Tuning fork oscillators

Stable low frequency sources were often required in several applications, precision clockworks, facsimile equipment, instrumentation, navigation and avionics systems. When each single bistable multivibrator (flip/flop) required at least a double triode, the use of quartz crystals for generating low frequencies was very expensive. A vacuum-sealed 100KHz crystal was very delicate and required several tubes, including a lot of bistable multivibrators, to scale down to frequencies under 1 kHz. It is true, there were some attractive solutions to divide by five or by ten with a single twin triode, but also in this way many components could be required. One of the best solution found to the problem of generating stable low frequency oscillations was the use of tuning fork resonators.

The operating principle of the tuning fork was simple and well known. Electronic industry quickly developed highly advanced solutions to achieve simple, reliable and extremely stable oscillators.

A typical tuning fork oscillator, used in the AN/TXC-1 facsimile equipment, is shown in fig. 1.

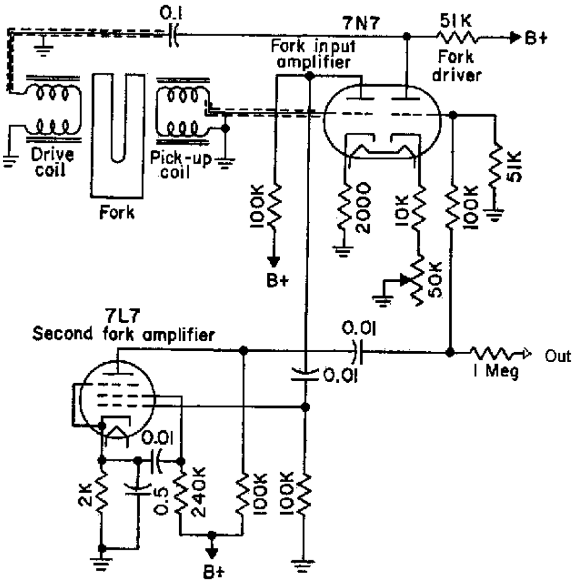

Fig. 1: Typical tuning fork oscillator

Two windings, a drive coil and a pick-up one, were placed close to the tines of the tuning fork, which was in the feedback loop of a three stage amplifier. This circuit gave stable oscillations at the resonating frequency of the fork, 1800 Hz. The signal was then amplified to feed the synchronous motor of the rotating drum.

Since the amplifier is designed to operate at a near constant drive level, the precision and the stability of the oscillator depends upon the precision and the stability of the tuning fork itself. Every effort was done to improve this component. The fork was made of nickel-steel alloys, with extremely low temperature coefficient of expansion. Tines were accurately balanced and thermally compensated, either with carbon steel laminations or with bimetal reeds. Fork units were then vacuum sealed, to avoid any environmental influence over their frequency and their Q.

Remarkable performances were reached. Temperature stability better than ± 0.2 part per millions per degree centigrade was specified over ambient temperature ranging from 10 to 65ºC. Overall stability within plus or minus 3 ppm without oven, 1 ppm after warm-up, was attainable. Stability as high as 1 part in 15 millions was possible if the fork was aged and operated into a thermostatic oven. (*)

The next three pictures show overall view and internal details of a tuning fork unit built by Philamon Laboratories Inc., Westbury, Long Island, N.Y.

Fig 2 - A 1350 Hz sealed tuning fork resonator used as frequency reference in the timing generator of a TACAN ground beacon transponder. On the bottom right of the unit well visible is the exhaust hose with sealed red tip. Right the same unit open, to show the fork, the single pick-up coil and the two drive coils close to the right tine. On the top of both tines there are the tuning and balancing masses, part of them supported by the two right angle reeds. To reduce acoustical coupling, the coils are connected to the pins of the case by the two spring wires visible aside the fork, near to the bottom. The unit was originally mounted on rubber spacers. Dimensions are 55 x 68 x 25 mm; weight is 240 grams.

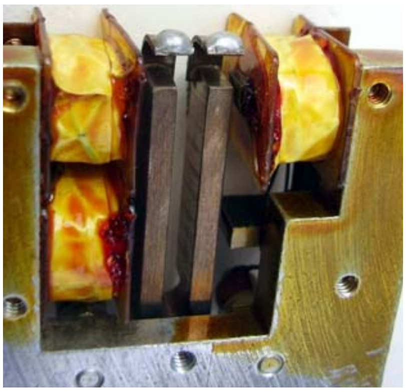

Fig.4 - Details of the bimetal temperature compensating reeds brazed at the top of resonating tines.

The last picture shows a tuning fork resonator built by American Time Prods. Inc., New York, under license of Western Electric Co. This unit was designed to operate at 240 Hz. It measures 93 mm in height by 25 mm in diameter. It has a 9 pin miniature base. On the top is visible the air exhaust hose.

(*) Stability figures taken from Radio Engineering Handbook, Fifth Edition, by Keith Henney.

References:

- **Radio Engineering Handbook, Fifth Edition, by Keith Henney**
- **TM11-2258, Facsimile sets AN/TXC-1, -1A, -1B, 1C and 1D, May 1955**