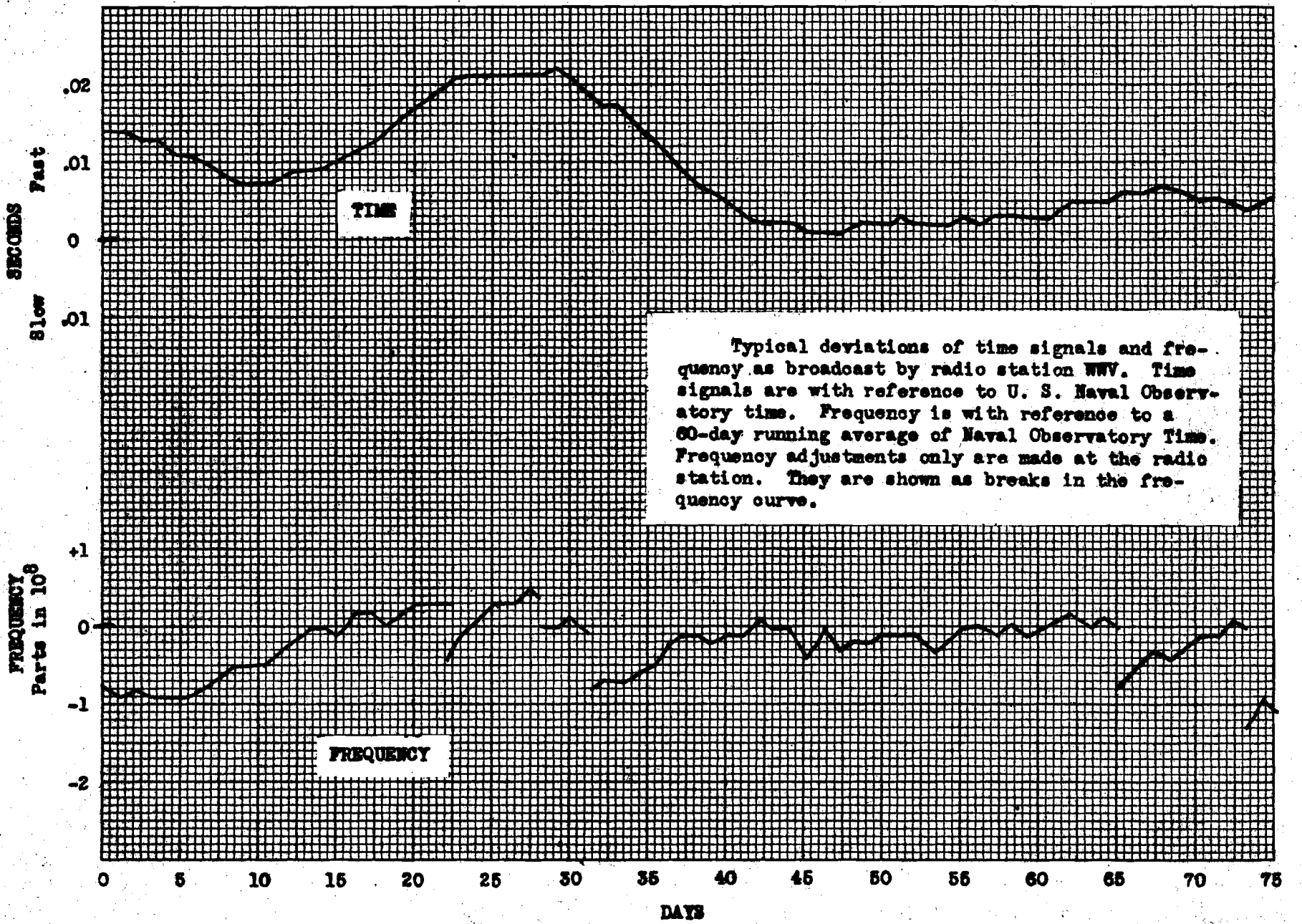


Fig. 3. VOLTAGE WAVEFORM AT OUTPUT OF SECONDS PULSES GENERATOR (POINT D)



TYPICAL RECORDING RECORD OF THREE INDEPENDENT 100 KC/S STANDARD OSCILLATORS OPERATED CONTINUOUSLY AT RADIO STATION WWV. A LOW POWER 40 KC TRANSMITTER IS CONTROLLED IN SUCCESSION BY EACH OF THE THREE OSCILLATORS. AT THE NATIONAL BUREAU OF STANDARDS ABOUT 12 MILES DISTANT THE 40 KC FREQUENCY IS RECEIVED AND BEAT WITH 40 KC DERIVED FROM AN INDEPENDENT 100 KC/S STANDARD OSCILLATOR. THE BEAT IS DOUBLED AND SUPPLIED TO A CONVENTIONAL 50 to 60 C/S FREQUENCY RECORDER.

THE CHART WIDTH IS 5 PARTS IN 10^8. THE FREQUENCY OF EACH OSCILLATOR AT THE STATION IS DECREASED ABOUT 5 PARTS IN 10^8 AT INTERVALS OF ABOUT 10 DAYS TO COMPENSATE FOR DRIFT AND TO MAINTAIN ACCURACY OF TIME SIGNALS DERIVED FROM THEM. FREQUENCY DRIFT IS CONSTANT TO ABOUT 5 PERCENT.


SECONDS
Fast
Slow
.02
.01
0
.01
TIME
Typical deviations of time signals and frequency as broadcast by radio station WWV. Time signals are with reference to U. S. Naval Observatory time. Frequency is with reference to a 60-day running average of Naval Observatory Time. Frequency adjustments only are made at the radio station. They are shown as breaks in the frequency curve.
FREQUENCY
Parts in 10^8
+1
0
-1
-2
FREQUENCY
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
DAYS