TAPE RECORDING OF SIDE SCANNING SONAR SIGNALS

by J.C. Hopkins
Bath University of Technology, England

ABSTRACT

A system for the tape recording of side scan sonar signals permitting automatic replay into a graphic recorder. The economical use of tape, and the facility to effect "on line" monitoring of the tape recorded signals, are further advantages.

INTRODUCTION

For some years, it has been quite usual to tape record the signals produced by sonar systems, seismic profilers, and similar instruments used in geophysical survey work. In most cases, the procedure is undertaken because the fidelity of magnetic tape recording is high, and replay of the material at the laboratory, perhaps with some additional signal processing, can usually offer the means of extracting more information than is apparent at the time of survey.

A problem which usually arises in connection with the replay of such recordings is the question of securing synchronisation of a graphic recorder to the reproduced tape signals. Unless this can be done successfully it is not possible to reproduce the tape recordings in graphic form, and the full advantages of the process cannot be realised. The solution to the problem requires that the speeds of the two mechanical systems be kept in step and that the relative phasing be correctly adjusted. The latter requirement is necessary so that the instant of transmission, as recorded on the tape, can also coincide with the start of a sweep of the stylus of the graphic recorder.

Both aspects of the problem have been solved in an experimental system used in conjunction with a side scanning sonar, previously described. (Chesterman *et al.* 1967). Although attention is directed to this application in this paper, similar methods might be applied to seismic profiling equipment.

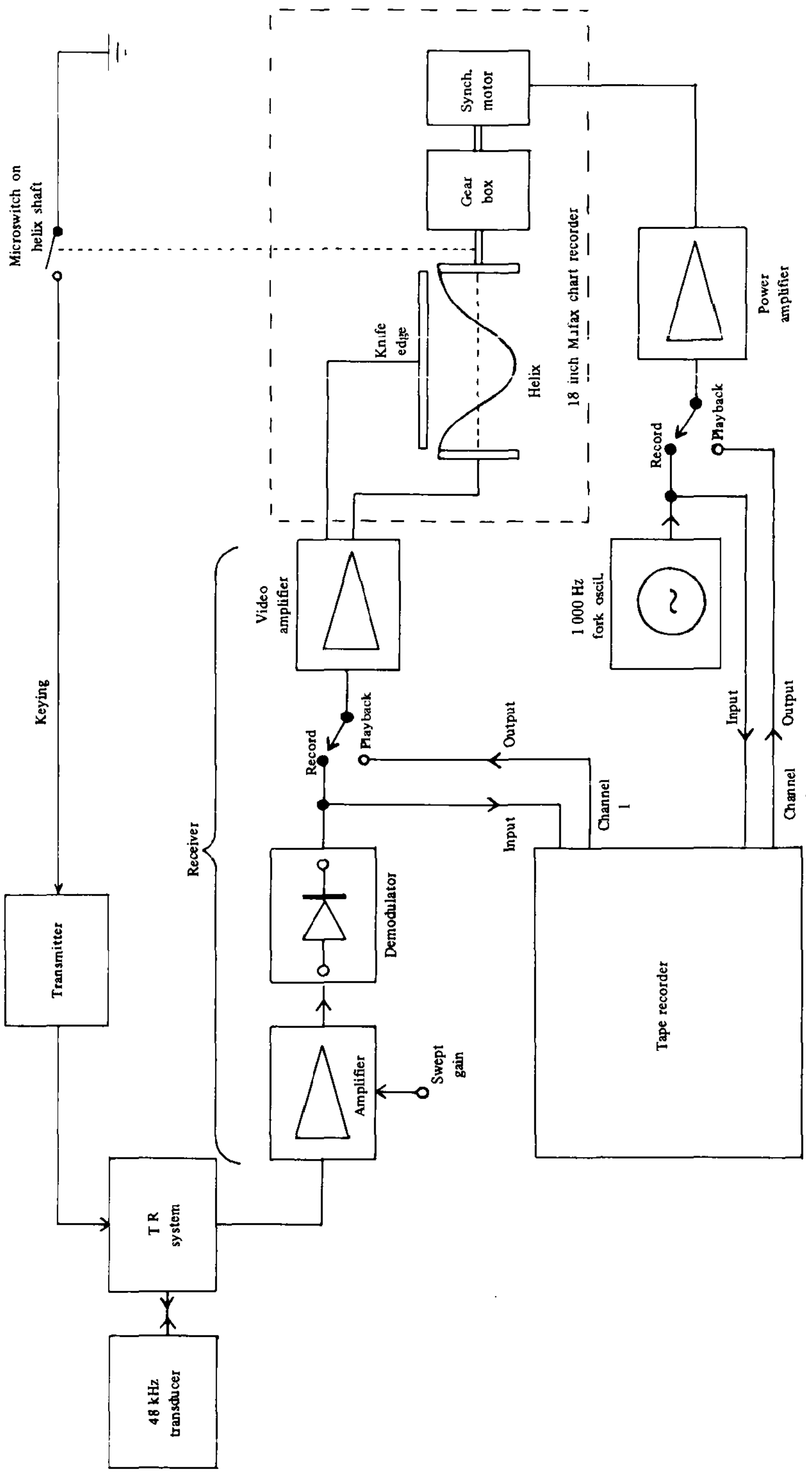

FIG. 1. — Conventional tape recording system, used in conjunction with side-scan sonar.

CONVENTIONAL METHOD OF TAPE RECORDING SONAR INFORMATION

The method usually employed involves extracting the video signal from the sonar receiver and recording this on one track of a two channel tape system. Both F.M. and direct recording modes have been employed.

The speed of the graphic recorder used in the sonar controls the pulse repetition rate of the transmitter, and a signal proportional to this pulse rate is simultaneously recorded on the second track of the tape system. This signal can be derived from the precision frequency source which is usually used to drive the synchronous motor of the graphic recorder during survey. See figure 1.

During replay, exact proportionality of speed of the two mechanical systems is achieved by using the recorded frequency on the second track to drive the chart recorder system, the precision source being disconnected. This procedure eliminates the effects of any speed changes occurring in the tape system between the instants of recording and replay, but cannot give the correct relative phasing. Thus, the instant of transmission (t_0) may be placed at any point across the width of the graphic recorder chart.

The usual remedy is to use an operator to start and stop the graphic recorder (while the tape system runs continuously) until correct synchronism is achieved. Provided that the original recording now proceeds without a break, synchronism will be maintained. Unfortunately, this is not usually the case when extensive surveys are undertaken.

It is felt that the conventional scheme can be improved upon by:

(a) providing automatic means for securing the correct phasing,
(b) reducing the tape requirements to a single track,
(c) extension of the recording scheme to permit "on line" monitoring of the tape recording during survey.

REQUIREMENTS FOR FULL SYNCHRONISATION

It is sufficient to be able to identify the instant of transmission (t_0) unambiguously. This, in itself, provides the phasing information while the time interval between one transmission pulse and the next can indicate the speed. If one can assume that significant speed changes cannot take place in either the tape system or the graphic recorder during the inter pulse period (usually about 1 second), effective synchronisation is possible. Since we are usually dealing with high inertia systems with good short term speed stability, this requirement is normally satisfied.

DESCRIPTION OF SERVO SYSTEM

The system developed at Bath is shown in figures 2, 3, 4, and 5. The recording takes place on a single track of a high quality tape recorder using the F.M. mode. The detailed specification of this tape recorder together with the relevant parameters of the sonar transmitter and receiver are given in the appendix. The work reported in this paper was done with the sonar operating on 800 yd range scale and with a transmitter pulse width of 1 ms. The tape recording was done on $\frac{1}{4}''$ tape at a speed of 6 i.p.s.

The signal extracted from the sonar receiver consists of a positive going video signal, comprising a transmitter break-through signal at the instant t_0, followed by a series of signal returns from the sea bed, out to a maximum range of 800 yd. (This corresponds to an interpulse period of exactly 1 second). Since swept gain is employed in the receiver, it occasionally happens that signal returns at quite large ranges can equal the magnitude of the transmitter break-through. It is thus necessary to generate a more clearly identified synchronising signal at the instant t_0. This is done by gating out the video from the receiver at t_0, and for a period of 30 ms thereafter. A negative synchronising pulse is then inserted in its place. The form of the composite signal, as recorded, is shown in figure 3. With an F.M. recording, the D.C. level is preserved on replay so that there is no difficulty in extracting the negative pulses to operate the servo system.

A block diagram of the electronic servo system used to control the 4″ graphic recorder is shown in figure 4. The synchronising signals are first separated from the composite video signal by means of an amplitude comparator set to operate at −0.5 volt. To offer further rejection to the occasional noise pulses which often arise in field situations, the positive output pulses of the comparator are integrated and used to trigger a unijunction transistor circuit. Thus a synchronising output is produced only if the input to the comparator system falls below −0.5 volt for at least 15 ms. The output of the unijunction circuit is then reshaped by a monostable multivibrator to give a pulse of defined amplitude and width, suitable for opening the signal gate of the "sample and hold" circuit.

The latter is fed with a negative sawtooth, triggered by a microswitch on the helix shaft of the graphic recorder. The instant of triggering is arranged to be at about mid-range on the recorder. Thus, the synchronising pulse from the tape recorder samples the negative going ramp, and the resulting voltage is stored on the capacitor C. This voltage is used to set the frequency of an oscillator which, via a power amplifier arrangement, drives the synchronous motor of the chart recorder. The control voltage on the capacitor can take all values from zero down to $-V_{max}$ (the amplitude of the sawtooth) depending on the relative phasing of the two systems, but will finally settle down at a value of approximately $-V_{max}/2$, when synchronism is achieved. A detailed circuit diagram of the main section of the servo electronics is shown in figure 5.

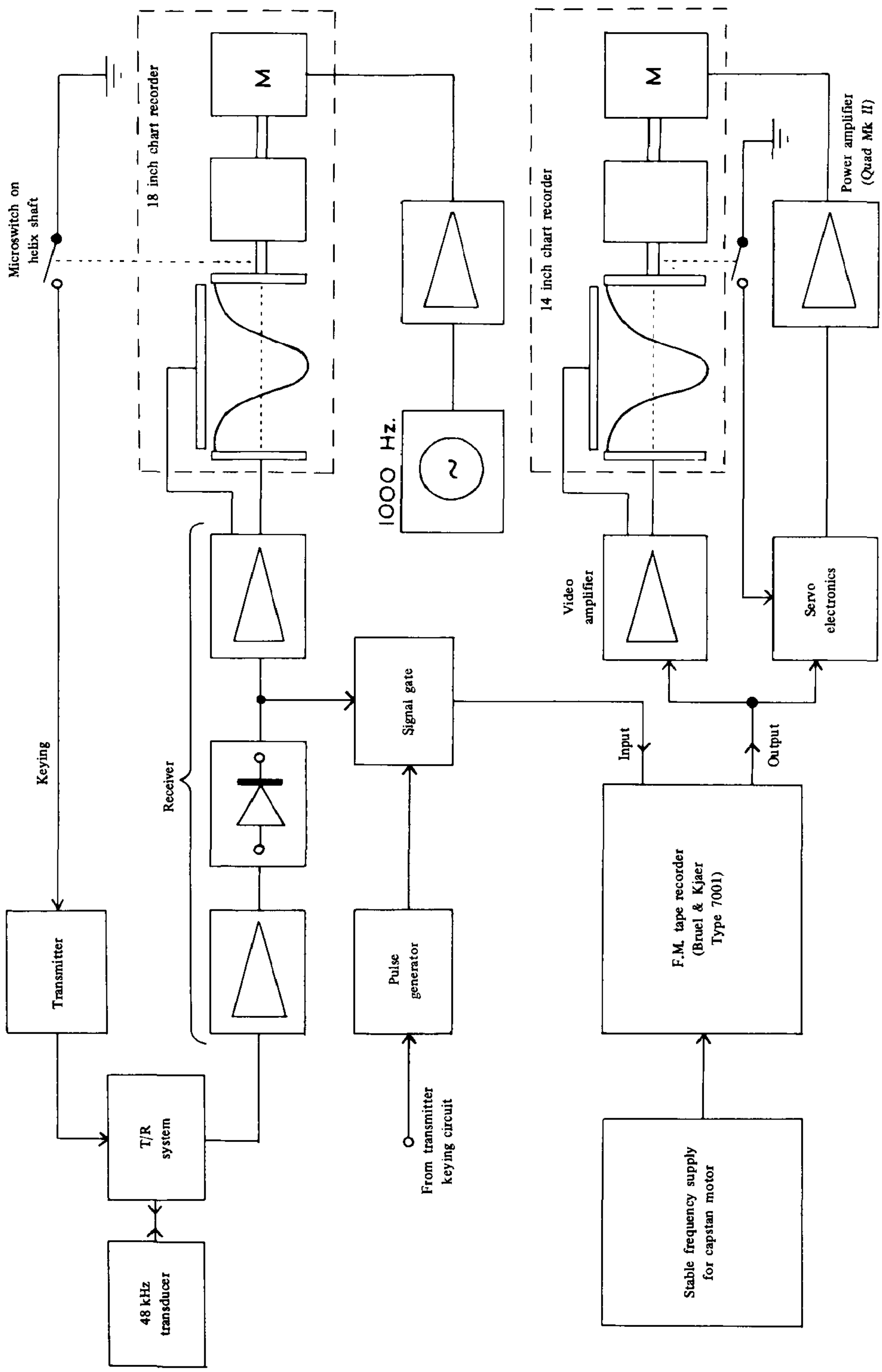

FIG. 2. — Modified recording system.

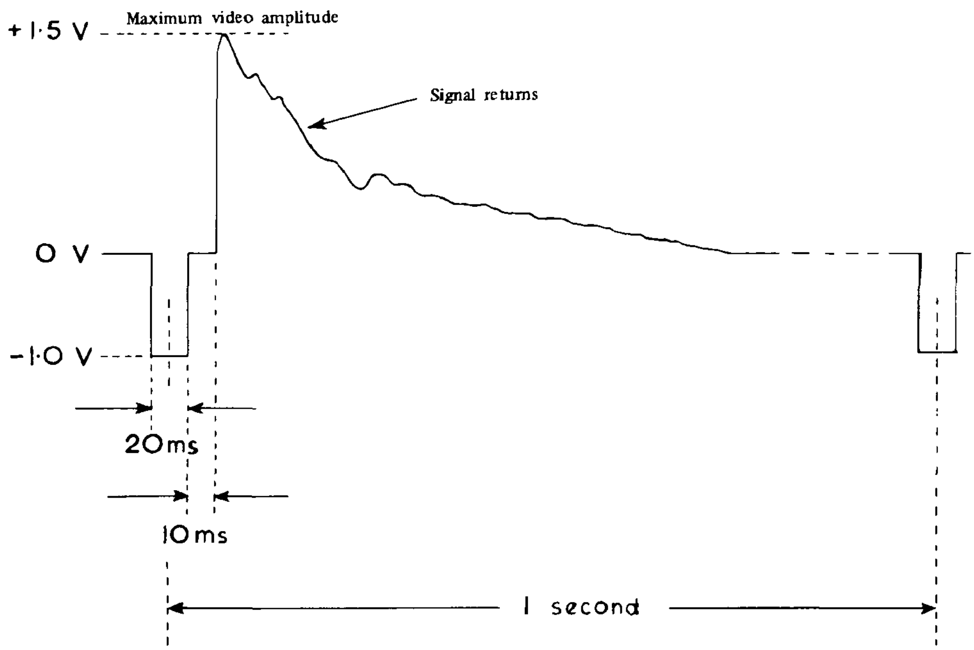

FIG. 3. — Synchronising pulse waveform.

An additional advantage of the system is that, if for any reason the tape recorded synchronising pulses are missing, the "sample and hold" arrangement will continue to remember its previous control voltage for a period of about 30 seconds.

PERFORMANCE OF THE SYSTEM

The servo system can be seen to be of the sampled data type, but due to the relatively rapid sampling, it can be regarded rather approximately as a linear first order system having a continuous error signal. The response of such a system to a step function input is an inverse exponential approach to equilibrium, with time constant T.

A typical record which has been reproduced by this system, including a section showing the approach to synchronism, is shown in figure 6. Since each scan of the paper recorder takes 1 second, it can be inferred that $T \sim 5$ sec.

One of the defects of this simple type of servo is that it will change the reproduced position of t_0 on the graphic recorder if the repetition rate of the synchronising pulses changes significantly. With the system used at present a 1% change of recorded pulse rate would produce a shift of t_0 of about 3% of chart width.

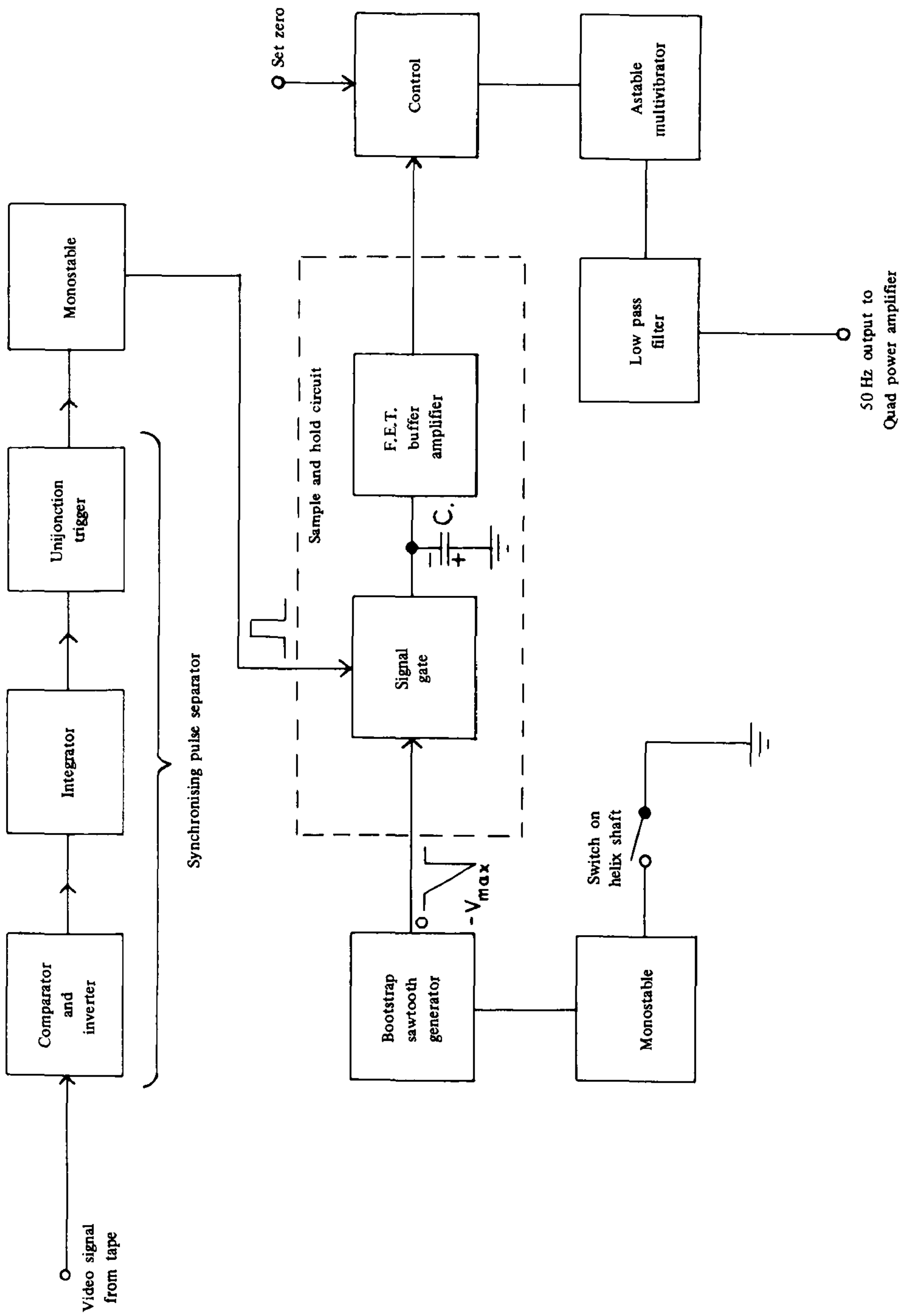

FIG. 4. — Four inch chart recorder servo electronics — block diagram.

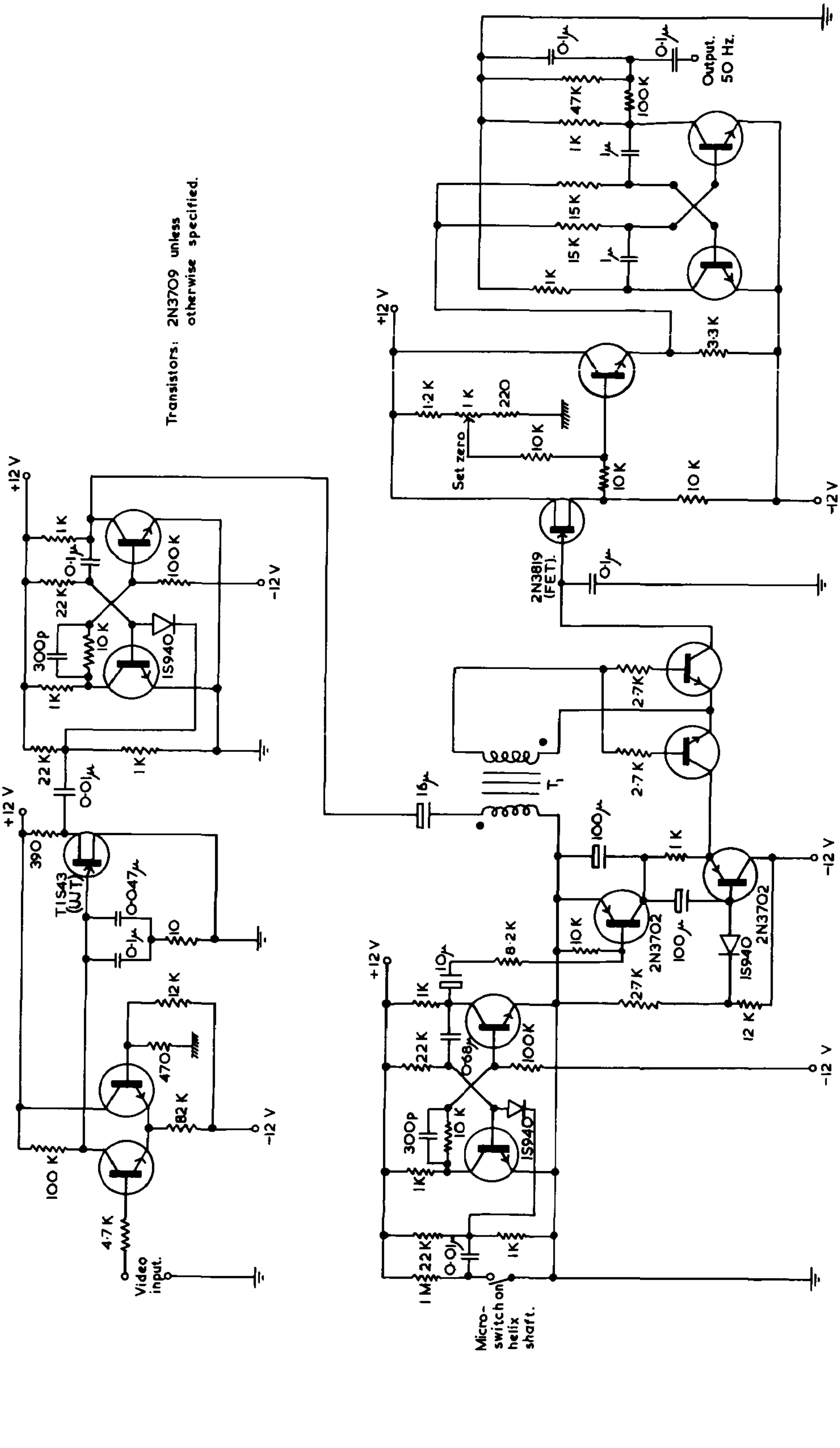

FIG. 5. — Circuit diagram of servo electronics.

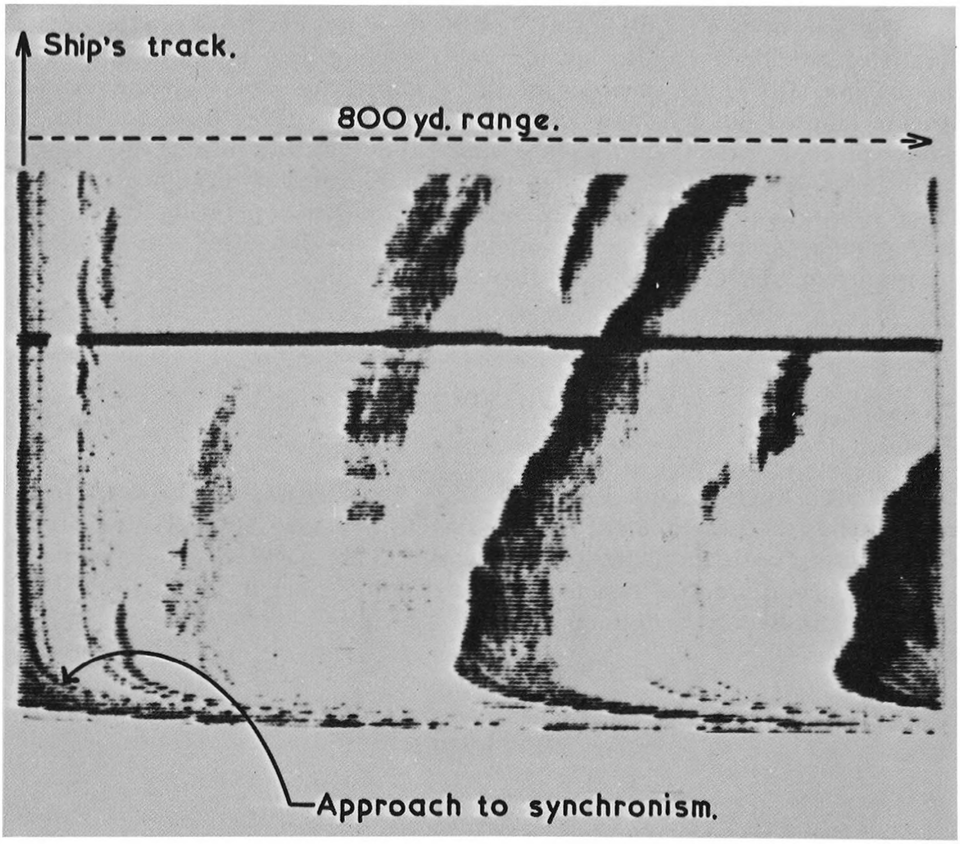

Fig. 6. — Typical record obtained from side scan sonar and replayed from tape via the servo system.

This defect can be overcome by employing a more sophisticated servo system or by simply controlling tape speed and transmitter pulsing rate closely. This latter course was adopted because transmission rate is already held at an accurate value by the 1 000 Hz tuning fork oscillator and because variations in tape speed (in an F.M. system) degrade the recording. A change of speed between recording and replay gives rise to a linear frequency translation in the recorded signals which produces amplitude changes and, more important for our purposes, a DC base line shift. We therefore chose to supply power for the tape capstan from an AC inverter having a quartz crystal control of frequency. Shifts in the reproduced position of t_0 now amount to less than 0.75 % of chart width.

FURTHER DEVELOPMENTS

The system described was developed for use with a sonar having a maximum range of 800 yds and hence a transmission interval of 1 second. It has been used experimentally for over two years and the design could now be improved. In particular it might be extended to other operating speeds so that several range scales could be accommodated.

The use of the additional 4″ chart recorder in the servo mode has permitted "on line" monitoring of the tape recording, and in many ways the original 18″ chart recorder of the sonar is no longer necessary. As already pointed out by CHESTERMAN, this latter recorder does not give an isometric chart when surveys are undertaken at the usual ship speeds (about 6 knots), whereas the small recorder used here is designed to do so. Thus, a single chart recorder of intermediate size, operating in the "on line" mode by means of a servo system of the type described, could fulfil all the requirements for immediate display.

ACKNOWLEDGEMENTS

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REFERENCE

CHESTERMAN, W.D., ST. QUINTON, J.M.P., CHAN Y., MATTHEWS, H.R. (1967) : Acoustic surveys of the sea floor near Hong Kong. *Int. Hyd. Rev.*, XLIV, No. 1, pp. 35-54.

APPENDIX

1. Sonar characteristics

Transmitter:

Carrier frequency: 48 kHz

Pulse length: 0.5 - 2.8 ms

Peak Power: 8 kW (electrical) into magnetostriction transducer
Maximum range scales: 400 yds, 800 yds, 1 600 yds

Receiver

Centre frequency: 48 kHz

Bandwidth: 4 kHz

Minimum detectable signal: 1 μV

Swept gain range: 40 dB

Transducer:

Magnetostriction type in towed fish

Polar diagram:
Vertical beamwidth 7.5° (−3dB points)
Horizontal beamwidth 1.8° (−3dB points)

2. **Tape recorder specification**
(BRUEL and KJAER type 7001)

This is a two channel F.M. instrument for acoustic and vibration data recording.

Tape: 6.35 mm ($\frac{1}{4}$ inch) wide on 267 mm (10.5 inch) diameter reels

Tape speeds:

Tape Speeds	38.1 1.5	152.4 6	381 15	1 524 60	mm/s i.p.s.
Frequency range (± 0.5 dB)	0–0.5	0–2	0–5	0–20	kHz
Signal to noise ratio	> 44	> 48	> 48	> 48	dB

Tape speed accuracy: ± 0.25% with precision frequency source
Cumulative flutter: generally <0.2% peak to peak.