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THE HORN SYSTEM

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I. Basic Design Considerations

The horn system of each antenna of the Stanford 5-element array comprises the rotatable mounting for the feed horn and the associated equipment for remote control and readout of the position angle of the polarization vector.

The maximum precision in setting the position angle of the horn is required when polarization measurements are made using pairs of antennas with crossed feeds to eliminate the response to randomly polarized radiation. In this case an error of δ in setting the orthogonality of the polarization vectors results in a response of amplitude $\sin\delta$ relative to that with parallel feeds. In general, there is a further residual response resulting from a small degree of circular polarization in the antennas, and experience shows that this and other errors generally limit the accuracy of polarization measurements to about 1% of the randomly polarized level. To keep errors introduced in setting the polarization angles small in comparison we thus require that $\sin\delta \leq 10^{-3}$, or $\delta \leq 3.5'$.

It is convenient to drive the horn rotator with a Slo-Syn stepping motor in which the output shaft moves in steps of 1.8°. The gear ratio between the motor and horn must therefore be at least 16:1 to reduce the corresponding steps in the horn position angle to less than 7′ so that the horn angle can be set within 3.5′ of any given position. The digital encoder chosen for reading the horn position angle has a readout accuracy of 0.01° and requires a 36:1 gear reduction between the encoder and the horn. It is possible to obtain this ratio

in a single pair of gears, and this is preferable to using a gearbox with several pairs which would almost certainly introduce more backlash. The 36:1 ratio can also be used for the stepping motor drive, resulting in a step size of 3′ for the horn position angle. The maximum operating rate for a stepping motor is approximately 300 steps per second resulting in a slewing time of 1 revolution of the horn in 24 seconds.

The maximum waveguide size likely to be required with the antennas is P-band, 1.12 to 1.70 GHz, which has an outer diagonal of 7.48 inches. The central aperture of the feed rotator should therefore have a diameter of not less than 7½ inches. To accommodate a horn for 21 cm wavelength operation the point at which the feed horn passes through the bearing should be positioned at least 6 inches from the focus on the side away from the paraboloid, to allow space for the flared section of the horn.

II. Mechanical Design of the Horn Rotator

The mechanical design of the horn rotator is shown in Drawings No. RC-262, RC-263, and RA-264. Note that the 18-inch outer dimension of these drawings has been reduced to 17 3/4 inches to allow economical cutting of the large aluminum plates. A bearing with internal bore 12 inches is used and the diameter of the aperture through which the waveguide passes is 9 3/4 inches. The horn is driven by a specially designed gear with a pitch diameter of 15 inches and internal bore diameter 10 inches. Both the stepping motor and the encoder are coupled to this gear by 5/12-inch diameter 20-tooth gears, resulting in a 36:1 ratio. The horn is mounted through a circular plate of diameter 11¼ inches which is fixed to the rotating part of the system by twelve 10-32 Allen screws. The bearing, gears, encoder and motor are enclosed in a box of outer dimensions 17 3/4 inches x 17 3/4 inches x 12 inches, access to the interior of which can be gained through removable panels on two opposite sides.

The top surface of the box contains a hole of diameter 10 inches through which the output waveguide passes to the RF box. With the X-band horn a waveguide rotating joint will be used, which will be located within the horn rotator box. A rubber or thin aluminum panel will be used to seal the box at the hole where the waveguide passes through.

III. Components

The various units of the horn system and their interconnections are shown in Fig. 1.

The rotatable horn mounting at the focus of each antenna is made up in the S.E.L. machine shop, using aluminum as the basic material. Are screws and washers are stainless steel. Each mounting contains the following main components.

Bearing (1)	Kaydon 'Reali Slim' 4-point contact KD 120 XP 12.000" bore, Kaydon Engineering Co., Muskegan, Michigan.	$79.75 ea.
Motor (1)	Slo-Syn, bifilar wound, SS-50-1008. Superior Electric Co.	$61.00 ea.
Gear (1)	15" pitch diameter, $\frac{1}{4}$" face, 720 teeth, 48 pitch, 20° pressure angle, central hole 10.000" $\pm$ 0.0005", material brass, American Precision Gear Company, San Carlos	$169.00 ea.
Gears (2)	48 teeth, 1/8" face, 48 pitch, 20° pressure angle, material stainless steel, precision 3, Sterling Instruments, # 21-20-P3 (two required)	$6.97 ea.
Encoder (1)	Decitrack TR-C-1038. Theta Instrument Corp.	$900.00 ea.

The components in the ground box of each antenna are the following.

Ground Box

Translator Module (1)	Superior Electric STM 1800	$55.00
Power Supply (1)	±15V for translator module. See Superior Electric catalog SS1265-2, page 23	
Terminal Block, 48 contacts (1)	For junction of encoder cable.	

In the control room one position-angle display unit is used for all 5 encoders and one preset indexer drives all 5 motors simultaneously. The main components are as follows.

Readout (1)	Decitrack C-5066, Theta Instrument Corp.
Preset Indexer (1)	Superior Electric SP-250-4
48-contact 5-way switch (1)	

IV. Interconnections

Focus to ground box for each antenna

Encoder cable	48-conductor
Motor cable	5-conductor

Ground box to laboratory

Encoder cable	48-conductor
Indexer to translator cables (2)	Coax (RG 58)

V. Power Requirements

No a.c. power is required for the components at the focus. In the ground box power is required for the translator power supply and in the control room for the readout unit and the indexer.

VI. Jobs to be Done

It will be necessary to modify the present preset indexer to bring out the pulses which drive the single translator unit which it contains. Since the pulses will be fed to 5 translators, a stage of amplification may be required. The translator modules require a 10-15V negative pulse and have an input impedance of 500 ohms.

The 48-contact 5-way switch for the angle readout may have to be specially designed for such a large number of contacts.

The following components have yet to be purchased or constructed (this list does not include items for which purchase or job orders have been written as of 6/5/67). Cables are not included.

3 15- inch gears
6 5/12-inch gears
3 stepping motors
4 encoders
3 mechanical horn-rotator systems
5 junction panels for ground boxes
3 translator modules
5 translator power supplies
1 control panel