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The Development of Portable Echo-Sounders in the Coast and Geodetic Survey

THOMAS J. HICKLEY

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Technical Bulletin Series

This series of Technical Bulletins is inaugurated to present to the personnel of the Coast and Geodetic Survey and to others the results of research and development in the various fields of the Bureau's activities. It is designed for quick publication and dissemination, and supersedes The Journal of the Coast and Geodetic Survey, the last issue of which was published in October 1957. Since many of the bulletins will deal with new practices and new techniques, the views expressed will be those of the authors and will not necessarily represent final Bureau policy.

Technical Bulletin Special A (for official distribution only) contains a brief description of the latest type of portable depth-recorder for hydrographic surveying. This instrument incorporates several new features which will eliminate some of the troubles and errors that are inherent in the depth-recorder first put into service in 1939. The instrument has a straight-line recorder and four depth ranges. The range switch is electronically rather than mechanically operated. The effect of the change of depth with the amount of gain is minimized.

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The Development of Portable Echo-Sounders in the Coast and Geodetic Survey

THOMAS J. HICKLEY, Electronic Scientist
U. S. Coast and Geodetic Survey

THE Coast and Geodetic Survey first used echo-sounding instruments in 1923 when a Sonic Depth Finder was installed on the ship *Guide*. While this equipment was far superior to earlier sounding instruments, it had numerous shortcomings as a hydrographic survey instrument. Ten years later, in 1933, the Bureau's Washington Laboratory started the design of a precision instrument with which soundings between a few feet and 20 fathoms could be obtained with far greater accuracy than any of the existing instruments. It used a frequency of sound very close to supersonic; this was the first attempt by the Survey to use the higher frequency sound waves in echo sounding.

This paper describes the latest type of sounding equipment designed for precise hydrographic surveying, compares the results obtained with the pilot model and the instrument which is presently standard equipment, and describes some of the modifications of the pilot model.

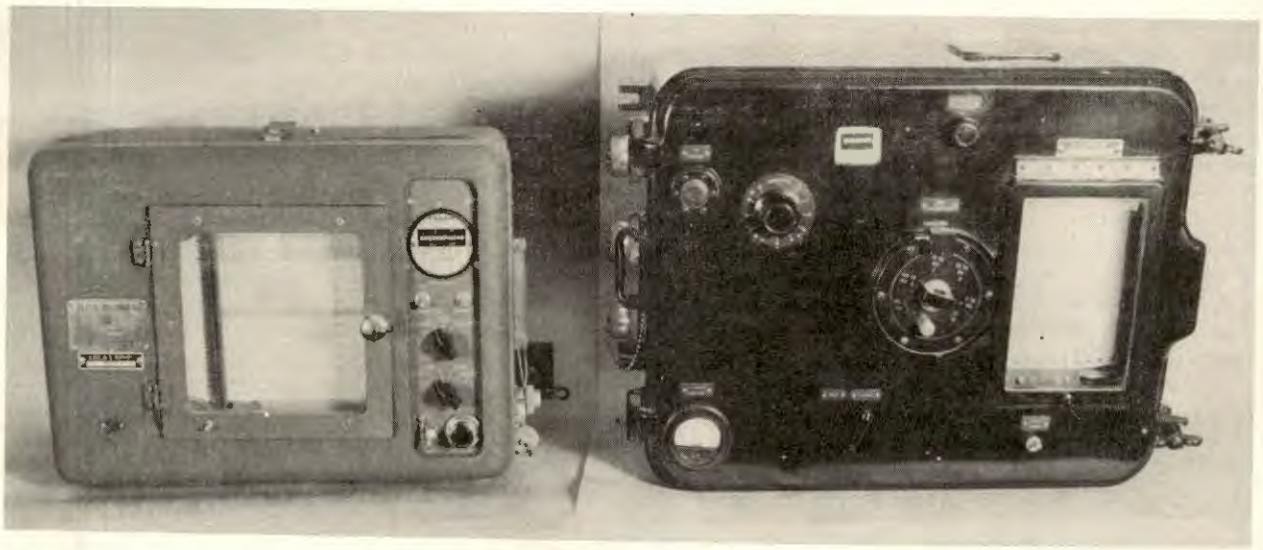
THE 808 ECHO-SOUNDER

The first actually portable echo-sounding instrument used by the Coast and Geodetic Survey was the 808 Fathometer equipment, developed in 1939 in accordance with performance specifications prepared by the Bureau. Although the first 808 instruments were manufactured for the Coast and Geodetic Survey, many other survey organizations later used this system for primary shoal-water echo-sounding operations. This equipment was originally so well designed and constructed that for almost 18 years it remained the Bureau's primary shoal-water sounding instrument. Many of these instruments have been rebuilt several times to keep them in service.

The 808 echo-sounder is no longer in production and spare parts are not available. However, technical advances in recent years have made possible the development of echo-sounders which better meet the more exacting requirements of modern surveys.

Although excellent in design, several faults and inadequacies of the 808 need correction. For example, there is a serious lack of correlation between various depth ranges, resulting in what is known as *phasing error*, which is difficult to establish and equally difficult to correct. The size, weight, and power needed to operate the 808 is somewhat excessive for small-boat operation. Objections have also been noted to its circular

Mr. Hickley is Chief of the Electronics Laboratory, Instruments Division.



Echo sounders, the 255 is on the left and the 808 is on the right. Note grouping of controls of the 255 in a small area on a single panel.

sweep because of the difficulty encountered in scanning the fathogram. The more serious fault of the circular sweep, however, is that any maladjustment of the fathogram paper or recording stylus can result in a sounding error which is often difficult to detect. Constant stylus speed which depends upon a mechanical governor attached to the stylus motor, has become the most prevalent source of sounding errors with this instrument. Only a skilled operator, constantly in attendance, can succeed in keeping the stylus speed constant.

EVOLUTION OF THE EDO 255

In the spring of 1953, representatives from several interested Government agencies met with engineers of the Edo Corporation in the Philadelphia office of the Corps of Engineers, U. S. Army. This meeting culminated a series of discussions among agencies interested in a modern portable echo-sounder.

At the Philadelphia meeting specifications were outlined for an echo-sounder which would meet the combined needs of all agencies concerned with hydrographic surveys. These specifications made adequate provision for the differences in surveying techniques of the various agencies, and were incorporated in a "bill of particulars" of design subsequently presented by Edo engineers. The instrument developed became known as the 255.

Features of the 255

The 255 incorporates the most recent advances in electronic hydrographic surveying methods. Briefly its more noteworthy features are:

(a) The depth recording is linear rather than circular. This facilitates reading of the fathogram and substantially reduces stylus and paper adjustment error. The stylus mechanism consists of a positive-drive, cogged rubber belt.

(b) A synchronous motor assures correct stylus speed when the motor is powered by a supply source of dependable frequency.

(c) Phasing error is minimized by the use of fixed keying contacts. An electric switch permits selection of the desired depth range.

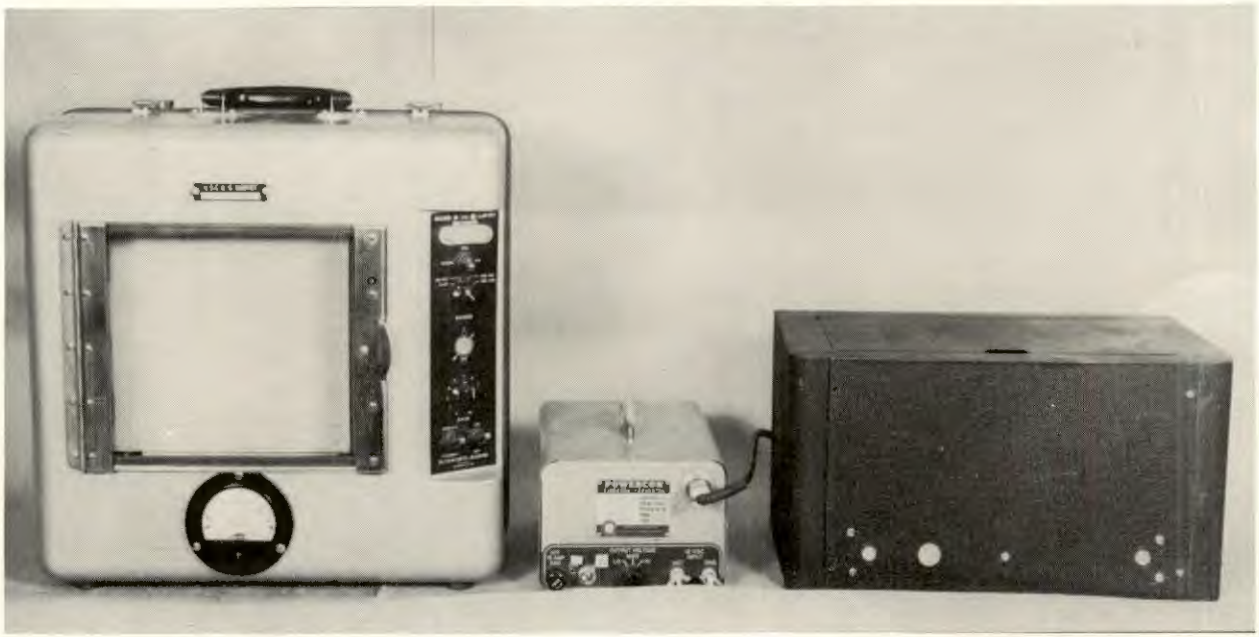
(d) Barium titanate is the acoustic element in a narrow beam transducer. Only one transducer is needed as it is a combined transmitting and receiving unit.

(e) A vacuum tube transmitter is used to power the transducer. The shock-excited transducer used in the 808 has been supplanted by a vacuum tube transmitter which supplies power to the transducer, making it possible to put more acoustic power into the water. Furthermore, the length of the acoustic pulse can be controlled to assure stronger echoes at greater depths and over rugged bottom features.

(f) Electronic units are of the plug-in type and necessary replacements can be made simply and quickly. Removable units make for a much wider range of utility, as entirely new units for various types of surveys can be plugged in when needed.

EVALUATION PROCEDURE

A widely held belief is that an instrument must be subjected to field testing, where any weak-



The new Bludworth echo sounder designed specifically for surveys needed in dredging operations. Its high-frequency, narrow beam transducer gives highly accurate bottom delineation. The Electronics Laboratory added the magmeter speed indicator, placed under the paper opening, and the tuning fork power supply shown on the right.

nesses will soon be revealed, if its performance efficiency is to be accurately evaluated. It is true that flaws soon appear in field operations, but we have learned through experience that this is the most difficult and least satisfactory manner of assessing the true potential of an instrument. Field tests should always be the final tests, and should take place only after the laboratory has determined that all basic design features are sound and all obvious "bugs" eliminated. Only rarely are complete useful reports obtained from field tests alone; consequently, the laboratory must eventually make the comprehensive tests which should have been made before the instrument was placed in the field.

The Coast and Geodetic Survey purchased 15 of the new 255 echo-sounders late in the spring of 1953. The working season was almost over when these instruments were delivered. After superficial testing in the Electronics Laboratory, they were rushed into the field so that operational tests could be made the same year. It is recognized that the operator of an echo-sounding instrument has neither the time nor the training to evaluate a piece of highly technical, complex equipment. His responsibility is to get a creditable survey with the echo-sounder, and he should not be expected to analyze its faults or do makeshift repairs to keep it running.

In order to get better field reports on the performance of these instruments, a special report form containing key questions was designed which would reveal weaknesses in the more critical parts. These forms were completed and submitted monthly by the operators of the 255 equipment. After a sufficient number of these reports had been received, a statistical study based on the reported data was made in the Electronics Laboratory. This study revealed the most likely sources of trouble.

Another important fact that was learned is that it is a mistake to attempt to make a wide distribution of a relatively small number of instruments for testing. In this case no field party received more than two echo-sounders--many received only one. Most radio technicians follow a program of "preventive maintenance," enabling them to draw on a backlog of spare instruments when repairs, adjustments, or replacements are needed. It is impossible to follow this plan when only one or two instruments are available. Consequently, substitution of the 808 echo-sounder for the 255 equipment was sometimes necessary.

A better field performance test would have been obtained if more instruments and an abundant supply of spare parts had been furnished to only a few parties. Then, the hydrographers would have become thoroughly familiar with the new equipment and serious operational delays could have been avoided. Also, the technicians would have learned more about the instrument and been able to develop new service techniques.

PERFORMANCE ANALYSIS OF THE 255

The analysis of the 255 echo-sounder field reports indicated that certain features caused more difficulties than had been anticipated. Some of the instruments were recalled to the laboratory for further study and analysis of these particular

The transistor power supply on the left can replace the two rotary converters on the right for powering the 808 echo sounders. The efficiency of the transistor unit is nearly 90 percent while that of the rotary converters is about 50 percent. The transistor unit has no moving parts, hence its life far exceeds that of the rotary units. The cost of the transistor unit is about 20 percent less than the other type.

problems. Most of the difficulties were found in the recording system. Specific faults were:

(a) The stylus belt was too bulky and required more power than the motor was capable of producing. Belt tension was critical and had to be carefully adjusted to keep from overloading the motor.

(b) If not properly alined, the stylus trolley bar and trolley brush would bind the stylus belt. The trolley brush was not durable and had to be replaced frequently.

(c) The keying contacts for the various depth phases were difficult to keep in adjustment, and the insulated slot between the commutator segments required frequent cleaning to prevent erratic keying. The contact brushes which bear on the commutator wore and jammed because of faulty holder design.

(d) The stylus motor required excessive power, more than 70 watts, and was still not capable of furnishing sufficient synchronous power to drive the stylus belt. Being inefficient, the motor produced considerable heat.

(e) The instrument was not capable of sounding shallower than 5 feet.

(f) Other defects were discovered, but most of these were trivial or were easily corrected.

In spite of the above faults, the 255 equipment incorporates many excellent features. Briefly, the more notable points are:

(a) The recording cabinet is small and sturdy. All other mechanical features are also sturdy and the best quality of material has been used throughout.

(b) The electronic circuits are well designed and have a large safety factor.

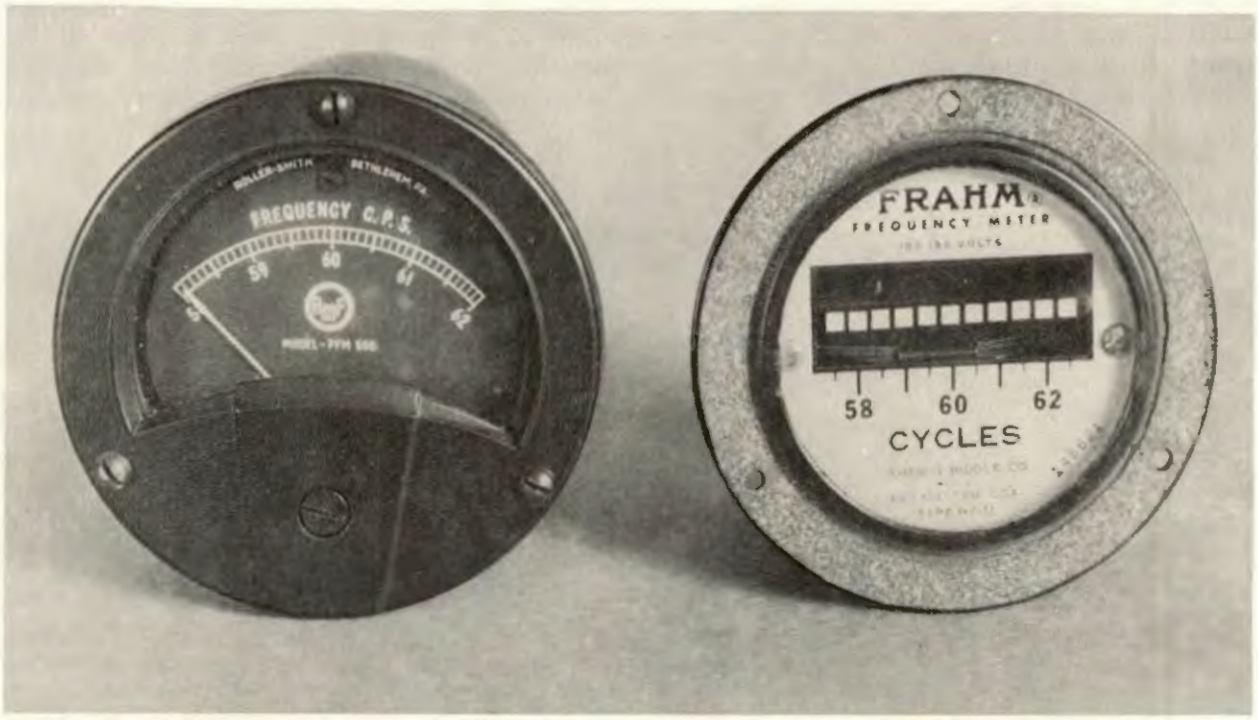
(c) The transmitter is capable of delivering considerable power of short duration to the transducer.

(d) The transducer is very efficient, using barium titanate as the acoustic element. The beam width is narrow (total beam width of 20° at 10db down), which makes for more accurate soundings in certain areas. The high efficiency delivers considerable sound to the water and is sensitive to weak echo signals. Severe turbulence and other noises do not produce strays on the fathogram. An unfaired transducer can be supported over the side and produce noise-free soundings while the vessel moves at a speed of 10 knots.

(e) More accurate sounding is obtained through use of a synchronous stylus drive motor. Even the best governor speed controlled, direct current motor is never entirely satisfactory. The synchronous motor speed control can be as good as the frequency stability of the power source from which it is supplied. A power supply which is far more accurate than that needed for echo sounding can be easily designed.

EDO 255 CORRECTION PROGRAM

When it was certain that a correct analysis had been made of the 255 echo-sounder, plans were made to remedy the faults. In 1956, the report of evaluation tests by the Coast and Geodetic Survey were reported to the Edo Company for further analysis of the instrument. Considerable effort was made by Edo engineers to correct the faults reported in the 255 equipment. Two kit changes were made which resulted in better shoal water sounding with one transducer; by providing for two transducers even shallower soundings are possible. Improvements were made in the stylus



Speed indicators, the magmeter-type is shown on the left and the electric driven reed-type is on the right. The magmeter-type which will be used in the redesigned 255, is easier to read and to set to a definite value. This type is also more stable with temperature variations and is little influenced by vibrations.

brush and trolley bar, as well as in the recording and keying system.

The 255 echo-sounder was thus made a better instrument, but the faults in the recording and keying circuits had not been corrected, and the stylus motor was inefficient. These fundamental weaknesses were evident so the decision was made to withdraw gradually the 255 echo-sounders from the field, and to reconsider the entire portable echo-sounding problem.

RESTUDY OF PORTABLE ECHO-SOUNDERS

The kit changes to the 255 equipment had brought about some measure of improvement, but had glossed over rather than corrected certain weaknesses in the recording system. The disappointing results with the recording system were because of the difficulty of the problem. When sounding in feet, the stylus crosses the paper at a speed of over 200 inches per second, during which time the stylus must exert a correct and even pressure without vibration or slap. When the belt moves slowly, as with deepwater sounding, the problem of recording is much simpler.

These findings indicated the necessity of stopping all improvement programs until the entire problem was reexamined. This review was not to be restricted to simply making a better 255 echo-sounder, but the development of an entirely new system was to be undertaken if necessary. As the recording problem was one of the most difficult, the first studies centered there.

As Edo Company engineers had been kept acquainted with Coast Survey tests of the 255 equipment, they agreed that a redevelopment program was necessary. Consequently, the company made arrangements to conduct a complete restudy of portable echo-sounders independent of the work the Bureau was doing. Both organizations kept each other fully informed by the interchange of progress reports.

All possible methods of recording were first reviewed. Various methods are employed; however, most of them are variations of either a circular system where the depth is measured along the arc described by a rotating arm, or a linear system where the writing is straight across the paper at a uniform speed. Ways to produce these motions are many and some are complicated. When the stylus speed is fast, as in shoal-water sounding, only the simplest method is practical.

As the many methods of recording were studied, it became apparent that the best approach to the problem was to proceed with parallel design of both a circular and linear system in order to develop one which could be soon put into production.

Design and Development of Recording Systems

In spite of some weaknesses in the 808 circular recorder, it could still be depended on to give a very creditable record. Therefore, the first effort was to design a satisfactory circular system

EXPERIMENTAL TRANSISTOR POWER SUPPLIES

The two units on the left are 12-volt d.c. to higher voltage power supplies. The left unit supplies 400 volts and minus 50 volts for the receiver's amplifying and keying circuits; while the right unit supplies 3,000 volts for the transmitter plate current.

The cyclindrical shaped unit, left center, is a precise frequency transistor oscillator which is very frequency stable with time. It can be adjusted in frequency over a range of 58 to 62 cycles per second; this corresponds to a velocity of sound in sea water of from 4,650 to 4,950 feet per second. When combined with the transistor inverter, on its right, 100 watts of precisely controlled power can be supplied for the entire echo sounder requirements.

The two units on the right are for tuning-fork control of the 100-watt inverter when constant velocity soundings are desirable.

EDO 255 echo sounder with a KATO 12-volt d.c., to 110-volt a.c., 50- to 70-cycle rotary converter mounted in test launch. This converter is used for testing as it can be adjusted over a wide variation in frequency.

to fall back on if a linear system design could not be developed to meet requirements. While the circular system was being constructed, experiments with linear systems were being made. Some of the features of circular recording which are different from the 808 equipment are:

(a) The stylus is carried on a disc instead of an arm for better balance and reduction of windage resistance.
(b) Synchronous motor drive makes for better speed control.
(c) Electrical phase selection eliminates phase error.
(d) Adjustable stylus holder eliminates stylus radius arm error.

For a successful shoal-water linear recording system the weight of the belt and stylus assembly must be reduced to a minimum. Directional changes, as when the belt circles the pulley, cause acceleration forces which are responsible for vibration and slap. If the belt or parts connected to the belt are massive, the belt vibrations cause poor recording. Excessive power is required and this power is expensive to produce. When the belt vibrates, a guide is necessary to damp out this vibration; such a guide increases the load on the stylus motors. In the first 255 echo-sounder the damping exerted by the guide when not properly alined could stall the drive motor. In this instrument the guide also acted as the stylus trolley to carry signal current to the stylus.

Most of the successful high speed linear systems in use today use a nylon or teflon string-type belt, to which is attached a small stylus. The stylus is guided precisely along the paper to damp out vibrations and furnish signal power to the stylus. When a new stylus is needed, the entire belt with its stylus is replaced. Tests of these recording systems have been made in the Electronics Laboratory and even though the systems appear mechanically unsubstantial the recordings are quite satisfactory.

Any belt slippage on the drive pulley will result in sounding error. No slippage was found over moderate environmental changes--the laboratory is not presently equipped to simulate large environmental changes.

The stylus belt system appears fragile and when used for intensive survey operation the life of the stylus is quite short. These belts are considerably more expensive than a simple stylus replacement (some cost more than $2). This light-bodied system is the ultimate in design for a fast recording system, but it lacks ruggedness and a guarantee of positive drive under all environmental conditions and wear.

The original 255 equipment used a Gilmer gear timing belt, 5/8-inch wide, made of rubber fiber with molded gear teeth to match those of the drive and idler pulleys. The use of this belt always insures a positive drive. The redesigned linear belt system, also made by Gilmer, is only about 1/4-inch wide, with gear teeth of a smaller pitch; it is designed for higher speeds. The stylus and holder are light and simple, and are easy to install and adjust. The stylus or guide rail which carries current to the stylus and damps out vibrations is also quite simple. It consists of a stainless steel bar just above the paper, which the stylus contacts as it traverses the recording paper. Although working independently, Edo and the Coast Survey arrived at nearly the same belt design, but the stylus holders are somewhat different.

Other Recording Innovations

To simplify the system when sounding in feet, the stylus motor is connected directly to the drive pulley, eliminating a gear system between the stylus motor and stylus belt. Direct connection between the motor and the drive pulley minimizes hunting of the pulley and results in a cleaner sounding record. The echo-sounder will measure in either feet or fathoms, but cannot be quickly shifted from one unit to the other. However, it takes less than an hour to convert an instrument from feet to fathoms or vice versa, and no new components are required. The new belt, trolley band, and elimination of gear trains considerably reduce the power needed by the stylus motor. A smaller motor can be used, operating at a higher efficiency, with a consequent reduction in motor size and the production of less heat within the recorder cabinet.

The transmitter is keyed by contacts carried on the stylus belt which makes the keying more positive and minimizes the phase error. The

keying stylus makes four contacts, one for each depth range, as the belt makes a complete turn. The keying contacts are placed parallel to the belt and spaced along it to key at precisely the correct time. Once positioned, the contacts will remain fixed for long periods. The keying contacts lead to a switch on the front panel where the depth scale is selected. Draft adjustment is done electrically by a screw driver control, also on the front panel.

CONSIDERATION OF ACOUSTICAL FEATURES

Concurrent with the redesign of the mechanical parts of the echo-sounder, the electronic features of the system were reexamined. Further consideration was given to the choice of acoustic frequency and the problem was examined theoretically as well as experimentally. The laboratory test launch proved most valuable in experimental verification. A few of the tests made are described as follows:

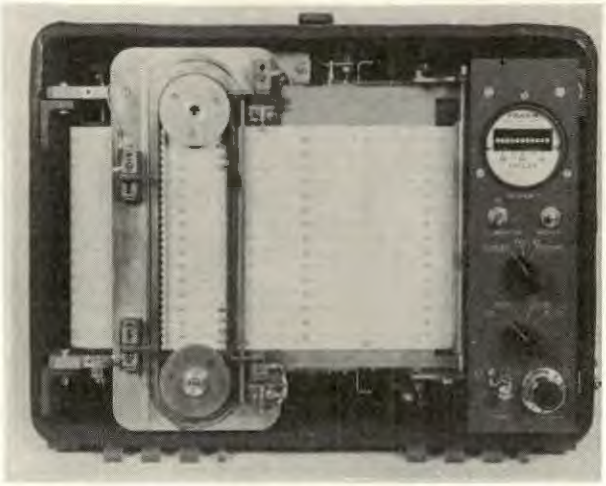
The 808 and 255 echo-sounders were set up side by side in the test launch, and each adjusted for optimum operation. The purpose of these tests was to compare the performance of the two instruments under varied conditions found in Chesapeake Bay. Soundings were made over a great variety of bottom contours and bottom compositions. No area exists in the bay where soundings can be compared over rocky or rugged bottoms; moreover no depths exceed 170 feet. Some steep slopes and areas exist where the sound wave penetrates into the bottom to reveal deep basement layers.

Little difference was noted in the characteristics of the 808 and 255 soundings in any of the areas. The 255 equipment is superior in distinguishing small bottom features and detecting the presence of reflecting objects suspended above the bottom. Because of this, the 255 echo-sounder should be capable of recording more accurate sounding details over very rugged bottoms. The better resolution of the 255 equipment is in part because it has a much narrower transducer beam than the 808 instrument. The lower sound frequency of the 808 echo-sounder makes it potentially capable of penetrating deeper into the bottom, but in areas where bottom penetration was noted both instruments showed nearly equal ability.

The conclusion derived from these tests, combined with other studies, was to continue to use the 37.5 kc. used by the first 255 instruments. One advantage of the 255 acoustic system over the 808 system is the more efficient transducer system resulting from a narrower transducer beam which puts more sound energy into the water. Also, the transducer picks up less noise. In fact, the transducer can be moved through the water

Closeup of 9-inch transducer well made of fibreglass. The well ring is cemented directly to the fibreglass hull. The transducer has been removed.

Looking forward in the 18-foot fibreglass-test launch. The 808 and 255 echo sounders are mounted on the bench in the cabin to the left. On either side of the cockpit are the two transducer wells. The one on the right is open to show arrangement of experimental transducer. The left well contains the calibrated transducer.



Prototype of the redesigned 255 echo sounder built in the Coast and Geodetic Survey. The new lightweight belt and keying contacts are clearly seen.

at high speeds without fairing and no noise will be recorded on the fathogram.

Certain advantages are apparent in the 255 system over the 808 instrument in the way the signal is generated which drives the transducer. The 808 transducer is excited by the discharge of a high-voltage condenser, which shocks it into oscillation much as a bell will ring from a single stroke of the clapper. Most of the energy is in the first few cycles of the sound wave from the transducer, after which it rapidly tails away. While the 255 transmitter is a vacuum oscillator which quickly comes to full amplitude when turned "on" by the keying circuit and continues to furnish energy of uniform amplitude to the transducer for the "on" period. Thus the full energy of the transmitter is supplied to the transducer all during the keying period. This pulse can be made short for shoal water sounding. For precise bottom delineation the pulse should be short, fast starting and quick ending. The long tailing of the shock-excited signal often blurs over what might be a sharp echo feature. This will give a smoothed profile to what was in reality a rugged feature.

An important advantage is in being able to control the length of the pulse for deep-water sounding. In deep water the recording on the fathogram depends, among other factors, upon the length of the transmitted signal. In grass- or kelp-free areas, or when a knowledge of bottom composition is not important, a narrow-beam 200 kc. transducer will give a more accurate sounding and fathograms are easy to process. The attenuation of these frequencies is high through water, and 300 feet seems a practical depth limit with practical values of power to the transducer.

The conclusions reached from these studies are:

(a) The frequency chosen for the original 255 equipment seems to be well selected and will be used in the redesigned instrument for all standard sounding conditions.

(b) Important advantages are apparent in using high frequencies such as 200 kc. in certain sounding areas.

(c) Some advantages may exist in using a somewhat lower frequency (10 kc. or lower) for other special areas such as sounding through grass or kelp.

(d) A new instrument will be designed so that the transmitter and receiver can be replaced in the recorder to adapt the instrument for any special sounding condition.

(e) The need is recognized for a small transducer, about 3 inches in diameter, for small vessels, launches and dinghies. This will also be a 37.5 kc. transducer.

(f) Test points will be incorporated in the instrument so that one with little electronic knowledge can easily determine if a particular unit is faulty and replace it from his spare parts kit.

GENERAL ELECTRONICS PLANS

From the foregoing studies and experiments, the following decisions were made regarding the electronic circuits. Except for minor changes, the present 255 electronic circuits will be retained as they are; however, there will be a rearrangement of parts to accommodate new power supplies now being developed. Several transistor power supplies show promise.

Power Supply

Transistorized techniques are now such that they can be used with confidence to furnish power for portable echo-sounders. Two experienced companies are now developing transistor power supplies for the Coast and Geodetic Survey.

The design object in this portable echo-sounder is to develop a completely self-contained instrument which needs only an external 12-volt battery and transducer. All the necessary plate voltages and the precise frequency power to run the stylus and motors will be generated within the recorder cabinet. Two precise frequency sources are being developed. One is a tuning fork which will be used for sounding velocities of 4,800 feet per second. When it becomes feasible to correct the velocity by a change of stylus speed, a variable-frequency oscillator can replace the tuning fork.

Precise speed control will eliminate one of the largest errors in most echo-soundings. Also, because of the high efficiency of transistorized power supplies combined with a more efficient recorder system, about 25 percent less battery power is needed than required by the present 255 and 808 systems, with the added feature of precise speed control on the new instrument.

Tests have been completed on a new stylus motor speed inductor which is more accurate and dependable than the present vibrating reed-type speed indicator. The speed reading is on a meter which can be calibrated in the frequency

Comparison of the characteristics of the 808 and the redesigned 255 echo sounders

		808	255
RECORDER CABINET			
Length	inches	22-3/4	18-1/2
Width	do	17	13-1/2
Height	do	11	9-1/2
Weight	pounds	95	63
POWER			
Voltage (source)	volts d.c.	12	12
Current	amperes	15-20	10
Power	watts	180-240	120
SOUNDING DATA			
Sounding units		feet or fathoms	feet or fathoms
Sounding ranges (feet or fathoms)		0-55	0-65
		35-90	55-120
		65-125	110-175
		105-160	165-230
Overlap between scales	feet or fathoms	20	10
PAPER DATA			
Paper width (overall)	inches	7.062	7.0
Paper width (active)	do	6.25	6.093
Paper length	feet	72	100
Kind		Teledeltose	Teledeltose or Timefax
TRANSMITTER			
Kind		Condenser discharge	Vacuum-tube
Power (peak)	watts	38 (approx.)	150
RECEIVER			
Gain		1 microvolt in for 2 volts out (max. gain)	120 db
TRANSDUCER			
Kind		Magnetostriction	Barium titanate
Number needed		2	1
Frequency	kc	20.5	37.5
Beam width (total to 10 db down point)			
Fore and aft	degrees	42	20
Athwart ship	do	80	20
Length	inches	6-1/2	.....
Width	do	4.0	.....
Height	do	3-1/2	4-1/16
Diameter	do	.....	8-13/16
Weight	pounds	20/unit	12-1/2 (plastic)
Impedance		10 ohms .1 ohms d.c	30 - J400 at 37.5 kc.
Source level		unknown	108 db
Min. detectable pressure		do	plus 15 db
CALIBRATION VELOCITY feet per second		800 & 4920	4800
PRICE (approx.)	dollars	3000.00	2740.00

of the driving power, revolutions per minute, or the velocity of sound in water. Economic factors and other reasons will determine if this instrument will replace the reed-type meter.

Means are being provided so that an external 115-volt, 60-cycle power source can also be used to activate the instrument. Maintenance of a supply of storage batteries for larger vessels is not always convenient but they all have precise 115-volt, 60-cycle supplies.

Two types of power supplies are now being developed. One type will furnish 100 watts of precise 60-cycle power. This transistor amplifier will supply all the power needed by the synchronous motors, as well as the transformer and rectifier which furnish the plate and heater power for the vacuum tubes. The other experimental transistor power supply is composed of two parts: the first is a 25-watt amplifier driven from a tuning fork or other precise frequency source to supply the power for the synchronous motors; while the second is a d.c. to d.c. transistor power supply which converts 12 volts to the high d.c. voltage needed for the vacuum tube plate circuits.

Each of these power systems will be built into an experimental 255 echo-sounder, and the features of each studied. The best of these two systems will be selected before the production models of the new 255 equipment are ready.

In the redesigned 255 system, in which the stylus speed is controlled by a tuning fork, all the circuits are built into the present 255 cabinet and it is only necessary to connect a transducer and 12-volt battery. This power supply is only partly transistorized. The tuning fork furnishes driving power to a 115-volt, 60-cycle vibrator which in turn furnishes 100 watts of power to run both motors and the plates and heaters. The vibrator is a conventional self-vibrating type, capable of holding frequency better than plus or minus a cycle. When driven from the fork, the vibrator's frequency is as accurate as that of the fork. Several such power supplies will be in the field this season, but they will be outside the cabinet of the experimental 255 instrument. Preproduction units are now available for testing the soundness of several ideas under consideration.

TABULAR COMPARISON OF 808 EQUIPMENT WITH NEW PORTABLE ECHO-SOUNDER

The accompanying table has been prepared so that the features of the 808 equipment and the new portable echo-sounding instrument can be easily compared. Slight adjustment may be expected in the specifications of the new instrument as construction progresses, but any changes will be minor.

PROCUREMENT PLANS FOR THE NEW PORTABLE ECHO-SOUNDER

The contract for the new portable echo-sounder was let in the spring of 1958. An engineering model will be used in the field during the 1958 season, but only a few production models will be ready during the year. Specifications require the production model to be finished by late summer or early winter of 1958. Sufficient time will be allowed for laboratory tests and any needed corrections to equipment before the 1959 field season.

Since only a few of these new instruments will be purchased, these will be concentrated in one or two (at most, three) field parties. Indications are that one east and one west coast party will be selected to test the performance of the new instrument. As additional instruments are purchased, they will be distributed more widely.

The 808 echo-sounders will be systematically retired, inasmuch as many of the replacement parts are no longer obtainable. Spare parts that can be salvaged will be used to keep the remaining instruments in operation.

FUTURE PLANS FOR ECHO SOUNDING

When the tests have been completed and the new portable echo-sounder accepted, then special features will be developed and added to this instrument. Some of these have already been mentioned, such as 200 kc. units and the small 37.5 kc. transducer. Tests will be made during the summer of 1958 on the use of lower frequencies especially helpful in bottom penetration studies. Such soundings are intended to reveal the nature and composition of the earth below the sea bottom. This information may appear as a byproduct of sounding for charting purposes and will add much useful data to science and engineering. Special studies will be made of methods for sounding through kelp and bottom grass.

For a long period following the development of the 808 equipment, little or no work was done to improve shoal-water sounding instruments. In the future the echo-sounding program will be kept continuously active, and existing instruments will be improved and modified as indicated. A better recorder is definitely needed for the deep-water sounding instruments. The Precise Depth Indicator (PDI) working in conjunction with the Deep Water Sounder Type UQN on the Coast and Geodetic Survey ship *Pioneer*, has improved the definition and accuracy of deep-water soundings. At this time it is not known if the PDI will be added to other Coast Survey vessels or if the Bureau will design its own recorder.

The Committee on Instrumentation has directed the Electronics Laboratory to review all the methods of deriving corrections for echo-sounding. This is intended to simplify the entire process of echo-sounding correctors. Most of the research in this problem will be directed toward the establishment of velocity correctors. Ideal correctors should be continually fed into the echo-sounder to produce a sounding free of error. Other instrumentation techniques which might lead to direct readout of soundings will also be investigated.

Because it is believed that better echo-sounders can be designed, a concentrated study is being made of the physical nature of underwater sound, particularly the attenuation and dispersion of sound in the water and sea bottom. This knowledge is fundamental to an accurate analysis of the record appearing on the fathogram. It is important to the optimum adjustment of the instrument in different sounding areas. A tutorial paper, in which the physics of underwater sound will be discussed, is being prepared for a future bulletin, to afford a better understanding of echo-sounders by those who use them for survey purposes.