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PROPOSAL TO BUY A SMALL COMPUTER FOR DATA HANDLING AND PROGRAMME CONTROL

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A. Requirements

The computer will be required to perform the following essential functions:

1. The computation of the hour angle of a source.-- This requires input information to the computer in the form of: 1) Real Sidereal Time, 2) Precessed apparent local R.A. of the source for the date. The calculation involves subtraction of the two above quantities for hours, minutes, seconds and subsequent conversion to radians. The precision required is approximately 1 part in 10^6, i.e., for the maximum spacing the change in wavelengths for a change in hour angle DH is

$$d\lambda = 7336\lambda \cos H \, dH$$

$$dH = \frac{10}{7336 \times 360 \times 1/2} \qquad \text{for } H = 60^{\circ} \text{ and } d\lambda = \frac{10}{360}\lambda.$$

$$= 7.6 \times 10^{-6} \simeq \frac{1}{10^5},$$

and we should allow one further order of magnitude for later rounding off.

2. If many cycles of the fringe are to be added in the correct phase it will be necessary to calculate the fringe phase for all of the spacings so that the timing for the superposition may be established. Associated with this is the necessity to calculate the times at which the delay lines have to be changed so that it would seem desirable first of all to calculate $\sin H \cos\delta$ which can then be used for both the above calculations. The precision required here is again one part in 10^6.

To do this we require the precessed apparent declination of the source for the date. (This, together with the precessed R.A., could be calculated in the computer at the time, however it would seem better to do these calculations separately which avoids storage and time in the computer. This same information, although perhaps in a different format is required to set the antennas.)

The value of sin H cosδ is then stored for further use.

a. The delay lines are then set using this value multiplied by a suitable constant. The present system is to have all the delay line switches in parallel but with a bit length appropriate to each antenna. Hence for this value of H the delay lines are set to the nearest integral bit length. Each time H changes the delay lines are reset.

Another approach would be for the computer to put out a pulse whenever the value of K sinH cosδ reached a prestored table of values. This would need about 512 numbers to be stored. If the hour angle was changed to look at another source, then the computer would have to generate a train of pulses to reset the delay lines.

b. The computation of the fringe phase can be carried out in a similar fashion. That is sinH cosδ has to be multiplied by 9 different constants to give the predicted phase at hour angle H. This information has then to be used to sample the data and cause it to be stored in the computer memory for the duration of the observing period $\simeq$ 5 minutes. One method for doing this is shown in the flow chart, Fig. 1. The idea is as follows.

The predicted fringe phase is calculated first and gives a value 6943.26 wavelengths say for the fastest fringe. The derived value is then rounded off to 0.3 and hence we sample the data and put it into slot 3 in the memory. In this way 10 samples per fringe would be obtained and each time the predicted fringe phase was rounded off to 0.3 the data would be sampled and stored in the same slot. Since the fringes are not all at the same rate, the slowest fringe's predicted phase is rounded off to the same value for several cycles of the computer and hence several data samples will be stored in the same slot. With this method the computer finishes its run with 10 slots per fringe of data - i.e. 90 slots total. The 10 slots define the fringe and are sufficient to lose only 0.05 db in signal to noise ratio. Slower sampling could be used but a loss in signal to noise would be the penalty. Also the sampling interval should be related to the fringe period. (This method is illustrated in the flow chart, Fig. 1.)

This is just one method of sampling. Another approach would be to multiply the data continually by $C \sin H \cos\delta$ and $C \cos H \cos\delta$ so that after the observing period is over the computer memory has just two numbers stored per fringe from which the phase and amplitude can be obtained.

Yet another approach could be to use linear sampling at a rate fixed at the beginning of each observing interval. The data would then be sampled regularly and stored in the computer in a manner similar to that above.

Until the detailed programmes are written it is not obvious which is the best approach.

c. The output of the computer is finally stored on magnetic tape for further processing.

B. <u>Further Uses of the Computer</u>

It is not intended initially to use the computer to set up the antenna pointing although it could obviously be used to do so. This is a refinement which should be left until the more important programmes are written and working.

C. <u>Choice of the Computer</u>

There are quite a few small computers available all at competitive prices. However the H.P. machines are favoured for the following reasons:

1. Service facilities are easily available.
2. Interfacing existing H.P. equipment at Heliopolis with other computers would undoubtedly cost time and money.
3. Can be programmed using ASA basic Fortran.
4. Word length 16 bits - desirable to cut down storage space. Nearest competitor is 12 bit computer.

There are three H.P. computers to choose from. All have same basic format but have different degrees of expansion facilities. The smallest computer 2114A has no facilities for extra multiply/divide hardware, has only 8 external interrupts (i.e., external channels), and has no facilities for high speed input-output.

The HP 2115A has all these facilities plus 32 interrupts for input-output. The HP 2116B is a bigger machine and would seem not to be required for the present installation.

The block diagram of the system is shown in Fig. 2. The hardware which already exists is shown shaded, and hence all other components will have to be purchased. The overall cost of the system is shown on page 6.

Note that all of the available 8 output-input channels have been used up and any further extension will require either the extender option or sacrifice of one or other of the existing functions.

It is not known at this stage how long it will take for the programme to be written. The machine is programmed by a paper tape which is compiled from supplied programme tapes and the teletype. Hence once a programme has been written it is always available to be read into the computer and can be used again and again.

Some idea of the time taken to perform the sample programme has been obtained and is given in the next two pages together with an estimate of the storage required. These have been obtained from the H.P. representative and the H.P. pocket guide to H.P. computers. We can get some idea of the time taken to feed the programme into the machine as follows.

If we want to store 1000 words into the machine and if each word has on the average 6 characters, say e.g. AERIAL is a six character word, -- then 1000 stored words requires 6,000 characters. Using the slow speed reader this takes 600 seconds to feed into the machine, whereas the high speed reader operating at 300 characters per second takes 20 seconds. This calculation is obviously not accurate but should give the order of magnitude.

Note that the computing time calculated above has to be less than the sampling interval of the fastest fringe. This time is of the order of $\frac{1.88}{10} = 0.188$ seconds so that the sample programme indicates that the computer can do all the necessary calculations well within this time.

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Computation

	APPROX TIME Milliseconds	STORE REQUIRED Words
1) Calculate difference between Sidereal time and Precessed R.A. 3 calculations H, M, S	2.7	94
2) Convert to Radians Multiply each of 3 numbers by constant and add	2.2	51

Result. Hour angle now established (could be updated to allow for computer time).

	APPROX TIME Milliseconds	STORE REQUIRED Words
3) Calculate sin H cosδ. cosδ considered a constant	21	66
4) Calculate C sinH cosδ	0.75	51
5) Round off this value to nearest integral number	1.0	29

Result. This number is now the number of bits required for the delay lines and is used to set the delay line register.

	APPROX TIME Milliseconds	STORE REQUIRED Words
6) Calculate K_1 sinH cosδ	0.75	51
7) Round off to 1st decimal place	0.5 ms	29
8) Use the decimal to select a memory slot then read appropriate channel into the memory.	0.5 ms	220
9) Step digital voltmeter to next channel to await sample.		
10) Go back to 6 and repeat 8 more times		50
11) Stop after this and go back to (1) and recalculate for new value of H		50
12) After 1500 Repeat stop and print out onto MAG tape constant of 90 memory cells.		90 50

Result. Each fringe will have been sampled at least 10 times and hence there are 10 numbers specifying each fringe.-- 90 total.

Hence total time for once around the loop 1-10 is ≃ 50 ms. Total storage is approx. 1000 words.

This does not include any subroutines however which would be necessary to operate paper tape, reader teleprinter and magnetic tape. It is expected that another 1000 words would cover the amount of storage for these functions. Hence 4000 words of memory is probably enough. However, an 8000 word memory would allow the flexibility for other functions of control of the whole antenna system for example.

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Estimated Cost

	✓ 2114A Computer		2115A Computer
Computer	9950		14,500
8 K memory	4000		5,000
Teletype - Paper tape punch	2000	10 characters/ sec	2,000
Clock interface	750		750
Counter interface	750		750
Relay Register for delay line	600		600
Power fail interrupt	500		500
High speed tape input	2100	300 characters/ sec	2100
Mag. tape interface	1500		1500
General purpose dupl registers	1500		1500
	23,650		29,200

Delivery 6 months

Delivery 6 weeks.

Prices less 5% for educational purposes

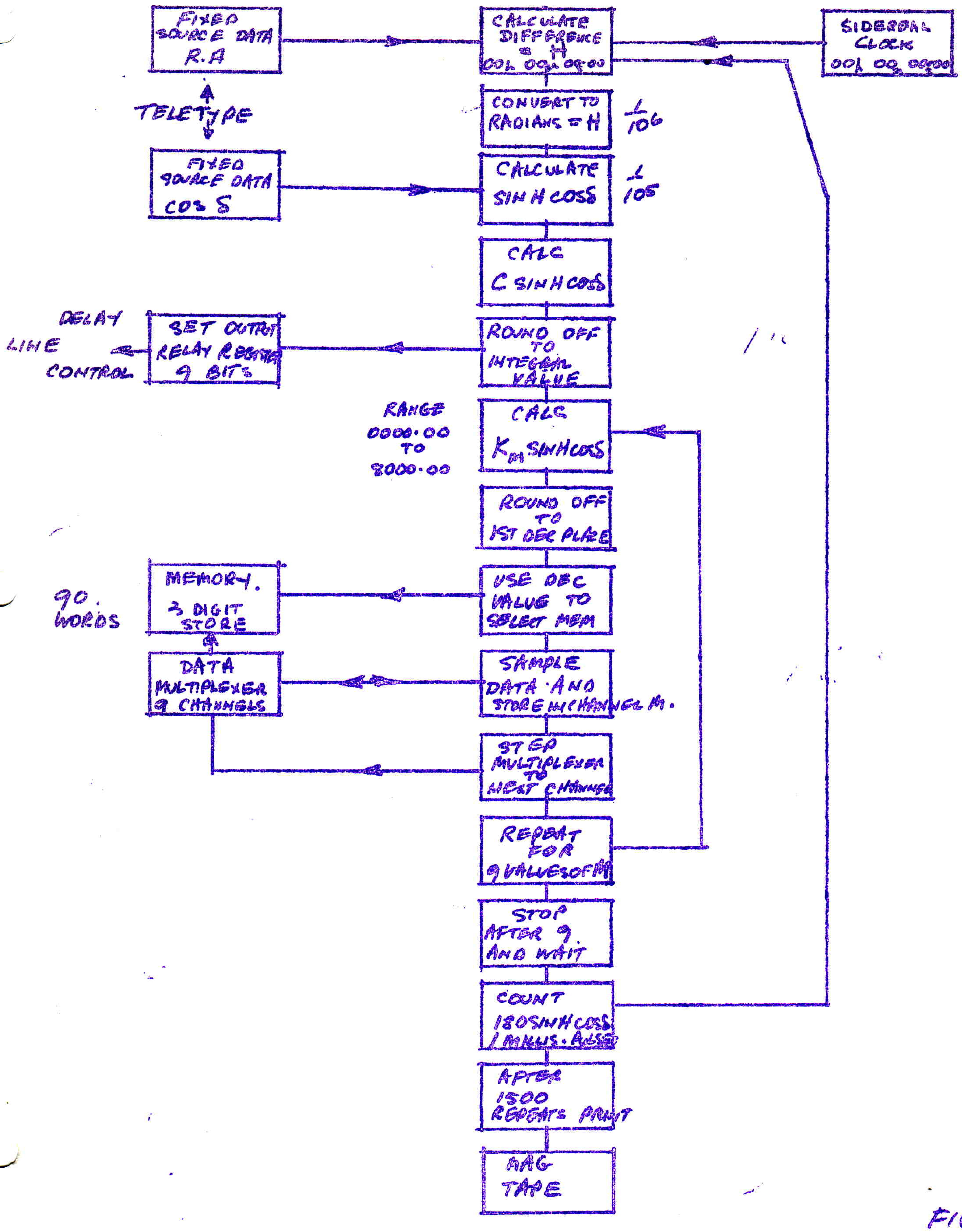
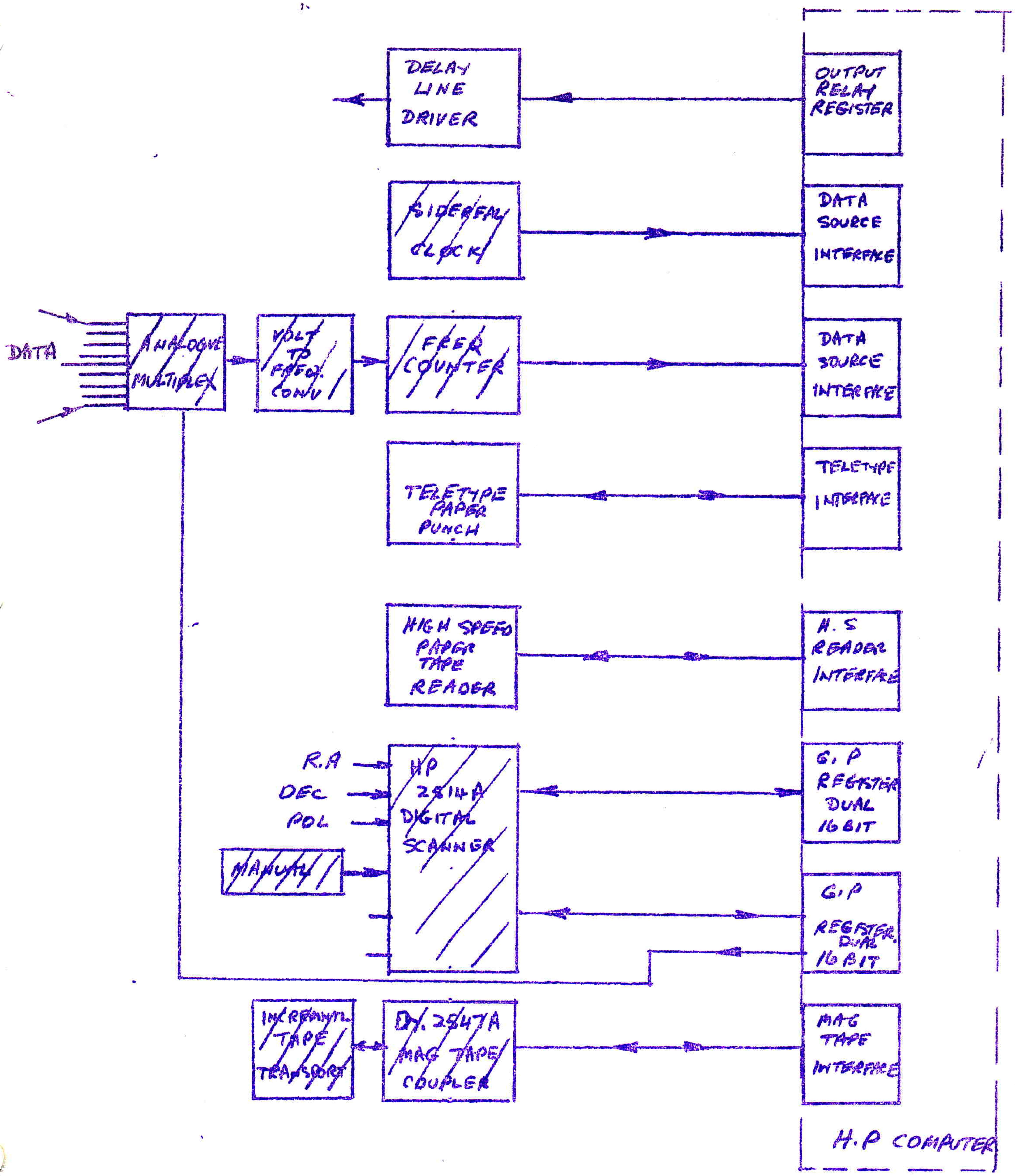


FIG 1.

SAMPLE FLOW CHART FOR DATA HANDLING 5 ELEMENT ARRAY



NOTE: ALL ITEMS CROSS-HATCHED AT PRESENT ON HAND.

FIG 2

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PROPOSED COMPUTER SYSTEM.

AB.L

DATA RECORDING SYSTEM

R.S. COLVIN

This describes briefly some thoughts and plans for data recording. In the process of observing, every twenty minutes or so (27 min?) a new record will begin. At this time we will be able to put much information on tape that is of a slowly varing nature. The information on tape may be in a form as follows. (Tape information is described in terms of six character words).

2 WORDS OF FIXED NUMERICAL DATA: DATE, SOURCE CODE RECORD NO.

1 WORD OF POSITION ANGLE INFORMATION
1 WORD OF DECLINATION "
1 " " HOUR ANGLE "
1 " " SID. TIME "
1 " " RCVR OUTPUT CHANNEL #1
1 " " " " " #2

↓

1 " " " " " #10
1 " " " " " #1

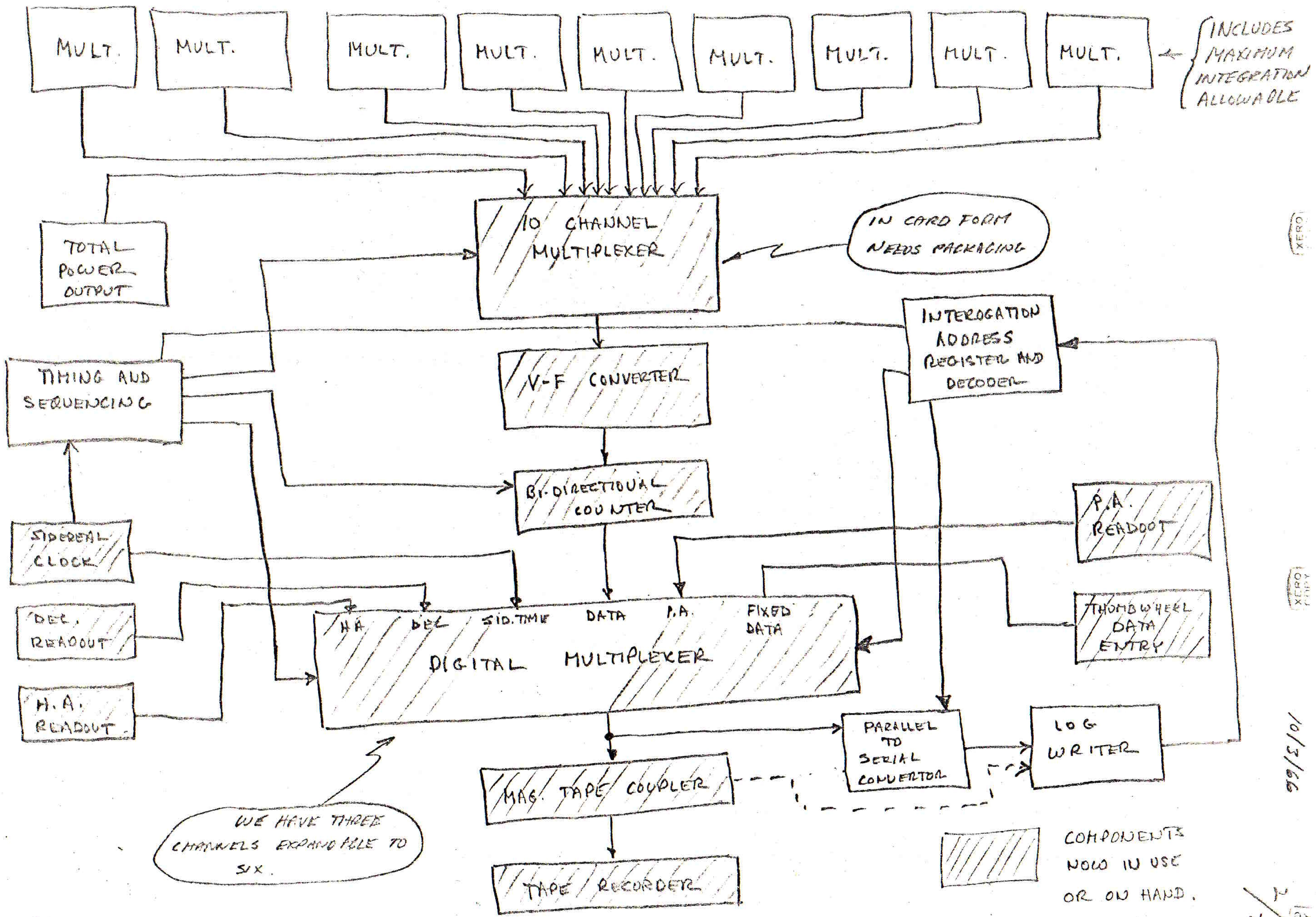
↓

ETC.

END. OF RECORD.

10/3/66

2/2



DATA RECORDING SYSTEM

A PROPOSAL FOR DATA PROCESSING

R.S. COLVIN

In as much as our basic data rate is so slow (approximately 6 bits per minute or 1 typewriter characters per minute which is about a sixteenth the rate of the cross), the total output of an 10^h observing period could be transmitted to the computation center in 5^m. Doing this of course would require considerable pre-processing of the receiver outputs to compact the data.

A possible means of performing this data preprocessing is described here.

As an observation proceeds, a considerable amount of observor anxiety will be dispelled if some means of viewing the results is available. Therefore I propose providing an analog output every 30 minutes and possibly monitoring within that period. This processor would operate on the natural fringe rates produced by the antenna thereby avoiding the fringe slowing equipment.