W. A. Higinbotham
4/29/76

BNL Tennis Game

William A. Higinbotham
Apr. 29, 1976

I was head of The Instrumentation Division at Brookhaven from 1951 until 1968. I had the idea for the Cathode Ray Tennis game and gave the general design to Robert V. Dvorak to build and to debug.

Brookhaven used to have visitor days on two weekends in the fall. High School classes, PTA's, etc. came from all over to see the exhibits and to tour the laboratory (reactor, accelerators, biology dept. etc.). The exhibits were placed in our gymnasium. Our division always tried to have something with action, such as this game. Several hundred people played it.

After studying the prints I have figured out how it all worked. I also find that Bob has a few relay contacts in the wrong positions. The game worked beautifully, so he must have fixed them in the actual circuit.

At the right of EH1-900-1-3 is a 2 pole three position switch with outputs to vertical and horizontal deflection. In the upper position, the output signals are taken from the analogue computer and define the locus of the ball. In the middle position, a horizontal line, to represent the floor of the tennis court is generated by 60 cycle a.c. from the transformer at bottom right. In the lower position, the net is generated by applying an a.c. signal to the vertical output. Pots are provided to adjust the length of the court and the height of the net and their positions on the C.R.T.

Actually, this 2-pole, three position switch was electronic. It is shown on EH1-900-2-3, at the left. There is an unregulated d.c. supply at the top. In the center are the circuits to rotate the switch at a rate of about 36 hz. to avoid flicker. The square-wave oscillator ran at about 72 hz. The divide-by-two circuit ran at just half this speed. The bases of 5 transisters are driven from the four emitters of the oscillator and divider circuits. The five collectors are interconnected to 3-5.1 k resistors (above) and through 51 k resistors to the switch transistors at the left, in pairs. The connections are such that the ball potentials are connected to the oscilloscope each half cycle of the oscillator. The net and court signals are alternately connected for the other half cycle.

The oscilloscope used was a laboratory instrument with a 5 inch diameter, round tube, electrostatic deflection and direct-coupled amplifiers to the vertical and horizontal deflection plates. As you can see, the signals from the analogue computer were attenuated by 50:1, giving about ±2 volts maximum input to the oscilloscope input.

Returning to EH1-900-1-3, the triangles numbered from 1 to 10 are the operational amplifiers of a Donner analogue computer. It was a tube job with ±100 volt d.c. output.

At the left are a set of relays which all operate in parallel. The labelling is odd. Anyway, all of the contacts, A, B ···J, are shown in their normally unactivated position. This has the ball traveling to the right, let's say. The horizontal speed is determined by the charge on the 1 ufd capacitor at contacts 1H and 1J, which is connected across amplifier 6. Amplifier 7, integrates the d.c. output from amplifier 6. If no one is playing, the ball reaches the end of the court, relay 6 is activated and the ball is frozen in the serve position by relay 2 (there is a missing connection). Relay 2 clamps amplifier 2 at zero output and amplifier 7 at the appropriate end of the court.

Relay 7 fixes it so that only the operator with the control for the end of the court where the ball is can serve.

Controls, in our case, were two hand-held boxes, one for each of two players. I have circled these controls. Each box had a normally-open push button (P.B.) and a dual 50 k pot. Turning up the pot increased the vertical speed and decreased the horizontal at service. The two 5 k pots adjusted the mean velocities and were fixed.

The server would set his angle and push the serve button. This flipped the set of relays, at left, and connected capacitors to amplifiers 1 and 6, the capacitors retaining the potentials selected by the angle pots. In the case of amplifier 6, this gave a fixed output which amplifier 7 integrated to provide a constant horizontal velocity.

Amplifier 1 has a 1 megohm resistor connected to a negative potential to leak charge off of the feedback capacitor (the permant 10 meg and .01 mfd across amplifiers 1 and 6 are to suppress transients). The output of amplifier 1 goes negative at first, then drifts positive. Amplifier 2 integrates and inverts giving a sort-of positive perabola. Amplifier 4 senses when the ball hits the floor and slaps another capacitor across amplifier 1 to give a proper bounce.

Amplifier 4 and relay 5 do the net bounce. 4A and B reverse the horizontal direction and 4C (not 3C) reverses switch 1 to keep the ball going back.

Amplifier 5 shifts the manual controls when the ball passes the net. The receiver must return the ball before it passes the end of the court.

That is about it.

Alex Elia, who did the drawings, is still in The Instrumentation Division.