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The Italian Cross Radiotelescope.

II. – Preliminary Design of the Receiver.

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The receiving system that we are going to describe, is intended to operate in connection with the antenna system which has been described in part I of this paper.

The entire system (antenna plus receiver) has been conceived as a whole, functionally interdependent, and the designs of the two go on side by side. The main purposes of the receiver shall be:

a) To amplify the signals being collected by different sections of the antenna system, to convert them to a suitable intermediate frequency, and to send them to a central signal-handling station, through separate cables, so as to constitute a number of different reception « channels », each of them corresponding to a different section of the antenna.

b) To introduce on the single channels phase shifts, delays and attenuations, according to strictly controlled characteristics, in order to meet the required conditions for proper operation of the antenna system.

c) To divide each channel into a group of « subchannels » with different phase shifts, and recombine groups of properly chosen subchannels, so as to obtain new channels corresponding to a number of independent pointings of the antenna beam.

d) To multiply, in pairs, the outputs of said new channels so as to obtain different outputs corresponding to independent beams.

e) To handle these outputs, first by an analogic data process, (clippers, integrators), then by a digital one, through suitable electronic computing devices.

An integral part of the receiving system will consist of the equipment required to measure the system's performances, to check its stability, and to perform the necessary adjustments to bring the antenna beams to their desired angular positions.

The final composition of each receiving section is still under discussion. Each one will probably consist, basically, of a « parametric » amplifier, a balanced mixer and an intermediate frequency preamplifier (*).

(*) In the first period of operation, ordinary converters, with conventional crystal diodes will be most probably employed to give the I.F. frequency signal.

Fig. 1 shows one of the possible configurations which have been proposed and are being evaluated.

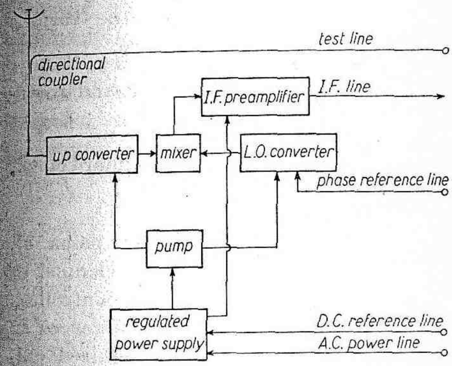

Fig. 1.

The (408 ± 1) MHz signal coming from the antenna is amplified through a parametric up-converter, and converted to a frequency in the X band (let us say, for instance, (10408 ± 1) MHz). The signal thus obtained is mixed with a 10378 MHz signal, so giving an output signal at (30 ± 1) MHz. This 10378 MHz signal is, in turn, obtained by conversion of a 378 MHz reference signal coming from the central station, which is mixed with the pump frequency (10 000 MHz). Since the two converters (378 to 10378 and 408 to 10408) utilize a common pump, any frequency or phase variation of the latter has no effect on the mixer output ((30 ± 1) MHz) frequency or phase. The same thing, of course, cannot be said for variations of the reference signal (378 MHz) frequency or phase, which must therefore be controlled and kept constant with great accuracy.

The I.F. signal is then amplified and sent to the central station through an underground coaxial cable.

Fig. 2 shows the simplified block diagram of the central station equipment.

At the station, each incoming I.F. signal goes through the following circuits, in the order listed below:

L_2) fixed delay line, to equalize the lengths of the I.F. lines from the antenna;

G_2) I.F. amplifier, to raise the signal level after the attenuation introduced by the cables;

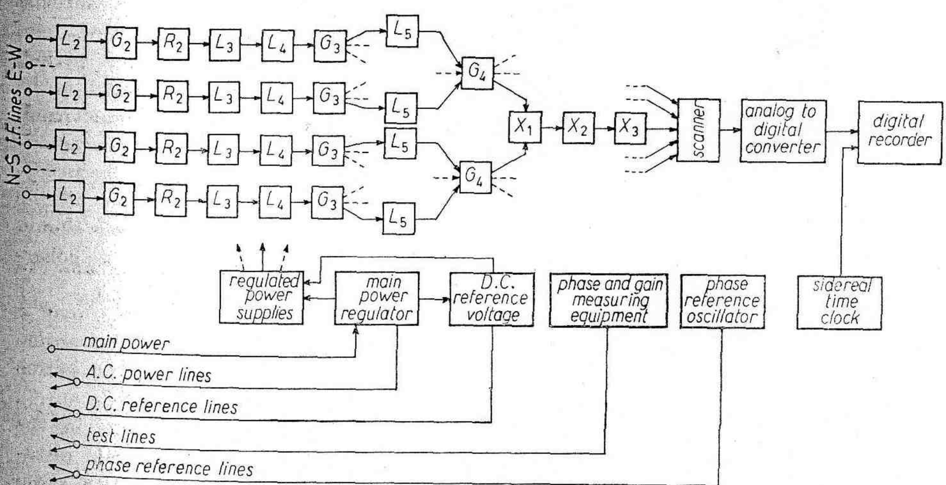

Fig. 2.

R_3) attenuator, to equalize the actual gain (gain plus losses) of the different channels, as well as to provide the required amount of attenuation for the correct tapering of the antenna-receiver system;

L_3) adjustable delay, to reduce the chromatic aberrations of the antenna-receiver system;

L_4) adjustable phase shifter, which allows the global angular positioning of the antenna beams;

G_3) isolating amplifier, which allows the division of each channel into a number of independent subchannels;

L_5) fixed phase shifters, one for each subchannel, with different phase shifts;

G_4) summing amplifiers, allowing the recombination of the subchannels into convenient groups. (At least three groups for the E-W arm, and five groups for the N-S arm will be provided);

X_1) electronic multiplier (correlator) (1) which performs the multiplication of one group of signals coming from the N-S arm by another one coming from the E-W arm. The total number of correlators will be fifteen at least, so giving fifteen independent beams. The correlator will also rectify the signal, giving a d.c. output;

X_2) clipper, to suppress high level pulse interference;

X_3) integrator, which reduces the signal bandwidth to about 1 Hz.

The output signals from the integrators will be fed, through a scanner, to an analogue to digital converter, which in turn will feed them to a data processing machine or a digital recorder.

Besides the essential items listed above, the central station will contain the following:

1) Regulated power supplies, reference voltage and reference frequency generators.

2) Gain, attenuation and phase (2) measuring instruments for the various parts of the receiving system.

3) Auxiliary measuring and recording equipment.

4) Precision sidereal standard clock, to provide time marks.

As we mentioned under point *b*), gain and phase shift of each channel of the receiver must be strictly controlled. This is necessary because differences in gain and phase from the required calculated values may change the behaviour of the antenna-receiver system, giving rise to unwanted side-lobes.

The change in gain must be less than 1% over a twenty-four hour period, and the change in phase shift less than 1 electrical degree over the same period, if the side-lobes introduced by the receiver must be kept smaller than those inherent in the antenna system. We are not concerned here with stability over a longer period, because the system is supposed to be checked daily, with measurement and, if necessary, adjustment of its characteristics to the required degree of accuracy.

Furthermore, the response of the multipliers to noncoherent signals should be $(25 \div 30)$ dB lower than that to coherent signals.

The short gain stability (*i.e.* over a period of the same order of magnitude as the transit time of a point source across the beams) shall be at least 0.1%, to prevent random variations in the background level caused by gain instability from being confused with radio sources.

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(1) E. J. BLUM: *Annales Astrophysique*, T. 22 (1959).

(2) G. SWARUP and K. S. YANG: *IRE Transactions on Antennas and Propagation*, AP 9, 1 (1961).

The noise figure of the receiver should be as low as possible, because the receiver noise, even if not strong enough to directly affect the capability of detecting weak sources, might give a significant contribution to the background level, thus rendering more stringent the gain stability requirements. It seems that it is possible, by using parametric amplifiers, to achieve an overall noise figure of 2 dB or less. If these requirements will be met, we hope to be able to reach an overall temperature resolving power of the order of a few hundredths of degree Kelvin, referred to the receiver input.

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