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POSITION READOUT SYSTEMS FOR 85-1, 85-2, AND NIKE MOUNT

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I. Purpose

The readout receives data from two 17-bit binary encoders and from the sidereal clock. Electrical binary coded decimal and nixie outputs are provided for Declination, Hour Angle and Right Ascension. One encoder bit equals approximately 9.89 seconds of arc and 0.66 seconds of time angle. Since these numbers are not integers, the output resolution must be greater than the encoder resolution. The error on Hour Angle and Right Ascension due to conversion does not exceed 0.05 seconds of time angle.

The maximum uncertainty of Declination is estimated to be ± 8.4 seconds of arc (0.5 conversion, 4.9 encoder resolution, and 3.0 encoder error). The maximum uncertainty of Hour Angle and Right Ascension is estimated at .58 seconds of time angle (.05 conversion, .33 encoder resolution, and .2 encoder error). Mechanical errors occurring before the encoder are not included.

The encoders are Baldwin 17-bit binary encoders, model 1011, with negative output modules. The logic is performed with commercial logic cards by Computer Control Corporation. The 200 kc S-pac series of cards are used.

A position transmitter and position receiver will be constructed to provide a readout of the position of the remote telescope in the main telescope control room. Only the 85-2 readout has output connectors to drive the position transmitter.

II. Controls

The power switch on the right side of the panel controls all the logic voltages. The 200 volt power for the nixie readouts does not pass through the logic system.

A similar group of controls for both the encoders are provided. The "strobe test" banana jack indicates the lamp is flashing in the encoder. An amplitude "adjust" pot and a "test" jack are provided for the "Interrogation Pulse". The Interrogation Pulse should be adjusted to the minimum signal that gives consistent triggering of the strobe lamp. In the "amp test" position the Interrogation Pulse generator is switched from the Interrogation Pulse coax to the amplifier test encoder coax. The amplifier test signals cause all the output amplifiers in the encoder to give an output. These encoder outputs are available on a terminal strip behind the front panel. The clock slave supplies the pulse that starts the readout process every $\frac{1}{10}$ second.

III. Block Diagram

The data is received from the 17-bit Baldwin encoder in gray code. The data is converted to non-cyclic binary code in a modified shift register. This is accomplished by shifting the data 16 times (places) around the 17-bit register. Refer to figure 1.

Each binary bit in the register now represents a specific number of hours or degrees, minutes, seconds, and tenths of seconds. Refer to table 1 for degrees and to table 2 for hours. The most significant digit represents half of a rotation of the encoder (180 degrees or 12 hours). The second digit represent 1/4 of a revolution, the third 1/8 revolution, etc. The last digit (the seventeenth) represents approximately 9.89 seconds of arc or approximately 0.66 seconds of time angle.

The three output registers are designated Declination Counter, Hour Angle Counter, and Right Ascension Counter. A counter is set to zero and then caused to count the proper number of pulses to reach the correct output. The three registers are slightly different in actual operation. The most complicated one (Right Ascension Counter) will be discussed first.

The Right Ascension Counter is first reset, then loaded with sidereal time, and then counted up by amount measured by the polar encoder. The R. A. Counter is divided up by decimal digits into groups called "columns". See table 2. The "columns" are further divided into four "rows".

At the beginning of each new "column" the sidereal time is loaded into that decimal digit (or digits) represented by the new "column". For each "row" one and only one of each "weight one", "weight two", "weight four", and "weight eight" are loaded into the "Scaler Down Counter" by the "Scaler Gates". The binary weights loaded follow the rules shown in table 2. The "Down Counter" now holds a number from 0 to 15, depending upon the bits loaded. At the same time that the "Down Counter" is counted down to zero the same pulses are fed to the decimal digit selected by the column number. After this operation is repeated for each "row", this decimal digit will be counted up by the required amount.

The Hour Angle Counter is loaded similarly to the Right Ascension Counter. Two major differences exist. Time is not loaded into the register. The most significant encoder digit represents East or West instead of 12 hours. The Gray to Binary Converter is not loaded with the most significant digit. The binary code then becomes a mirror code with two zero's and increasing in number (count) in both directions from zero. The West zero is eliminated by adding 0.7 seconds of time to the Hour Angle Register if the angle is West.

The Declination Counter also uses the most significant encoder bit as a sign bit. The Declination Scaler Gates are used for this register. These gates follow the rules in table 1. This is the only output that is displayed in degrees, minutes, and seconds. Some of the numbers from table 1 are placed into the Declination Counter without using the Declination Scaler Gates and the Scaler Down Counter. The directly loaded numbers are indicated by a "D" in table 1. A decimal digit may be loaded with a "one", a "two", and a "four" without error. A senary digit may be loaded with a "one" and a "two".

IV. Logic Sequence of Operations

This section is written with the service of the equipment in mind. It is not recommended reading for the general knowledge of the system. Refer to logic drawings DL 1350, DL 1351, and DL 1352 for the readout system at the 85-2. The drawings for the 85-1 are DL 1250, DL 1251, and DL 1252. The system at the 85-1 has the added feature of sampled encoder lines. The readout system for the 12-foot (nike mount) telescope (drawings DL 850, DL 851, and DL 852) is somewhat similar to the 85-foot systems. The standard 3C logic symbols are used for the logic drawing. Literature describing 3C logic is recommended reading. In order to guide someone through the logic drawings, the following sequence of operations is provided:

End of "0.1 ΔT" (starts operation each $\frac{1}{10}$ second).

20 μsec pulse on T_{P8} Block 2, set "F21"; reset "F22".

20 μsec pulse at "S_{EB}", and "S_{EA}", interrogate polar encoder, "R_{DRR}" (reset Right Ascension Decimal Register); reset Shift Register.

Encoder data loaded into shift register (under control of encoder at 85-2; under control of "S_{EC}" at 85-1.

Set "F204".

Shift the Gray to Binary Shift Register 16 times.

Reset "F204".

Pulse on TP2 block 2; reset Column Counter, "C2" state.

Set "F205"; start Row Counter, "R1" state (F206 is in reset state); load Scaler with "Ps" pulse (F21 selects H.A. and R.A. Scaler Gates). Note that table 2 specified that nothing will be loaded into the scaler during C2 R1; "Pz" causes sidereal time hour to be loaded into the Right Ascension Counter.

F206 is not set since the Scaler is already on "zero". F205 reset.

Set F205; step Row Counter to state R2; nothing is loaded into the scaler on C2 R2; reset F205.

Set F205 row counter to state R3; under control of "Ps" load a "4" and an "8" into scaler if "F1" is true; load a "1" and a "2" if "F2" is true.

Assuming Scaler is loaded with something, Set F206; reset F205; begin counting down Scaler and counting up unit hours of the Right Ascension Counter; "P_{CR}" controls the counting up of the R.A. Counter.

Scaler reaches count "one"; reset F206.

Set F205; advance "Row Counter" to "R1"; advance "Column Counter" to "C3". Load tens of minutes of sidereal time into the Right Ascension Counter; load the Scaler with a "one" and a "two" if F4 is true and with a "four" if F5 is true.

Repeat above operations until end of C8 R4 advances Column Counter to "C9"; the Row Counter goes to a "no action" state; pulse on TP9 block 2.

Pulse TP10 block 2, toggle F21 to pulse state; set F22.

Pulse on S_{EA} and S_{EB}; interrogate Declination Encoder; reset Declination Counter; reset Shift Register.

The most significant encoder bit is loaded into the North-South flip-flop (F_S). The remaining encoder bits are loaded into the Shift Register and are converted to binary code from gray code.

F204 reset (starts) Column Counter.

C2 R2 produces P_{PD}; loads data into Declination Counter without using the Scaler Gate and the Scaler.

C2 R4 is the time the Scaler is first used. The counting-up process of the Declination Counter proceeds like the Right Ascension Counter except the Declination Scaler Gates are used.

End of C8 R4; step to C9 and to a "no action" state of the Row Counter; pulse TP9 block 2.

Pulse on TP10 block 2; toggle F21 (F21, F22 now selects Hour Angle measurement).

S_{EA}, $\overline{S_{EB}}$, reset Hour Angle Counter; reset shift register; interrogate Polar Encoder. (The readout system is slowed down to allow the Polar Encoder time to recover from the previous readout.)

Encoder data is loaded into the Shift Register. The most significant encoder digit is loaded into "F_E" instead of the shift register.

At the completion of R4 C8 the system is inhibited from restarting by $\overline{F22}$. The system is now waiting for the next 0.1 ΔT at the next $\frac{1}{10}$ second.

V. Special Purpose Card

One special purpose card is required in the Position Readout System. The card contains two Interrogation Driver Circuits. Refer to Digital Drawing DS 875. Each circuit consists of a two input "and" gate, and emitter follower, and an inverting output amplifier. This amplifier is AC coupled to the encoder cable. The "-12 volts to gnd" pulse at the output of the transistor produces a "gnd to +12 volt" pulse on the encoder cable.

TABLE 1

Truth Table for Declination Scaler Gates

Angle	Binary Bit	C_2	C_3	C_4	C_5	C_6	C_7	C_8
		Degrees		Minutes		Seconds		
		10	1	10	1	10		1
90°	2	D 1 - 8						
45°	3	4	1 - 4 D					
22° 30'	4	2 R4	2	D 1 - 2				
11° 15'	5	1	1 R1	1 R1	R1 1 - 4			
05° 37' 30"	6		1 - 4 R2	1 - 2	D 1-2-4	1 - 2 R1		
02° 48' 45"	7		2 R3	R2 4	8	4		1 - 4 D
01° 24' 22"	8		1	2	4 R2	2 D		2
00° 42' 11"	9			4	2	1		1 R1
00° 21' 06"	10			2 R3	1			2 - 4
00° 10' 33"	11			1		R2 1 - 2		1 - 2
00° 05' 16"	12				1 - 4 R3	1 R3		2 - 4 R2
00° 02' 38"	13				2		R1 1 - 2	R3 8
00° 01' 19"	14				1 R4		1 R2	1 - 8
00° 00' 40"	15						4	
00° 00' 20"	16						2 R3	
00° 00' 10"	17						1	
00° 00' 10"	N						1 R4	

TABLE 2

Truth Table for Hour Angle and Right Ascension Scaler Gates

Angle	Binary Bit	C_2	C_3	C_4	C_5	C_6	C_7	C_8
		1 H	10 min	1 mW	10 sec	1 sec	$\frac{1}{10}$ sec	
12° 00' 00.0"	1	4 - 8 R3						
06° 00' 00.0"	2	2 - 4 R4						
03° 00' 00.0"	3	1 - 2						
01° 30' 00.0"	4	1	1 - 2 R1					
00° 45' 00.0"	5		4	4 - 1				
00° 22' 30.0"	6		2	R1 2	R1 1 - 2			
00° 11' 15.0"	7		R2 1	1 R2	1	R1 1 - 4		
00° 05' 37.5"	8			1 - 4 R3	1 - 2 R3	R2 1-2-4	1 - 4 R1	
00° 02' 48.8"	9			2 R4	4	8	8	
00° 01' 24.4"	10			1	R2 2	4	4 R2	
00° 00' 42.2"	11				4 R4	R3 2	2	
00° 00' 21.1"	12				2	1	1	
00° 00' 10.5"	13				1		1 - 4 R3	
00° 00' 05.3"	14					1 - 4	1 - 2	
00° 00' 02.6"	15					R4 2	R4 2 4	
00° 00' 01.3"	16							R1 1 - 4 - 8
00° 00' 00.7"	17							R2 1 - 2 - 4
EW - Hour Angle Only								R3 1 - 2 - 4

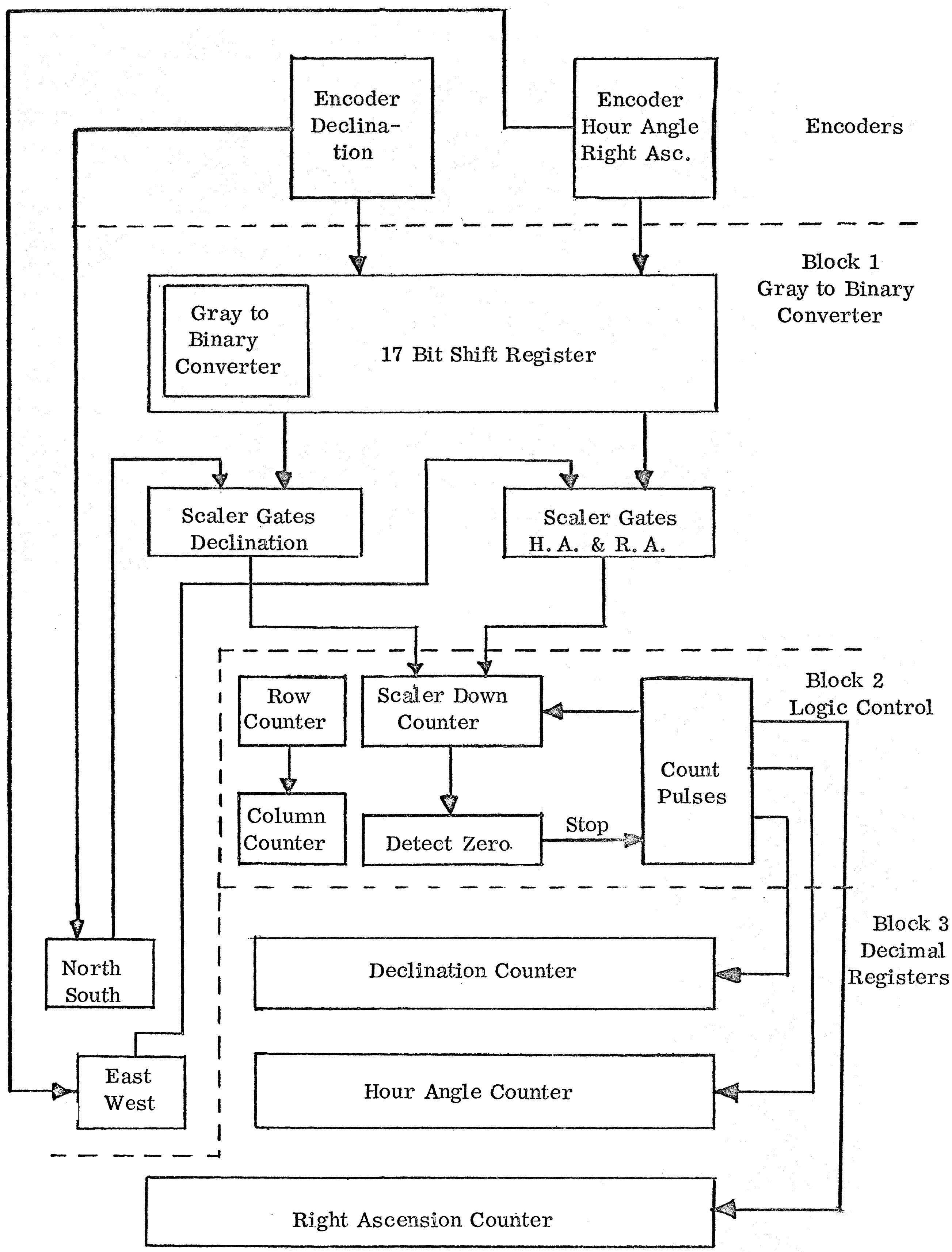

FIG. 1 — BLOCK DIAGRAM OF POSITION READOUT SYSTEM