WASHINGTON
SEA GRANT
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A PORTABLE HYDROACOUSTIC DATA ACQUISITION SYSTEM FOR FISH STOCK ASSESSMENT

by Richard E. Thorne, Edmund P. Nunnallee, and James H. Green

WSG 72-4
December 1972

DIVISION OF MARINE RESOURCES
UNIVERSITY OF WASHINGTON 98195
Prepared under the
National Sea Grant Program

A WASHINGTON SEA GRANT PUBLICATION

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ACKNOWLEDGMENTS

The system described in this paper was developed primarily under the Washington Sea Grant Program, grant number 1-35320 from the NOAA Office of Sea Grant. Additional funds were provided by the Alaska Department of Fish and Game for the development of the calibration oscillator and modification of the interface amplifier.

A PORTABLE HYDROACOUSTIC DATA ACQUISITION SYSTEM FOR FISH STOCK ASSESSMENT*

Since March 1968, research in acoustic techniques for resource assessment has been conducted by the Washington Sea Grant marine acoustics program. These studies have included development of data acquisition and processing systems, theoretical studies of sources of variance in hydroacoustic techniques, and applications of hydroacoustic techniques to fish stock assessments, especially to juvenile sockeye salmon in Lake Washington (Thorne and Woodey, 1970) and to Pacific hake in Port Susan (Thorne, Reeves, and Millikan, 1971).

Portable data collection systems that can be used on small boats are desirable because such systems reduce the cost of surveys, permit access to remote locations where large vessels are not available, and eliminate the risk of failure due to malfunction of data processing equipment.

A block diagram of a system in which acoustic data are recorded on magnetic tape is shown in Fig. 1. The system, developed under the marine acoustics program, consists of an echo sounder with an internal calibration oscillator, a chart recorder and transducer mounted on a towed vehicle, and an analog magnetic tape recorder with an interface for converting acoustic data to a frequency compatible with the tape recorder. The entire system is monitored with an oscilloscope and is powered by a 12-v battery in conjunction with an inverter. The echo sounder data recorded on magnetic tape can then be processed in the laboratory by data processing systems such as echo integrators and echo counters (Moose, Thorne, and Nelson, 1971; Thorne, 1972).

*Contribution no. 374, College of Fisheries, University of Washington.

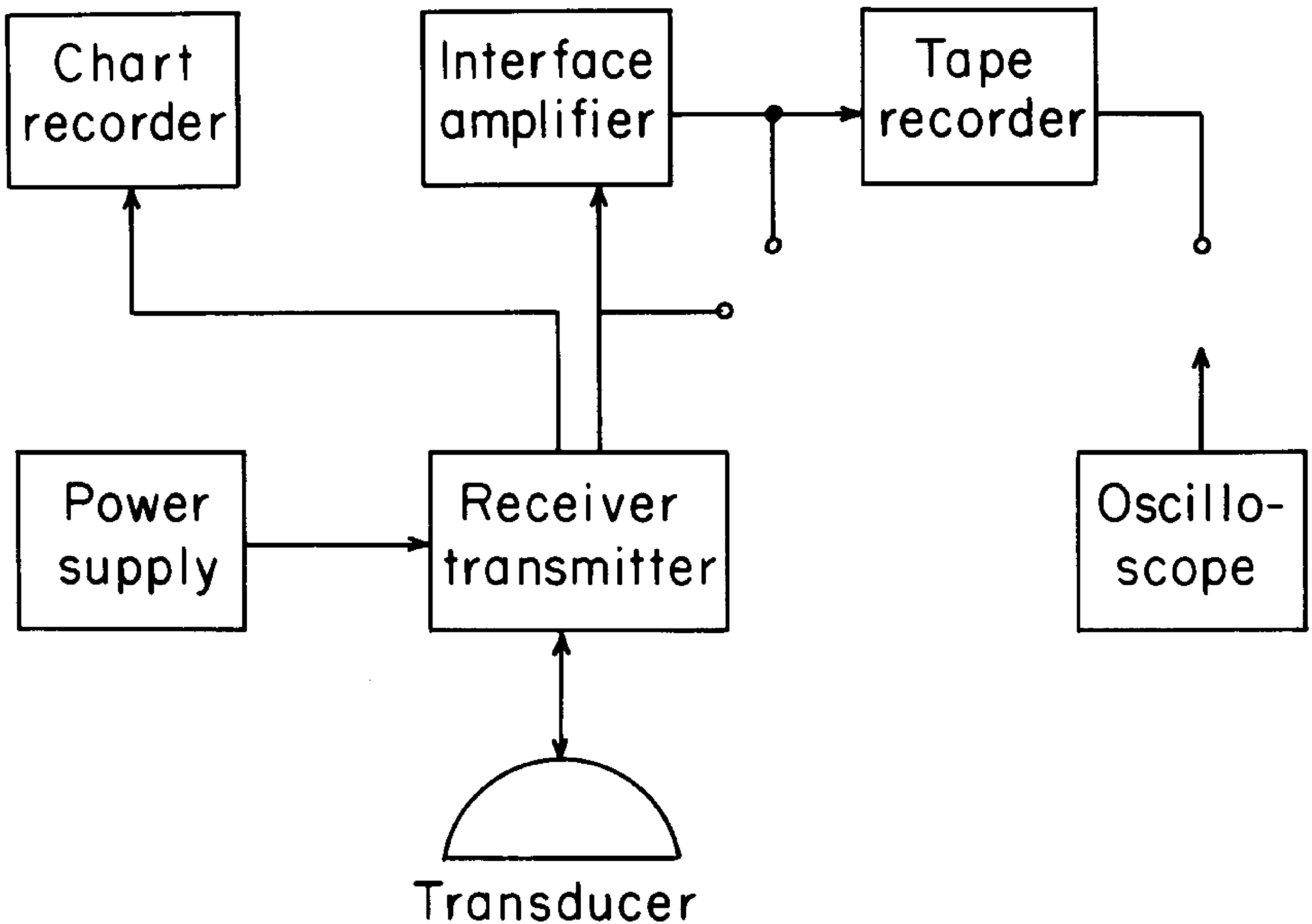

Fig. 1 Block diagram of echo recording system

ECHO SOUNDER AND RECORDER

The echo sounder is a Ross 200-A Fineline model with a frequency of 105 kH_z. A pulse control switch allows choice of 0.1 or 0.6 msec transmitter pulse durations. The longer pulse usually is preferred in routine surveys. The shorter pulse length provides higher resolution of closely packed targets, but has less power and is not so suited to the bandwidth limitations of the recording equipment.

The sounder has a single stylus speed and four phases corresponding to depth ranges of 0-50, 50-100, 100-150, and 150-200 fathoms. Any one or all of four depth-range switches can be actuated for pulse rates of 2,4,8, or 16 per second. Usually a single depth range is used--that of particular interest at the time. All insonifications detected between consecutive transmissions are recorded on magnetic tape. Multiple triggering may be used in shallow water to record a greater number of reflections from targets, but sufficient time between successive pulses must be allowed for multiple bottom-surface reflections to dissipate.

Received echo signals are amplified from microvolt levels to amplitudes of several volts. The gain control provided by the manfacturer was a single-turn, 10,000-ohm wire-wound potentiometer. This was replaced with a 10-turn, vernier-control potentiometer for precise adjustment and replication of receiver gain.

The receiver-amplifier of the sounder includes a time-varied-gain (TVG) circuit, which is an approximate correction for one-way spreading loss (20 log R in decibels, when R represents depth or time). Although the exact TVG function should be measured before quantitative processing, most units appear to provide satisfactory depth corrections for processing with voltage-squared integrators in fresh water. In salt water a correction for two-way absorption losses must be made.

TRANSDUCER

Several transducers are available from the manufacturer for use with the echo sounder. The transducer customarily used with the data acquisition system is a seven-element, barium titanate array producing a circular beam usually less than 10° full angle at the -6 dB level, referenced to the acoustic axis. An example of the directivity pattern of this transducer is given in Fig. 2. The side lobes are well suppressed, with the first side lobe usually -17 or -18 dB referenced to the acoustic axis.

The transducer is mounted in a vehicle suspended from the end of a wooden beam extending about 1.5 m from the side of the boat and is towed at a depth of about 1m. The towed transducer vehicle allows complete portability of the equipment and removes dependence on any particular vessel. Several different vehicle designs have been tried, and a simple delta-wing vehicle constructed of plywood has been used successfully at speeds as high as 5 m/sec. The vehicle is lightweight and can be constructed in less than a day.

MODIFICATIONS OF THE ECHO SOUNDER

Several modifications of the echo sounder were necessary in order to use it as part of a system in which acoustic data are recorded on magnetic tape. In addition to the change in the gain control mentioned previously, an isolation amplifier and a calibration oscillator were designed so that the sounder could be used for quantitative data collection. These additions to the sounder, including their power supply, are shown schematically in Fig. 3.

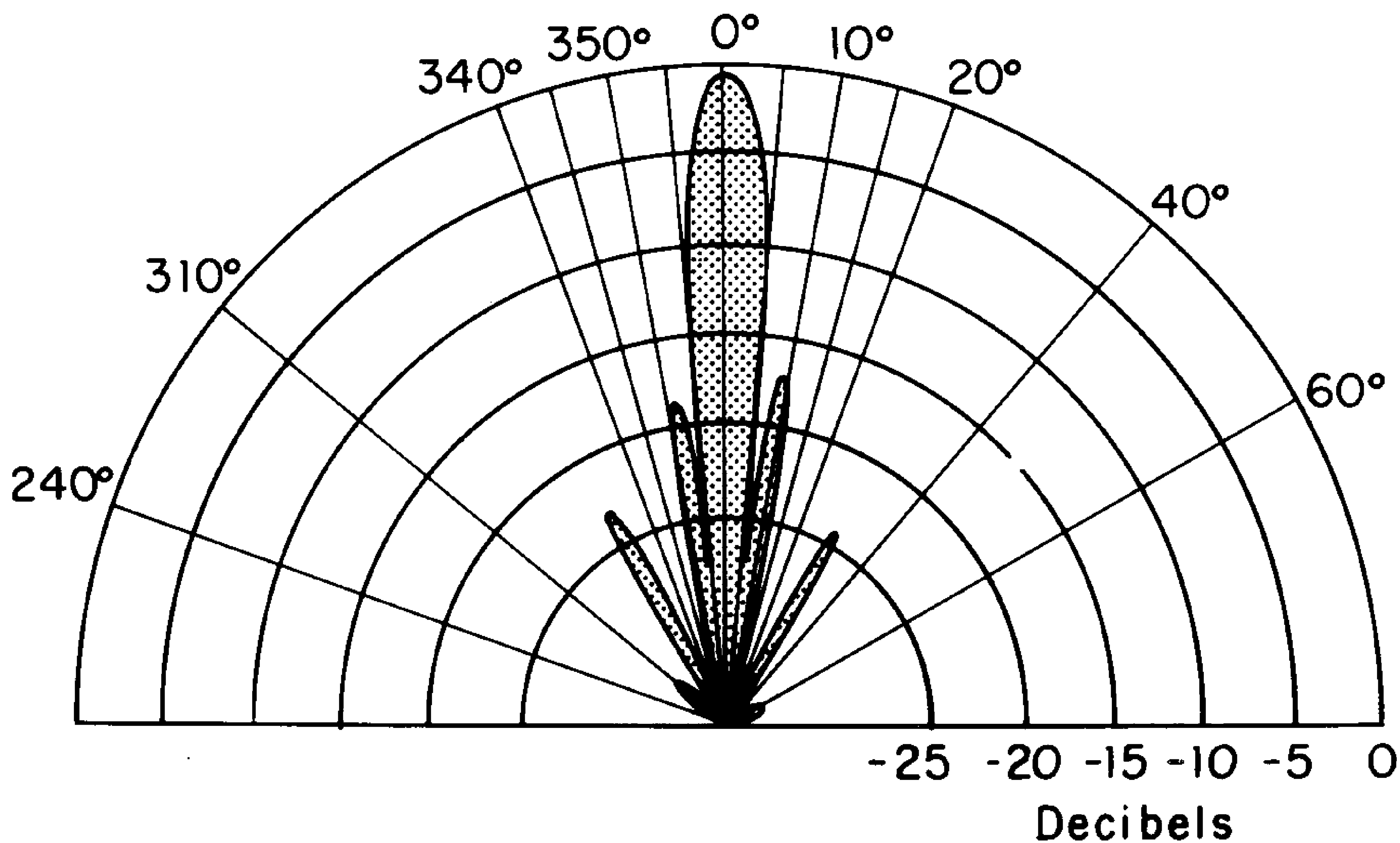

Fig. 2 Typical transducer directivity pattern

Isolation Amplifier

The isolation amplifier connects to the receiver's high voltage, high impedance (vacuum-tube type) circuitry and converts the signal to low voltage, low impedance levels. This allows connection of the tape recording system without loading the receiver's amplifier circuitry. The isolation amplifier (see Fig. 3) is a simple emitter follower. The high impedance (greater than 10 megohm) input of the isolation amplifier is connected to the third I.F. transformer in the receiver, and the low impedance output is connected to a BNC connector, which allows easy connection to the tape recording system.

Calibration Oscillator

The calibration oscillator was installed to allow simple, rapid checks of the receiver gain. Since estimates of biomass are directly dependent on the acoustic intensity of the reflected echoes, reliable information about the transmitted source level, transducer response, and gain of the receiver is needed.

The calibration oscillator circuit was designed to allow a signal of known amplitude to be inserted at the transducer terminals of the receiver. The signal, after being amplified by the receiver, is recorded on the data tape, thus giving a permanent record of the receiver performance.

The calibration oscillator consists of two parts: the timer circuit and the oscillator circuit. At the beginning of each data tape, the operator pushes the calibrate button. This initiates the timer, which disables the transmitter and causes the calibration oscillator to run approximately one minute.

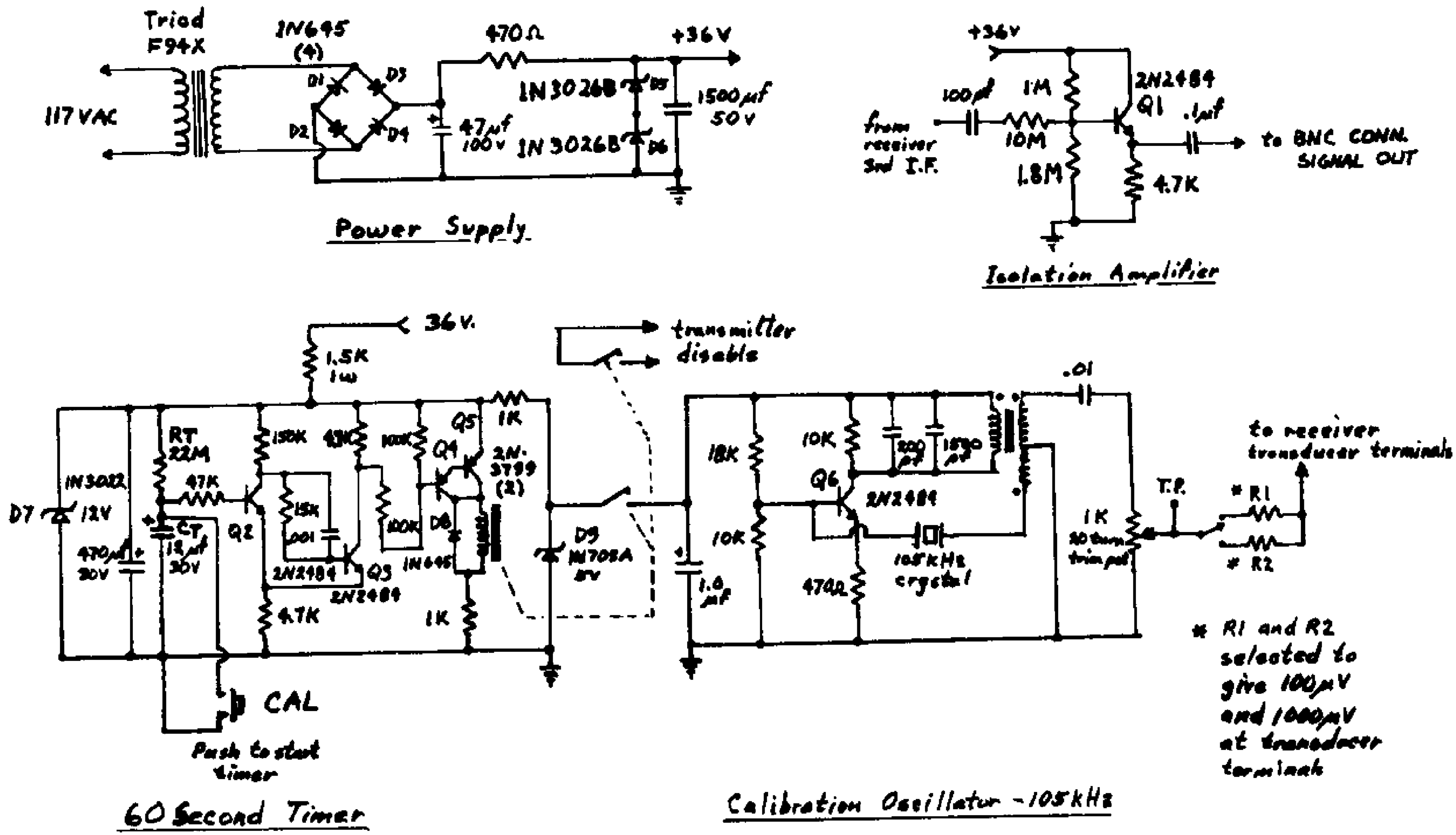

Fig. 3 Schematic diagram of echo sounder modifications

The timer circuit (see Fig. 3) consists of a Scmitt trigger controlled by the voltage across C_t. Pushing the CAL switch discharges C_t. This causes Q_2 to turn off, which in turn causes Q_3 to turn on. When Q_3 is on, the voltage at the emmiters of Q_2 and Q_3 is approximately 6 volts. Q_2 remains off until the voltage across C_t has increased to approximately 6.5v, at which time Q_2 turns off. The time is controlled by R_t and by C_t and is approximately 2RC. When Q_3 is on, the Darlington-connected pair, Q_4 and Q_5, cause the relay that supplies power to the calibration oscillator to close, disabling the transmitter.

INTERFACE AMPLIFIER

An interface amplifier is included in the acoustic data collection system to connect the signal output of the echo sounder to the input of the tape recorder. A direct connection between the two units is not possible because of bandpass limitations of the tape recorder. Target data from the output of the echo sounder are of a 105-kHz frequency, whereas the maximum frequency response of the tape recorder at unity gain is about 8 kHz at a tape speed of 3 3/4 ips. The interface amplifier converts the 105-kHz output frequency of the echo sounder to a frequency of 5 kHz by the use of chopper and filter circuits. A schematic of the interface amplifier is given in Fig. 4. A design for a universal interface amplifier and principles of its use have been described previously (Nunnallee and Green, 1970). The model presently used with the Ross echo sounder is similar to the original design except that frequency control is obtained using a crystal oscillator. An additional output stage was incorporated to improve bandpass characteristics. These modifications improve the stability of the amplifier, but restrict its use to a given frequency sounder--in this case 105 kHz.

The gain of the interface amplifier is unity for any signal amplitude within the operating limits of the circuitry. An attenuator on the output of the interface amplifier allows control of output signal levels in steps of 0 dB, -6 dB, -12 dB, and -20 dB. These decibel steps correspond to amplifier gains (voltage output/voltage input) of 1.0, 0.5, 0.25, and 0.1, respectively.

Tape Recorder

The echo signals at the output frequency (5 kHz) of the interface amplifier are recorded on a standard stereophonic tape recorder. A Sony 560D sterophonic recorder has been used with some minor modifications, such as replacement of input and output signal cable connectors on the rear panel. Coaxial signal cable connectors (BNC type) were installed to prevent accidental cable disconnection, which can occur when the nonlocking type connectors supplied by the manufacturer are used. Care must be taken in the data collection to ensure that target amplitudes do not exceed the limits of the recorder. Signal input amplitudes greater than 1.5v peak will saturate the magnetic tape because the oxide can be magnetized in a linear manner over a limited range. A typical input versus playback voltage curve made with Sony 560D tape recorder using Scotch 203 tape is shown in Fig. 5.

Power

Power is supplied by a lead acid battery and converted to 115 VAC by an inverter. The Atlas model inverter manufactured by the Toredo Company has been used for this purpose. It is frequency-stabilized by the use of a 60-Hz reed-type vibrator and supplies a square-wave output. Output voltage from the inverter is manually regulated by an autotransformer, equipped with a panel-mounted ac voltmeter. The power requirements of the pieces of equipment in

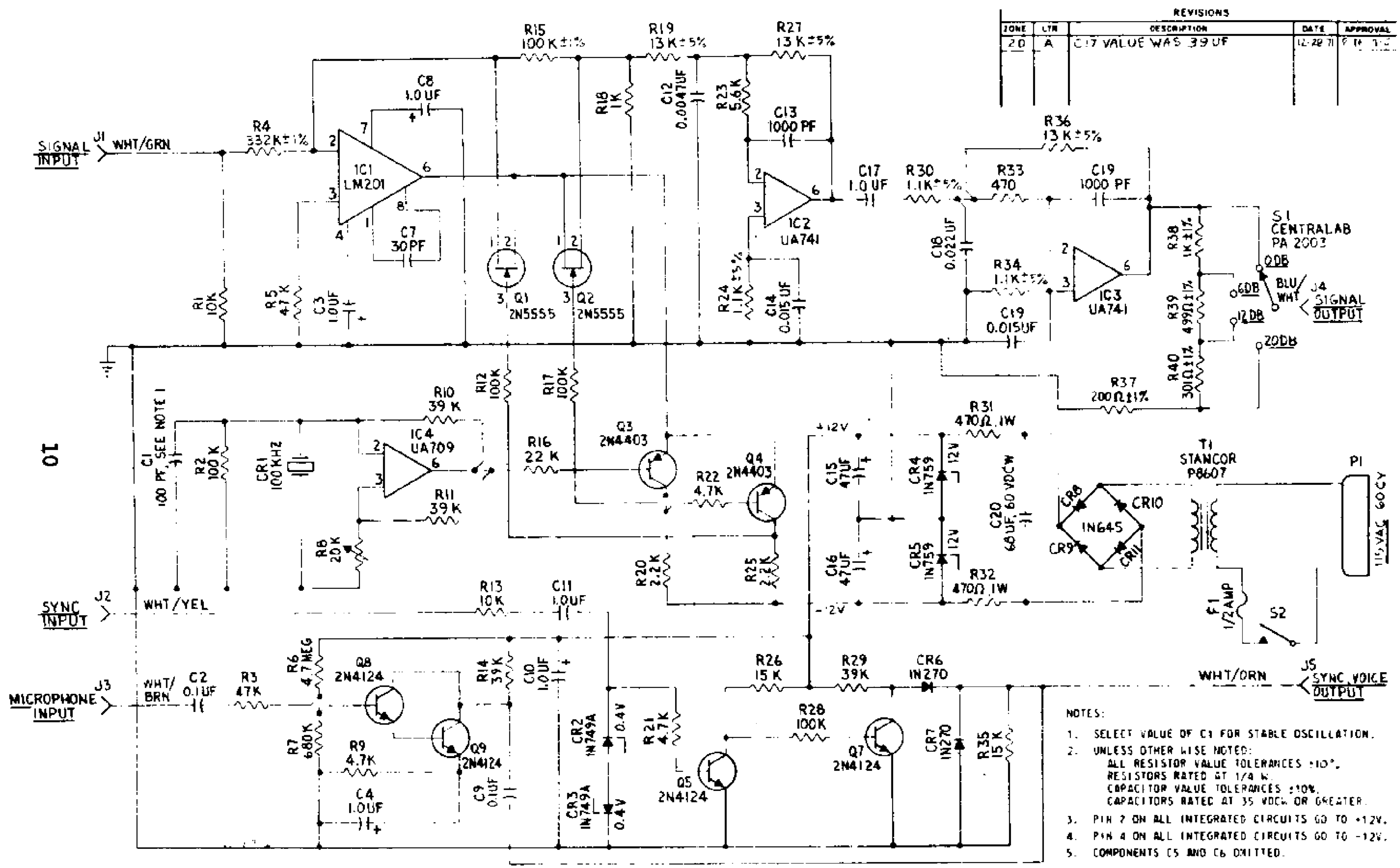

Fig. 4 Schematic diagram of interface amplifer

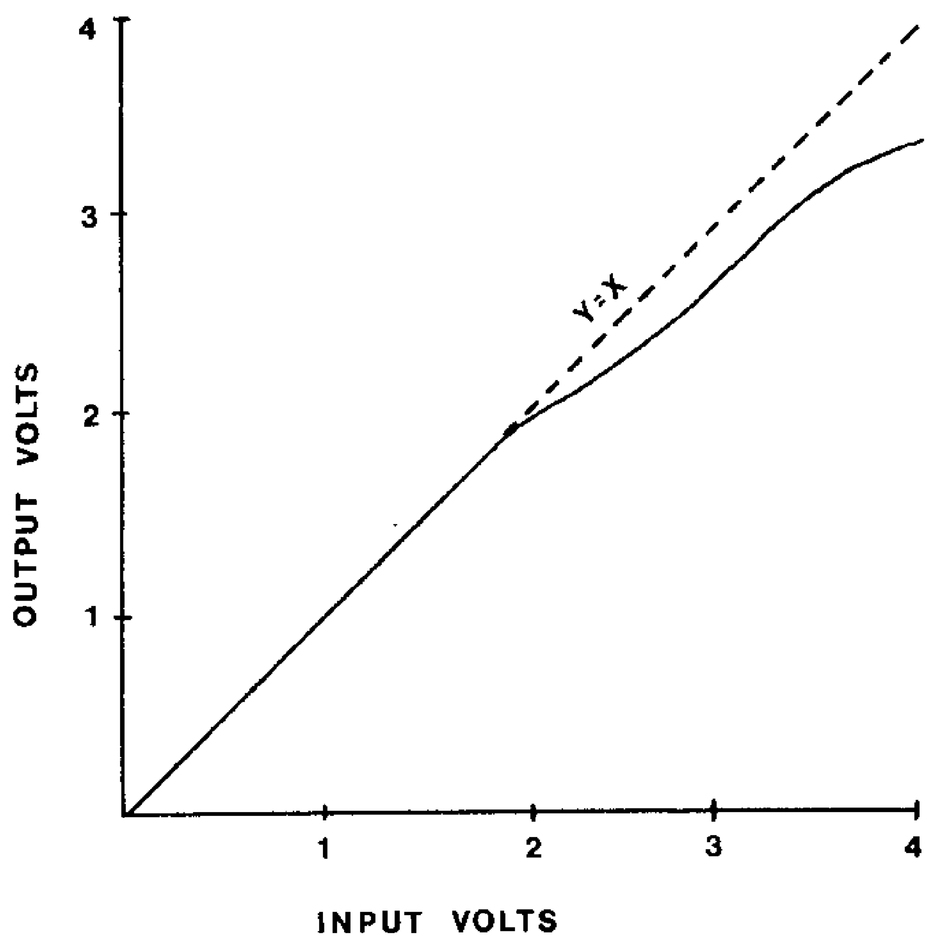

Fig 5. Typical input versus playback voltage curve showing limit of tape saturation

the acoustic data collection system are listed in Table 1.

The total power consumption of the above system amounts to 110 w of 115 vac power. If we assume 75 percent efficiency of the inverter, the power drain from the battery is about 12 amp. The operating time from a well-charged battery is about 2 hours, during which time 115 vac can be maintained at the output of the inverter. For this reason two or more batteries usually are connected in parallel to allow 4 to 5 hours of uninterrupted operating time.

Table 1. Summary of power requirements of equipment in acoustic data collection system

Unit	Type of power	Operating voltage	Power requirement (watts)
Echo sounder-chart recorder	ac	115	92
Interface amplifier	ac	115	2
Tape recorder	ac	115	16
	dc[1]	12[1]	16[1]
Total power drain			110

[1] The tape recorder can operate on either ac or dc current.

GENERAL COMMENTS

This acoustic system was built because there is no reliable and completely portable quantitative data acquisition system available commercially. The only sounder specifically designed for research purposes is the Simrad EK scientific sounder, and it is designed for large vessel operation. Its chart recorder and transceiver electronics are contained in a single, bulky package. Besides lacking portability, the higher frequency EK models do not have an adequate tape recording system, and there is no provision for internal calibration.

The equipment described in this paper is portable, and the system with the towed transducer is routinely used from a number of vessels, as small as 16-foot outboards and as large as the University of Washington's 67-foot RV Commando. In addition to the portability achieved, using the transducer in conjunction with a towed vehicle reduces problems of routine calibration. At least every 2 years, hull-mounted transducers must be removed for calibration and this requires dry-docking. The towed vehicle, however, does necessitate reduced transect speed and more handling, and it increases the probability of damage by surface debris. Greater towing speed undoubtedly could be achieved with improved vehicle design.

The portable system has proved to be reliable: it has been used in more than 100 surveys involving about 400 hours of data collection. Malfunctions have occurred four times--twice with the inverter, once with the tape recorder, and once with the echo sounder. The echo sounder is subject to gain changes resulting from gradual distuning by vibrations and small shocks associated with small boat operations. Before addition of the calibration oscillator, the sounder required retuning and calibration several times a year, with gain changes typically 2-3 dB between calibrations.

Several improvements in the present system are suggested. A completely transistorized echo sounder would reduce the size of the system and decrease the power requirements. A transistorized echo sounder with a 12-v dc power supply would also eliminate the requirement for the inverter, since the Sony 560D tape recorder can be used directly from 12-v dc. Several oscilloscope models with internal batteries are available. Ideally, a portable data acquisition system would combine the power supply, calibrate oscillator, and interface amplifier with the transceiver electronics in a single package, thus reducing the entire system to four packages plus the battery and oscilloscope.

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