Some Recollections of Peter L Joyce of the Ultrasonic Gear
12 May 2003

The oscillator frequencies are marked as 230 Mc/s, 170 Mc/s, 110 Mc/s, 70Mc/s and 30Mc/s. To the right of the Piston Attenuator (PA) and the micrometer is an Evershed and Vignoles synchronous motor which via gearing drives the receiver rod and crystal up and down and also the recording drum. The PA and pen were driven by a servo motor Evershed & Vignoles type FQ12 but I cannot see it. I seem to remember using something like a Meccano chain to connect the PA and servo system; it can be seen behind the micrometer.

The output from the Rx crystal went to the appropriate receiver in the lower part of the rack; each had its own mixer and local oscillator as you mention The output was connected to the 45 MHz IF strip on the left under the oscilloscope (Landscape view). The IF strip was originally made by Pye, but was replaced by a unit which I wired up; it improved the gain over the Pye unit by about 10dB and the input signal for 50 - 50 signal to noise ratio was 3 microvolts.

The coaxial cable from the Tx crystal goes around the back to the output of the PA.

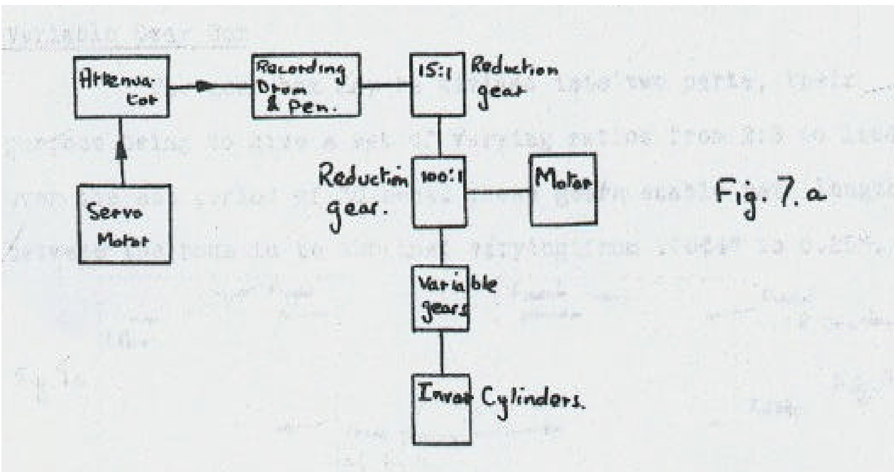
The Advance instrument is a Type 74 Crystal Calibrator; it appears to have a a loudspeaker and a 'magic eye' perhaps to indicate beats although I have no memory of how it was used. The box behind it could be an oscillator and my notes refer to calibrating a D.I. (Dawe Instruments ?) RF oscillator with the Advance unit. I have also found reference to a Marconi UHF type TF517F/1 signal generator range, 150 - 300 Mc/s.

The temperature of the cell was measured with a thermistor, type R6092 mentioned at one point in the Report. The cell was also fitted with a heater coil and cooling jacket.There must have been a temperature controller but I have no memory of its details or where it was fitted. I believe the flow of liquid nitrogen was effected by means of pressure from a nitrogen gas cylinder {can just be seen in (Portrait view) behind the liquid nitrogen flask on the right} it was controlled by a thyratron operated temperature controller and solenoid valve, presumably in the cabinet on the right and wired up by Vic. The liquid in the Dewar Flask was temperature controlled then pumped around coils fitted to the invar cylinders. It was found that these seized at -30 degreesC. I do not remember how the cooling jacket of the cell was supplied.

The portrait picture has 110/1/1961 on the back, the landscape picture 4/59, both are stamped with a photographic department stamp. (The Landscape view is shown in the Biography section of the Web Page.)

Part of Report written by Peter L. Joyce, 8th June 1958

Mechanical Construction of Quartz Rods and Invar Cylinders



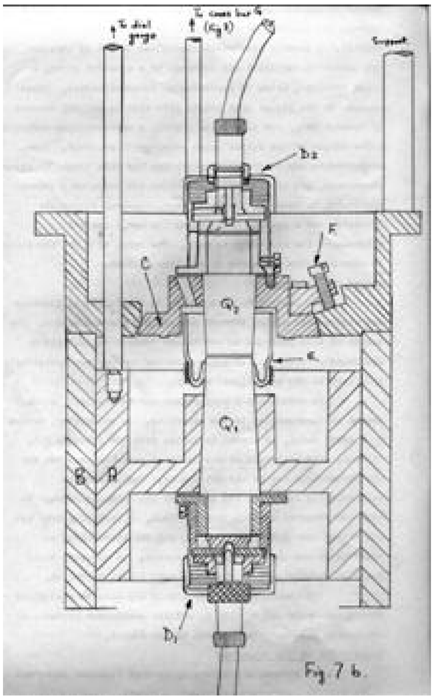
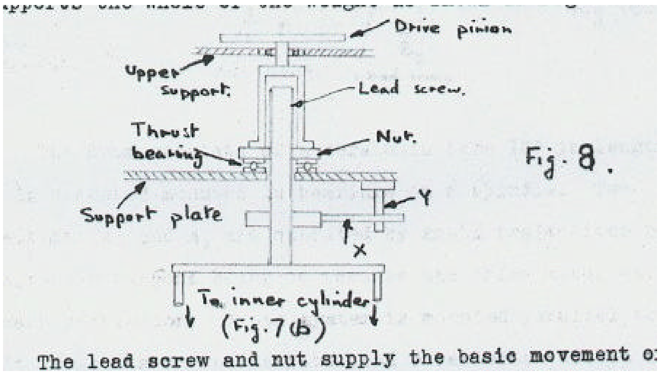


Fig. 7 b.

The two quartz rods Q_1 and Q_2 are fitted co-axially into two co-axial Invar steel cylinders A and B as shown in Figure 7b. The inner cylinder A slides within B and is very accurately fitted, so that only vertical movement is possible. The lower quartz rod Q_1 is fitted firmly into the inner cylinder A, whilst the upper quartz rod Q_2 is mounted in a holder C. This may be adjusted by means of three screws F, so that the two rods are exactly in line. The inner cylinder is moved vertically by means of two rods and a crossbar G, which is in turn connected to the variable gear box. 10 Mc/s quartz crystals are mounted on the ends of the rods by means of the crystal holders D_1 and D_2. The tank containing the liquid E is wound with a heater coil and a cooling jacket.

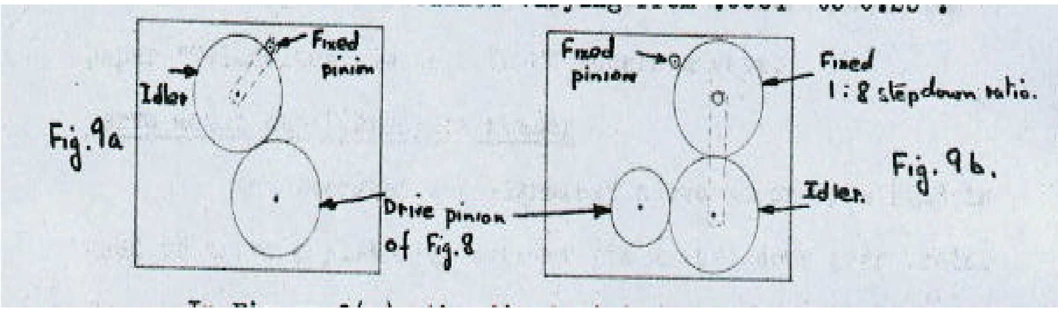
The inner cylinder is fixed to a nut and lead screw which supports the whole of the weight as shown in Figure 8.



The lead screw and nut supply the basic movement of the inner cylinder and, to ensure accuracy, these parts must be very carefully engineered. The nut is driven from a variable gear box, whilst the lead screw is prevented from rotating by means of a fixed arm X, which slides between two parallel guides Y.

Variable Gear Box

The gear box may be divided into two parts, their purpose being to give a set of varying ratios from 2:3 to 1:64. Over the set period of 30 secs, these gears enable path lengths between the rods to be obtained varying from 0.0064" to 0.25".

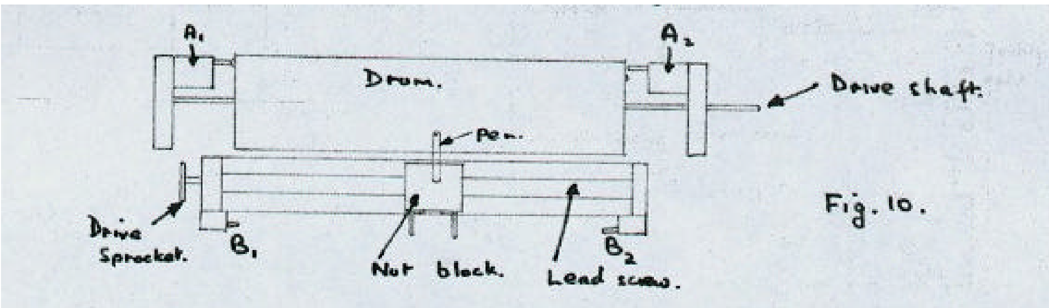


In Figure 9(a), the fixed pinion which is supplying the drive to the unit may be meshed through the idler gear to any one of seven drive pinions. These give effective path lengths of 0.25", 0.125", 0.0938", 0.0625", 0.0469" and 0.0315".

Figure 9(b) has a fixed step down ratio of 8:1 coupled by an idler gear to any one of five drive pinions. These give effective path lengths of 0.0234", 0.0158", 0.0128", 0.0078" and 0.0064". The drive to this unit is supplied by a 100:1 reduction gear which is in turn driven by a 3000 r.p.m. synchronous motor.

<u>Recording Drum</u>

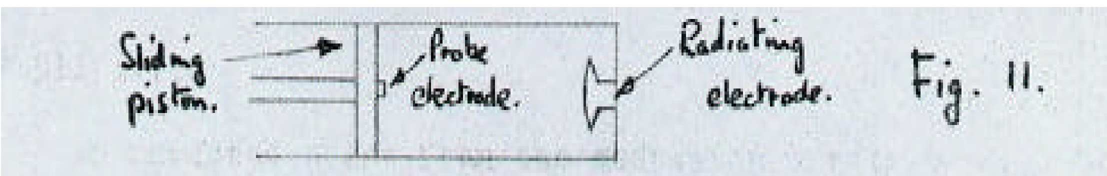
The 100:1 reduction gear drives, via a further 15:1 reduction, a recording drum as shown in Figure 10:



The drum consists of a duralumin tube 10" in length and 2 ½" in diameter mounted in bearings on a spindle. The limit switches A_1 and A_2 are operated by small projections on the drum, their purpose being to reverse the drive motor at the end of each revolution. A pen system is mounted parallel to the drum. It consists of an accurate lead screw which drives a nut block along the face of the drum. The block is prevented from rotating by the use of a guide rod. The lead screw is driven by means of a chain from the attenuator servo motor. Micro-switches B_1 and B_2 are fitted to cut off the motor supply should the nut be driven too close to the end supports. The pen consists of a small piece of thin springy brass strip with a piece of steel wire attached at one end. The end of this wire presses onto the recording paper and burns a trace upon it when a voltage is applied to the supply lead. A special recording paper "Teledeltos" is used in 8" square sheets.

<u>Servo Motor and Piston Attenuator</u>

An "Evershed and Vignoles" servo motor Type FQ12 is used to drive a piston attenuator via a step down gear train. The attenuator, basically, consists of two electrodes fitted in a metal cylinder. When an R.F. voltage is radiated from one electrode, as in Figure 11, it is found that logarithmic attenuation of the signal



occurs with increasing distance from the electrode. Thus, if the other electrode is used as a probe an attenuated output signal is obtained.

The Electronic Apparatus

A hydrogen thyratron having an H.T. voltage of 4000V is fired at a rate of 780c/s, the exact frequency being unimportant. The length of time for which the thyratron fires is determined by a delay line and the time is about 3.5 μsecs. The unit delivers a 3000 volt pulse, 3.5 μsecs wide at an impedance of 150 ohms. This pulse is used to drive an oscillator, which in turn excites the transmitting crystal. Five oscillators are used separately at frequencies of 30, 70, 110, 170 and 239 Mc/s. A double tetrode valve Type QQVO6-40A (Mullard) is used with 'cross-over' feedback. R.F. voltages of up to 1000 volts have been obtained from these units.

The received signal is passed to an R.F. amplifier and mixer stage, which converts the signal to an intermediate frequency of 45 Mc/s. A cascode typ;e of input circuit is used to obtain low noise figures. Five units are again used, tuned to the five fixed frequencies.

A Pye I.F. strip working at 45 Mc/s amplifies the output from the mixer. The video output is monitored on an oscilloscope and is also peak rectified to measure the height of the output pulse, this being given as a D.C. voltage. This voltage is compared with a reference voltage and the difference amplified and passed to a conventional type of 'long tailed pair' servo amplifier.

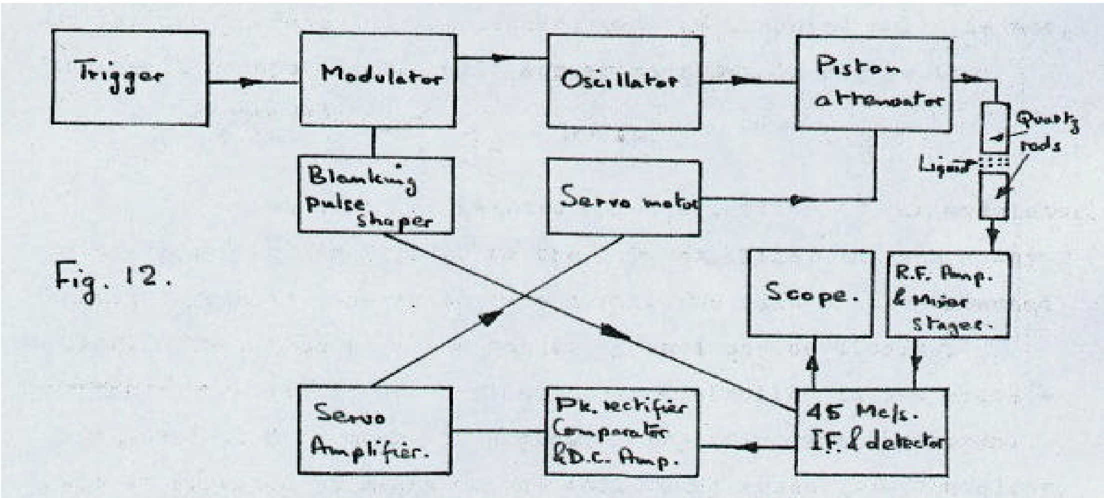


Fig. 12.

An unwanted pulse from the modulator breaks through the receiver system to appear as another pulse on the oscilloscope display. Since the wanted ultrasonic pulse is delayed in time by the quartz rod and the liquid, and the unwanted pulse is not, the oscilloscope display will appear as shown in Figure 13.

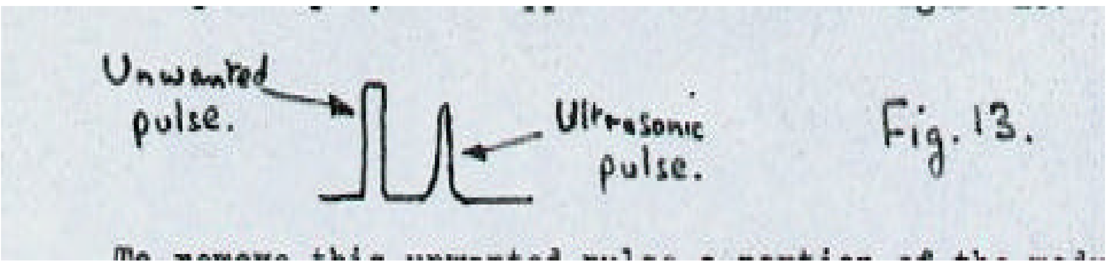


Fig. 13.

To remove this unwanted pulse a portion of the modulator pulse is shaped and applied to the I.F. amplifier in such a way that its gain is reduced to zero during the time of the unwanted pulse. Thus, this pulse no longer appears on the display.

The liquid to be measured is controlled in temperature to within ±0.1°C by means of a control amplifier and thyratron. Heat is supplied by means of the coil wound around the container, and a thermistor is used to detect variations. The liquid is stirred by the continuous travel of the rods.

Operation

The liquid to be measured is placed in the glass container. The drive is set in motion on a long path length to stir the liquid, and the temperature controller is set to the desired temperature and switched on. The 30 Mc/s oscillator and receiver are connected into circuit and switched on. When a pulse envelope is observed on the monitor oscilloscope, a suitable liquid path length is chosen and set up to give a 30 decibels attenuation change in the set 30 seconds travel of the rods. The servo motor is now switched on and a recording made with the pen system. This process is repeated at each frequency and at differing temperatures.

Results

Only a few results have been obtained with this apparatus since it has yet to reach completion. However, those results which have been obtained agree with accepted values. Two lines are obtained, one for the downward movement of the cylinder and one for the return. The gap between the two lines is due to the backlash in the electrical and mechanical systems.

Conclusions

Many problems have arisen during the design of the apparatus which was originally intended only for manual control. It was hoped that the Invar steel cylinders would be capable of working at temperatures down to -80°C. This has proved impracticable since they are found to seize at -30°C in spite of careful drying techniques, and the use of special lubricants. An entirely new apparatus is therefore under construction, the moving parts of which are made of quartz. Preliminary tests have shown that this system can be expected to function at -80°C. At the present time, a new idea is being tried out for operation at low temperatures with the existing apparatus. Basically, this consists of cooling down the Invar cylinders to approximately -20°C, and colling down the glass container to about -80°C. No results have been obtained from this system at present.

It is found that at 170 and 230 Mc/s, the amount of signal received through the ultrasonic system is small. This means that the receiver must be used at maximum gain, which gives a high noise content to the output signal. At the present time, efforts are being made to reduce this noise content which is undesirable.

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