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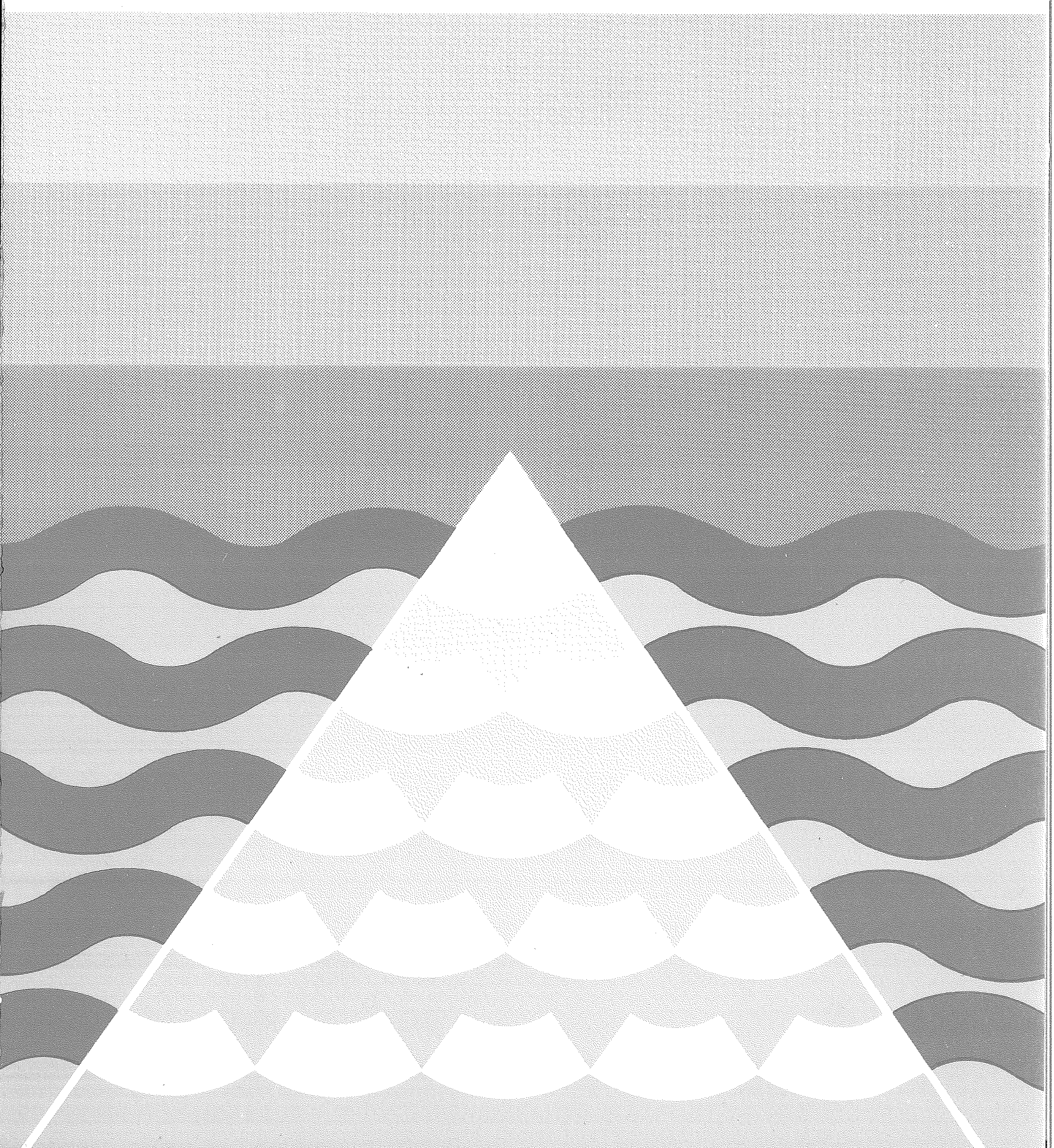

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ECHO SOUNDER MEASUREMENTS OF BACKSCATTERING CROSS SECTIONS OF ELASTIC SPHERES

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ABSTRACT

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Acoustic backscattering by solid elastic spheres has a history of experimental and theoretical investigation, but little application. In order to facilitate the precision calibration of sonars, echo sounders, and echo integrators, the present study aims to provide sufficient new experimental data to test a necessary extension of theory which avoids the limitations of continuous-wave ensonification and infinitely-narrow-bandwidth reception. The gathered data thus include the following parameters for each echo sounder: the duration and center frequency of the transmitted, pulsed sinusoidal signal, and the frequency response function of the receiver. Other essential data reported here are the diameter, density, and material composition of each sphere, and the medium hydrography, or temperature and salinity. Annexed periferal data include the individual sphere suspensions and received echo waveforms.

The backscattering cross sections of twenty nine spheres were measured with each of the echo sounders whose respective nominal operating frequencies were 38, 49.5, 70, and 120 kHz. The same nominal pulse duration of 0.6 ms was used. Sphere diameters varied from 35 to 130 mm. The characteristic product of wavenumber and sphere radius thus spanned the range from 3 to 34. No assumptions were made about the equipment calibration other than that it remained constant over the duration of the experiment. The measurements are thus purely relative, but consistent for each echo sounder. Conversion factors allowing expression of the measurements in absolute units are provided by reference to theory.

INTRODUCTION

Calibration of hydroacoustic equipment is generally problematical. In the case of transducers, for instance, there appear at times to be as many techniques as there are experimenters or users. URICK (1975) gave twenty seven references on the subject. The number today is much larger as is evident from inspection of recent indexes of the Journal of the Acoustical Society of America and from bibliographies compiled for the same journal by WHITE and TEAS (1976-81).

The current problem of interest, and motivation for the study reported here, that of calibrating echo sounders and echo integrators for use in fisheries research, is no less troublesome or intriguing. Some popular solutions are the following: conventional calibration by hydrophone (PETTERSEN 1969, FORBES and NAKKEN 1972, BODHOLT *et al*. 1979), simultaneous counting and integration of single fish echoes from a sufficiently dispersed aggregation (MIDTTUN and NAKKEN 1971), integration of the echo from an encaged aggregation of fish suspended in the echo sounder beam (JOHANNESSEN and LOSSE 1977), and measurement of a stationary, passive target with presumed known target strength, e.g., ping pong ball (WELSBY and HUDSON 1972, TRAYNOR and EHRENBERG 1979, FORBES *et al*. 1980, TRAYNOR and NELSON 1981) or metal sphere (WALLACE *et al*. 1975, TRAYNOR and EHRENBERG 1979). These methods display a diversity like those of transducer calibration, and similarly express a latent dissatisfaction with available methods or need for highly specific techniques.

The present study springs from several sources. The first is the experience of the instrumentation group at the Institute of Marine Research with the hydrophone method, which has proved unreliable. The second is the long-standing desire of the acoustics group at the Institute to know what the absolute calibration of the equipment is, independently of fish behaviour. Such considerations restrict choice of the calibration method to that of a simple target with presumed known acoustic backscattering cross section. Given the success of the instrumentation group in obtaining consistent, if relative results with metal spheres in exercises conducted along with conventional hydrophone calibrations since 1979, it was natural to investigate similar targets. The fact of distant colleagues' complaints about ping pong balls, including suspicions voiced in the literature (TRAYNOR and EHRENBERG 1979), precluded consideration of these and other non-robust targets. The existence of a rudimentary theory for scattering by elastic spheres (FARAN 1951, HICKLING 1962), moreover, and possibility of forming the target of glass or plastic led to the general investigation of elastic spheres as calibration targets.

General aims of the overall calibration study, the so-called Calibration Sphere Project, may be phrased through these questions: What is the target strength of an elastic sphere as observed by an echo sounder? What is the best material and sphere size for calibration of a given echo sounder? How should the sphere be suspended in the echo sounder beam? What methodology is most efficient for calibrating echo sounders and echo integrators by elastic spheres?

A shortcoming with theory that was recognized at the outset of the study was its formal limitation to the idealized conditions of continuous-wave ensonification of the target or infinitely-narrowband reception of the echo (URICK 1975, CLAY and MEDWIN 1977). Extension of theory to the general case of transient ensonification of an elastic sphere and reception of the echo by an intrinsically wideband receiver, which characterize ordinary uses of echo sounders and sonars, thus constituted a first step in the study. Confirmation of the expanded theory and exploration of different candidate materials for the calibration sphere was the goal of the first experiment of the project.

The success of the experiment may justify the somewhat inclusive presentation of its data here. At the least, such detailed documentation establishes a solid foundation for the further exercise of theory, as in solving the dual problem of specifying the best material and sphere size. As a second experiment has

Table 1. Description of machined copper spheres used as acoustic targets. Parenthetical quantities are estimates.

Name	Diameter (mm) Nominal	Diameter (mm) Computed	Mass (g)	Other description	Net bag Type	Net bag Line diam. (mm)	Suspension line diam. (mm)
CU35A	35	35.00	200.7		19 mm mesh	0.19	0.36
CU35B	35	34.99	(200.6)		19 mm mesh	0.19	0.36
CU35B-			197.6	With central 3.5 mm diameter bore	19 mm mesh	0.19	0.36
CU35C+	35	34.98	(201.5)	With c. 1.1 g, 4 mm high, 2mm diameter cylindrical knob	None: hole through knob		0.36
CU35C-			199.4	With central 2.0 mm diameter bore	19 mm mesh	0.19	0.36
CU40	40	39.99	299.4		19 mm mesh	0.19	0.36
CU45	45	45.02	427.2		19 mm mesh	0.19	0.36
CU50A	50	49.86	580.2		19 mm mesh	0.19	0.36
CU50B	50	50.02	586.0		19 mm mesh	0.19	0.36
CU50C+	50	49.99	(587.4)	With c. 2.6 g, 6 mm high, 2.5 mm diam. cylindrical knob	None: hole through knob		0.36
CU50C			584.8		19 mm mesh	0.19	0.36
CU60	60	60.08	1015.2		Handmade	0.58	0.58

already been conducted, with both confirmation of the target strengths of new, theoretically optimal spheres and elucidation of a rather simple calibration methodology, the present report also prefaces and supplements other reports, e.g., FOOTE et al. (1981) and FOOTE (1982), describing attainment of the project goal: straightforward absolute calibration of echo sounders and echo integrators.

MATERIALS AND METHODS

The measurements were made from an instrumented raft anchored near the end of a narrow, sheltered fjord called Kvalsvaagen, near Skogsvaag on the island of Sotra, west of Bergen. Under ordinary conditions the raft acted as an essentially stable platform. The water column, including measurement volume immediately beneath the raft, was completely isolated by a sprat seine with 10 mm-mesh size. This was held to the soft mud bottom at uniform depth of 15 m both by the weight of an extra 5 m-length of seine and by lead weights attached to the bottom edge. All but the smallest fish, larvae, plankton, and other extraneous scatterers were thereby excluded from the measurement region. The tidal range of 0.75 m produced only an immeasurable current.

Nearby shore power - 5 kw of 50 Hz, three-phase alternating current - was carried to the raft by underwater cable. This was distributed in two networks, with regulation of the mains voltage of that network supplying the echo sounders and echo integrator.

The acoustic backscattering cross sections of twenty five spheres, the subjects of the experiment, were measured. Several of these were used in different forms, e.g., with and without protuberances and diametral bores, producing a total of twenty nine different scattering entities. These are divided into three groups for ease of description in Tables 1-3.

The copper spheres are described in Table 1. The copper was

Table 2. Description of non-copper machined spheres used as acoustic targets. Parenthetical quantities are estimates.

Name	Material	Diameter (mm)		Mass (g)	Computed density (g/cm^3)	Net bag		Suspension line diam. (mm)
		Nominal	Computed			Type	Line diam. (mm)	
STL60A	Acid-fast steel	60	60.01	900.0	7.954	Handmade	0.59	0.58
STL60B	Acid-fast steel	60	60.03	897.3	7.922	Handmade	0.55	0.57
STL99	Acid-fast steel	99	98.92	4027	7.946	Handmade	1.00	1.00
AS130	Axle steel	130	130.0	9001	7.825	Handmade	1.20	1.20
RS130	Stainless steel	130	130.0	8951	7.781	Handmade	1.20	1.20
SS130	Acid-fast steel	130	130.0	(9140)	7.945	Handmade	(1.20)	1.20
AL60	Aluminum	60	60.02	306.6	2.708	19 mm mesh	0.19	0.36
BRS60T }	Ferromanganese	60	60.00	948.1	8.383	19 mm mesh	0.19	0.57
BRS60 }	bronze					Handmade	0.58	0.61
NYL60	Duralin	60	59.99	161.6	1.430	19 mm mesh	0.19	0.36
ZN60	Zinc	60	59.95	760.4	6.740	Handmade	0.56	0.58

obtained from P. Ericksen A/S in Bergen. It is electrical-grade, at least 99.9 per cent pure, with possible admixture of silver. It satisfies the Norwegian materials standards NS 16010 or 16011, which conform to the International Standards Organization ISO Cu-ETP/Cu-FRHC and Cu-OF, respectively. The density of the copper was obtained by measurement of a cylinder machined from the source bar of several spheres. This yielded 8.942 $\pm$ 0.002 g/cm^3. The mean sphere diameters shown in Table 1 were computed from this value and measurements of the mass. Agreement of computed and directly measured diameters was excellent; the computations effectively served to determine the averages of such measurements. Deviations from sphericity exceeded 0.03 mm only in two cases, for spheres CU40 and CU50A, for which the greatest deviations were about 0.05 mm.

Other machined spheres are described in Table 2. The percentage alloying composition of the acid-fast steel is 17.5 Cr, 12.5 Ni, and 2.7 Mo, with a maximum carbon content of 0.06. This meets the Swedish standard SIS 2343 and U.S. standard AISI 316, with nominal density of 7.9 g/cm^3. The exact compositions of the two other steels are unknown. The brass is actually ferromanganese bronze with percentage analysis: 60 Cu, 35.3 Zn, 0.5 Pb, 1 Sn, 0.4 Al, 0.8 Fe, 2 Mn. Both the stainless and acid-fast steels and brass were chosen for their resistance to corrosion. The sphere designated NYL60 was machined from Dupont Duralin. The diameters of all spheres in Table 2 were determined by averaging several measurements with a micrometer. The material density was computed from corresponding measurements of mass and diameter.

Ball bearings used as target spheres are described in Table 3. These were obtained from the Swedish Ball Bearing Company, or Svensk Kulelager Fabrikk. The material composition is steel, but this was not the same for all the spheres, although precise quantitative differences are not known.

Each sphere, with a single exception, was enmeshed in fine seine or a specially constructed net bag woven of monofilament nylon. In the exceptional case, that of the sphere designated HOFFN2,

Table 3. Description of steel ball bearings used as acoustic targets. The parenthetical quantity is an estimate.

Name	Diameter (mm) Nominal	Diameter (mm) Measured	Mass (g)	Computed density (g/cm^3)	Other description	Net bag Type	Net bag Line diam. (mm)	Suspension line diam. (mm)
SKF1.5	38.1	38.10	225.9	7.797		Handmade	0.36	0.36
SKF2A	50.8	50.80	535.5	7.801		3.5 mm mesh	0.37	0.36
SKF2B	50.8	50.80	535.5	7.801		19 mm mesh	0.19	0.36
HOFFN2	50.8	50.62	525.4	-	Annealed, with central 2.5 mm diameter bore	None: line through bore knotted on underside		0.36
SKF2.5	63.5	63.50	1046.5	7.806		Handmade	0.65	(0.60)
CMP2.5	Unknown	60.10	904.3	-	Scarred, with brass-plugged, central 15 mm bore	Handmade	0.57	0.57

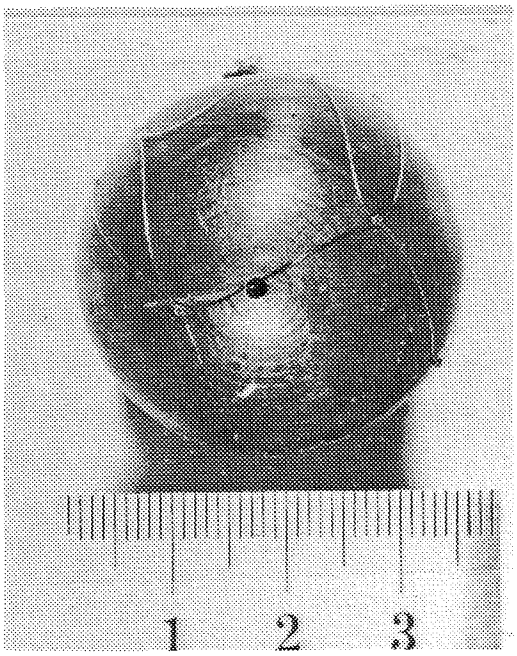
the sphere was hung by a single line passed through the bore and knotted on the underside. The type of wrapping and thickness of constituent line are shown with corresponding sphere in Tables 1-3. Also shown there is the thickness of line used in suspending the sphere. Typical examples of net bags with enmeshed spheres are shown in Fig. 1.

The spheres were generally kept in buckets half-filled with a solution of ordinary household detergent and fresh water mixed in the approximate proportion of 1 to 25. The use of a separate suspension line for each sphere allowed the transfer from soapy bath to water column beneath the measurement well to be made without direct handling of the sphere. The wetted surface was thus maintained.

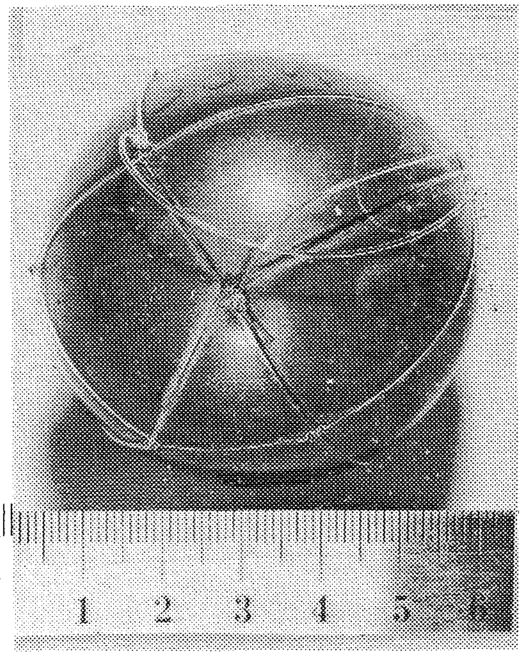
Under measurement the target sphere was suspended at 2.5 m depth on the nearly common geometric and acoustic axes of four transducers. These were arranged in a tight cluster on a stabilized frame suspended at 11.5 m depth, within the raft-isolating seine and directly beneath the measurement well, looking upwards toward the surface. The geometry of measurement, sans seine, is shown in Fig. 2.

The basic hydroacoustic equipment consisted of four pairs of Simrad echo sounders and transducers. The echo sounders were the EK-38, EK-50, EY-M, and EK-120. At each nominal center or operating frequency, respectively 38, 49.5, 70, and 120 kHz, the corresponding transducer had a full-beamwidth of approximately 20 deg. Because of their rather dense clustering on the suspended frame and use of a 9 m-range, the beam patterns were nearly coincidental and constant in the vicinity of the target sphere. Possible detrimental coupling effects between adjacent active and passive transducers were not observed, at least for the transmit pulse duration of 0.6 ms. This was nominally the same for each echo sounder throughout the measurements. Circuitry effecting time-varied gain in the receiving halves of each echo sounder was bypassed. The 3 kHz-bandwidth filters of the EK-38 and EK-120 echo sounders,

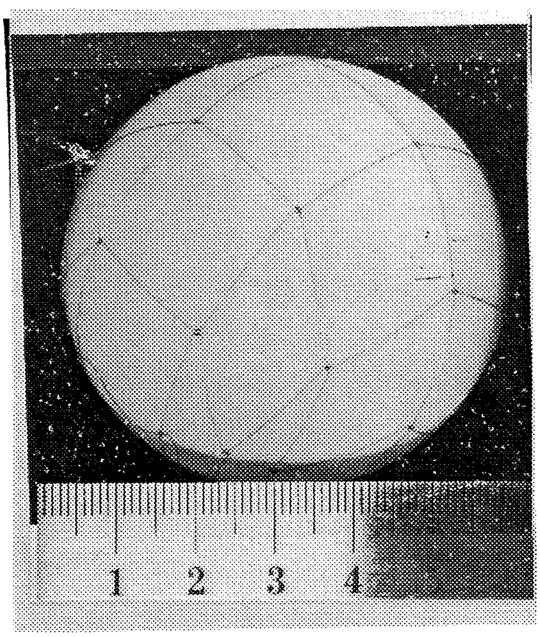
(a) CU35C-



(b) BRS60



(c) NYL60



(d) STL99

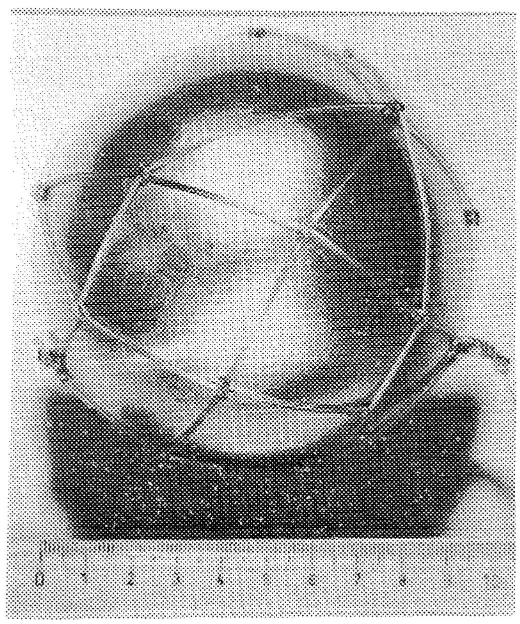


Fig. 1. Examples of net bags with enmeshed spheres. Dimensions are indicated only approximately owing to parallax.

the two units having several filters, were selected.

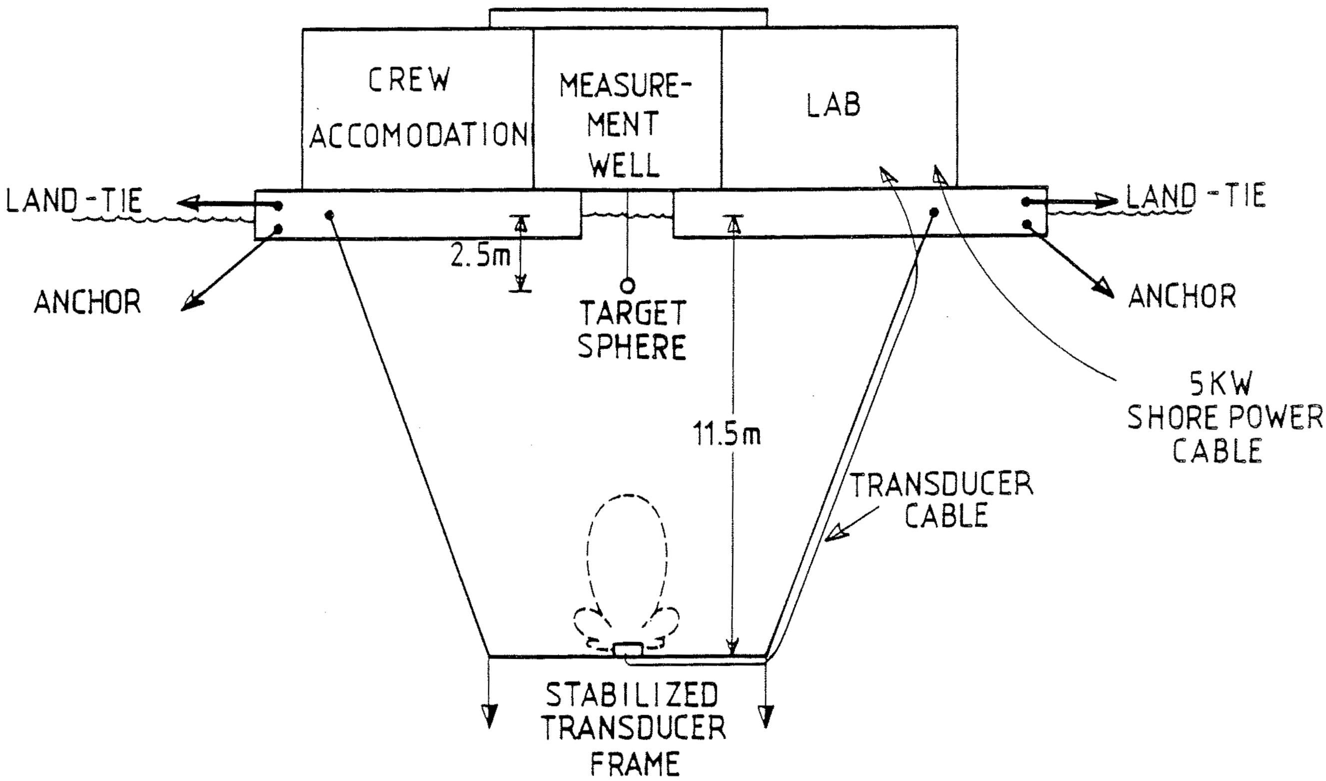


Fig. 2. Side-view of the measurement configuration, showing one of four clustered transducers with its approximate beam pattern.

The echo sounders were triggered pairwise by signals generated in a specially-built electronics unit whose timing was controlled either discretely by an external clock, e.g., time-code generator, or continuously by internal clock. Pulse repetition frequencies from 54 to 594 pulses per minute per echo sounder were available. Given the 9 m active range and ensonification geometry, the nominal rate of 200 ppm per echo sounder was used.

Echoes were processed first by the receiving units of the individual echo sounders less time-varied-gain functions. The calibrated output signal of each echo sounder was further processed by the Simrad QD digital echo integrator. This computed the energy contained in the echo from a specified range interval, stored the value, and periodically, according to programmed instruction, computed the various statistics of the echo energy. These included the mean, standard deviation, and coefficient of variation. Computations were performed both for the immediately preceding series of ensonifications and cumulatively for all ensonifications from the start of a particular sequence. Results, which were discriminated by echo sounder, were rapidly printed out through the input/output link of a Silent 700 typewriter terminal.

Typical parameters of the data collection process were 500 pings per printout series and from two to ten printout series per sequence. Typical measurement sequences contained, therefore, from 1000 to 5000 pings per echo sounder and lasted roughly from five to 25 minutes. The frequent tabulation of data statistics facilitated monitoring of the overall measurement and data gathering processes. Inspection of the coefficient of variation, for instance, allowed immediate gauging of the quality of data, essentially concurrently with their collection. Comparison of current data statistics with those of earlier measurement sequences on the same sphere effected a stronger test of data goodness.

Use of a four-channel oscilloscope to monitor the calibrated output signals was always helpful in resolving or anticipating problems with the data gathering. Additional use of a two-channel strip chart recorder to display the echo energy from each of the two alternately triggered echo sounders was similarly expedient in trouble-shooting. Experience gained in an earlier, unrelated experiment with fish, but with the identical equipment employed in the present investigation proved the value of both devices for detecting such problems as interference caused by extraneous biological scatterers and the occasional influx of air bubbles entrained by breaking waves in the outer fjord and transported to the measurement site by tidal currents.

The configuration of acoustic and electronics instrumentation described here is summarized in Fig. 3.

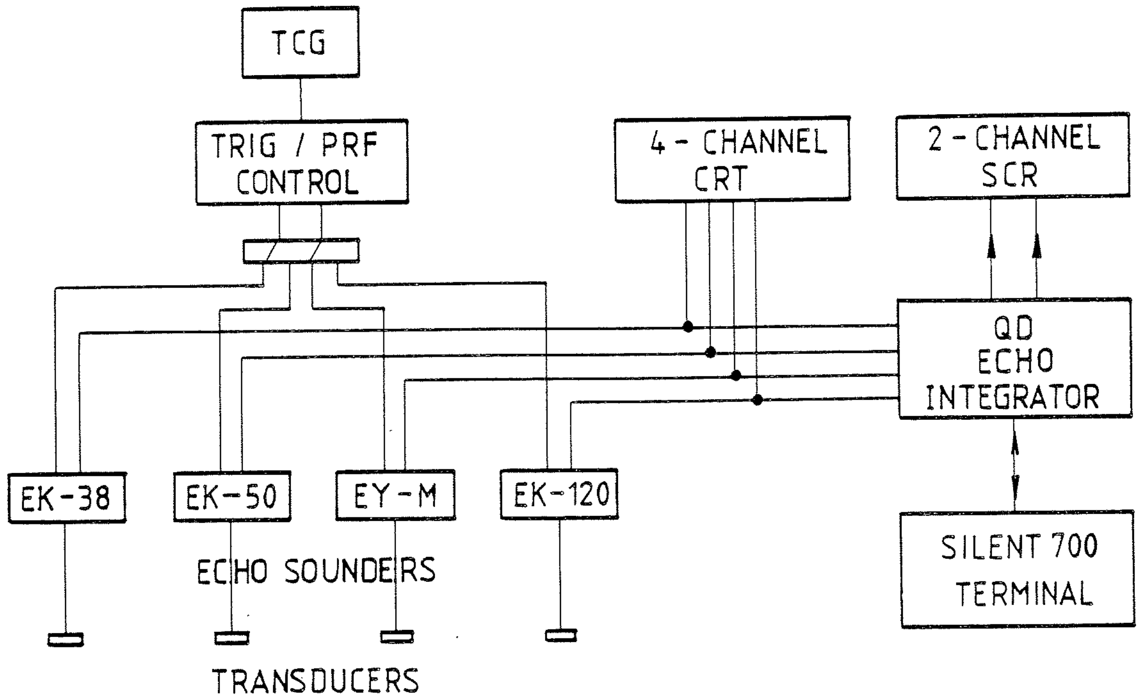


Fig. 3. Equipment configuration.

Measurements on the same spheres were made repeatedly over a two-week period. These were subsequently collected and combined, if judged valid. The criterion of validity generally consisted in the freedom of observations from the recorded or likely presence of extraneous scatterers near the target sphere, and the sufficiency of preparation of the sphere surface by washing in a detergent solution.

Because of the number of spheres and frequency-diversity of measurements, no attempt was made to extract absolute measures of backscattering cross sections from the digital echo integrator. Instead, the measurements were considered to express the backscattering cross section in relative units. By means of the confirmed, extended acoustical theory mentioned in the Introduction, relative numbers given in QD-units in the data tabulations below may be converted to absolute backscattering cross sections by the scaling factors listed in Table 4. These were derived by comparing theoretical calculations and the measurements of the mean 35 mm copper sphere.

Table 4. Conversion factors for expressing relative measurements of backscattering cross section in absolute units.

Echo sounder	Conversion factor (cm^2/QD-unit)
EK-38	0.383
EK-50	0.512
EY-M	0.591
EK-120	0.920

The pulse lengths and center frequencies of the transmitted signals were measured several times in the course of the experiment. The averages of these are shown in Table 5. Variations did not exceed several per cent and are consequently not recorded here. The magnitudes of the frequency response functions were measured at the conclusion of the measurements. The phase parts for the EK-38, EY-M, and EK-120 echo sounders were measured later in the Simrad laboratory, but without transducer-loading. The effect of loading on the phase function was assumed to be simple translation in frequency by the difference in measured frequencies of greatest sensitivity with and without loading. In the absence of measurements, the phase function for the EK-50 echo sounder was assumed to be identical to that of the EK-38 after appropriate frequency-shifting. The composite, field-measured magnitudes and frequency-shifted, laboratory-measured or simulated phases of the four frequency response functions are shown in Figs. 4-7.

Table 5. Pulse durations and center frequencies of transmitted signals.

Echo	Pulse duration (ms)		Center frequency (kHz)	
sounder	Nominal	Measured	Nominal	Measured
EK-38	0.6	0.75	38.0	38.0
EK-50	0.6	0.58	49.5	49.6
EY-M	0.6	0.62	70.0	68.4
EK-120	0.6	0.69	120.0	120.4

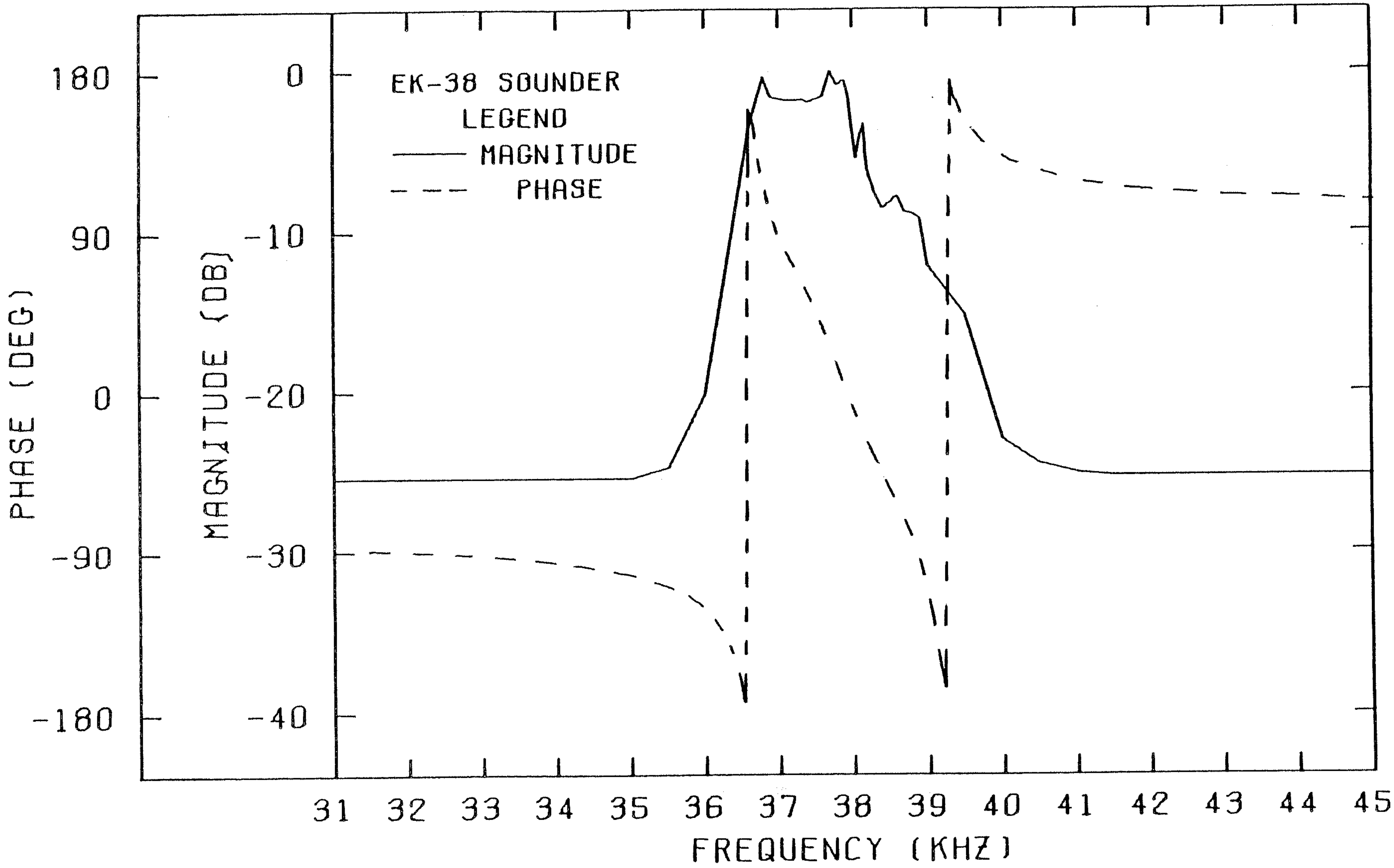


Fig. 4. Frequency response function of the receiver of the EK-38 echo sounder.

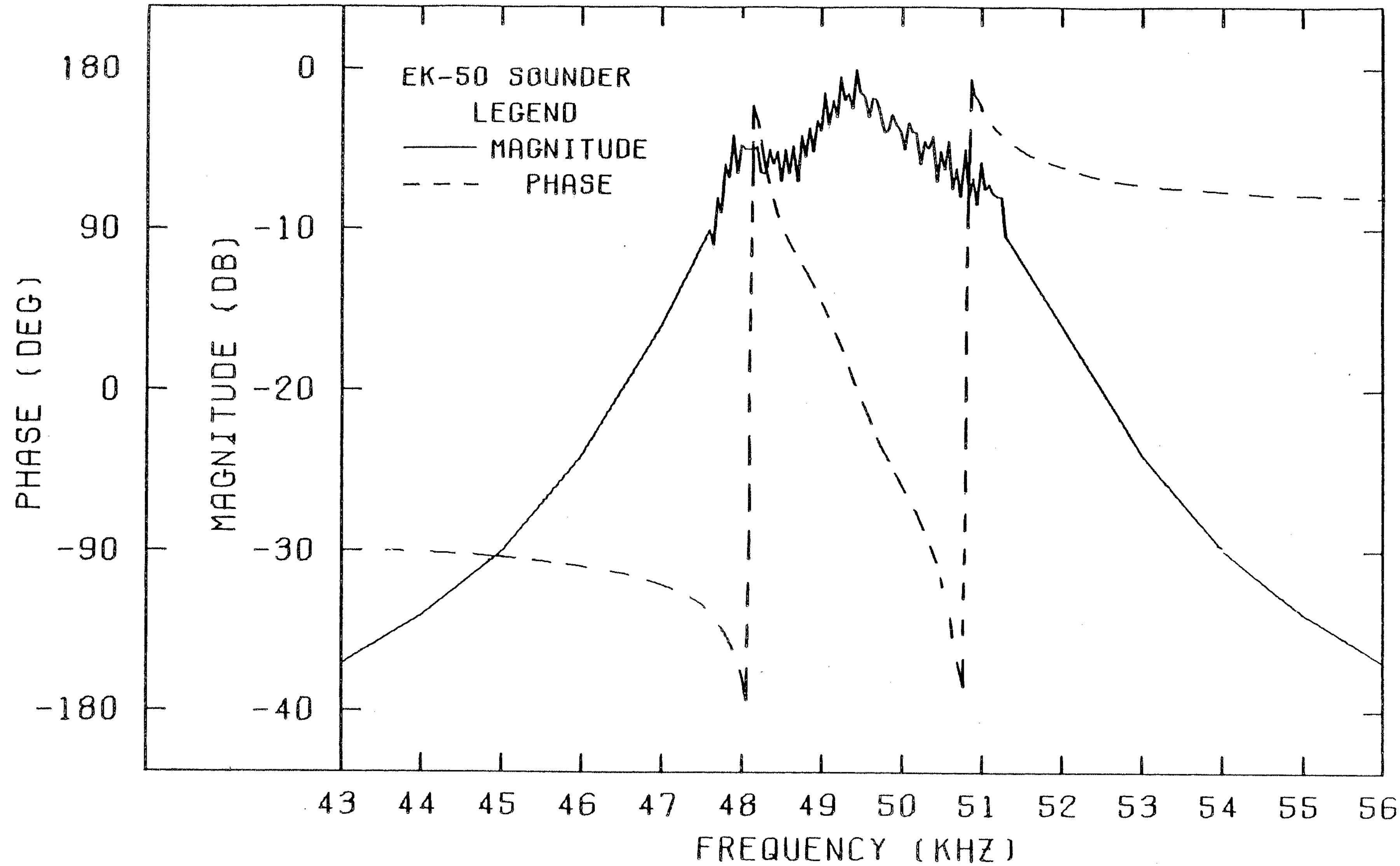


Fig. 5. Frequency response function of the receiver of the EK-50 echo sounder.

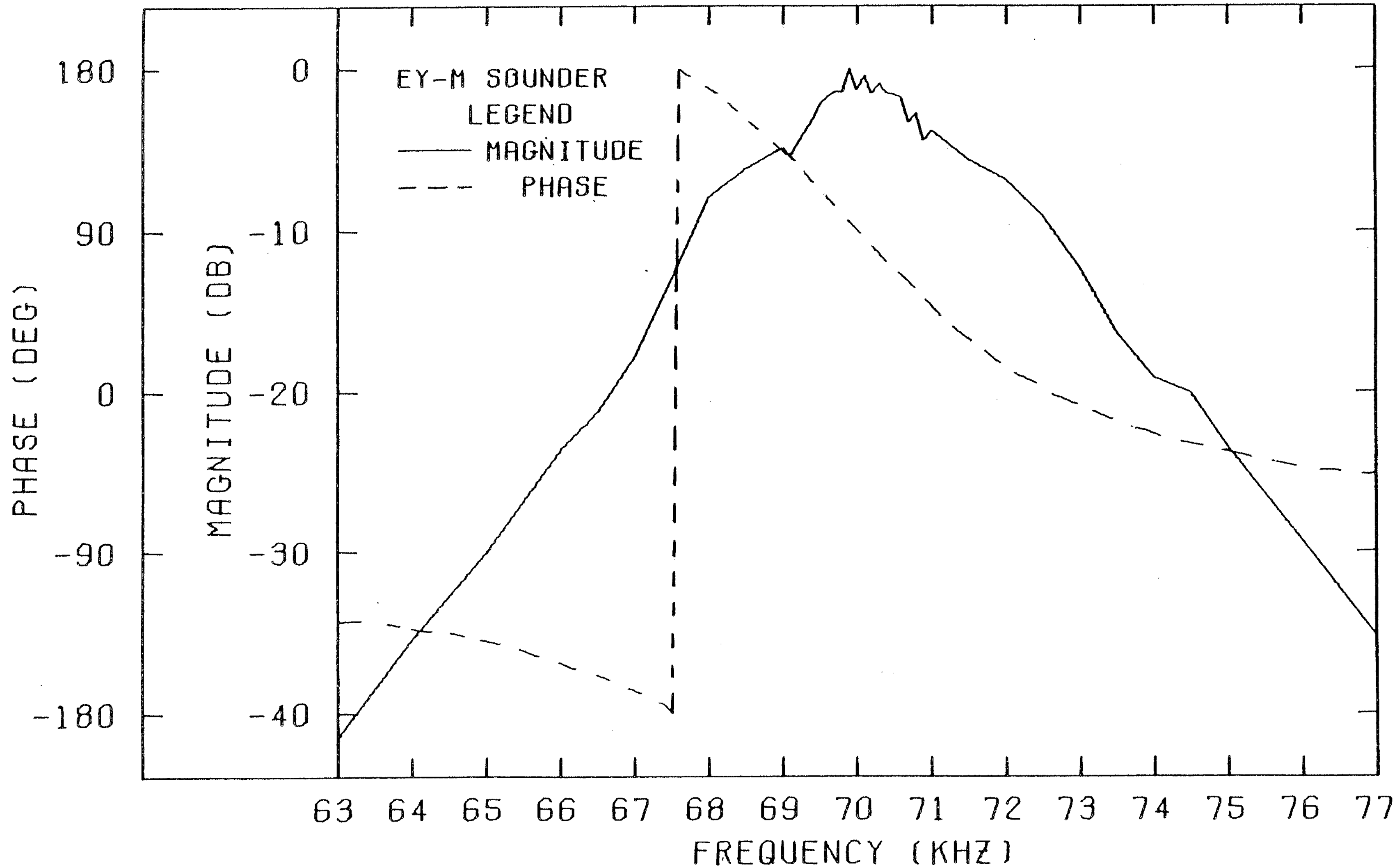


Fig. 6. Frequency response function of the receiver of the EY-M echo sounder.

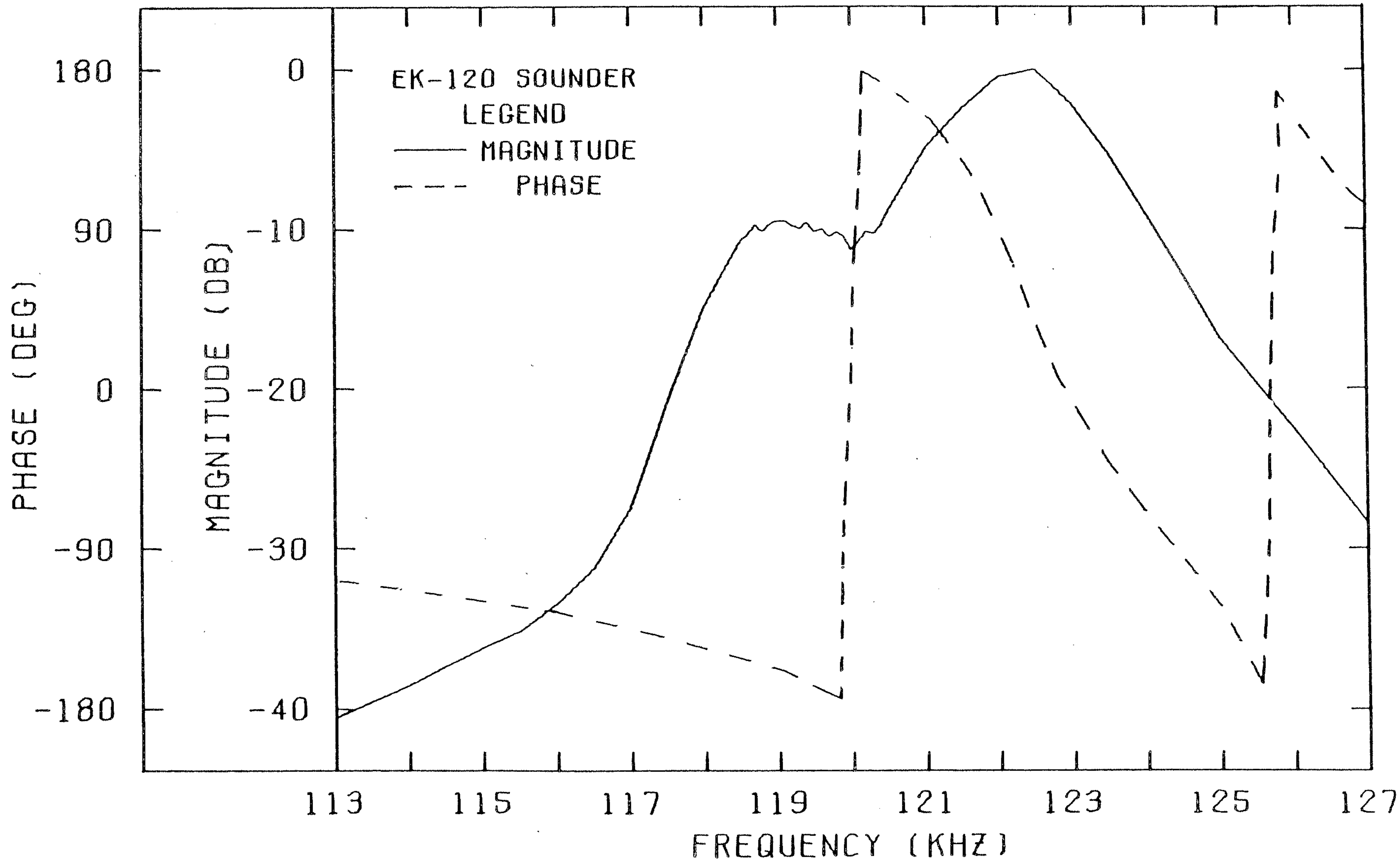


Fig. 7. Frequency response function of the receiver of the EK-120 echo sounder.

The local hydrography was measured before and after the experiment. Interpolation of the pairs of measurements performed at the 2.5 m-depth of sphere suspension specifies a mean temperature of 13°C and mean salinity of 29 ppt. This combination implies a medium density of 1.022 g/cm^3 and sound speed of 1493 m/s, according to DIETRICH (1952) and DEL GROSSO (1974), respectively.

STATISTICAL ANALYSES

The above description of the data analysis is mostly complete, but brief. It is supplemented here by further discussion and several equations which may indicate at a glance just how the data were condensed.

The fundamental quantity or unit of measurement is the energy contained in the total echo from the target sphere. This is defined as that clearly distinguishable part of the echo lying above the noise level. It was measured in relative units by selection of a sufficiently broad range interval for echo integration. Background noise was due primarily to two sources: small biological scatterers in the main lobes of the echo sounder beams and the lines supporting the transducer frame in the sidelobe regions. The integrated reverberation intensity or noise energy was seldom more than one per cent of the energy contained in the echo from a target sphere. When the reverberation level was higher, for instance, when breaking waves entrained air and forced the bubbles down into the integration region of the sphere echo, measurements were suspended until the return of more favorable conditions. In a single exceptional case of strong acoustic resonance, that of the 45 mm copper sphere when measured with the EK-120 echo sounder, the noise and signal contributions were comparable. For this case the noise energy was subtracted from the total echo energy in calculating the echo energy due to the sphere. The noise energy was otherwise considered negligible and was not subtracted from the measured total echo energy.

Because of the conduct of measurements in sequences, which were generally repeated at least several times in the course of the experiment, it is convenient to denote a single measurement of echo energy as ε_{ij}, where the i-index denotes the sequence number and the j-index, the order of measurement within the i-th sequence. As the number of measurements in any one sequence was never less than 500 and as little credence is attached to isolated single measurements in experimental acoustics, the measurements were combined during their gathering. The only quantities preserved by the programmable digital echo integrator at the end of a particular sequence were the two lowest-order statistical moments and the number of measurements. For the i-th sequence of measurements on a given sphere with a given echo sounder the average echo energy is

$$E_i = \frac{1}{n_i} \sum_{j=1}^{n_i} \varepsilon_{ij} \quad , \tag{1}$$

where n_i is the number of measurements in the sequence. The standard deviation S_i is naturally given through the estimated variance

$$S_i^2 = \frac{1}{n_i - 1} \sum_{j=1}^{n_i} (\varepsilon_{ij} - E_i)^2 \quad , \tag{2}$$

which is computed by the form

$$S_i^2 = \frac{1}{n_i - 1} \left(\sum_{j=1}^{n_i} \varepsilon_{ij}^2 - n_i E_i^2 \right) \quad . \tag{3}$$

The coefficient of variation for the same sequence is expressed as a percentage, hence

$$V_i = 100 \, \frac{S_i}{E_i} \quad . \tag{4}$$

Repeated measurement sequences on the same sphere with the same echo sounder were later summarized through cumulative statistics. These are computed in each of two ways, as the measurement sequences were regarded as independent or as the individual measurements were regarded as independent.

Case 1. Independent measurement sequences. In this case the average echo energy from a given sphere and echo sounder is computed from the equally weighted averages of each appropriate, valid measurement sequence. Thus

$$\mathrm{Ave}_1(E) = \frac{1}{m} \sum_{i=1}^{m} E_i \quad , \tag{5}$$

where m is the number of valid measurement sequences. The standard deviation $SD_1(E)$ is computed similarly, viz.

$$SD_1^2(E) = \frac{1}{m-1} \sum_{i=1}^{m} \left[E_i - \mathrm{Ave}_1(E) \right] \quad . \tag{6}$$

Case 2. Independent measurements. The individual measurements are weighted equally here, hence the statistics of each measurement sequence are weighted in proportion to the constituent number of measurements. Thus

$$\mathrm{Ave}_2(E) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n_i} \varepsilon_{ij}}{\sum_{i=1}^{m} n_i} = \frac{\sum_{i=1}^{m} n_i E_i}{\sum_{i=1}^{m} n_i} \tag{7}$$

and

$$SD_2^2(E) = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n_i} \left[\varepsilon_{ij} - \mathrm{Ave}_2(E) \right]^2}{\sum_{i=1}^{m} n_i - 1} \tag{8}$$

or

$$SD_2^2(E) = \frac{\sum_{i=1}^{m} \left[(n_i-1)S_i^2 + n_i E_i^2 \right] - \sum_{i=1}^{m} n_i Ave_2^2(E)}{\sum_{i=1}^{m} n_i - 1} \quad . \qquad (9)$$

The percentage coefficients of variation are computed for each of the two cases after the definition in Eq. (4).

SYNONYMY OF ENERGY AND BACKSCATTERING CROSS SECTION

Determination of the echo energy in linear, if relative units, allows its direct comparison for different spheres. This is further facilitated by the constancy of conditions of measurement throughout the experiment. For this reason, the measurements also specify the backscattering cross section in relative, but linear units. Expressions of energy and backscattering cross section in units of the QD digital echo integrator, called QD-units, are therefore equivalent and permit their synonymous use in this report.

The proportionality of echo energy and backscattering cross section is also evident from the definition of backscattering cross section as an echo sounder-observable quantity. According to the extension of theory mentioned in the Introduction, which is described briefly in FOOTE et al. (1981) and fully in FOOTE (1982), the backscattering cross section is defined operationally, in terms of physically realizable operations. Thus, for ensonification of a target by a transient signal and observation of the echo by an echo sounder or other physical device with non-infinitesimal bandwidth, the backscattering cross section is essentially the ratio of echo energy to energy density of incident signal as it would be observed by the same device. In terms of the Fourier spectrum $S(\omega)$ of incident signal, frequency response function or filter characteristic $H(\omega)$ of the receiver, and scattering amplitude $F(\omega)$ of the target, the backscattering cross section σ is (FOOTE et al., FOOTE 1982)

$$\sigma = 4\pi \frac{\int_0^\infty |S(\omega)F(\omega)H(\omega)|^2 d\omega}{\int_0^\infty |S(\omega)H(\omega)|^2 d\omega} , \qquad (10)$$

where the integration is performed over the entire range of the frequency ω. The numerator, hence σ, is proportional to the energy contained in the echo as observed by the receiving half of the echo sounder. For constant conditions of observation, including fixed geometry, the energy ratio of echoes from two spheres are equal to the ratio of their backscattering cross sections. Symbolically,

$$\frac{(\text{Energy})_1}{(\text{Energy})_2} = \frac{\int_0^\infty |SF_1H|^2 d\omega}{\int_0^\infty |SF_2H|^2 d\omega} = \frac{\sigma_1}{\sigma_2} , \qquad (11)$$

where F_1 and F_2 are the respective backscattering amplitudes of the two targets.

ACOUSTIC MEASUREMENTS

Measurements of echo energy or backscattering cross section comprise the principal acoustic data. Summaries of each measurement sequence for each sphere are presented in Tables 6-34. The data are given uniformily in the arbitrary, but linear units of the QD echo integrator. The validity of individual measurement sequences is, for averaging purposes, indicated by the weight parameter WT, which is assigned according to the criteria described in Materials and Methods. In short, WT=1 indicates acceptance of the data, while WT=0 describes their rejection. Statistical summaries of valid sequences are presented at the bottom of each table. The computations follow each of the two schemes described in Statistical Analyses, with the preferred scheme of independent, equally weighted measurement sequences placed first. The measurement sequences of reverberation energy or equivalent backscattering cross section are presented in Table 35, but without statistical summary owing to the understandably biased sampling evident from the comments.

The several statistical analyses are performed on the data of Tables 6-34 and rearranged in Tables 36-39 according to the echo sounder of measurement. The final three lines of each of these tables describe the results of averaging valid measurements of each of three sets of nominally identical spheres. These are the integral 35 mm copper spheres CU35A and CU35B; integral 50 mm copper spheres CU50A, CU50B, and CU50C; and the two 60 mm acid-fast steel spheres STL60A and STL60B.

Relative and absolute measures of backscattering cross sections are presented in Tables 40-43 for each of the four echo sounders. The relative measures are extracted from the collations of Tables 36-39 by referring the measurements to corresponding averages of the two integral 35 mm copper spheres. The absolute measures, denoted SB(CM**2), are derived from these by application of the conversion factors given in Table 4. The backscattering cross sections are also expressed relative to the respective geometric cross sections under the heading SB/SGEOM. The target strength describes the absolute backscattering cross section in units of decibels according to the definition (URICK 1975)

$$TS = 10 \log \frac{\sigma}{4\pi} \quad , \tag{12}$$

where σ is given in units of square meters.

To put the various measurement sequences of Tables 6-35 in context, the entire time-history of measurements is presented in Table 44. This is expressed in an alternative, more selective manner in Figs. 8-27. These are composed of five sets of four figures each, which are generally distinguished by type of sphere and echo sounder. Measurements of the integral copper spheres are presented in Figs. 8-11. The remaining copper spheres with three integral copper spheres, CU35A, CU35B, and CU50C, included for reference, are reported in Figs. 12-15. Measurements of the steel spheres are presented in Figs. 16-19; the 60 mm-diameter spheres, in Figs. 20-23; and the ball bearings with single copper reference sphere, CU35A, in Figs. 24-27. The standard error of the mean is not shown in any of the figures because it is generally so small as to lie within the symbol.

Waveforms of received echoes as displayed on a monitoring oscilloscope or CRT were photographed. Representative examples for various spheres are presented in Figs. 28-49. Representative transmit signals of the four echo sounders are presented in Fig. 50. These differ from the previous CRT photographs in several respects: they were taken outside of the actual measurement period of the project, in fact, six weeks before the first sphere measurements were made; a different unit of the 38 kHz echo sounder was used; and the scale size of the figures is different. The poorer quality of the transmit signals photographed during the sphere measurements precluded their use here, but direct comparisons of corresponding signals was favorable. Except for the exact pulse lengths, cf. Table 5, the features of corresponding waveforms are identical.

CRITIQUE

Collection of the various kinds of data presented here was motivated by the definition of backscattering cross section as an echo sounder-observable quantity. This definition was formulated at the outset of the study and is described briefly in Eq. (9). As a consequence, at least four different kinds of data are required to understand echo sounder observations of target strength. These are enumerated here for the case of elastic spheres.

1. Sphere characterization. The diameter, density, and material elasticity are fundamental quantities in the idealized model of monochromatic or single-frequency scattering by elastic spheres. This work, which is developed in FARAN (1951) and HICKLING (1962) and emended in minor degree by GOODMAN and STERN (1962), among others, is one of the building blocks of the extended theory.

2. Medium characteristics. The density and sound speed are additional essential ingredients in the basic model for acoustic scattering by elastic spheres. Each quantity may be derived directly from the hydrography, or temperature and salinity, through such well-known references as DIETRICH (1952) and DEL GROSSO (1974), for example.

3. Transmit signal. Because reception of the echo is accomplished by an intrinsically broadband receiver, the spectral content of the pressure field incident on the sphere is generally important. In the case of a simple pulsed sinusoid and ordinary non-dispersive conditions, the spectrum is determined completely by the pulse length and center frequency, if the effects of rise-time and ringing of the transducer can be neglected.

4. Receiver characteristics. The frequency response function describes the frequency selectivity of the receiver. This allows determination of the effect of pre-detection signal processing on the echo waveform.

Since the theory of acoustic scattering by elastic spheres does not refer to the manner of support or suspension of the sphere, this was noted in Tables 1-3 for each sphere. A number of measurements performed in the course of the present study and in other studies demonstrate the acoustic negligibility of the large-mesh, net bag-suspension method used here, whether handmade or formed of fine seine.

Inspection of Table 5 and Figs. 4-7 shows a definite mismatch of corresponding transmitting and receiving halves of several echo sounders. The fact of the receiver frequency response functions having been measured incompletely and then under difficult or doubtful conditions is significant for two reasons: the functions in Figs. 4-7 are approximations, and measurements of the backscattering cross sections are not necessarily representative of those expected under nominal operating·conditions. This last caveat also applies to discrepancies in the actual pulse length and center frequency of the transmitted signals from their nominal values, cf. Table. 5.

The specified values of temperature and salinity, thence density and sound speed, are similarly nominal, but in the sense of not having remained constant, but having varied over the two-week duration of the measurements. The variations were small, however, but still impose a limitation on the ultimate possible agreement of theory and experiment.

Notwithstanding the several cautionary remarks, the present data are consistent. Computations performed subsequently to the experiment have shown an excellent agreement with experiment in the important case of the integral copper spheres, whose elasticity is known best of all the investigated materials. More recent experiments and several calibration exercises in which some of the same spheres of this study were used have also confirmed the measurements and shown their consistency with theory when allowance is made for the precise conditions of observation. Results of the various studies have been presented in part in FOOTE <u>et</u> <u>al</u>. (1981) and FOOTE (1982), and are being elaborated or pursued in other reports under preparation.

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TABLE 6. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU35A (1).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1552			42.5	12			41.1	12	1000	1	
2	190980	1558	30.4	18			31.7	10			500	1	
3	190980	1812			46.3	6			39.8	10	500	1	
4	190980	1815	30.0	11			34.6	6			500	1	
5	210980	1303			43.4	6			32.2	9	500	1	
6	210980	1306	30.7	13			31.9	8			500	1	
7	210980	1801			41.1	6			29.7	7	500	1	
8	210980	1804	28.5	14			29.3	8			500	1	
9	230980	1341			42.6	5			34.4	7	500	1	
10	230980	1344	30.7	12			32.8	7			500	1	
11	230980	1500	30.1	10			31.4	7			500	1	
12	230980	1503			42.8	5			37.3	7	500	1	
13	260980	1324	30.1	21			34.4	14			500	1	
14	260980	1327			47.1	9			47.7	11	1000	1	
15	260980	1412			45.5	8			41.9	11	500	1	
16	260980	1415	30.0	19			34.1	14			500	1	
17	260980	1440			42.3	7			43.3	11	500	1	
18	260980	1443	30.7	23			33.4	15			500	1	
19	260980	1559			46.3	12			46.7	15	500	1	
20	260980	1603	33.2	36			37.9	33			500	0	
21	300980	1008	29.0	10			32.7	9			500	1	
22	300980	1011			44.9	7			41.6	11	500	1	
23	300980	1401	28.6	19			31.7	14			500	1	
24	300980	1404			42.2	8			33.7	13	500	1	
	NO(E/I/)			11		12		11		12			
	AVE(E/I/)			29.9		43.9		32.5		39.1			
	SD(E/I/)			.8		2.0		1.6		5.7			
	V(E/I/)			3		5		5		15			
	NO(E/IJ/)			5500		7000		5500		7000			
	AVE(E/IJ/)			29.9		44.0		32.5		39.9			
	SD(E/IJ/)			4.9		4.2		3.8		7.1			
	V(E/IJ/)			16		10		12		18			

TABLE 7. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU35B (2).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1602	31.2	12			34.1	8			1000	1	
2	190980	1607			45.6	6			43.5	10	500	1	
3	210980	1310	30.9	10			30.6	7			500	1	
4	210980	1313			44.0	6			33.1	9	500	1	
5	230980	1349	31.4	12			32.9	10			500	1	
6	230980	1352			45.2	6			38.5	8	500	1	
7	230980	1508			44.2	4			36.7	10	500	1	
8	230980	1511	31.6	12			31.4	7			1500	1	
	NO(E/I/)		4		4		4		4				
	AVE(E/I/)		31.3		44.7		32.2		37.9				
	SD(E/I/)		.3		.8		1.6		4.3				
	V(E/I/)		1		2		5		11				
	NO(E/IJ/)		3500		2000		3500		2000				
	AVE(E/IJ/)		31.4		44.7		32.3		37.9				
	SD(E/IJ/)		3.7		2.6		2.9		5.2				
	V(E/IJ/)		12		6		9		14				

TABLE 8. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU35B-(3).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	260980	1333			58.3	6			41.8	10	500	1	TILT 20
2	260980	1337	15.8	30			36.8	14			500	1	TILT 20
3	260980	1419	11.6	28			35.7	13			500	1	TILT 10
4	260980	1422			57.5	5			44.8	11	500	1	TILT 10
5	260980	1426			38.4	6			37.7	10	500	1	TILT 90
6	260980	1429	38.6	19			25.4	21			500	1	TILT 90
7	260980	1433	23.4	22			37.0	13			500	1	TILT 0
8	260980	1436			56.6	6			42.1	11	500	1	TILT 0
9	260980	1447	38.3	23			25.9	21			500	1	TILT 90
10	260980	1450			38.6	6			39.5	11	500	1	TILT 90
11	260980	1606	41.4	33			28.7	35			500	1	TILT 90
12	260980	1609			41.4	17			42.5	16	500	1	TILT 90
13	300980	1015			55.9	6			41.4	9	500	1	TILT 5
14	300980	1018	24.9	10			35.9	7			500	1	TILT 5
15	300980	1031			59.0	6			39.5	8	500	1	TILT 45
16	300980	1034	9.99	20			35.10	8			500	1	TILT 45
17	300980	1039	39.9	8			24.3	9			500	1	TILT 90
18	300980	1042			39.2	5			34.7	8	500	1	TILT 90
19	300980	1218			37.5	6			31.4	10	500	1	TILT 90
20	300980	1221	38.5	14			24.4	10			500	1	TILT 90
21	300980	1228	29.9	17			35.9	8			500	1	TILT 0
22	300980	1231			57.5	9			34.0	12	500	1	TILT 0
23	300980	1344	28.5	17			36.7	11			500	1	TILT 0
24	300980	1347			56.1	6			29.8	15	500	1	TILT 0
25	300980	1353			36.7	6			30.1	15	500	1	TILT 90
26	300980	1357	35.1	13			24.3	13			500	1	TILT 90
	NO(E/I/)		13		13		13		13				
	AVE(E/I/)		28.9		48.7		31.2		37.6				
	SD(E/I/)		11.1		9.8		5.7		5.1				
	V(E/I/)		38		20		18		14				
	NO(E/IJ/)		6500		6500		6500		6500				
	AVE(E/IJ/)		28.9		48.7		31.2		37.6				
	SD(E/IJ/)		12.3		10.0		7.2		6.5				
	V(E/IJ/)		42		21		23		17				

TABLE 9. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU35C+(4).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	230980	1521	32.4	12			59.6	9			1000	1	
2	230980	1526			38.5	6			34.2	11	500	1	
3	230980	1713	31.6	14			58.2	8			1000	1	
4	230980	1721			38.4	6			33.7	10	1000	1	
5	230980	1729	31.9	12			61.0	6			1000	1	
NO(E/I/)			3		2		3		2				
AVE(E/I/)			32.0		38.4		59.6		33.9				
SD(E/I/)			.4		.1		1.4		.4				
V(E/I/)			1		0		2		1				
NO(E/IJ/)			3000		1500		3000		1500				
AVE(E/IJ/)			32.0		38.4		59.6		33.9				
SD(E/IJ/)			4.1		2.3		4.8		3.5				
V(E/IJ/)			13		6		8		10				

TABLE 10. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU35C-(5).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	260980	1341	30.5	41			33.0	25			500	1	TILT 10
2	260980	1344			43.1	6			45.6	9	500	1	TILT 10
3	300980	1023	29.4	12			32.4	9			500	1	TILT 10
4	300980	1027			47.4	6			42.2	9	500	1	TILT 10
5	300980	1046			40.7	6			36.5	12	500	1	TILT 90
6	300980	1050	26.3	15			29.7	12			500	1	TILT 90
NO(E/I/)			3		3		3		3				
AVE(E/I/)			28.7		43.7		31.7		41.4				
SD(E/I/)			2.2		3.4		1.8		4.6				
V(E/I/)			8		8		6		11				
NO(E/IJ/)			1500		1500		1500		1500				
AVE(E/IJ/)			28.7		43.7		31.7		41.4				
SD(E/IJ/)			8.0		3.8		5.6		5.6				
V(E/IJ/)			28		9		18		13				

TABLE 11. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU40 (6).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1611			30.4	16			8.94	25	1000	0	JELLYFISH
2	190980	1618	37.8	17			58.6	7			1000	1	
3	210980	1318			29.6	8			7.78	15	500	1	
4	210980	1321	39.7	11			55.7	5			500	1	
5	230980	1356			30.1	6			8.58	11	500	1	
6	230980	1359	39.4	11			58.1	6			500	1	
7	300980	1141	35.4	13			56.3	7			500	1	
8	300980	1145			28.8	6			9.49	15	500	1	
NO(E/I/)			4		3		4		3				
AVE(E/I/)			38.1		29.5		57.2		8.62				
SD(E/I/)			2.0		.7		1.4		.86				
V(E/I/)			5		2		2		10				
NO(E/IJ/)			2500		1500		2500		1500				
AVE(E/IJ/)			38.0		29.5		57.5		8.62				
SD(E/IJ/)			5.5		2.1		3.9		1.38				
V(E/IJ/)			15		7		7		16				

TABLE 12. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU45 (7).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1624	84.1	11			27.3	11			500	1	
2	190980	1628			63.4	5			.59	48	500	1	
3	190980	1749			64.5	4			.48	49	500	1	
4	210980	1325	89.5	10			24.9	10			500	1	
5	210980	1328			61.6	5			.46	45	1000	1	
6	210980	1521			61.4	4			.50	45	500	1	
7	210980	1545			60.8	6			.39	47	3000	1	
8	210980	1602	86.3	9			23.3	11			1000	1	
9	210980	1608			61.5	6			.40	50	5000	1	
10	210980	1645			59.9	5			.39	52	5000	1	
11	230980	1403	90.0	9			25.5	12			500	1	
12	230980	1407			64.1	4			.51	43	1000	1	
13	230980	1854			61.2	7			.46	51	14000	1	
14	230980	2011	89.2	12			25.2	13			1000	1	
15	230980	2016			60.3	8			.48	53	500	1	
16	300980	1128	84.8	9			24.1	11			500	1	
17	300980	1131			62.0	5			.42	44	500	1	
	NO(E/I/)		6		11		6		11				
	AVE(E/I/)		87.3		61.9		25.0		.46				
	SD(E/I/)		2.6		1.5		1.4		.06				
	V(E/I/)		3		2		5		13				
	NO(E/IJ/)		4000		31500		4000		31500				
	AVE(E/IJ/)		87.4		61.2		24.8		.44				
	SD(E/IJ/)		9.2		3.9		3.1		.22				
	V(E/IJ/)		11		6		13		51				

TABLE 13. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU50A (8).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1637	111.0	6			108.0	4			500	1	
2	190980	1641			84.2	4			23.4	11	500	1	
3	190980	1644			83.5	3			23.3	8	500	1	
4	190980	1717			82.0	4			36.9	9	500	1	
5	190980	1721	113.0	7			108.0	3			500	1	
6	190980	1724			81.7	4			37.6	11	500	1	
7	210980	1340			76.6	5			33.1	8	500	1	
8	210980	1343	126.0	7			104.0	3			500	1	
9	230980	1425	111.0	7			105.0	5			500	1	
10	230980	1428			77.7	4			45.3	6	500	1	
11	260980	1348			79.0	6			42.6	11	500	1	
12	260980	1352	113.0	9			114.0	7			500	1	
13	300980	1155	115.0	7			104.0	5			500	1	
14	300980	1158			75.9	5			30.5	9	500	1	
	NO(E/I/)		6		8		6		8				
	AVE(E/I/)		114.8		80.1		107.2		34.1				
	SD(E/I/)		5.7		3.2		3.8		8.1				
	V(E/I/)		5		4		4		24				
	NO(E/IJ/)		3000		4000		3000		4000				
	AVE(E/IJ/)		114.8		80.1		107.2		34.1				
	SD(E/IJ/)		9.8		4.6		6.2		8.3				
	V(E/IJ/)		9		6		6		24				

TABLE 14. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU50B (9).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1648			83.1	4			13.8	13	500	1	
2	190980	1652	96.3	7			122.0	2			500	1	
3	190980	1703			82.5	4			12.8	14	500	1	
4	190980	1706	89.4	7			121.0	3			500	1	
5	190980	1727			83.9	4			13.7	12	500	1	
6	210980	1347	117.0	8			116.0	4			500	1	
7	210980	1350			77.3	5			15.7	11	500	1	
8	230980	1437			77.6	4			15.4	11	500	1	
9	230980	1441	122.0	5			114.0	4			500	1	
10	260980	1356	119.0	10			122.0	8			500	1	
11	260980	1400			81.9	4			19.5	15	500	1	
12	300980	1203			75.5	5			14.2	14	500	1	
13	300980	1206	109.0	6			113.0	4			500	1	
	NO(E/I/)		6		7		6		7				
	AVE(E/I/)		108.8		80.3		118.0		15.0				
	SD(E/I/)		13.3		3.4		4.1		2.2				
	V(E/I/)		12		4		4		15				
	NO(E/IJ/)		3000		3500		3000		3500				
	AVE(E/IJ/)		108.8		80.3		118.0		15.0				
	SD(E/IJ/)		14.6		4.6		6.6		2.9				
	V(E/IJ/)		13		6		6		19				

TABLE 15. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU50C+(10).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	190980	1655	81.2	8			143.0	4			500	1	
2	190980	1659			87.4	4			33.0	7	500	1	
3	190980	1710	81.3	6			141.0	3			500	1	
4	190980	1713			87.6	4			34.1	8	500	1	
5	210980	1354			81.5	4			33.5	6	500	1	
6	210980	1357	83.4	5			135.0	2			500	1	
7	230980	1445	84.5	8			135.0	5			500	1	
8	230980	1449			83.5	4			35.6	7	500	1	
	NO(E/I/)		4		4		4		4				
	AVE(E/I/)		82.6		85.0		138.5		34.0				
	SD(E/I/)		1.6		3.0		4.1		1.1				
	V(E/I/)		2		4		3		3				
	NO(E/IJ/)		2000		2000		2000		2000				
	AVE(E/IJ/)		82.6		85.0		138.5		34.0				
	SD(E/IJ/)		5.8		4.3		6.2		2.6				
	V(E/IJ/)		7		5		4		8				

TABLE 16. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU50C (11).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	260980	1404			82.8	5			29.3	12	500	1	
2	260980	1407	113.0	8			119.0	6			500	1	
3	260980	1454			78.8	6			22.6	16	500	1	
4	260980	1525			85.6	5			27.3	14	500	1	
5	260980	1529	120.0	10			132.0	9			1500	1	
6	300980	1148			72.9	4			17.5	10	500	1	
7	300980	1152	95.2	9			112.0	5			500	1	
8	300980	1210	117.0	6			112.0	6			500	1	
9	300980	1213			76.5	4			22.8	10	500	1	
	NO(E/I/)		4		5		4		5				
	AVE(E/I/)		111.3		79.3		118.7		23.9				
	SD(E/I/)		11.1		5.0		9.4		4.6				
	V(E/I/)		10		6		8		19				
	NO(E/IJ/)		3000		2500		3000		2500				
	AVE(E/IJ/)		114.2		79.3		123.2		23.9				
	SD(E/IJ/)		13.6		5.9		13.2		5.2				
	V(E/IJ/)		12		7		11		22				

TABLE 17. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CU60 (12).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	230980	1531			26.0	7			114.0	6	500	1	
2	230980	1534	160.0	4			103.0	4			500	1	
3	230980	1737	156.0	5			106.0	5			500	1	
4	230980	1745			25.6	7			107.0	6	500	1	
5	300980	1120			25.3	6			121.0	9	500	1	
6	300980	1123	149.0	7			102.0	5			500	1	
7	300980	1236			25.1	7			111.0	8	500	1	
8	300980	1239	150.0	8			104.0	6			1500	1	
	NO(E/I/)		4		4		4		4				
	AVE(E/I/)		153.7		25.5		103.7		113.2				
	SD(E/I/)		5.2		.4		1.7		5.9				
	V(E/I/)		3		2		2		5				
	NO(E/IJ/)		3000		2000		3000		2000				
	AVE(E/IJ/)		152.5		25.5		103.8		113.2				
	SD(E/IJ/)		11.1		1.8		5.7		9.9				
	V(E/IJ/)		7		7		6		9				

TABLE 18. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE STL60A(21).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1356			66.9	8			14.8	20	1000	0	NH4-3
2	170980	1401	112.0	11			46.9	7			1000	0	NH4-3 1356
3	170980	1407			81.0	4			17.1	12	500	0	NH4-3 1356
4	170980	1552	95.5	12			72.0	10			1000	1	
5	170980	1558			91.3	6			26.2	11	1000	1	
6	180980	1302			90.3	4			22.3	11	1000	1	
7	180980	1308	95.6	10			69.3	6			1000	1	
8	180980	2122			92.0	5			24.7	12	500	1	
9	180980	2126	98.9	7			71.1	5			500	1	
10	190980	1436	95.2	6			72.7	6			500	1	
11	190980	1439			97.2	3			26.0	11	500	1	
12	210980	1408			90.5	5			17.9	12	500	1	
13	210980	1412	96.4	6			67.8	4			500	1	
14	230980	1602			91.8	6			19.8	16	500	1	
15	230980	1606	93.4	7			70.9	4			500	1	
16	230980	1835	93.0	9			70.8	6			500	1	
17	230980	1838			91.4	4			20.9	12	500	1	
		NO(E/I/)	7		7		7		7				
		AVE(E/I/)	95.4		92.1		70.7		22.5				
		SD(E/I/)	2.0		2.3		1.6		3.2				
		V(E/I/)	2		3		2		14				
		NO(E/IJ/)	4500		4500		4500		4500				
		AVE(E/IJ/)	95.5		91.8		70.7		22.9				
		SD(E/IJ/)	8.8		4.9		5.0		4.0				
		V(E/IJ/)	9		5		7		17				

TABLE 19. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE STL60B(22).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1340			113.0	17			1.51	46	1000	0	NH4-10
2	170980	1346	86.3	12			43.4	9			1000	0	NH4-10 1340
3	170980	1352			97.5	4			2.46	27	500	0	NH4-10 1340
4	170980	1539			93.8	5			4.55	20	500	1	
5	170980	1542	89.8	9			60.1	7			500	1	
6	170980	1545			93.5	5			4.93	22	500	1	
7	170980	1548	90.2	6			61.7	6			500	1	
8	180980	1210	94.0	8			60.9	6			9000	1	
9	180980	1255			95.2	4			3.90	23	1000	1	
10	180980	2131	93.8	6			63.3	6			1000	1	
11	180980	2137			97.6	4			4.39	20	500	1	
12	190980	1444			99.4	4			5.00	24	500	1	
13	190980	1447	95.9	7			63.6	6			500	1	
14	210980	1416	94.1	6			59.2	4			500	1	
15	210980	1419			93.5	5			3.18	24	500	1	
16	210980	1422			92.0	4			3.23	23	500	1	
17	230980	1555	92.0	9			61.0	7			500	1	
18	230980	1558			94.5	4			3.75	29	500	1	
19	230980	1844			93.6	4			3.60	23	500	1	
20	230980	1846	88.9	9			62.3	7			500	1	
		NO(E/I/)	8		9		8		9				
		AVE(E/I/)	92.3		94.8		61.5		4.06				
		SD(E/I/)	2.5		2.3		1.5		.69				
		V(E/I/)	3		2		2		17				
		NO(E/IJ/)	13000		5000		13000		5000				
		AVE(E/IJ/)	93.5		94.8		61.2		4.04				
		SD(E/IJ/)	7.5		4.6		3.8		1.12				
		V(E/IJ/)	8		5		6		28				

TABLE 20. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE STL99 (23).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1644			252.0	5			267.0	9	1000	1	
2	170980	1649	207.0	10			352.0	6			500	1	
3	170980	2146	235.0	6			351.0	6			10000	1	
4	170980	2245			236.0	1			247.0	7	14000	1	
5	180980	1342	246.0	5			345.0	3			1000	1	
6	180980	1348			237.0	3			250.0	6	1000	1	
7	180980	1825			222.0	5			221.0	6	500	1	
8	180980	1828	230.0	6			326.0	4			500	1	
9	190980	1050	235.0	6			355.0	4			500	1	
10	190980	1053			252.0	2			272.0	5	500	1	
11	190980	1057			252.0	2			249.0	4	500	1	
12	190980	1104			251.0	2			259.0	4	500	0	120T.1BW10
13	190980	1108			249.0	3			616.0	3	500	0	120T1.BW10
14	190980	1112	111.0	4			373.0	2			500	0	38T.3BW3
15	190980	1117	111.0	6			373.0	2			500	0	38T.6BW1
16	190980	1121	130.0	6			375.0	2			1000	0	38T1.BW1
17	190980	1836	244.0	5			354.0	2			500	1	
18	190980	1839			249.0	3			254.0	5	1000	1	
19	210980	1427			234.0	3			196.0	7	500	1	
20	210980	1430	241.0	4			346.0	3			500	1	
21	210980	1712			346.0	3			350.0	4	5000	1	
22	210980	1741	298.0	5			713.0	3			1500	1	
23	210980	1824			244.0	3			188.0	6	1000	1	
24	210980	1830	230.0	7			347.0	4			500	1	
25	230980	1610	238.0	4			366.0	3			500	1	
26	230980	1613			240.0	3			220.0	5	500	1	
27	230980	2023			221.0	5			190.0	9	1000	1	
28	230980	2029	242.0	8			347.0	5			500	1	
		NO(E/I/)	11		12		11		12				
		AVE(E/I/)	240.5		248.7		382.0		242.0				
		SD(E/I/)	21.8		32.5		110.2		44.9				
		V(E/I/)	9		13		29		19				
		NO(E/IJ/)	16500		26500		16500		26500				
		AVE(E/IJ/)	241.0		258.0		383.1		261.7				
		SD(E/IJ/)	23.8		43.4		106.2		49.0				
		V(E/IJ/)	10		17		28		19				

TABLE 21. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE AS130 (24).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	180980	2035			121.0	5			399.0	14	1000	1	
2	180980	2040	560.0	5			499.0	11			1000	1	
3	180980	2047			129.0	3			396.0	5	500	1	
4	180980	2157	520.0	7			507.0	7			1500	1	
5	180980	2205			132.0	10			594.0	5	1000	1	
6	190980	955	553.0	3			507.0	9			500	1	
7	190980	958			130.0	6			438.0	12	1000	1	
8	210980	1443			114.0	10			302.0	13	500	0	SOAP-3
9	210980	1446	562.0	6			459.0	11			500	1	
10	230980	1626	534.0	6			466.0	8			500	1	
11	230980	1630			134.0	8			357.0	5	500	1	
12	230980	1808			121.0	5			361.0	7	500	1	
13	230980	1811	564.0	6			494.0	4			500	1	
		NO(E/I/)	6		6		6		6				
		AVE(E/I/)	548.8		127.8		488.7		424.2				
		SD(E/I/)	17.9		5.6		21.0		88.3				
		V(E/I/)	3		4		4		21				
		NO(E/IJ/)	4500		4500		4500		4500				
		AVE(E/IJ/)	543.7		127.8		493.9		441.8				
		SD(E/IJ/)	36.9		10.2		45.9		94.7				
		V(E/IJ/)	7		8		9		21				

TABLE 22. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE RS130 (25).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	180980	1900			295.0	7			45.2	29	14000	1	
2	180980	2023	545.0	4			863.0	3			1000	1	
3	180980	2029			261.0	3			67.7	12	500	1	
4	180980	2145			323.0	4			98.3	24	1000	1	
5	180980	2151	505.0	4			783.0	5			500	1	
6	190980	933	498.0	6			868.0	8			1000	1	
7	190980	938			329.0	6			77.0	30	1500	0	
8	190980	947	522.0	4			912.0	2			1000	1	
9	190980	1027	518.0	4			860.0	8			500	1	
10	190980	1030			312.0	5			119.0	22	2000	0	JELLYFISH
11	190980	1151	511.0	3			771.0	4			3000	1	
12	190980	1207			315.0	3			146.0	6	1000	1	
13	230980	1617			452.0	8			71.1	12	500	1	
14	230980	1621	464.0	4			918.0	3			500	1	
15	230980	1817	479.0	5			837.0	9			500	1	
16	230980	1822			306.0	3			108.0	12	500	1	
17	230980	2141			338.0	7			67.2	30	500	0	
18	230980	2145	452.0	7			872.0	11			500	1	
19	230980	2148			345.0	3			58.6	24	3000	1	
20	300980	1302			265.0	4			65.0	13	1500	1	
21	300980	1310	499.0	10			761.0	4			2000	1	
		NO(E/I/)	10		8		10		8				
		AVE(E/I/)	499.3		320.2		844.5		82.5				
		SD(E/I/)	27.9		60.2		55.8		32.8				
		V(E/I/)	6		19		7		40				
		NO(E/IJ/)	10500		22000		10500		22000				
		AVE(E/IJ/)	505.2		305.0		820.3		57.9				
		SD(E/IJ/)	36.1		35.8		73.0		27.8				
		V(E/IJ/)	7		12		9		48				

TABLE 23. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE SS130 (26).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	180980	2059			366.0	4			517.0	4	2000	1	
2	180980	2110	271.0	5			957.0	3			1000	1	
3	180980	2117			381.0	3			563.0	4	500	1	
4	190980	1007			359.0	2			508.0	4	1500	1	
5	190980	1014	293.0	6			830.0	2			2000	1	
6	210980	1435	279.0	4			729.0	7			500	0	SOAP-5
7	210980	1439			349.0	4			412.0	7	500	1	
8	230980	1638			363.0	6			415.0	6	500	1	
9	230980	1643	282.0	6			836.0	7			1000	1	
10	230980	1826			365.0	5			444.0	7	500	1	
11	230980	1829	294.0	5			864.0	8			500	1	
12	300980	1249	279.0	5			830.0	5			500	1	
13	300980	1253			359.0	2			391.0	11	500	1	
14	300980	1334			367.0	4			433.0	10	500	0	TURNED 90
15	300980	1337	275.0	10			763.0	6			1000	0	TURNED 90
16	300980	1408			356.0	5			433.0	9	500	1	
17	300980	1412	302.0	6			741.0	7			500	1	
18	300980	1735			355.0	6			456.0	7	500	1	
19	300980	1739	322.0	4			824.0	5			500	1	
20	300980	1742	324.0	7			842.0	5			500	1	
21	300980	1745			350.0	3			497.0	3	500	1	
		NO(E/I/)	8		10		8		10				
		AVE(E/I/)	295.9		360.3		840.5		463.6				
		SD(E/I/)	19.3		9.3		59.2		55.3				
		V(E/I/)	7		3		7		12				
		NO(E/IJ/)	6500		7500		6500		7500				
		AVE(E/IJ/)	292.2		361.3		846.7		480.2				
		SD(E/IJ/)	23.0		16.2		68.0		55.6				
		V(E/IJ/)	8		4		8		12				

TABLE 24. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE AL60 (31).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1258			121.0	13			5.78	40	1000	0	NH4-1
2	170980	1303	94.1	14			48.3	14			1000	0	NH4-1 1258
3	170980	1309			118.0	3			9.44	17	500	0	NH4-1 1258
4	170980	1313	91.5	10			48.6	9			500	0	NH4-1 1258
5	170980	1508	91.2	6			44.4	8			500	1	
6	170980	1512			125.0	4			9.55	17	1000	1	
7	180980	749	87.0	9			44.8	9			14000	1	
8	180980	915	86.8	6			46.7	7			2000	1	
9	180980	1035			122.0	3			9.36	15	1000	1	
10	180980	1436			109.0	12			8.66	51	1000	0	
11	180980	1441	34.1	27			17.5	48			1000	0	JELLYFISH
12	180980	1447	31.2	16			14.4	53			500	0	JELLYFISH
13	180980	1507	30.6	71			24.1	38			1000	0	JELLYFISH
14	180980	1802	36.9	52			27.4	32			500	0	
15	180980	1805			52.4	21			14.60	37	500	0	
16	180980	1832	40.5	30			29.9	26			2500	0	
17	180980	2318	63.0	34			28.3	29			500	0	
18	230980	1650	77.7	8			47.8	7			500	1	
19	230980	1654			123.0	9			10.20	21	500	1	
20	230980	1759	84.5	7			47.9	8			500	1	
21	230980	1802			124.0	4			9.49	17	500	1	
22	260980	1538	68.2	20			54.0	17			500	1	
23	260980	1541			175.0	7			8.42	35	500	0	
24	260980	1614			88.7	12			5.65	49	500	0	
25	300980	1110	48.4	36			48.5	21			500	0	
26	300980	1113			164.0	10			6.61	32	500	0	
27	300980	1323	65.2	12			52.1	13			500	1	
28	300980	1327			125.0	10			8.19	34	500	0	
		NO(E/I/)	7		4		7		4				
		AVE(E/I/)	80.1		123.5		48.2		9.65				
		SD(E/I/)	10.0		1.3		3.6		.38				
		V(E/I/)	13		1		7		4				
		NO(E/IJ/)	18500		3000		18500		3000				
		AVE(E/IJ/)	85.7		123.5		45.6		9.58				
		SD(E/IJ/)	9.1		6.2		4.7		1.68				
		V(E/IJ/)	11		5		10		17				

TABLE 25. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE BRS60T(32).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1614			112.0	4			60.00	8	1000	1	
2	160980	1620	230.0	6			171.0	4			1000	1	
3	160980	1626			113.0	3			62.10	8	500	1	
4	160980	1656			114.0	4			59.20	7	500	1	
5	160980	1700	226.0	6			170.0	4			2500	1	
6	160980	1819			111.0	4			35.50	12	1000	1	
7	160980	1825	226.0	5			156.0	5			1000	1	
8	160980	1830			109.0	3			32.40	10	500	1	
9	160980	2053			105.0	5			9.53	14	1000	1	
10	160980	2059	212.0	6			151.0	5			1000	1	
11	160980	2105			106.0	4			10.00	13	500	1	
12	160980	2118			107.0	4			13.60	14	1500	1	
13	160980	2126	212.0	6			149.0	6			1500	1	
14	160980	2202	186.0	11			159.0	13			500	0	DRIED
15	160980	2206			123.0	10			2.25	29	2000	0	DRIED
16	160980	2217	209.0	9			208.0	6			500	0	DRIED
17	160980	2229			119.0	4			7.22	18	500	1	
18	160980	2233	234.0	24			220.0	19			500	1	
19	170980	1029			105.0	5			12.60	16	1000	1	
20	170980	1035	219.0	5			189.0	5			1000	1	
21	170980	1041			104.0	4			12.40	13	500	1	
22	170980	1056	213.0	5			185.0	6			500	1	
23	170980	1100			103.0	4			9.24	18	500	1	
24	170980	1249	209.0	13			191.0	12			500	1	
25	170980	1253			106.0	5			16.00	13	500	1	
26	170980	1445	211.0	8			185.0	5			1000	1	
27	170980	1451			108.0	5			12.00	15	1000	1	
28	170980	1500			109.0	3			13.90	12	500	1	
29	170980	1503	220.0	7			190.0	6			500	1	
		NO(E/I/)	11		15		11		15				
		AVE(E/I/)	219.3		108.7		177.9		24.38				
		SD(E/I/)	8.6		4.4		21.1		20.31				
		V(E/I/)	4		4		12		83				
		NO(E/IJ/)	11000		11000		11000		11000				
		AVE(E/IJ/)	219.9		108.5		172.1		23.75				
		SD(E/IJ/)	19.9		5.9		22.1		19.17				
		V(E/IJ/)	9		5		13		81				

TABLE 26. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE BRS60 (33).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1635	203.0	7			186.0	3			500	1	
2	170980	1639			102.0	4			12.2	13	500	1	
3	180980	1315	208.0	5			179.0	3			1000	1	
4	180980	1321			103.0	4			13.0	12	1000	1	
5	180980	1809			106.0	5			14.1	17	500	1	
6	180980	1813	210.0	8			182.0	5			500	1	
7	190980	1429			113.0	3			14.9	17	500	1	
8	190980	1432	212.0	5			185.0	4			500	1	
9	190980	1543	211.0	4			187.0	4			500	1	
10	190980	1547			110.0	3			14.9	18	500	1	
11	190980	1757			109.0	3			13.7	14	500	1	
12	190980	1800	208.0	6			188.0	4			500	1	
13	210980	1458			102.0	4			12.7	12	500	1	
14	210980	1502	217.0	5			168.0	3			500	1	
15	230980	1539	206.0	6			173.0	4			500	1	
16	230980	1542			105.0	4			14.2	12	500	1	
17	260980	1552	204.0	11			196.0	12			500	1	
18	260980	1555			110.0	4			15.7	18	500	1	
19	300980	1102			101.0	6			13.2	16	500	1	
20	300980	1106	198.0	7			178.0	5			500	1	
	NO(E/I/)		10		10		10		10				
	AVE(E/I/)		207.7		106.1		182.2		13.9				
	SD(E/I/)		5.3		4.2		8.1		1.1				
	V(E/I/)		3		4		4		8				
	NO(E/IJ/)		5500		5500		5500		5500				
	AVE(E/IJ/)		207.7		105.8		181.9		13.8				
	SD(E/IJ/)		14.3		5.8		12.2		2.3				
	V(E/IJ/)		7		5		7		17				

TABLE 27. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE NYL60 (34).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1416			71.7	6			155.0	6	1500	0	NH4-5
2	170980	1425	115.0	7			35.9	13			1000	0	NH4-5 1416
3	170980	1431			67.9	5			148.0	5	500	0	NH4-5 1416
4	170980	1605			62.2	8			146.0	5	1000	1	
5	170980	1611	109.0	8			24.5	10			1000	1	
6	170980	1654	110.0	10			26.2	11			500	1	
7	170980	1657			63.2	6			164.0	6	500	1	
8	170980	1843			62.2	7			141.0	8	14000	1	
9	170980	2001			59.8	4			123.0	4	1000	1	
10	170980	2010	109.0	7			22.1	10			1000	1	
11	180980	1328			62.5	5			144.0	5	1000	1	
12	180980	1334	119.0	6			22.1	8			1000	1	
13	190980	924			68.2	4			169.0	6	500	1	
14	190980	928	112.0	7			29.4	8			500	1	
15	190980	1041			67.3	3			185.0	4	500	1	
16	190980	1045	113.0	6			25.2	8			500	1	
17	190980	1132	112.0	8			24.5	9			500	1	
18	190980	1135			70.2	5			194.0	6	500	1	
19	190980	1214			70.3	4			180.0	5	500	1	
20	190980	1217	112.0	5			24.6	10			500	1	
21	190980	1346	112.0	5			22.1	10			500	1	
22	190980	1349			.0	0			172.0	6	1000	0	EK-50 OFF
23	190980	1415			71.0	4			165.0	5	500	0	MOVED 8CM E
24	190980	1418	105.0	6			21.6	9			500	0	MOVED 8CM E
25	190980	1422	111.0	7			22.8	8			500	1	
26	190980	1425			72.7	4			176.0	5	500	1	
27	190980	1451	113.0	5			21.2	9			500	1	
28	190980	1454			73.1	4			176.0	5	500	1	
29	190980	1534			71.2	4			156.0	7	500	1	
30	190980	1539	109.0	5			21.6	8			500	1	
31	190980	1731			71.2	4			149.0	5	500	1	
32	190980	1734	109.0	4			21.7	7			500	1	
33	210980	1450	78.5	8			41.7	7			500	1	
34	210980	1454			72.9	4			155.0	5	500	1	
35	210980	1506	82.6	7			37.7	10			500	1	
36	210980	1509			70.6	4			151.0	5	500	1	
37	210980	1808	88.5	9			34.1	12			2000	1	
38	210980	1819			66.6	4			135.0	4	500	1	
39	230980	1547			73.3	5			172.0	4	500	1	
40	230980	1550	86.8	9			33.6	8			500	1	
	NO(E/I/)		17		17		17		17				
	AVE(E/I/)		105.1		68.1		26.8		159.8				
	SD(E/I/)		12.4		4.5		6.3		19.3				
	V(E/I/)		12		7		23		12				
	NO(E/IJ/)		11500		23500		11500		23500				
	AVE(E/IJ/)		103.9		64.3		27.2		147.6				
	SD(E/IJ/)		14.4		5.5		6.6		17.9				
	V(E/IJ/)		14		9		24		12				

TABLE 28. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE ZN60 (35).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	170980	1317	101.0	15			48.9	13			1000	0	NH4-5
2	170980	1323			120.0	4			6.56	19	1000	0	NH4-5 1317
3	170980	1328	124.0	9			53.5	10			500	0	NH4-5 1317
4	170980	1519			94.9	5			7.75	19	1000	1	
5	170980	1524	143.0	7			54.3	7			2000	1	
6	170980	1535			92.9	4			8.84	16	500	1	
7	180980	1046			90.4	4			8.46	16	500	1	
8	180980	1050	144.0	5			.0	0			500	0	EY-M OFF
9	180980	1105			87.9	5			8.15	16	2000	1	
10	180980	1115	137.0	8			45.6	6			1000	1	
11	180980	1355			91.9	4			8.51	16	1000	1	
12	180980	1401	144.0	6			49.2	6			1000	1	
13	180980	1407			92.8	4			8.96	16	1500	1	
14	180980	1416	144.0	7			48.2	6			500	1	
15	190980	1408	145.0	11			52.5	12			500	1	
16	190980	1411			91.9	7			13.70	20	500	1	
17	190980	1738	96.1	12			40.3	8			500	0	RESOAKED
18	190980	1742			93.3	3			9.94	14	500	1	
19	190980	1805	148.0	5			35.7	10			500	1	
20	190980	1808			102.0	4			10.20	16	500	1	
21	230980	1701			92.6	3			7.32	21	500	1	
22	230980	1705	147.0	6			51.7	6			500	1	
23	230980	1750			89.7	4			6.94	18	500	1	
24	230980	1754	144.0	7			51.9	6			500	1	
25	230980	2034	141.0	6			48.5	8			500	1	
26	230980	2038			89.7	5			8.79	15	500	1	
27	260980	1545			104.0	5			7.36	29	500	1	
28	260980	1548	148.0	9			55.2	12			500	1	
29	260980	1702	142.0	18			38.7	26			500	1	
30	260980	1705			99.9	6			11.50	26	500	1	
31	260980	1708	143.0	10			49.4	11			500	1	
32	300980	1055	152.0	11			48.8	9			500	1	
33	300980	1058			95.2	6			8.70	20	500	1	
		NO(E/I/)	13		15		13		15				
		AVE(E/I/)	144.5		93.9		48.4		9.01				
		SD(E/I/)	3.7		4.6		5.7		1.76				
		V(E/I/)	3		5		12		20				
		NO(E/IJ/)	9000		11000		9000		11000				
		AVE(E/IJ/)	143.8		93.0		49.3		8.81				
		SD(E/IJ/)	12.9		6.1		6.9		2.19				
		V(E/IJ/)	9		7		14		25				

TABLE 29. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE SKF1.5(41).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	2239	19.3	26			5.47	16			500	1	
2	160980	2242			28.9	46			26.1	27	500	0	
3	170980	913	22.1	23			6.99	44			2500	0	
4	170980	927			25.4	9			21.5	13	1000	1	
5	170980	933	20.2	12			6.13	18			500	1	
6	170980	1015	19.7	16			5.95	21			1000	1	
7	170980	1020			22.8	8			19.0	10	1000	1	
8	170980	1814			24.0	9			23.1	10	1000	1	
9	170980	1820	19.7	35			6.53	41			1000	0	FISH
10	170980	1828			24.1	9			24.1	11	1000	1	
11	170980	1833	19.0	18			6.02	19			1000	1	
		NO(E/I/)	4		4		4		4				
		AVE(E/I/)	19.5		24.1		5.89		21.9				
		SD(E/I/)	.5		1.1		.29		2.2				
		V(E/I/)	3		4		5		10				
		NO(E/IJ/)	3000		4000		3000		4000				
		AVE(E/IJ/)	19.5		24.1		5.92		21.9				
		SD(E/IJ/)	3.5		2.3		1.15		3.1				
		V(E/IJ/)	18		10		19		14				

TABLE 30. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE SKF2A (42).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1537			41.6	6			21.9	13	1000	1	
2	160980	1544	65.3	11			49.1	8			1000	1	
3	160980	1550			41.9	8			22.2	13	500	1	
4	160980	1714	61.2	11			46.3	10			1000	1	
5	160980	1720			40.9	6			23.0	12	1000	1	
6	160980	2029	62.7	12			36.1	11			2000	1	
7	160980	2042			40.1	7			10.7	17	1500	1	
8	170980	1105			35.6	5			22.9	13	1000	1	
9	170980	1111	63.1	8			36.9	11			1000	1	
10	170980	1117			37.1	5			21.7	14	500	1	
11	170980	1801	61.1	13			37.3	10			1000	1	
12	170980	1807			40.1	8			23.3	11	1000	1	
		NO(E/I/)	5		7		5		7				
		AVE(E/I/)	62.7		39.6		41.1		20.8				
		SD(E/I/)	1.7		2.4		6.1		4.5				
		V(E/I/)	3		6		15		22				
		NO(E/IJ/)	6000		6500		6000		6500				
		AVE(E/IJ/)	62.7		39.7		40.3		19.9				
		SD(E/IJ/)	7.2		3.3		6.7		5.7				
		V(E/IJ/)	11		8		17		29				

TABLE 31. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE SKF2B (43).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1557			35.2	7			15.3	15	1000	1	
2	160980	1603	55.5	9			57.2	6			1000	1	
3	160980	1609			35.9	7			16.4	12	500	1	
4	160980	1643	54.8	12			57.0	7			1000	1	
5	160980	1650			35.4	8			15.4	14	500	1	
6	160980	1803			34.9	7			15.8	14	1000	1	
7	160980	1808	55.2	11			55.3	10			1000	1	
8	160980	1814			35.4	8			15.9	14	500	1	
9	160980	1901			33.3	8			14.4	12	14000	1	
10	160980	2020	56.0	15			53.6	13			1000	1	
11	160980	2110			35.5	9			12.3	15	1000	1	
12	170980	938	60.5	8			54.3	7			1000	1	
13	170980	944			35.2	6			15.3	11	1000	1	
14	170980	950	59.8	12			53.9	11			500	1	
15	170980	1047			30.9	6			12.8	12	500	1	
16	170980	1050	55.6	9			51.2	10			500	1	
17	170980	1236	55.5	20			50.2	21			500	1	
18	170980	1240			32.5	10			14.5	12	500	1	
19	170980	1243	54.2	17			49.5	19			500	1	
20	170980	1333	52.5	12			50.2	8			500	1	
21	170980	1337			35.2	8			14.5	18	500	1	
22	170980	1436			33.8	9			15.1	14	500	1	
23	170980	1439	54.5	12			50.9	8			500	1	
24	170980	1617	56.0	12			51.2	8			500	1	
25	170980	1620			32.5	15			15.0	15	500	1	
26	170980	1624	52.1	13			49.0	7			1500	1	
27	170980	1701			34.9	12			15.8	16	500	1	
28	170980	1705	54.6	11			53.2	7			1500	1	
29	180980	1154			31.9	7			15.2	12	1000	1	
30	180980	1201	54.4	8			49.7	6			1000	1	
31	180980	1817	65.3	26			54.7	10			500	1	
32	180980	1820			36.9	9			15.7	21	500	1	
33	180980	2212			35.8	23			16.4	23	5000	0	FISH
34	180980	2250	60.0	24			53.4	17			5000	0	FISH
35	190980	911			36.8	5			17.7	14	500	1	
36	190980	915	58.1	10			54.8	6			1000	1	
37	190980	920			36.2	6			17.7	15	500	1	
38	190980	1139			35.0	6			16.2	15	500	1	
39	190980	1144	56.3	10			51.9	6			1000	1	
40	190980	1356			.0	0			15.2	14	500	0	EK-50 OFF

TABLE 31. (CONTINUED)

41	190980	1359			34.2	6			15.4	15	500	1
42	190980	1403	56.1	8			51.2	6			500	1
43	190980	1828			34.8	5			14.6	15	500	1
44	190980	1831	54.9	9			51.8	6			500	1
45	210980	1255	55.3	10			50.8	10			500	1
46	210980	1259			33.6	9			14.7	14	500	1
47	210980	1401	55.1	7			48.4	6			500	1
48	210980	1404			32.5	5			14.2	11	500	1
49	210980	1513			32.6	7			12.7	15	500	1
50	210980	1516	57.9	20			47.9	7			500	1
51	210980	1538	54.6	6			47.3	5			500	1
52	210980	1541			32.9	6			13.7	13	500	1
53	210980	1753	54.3	8			47.4	6			500	1
54	210980	1756			32.4	8			13.2	16	500	1
55	230980	1453			32.7	7			14.3	15	500	1
56	230980	1456	55.1	6			48.9	5			500	1
57	300980	1750			30.6	9			13.6	16	500	1
58	300980	1756	51.6	8			48.0	6			500	1
		NO(E/I/)		27		28		27		28		
		AVE(E/I/)		55.8		34.1		51.5		14.9		
		SD(E/I/)		2.7		1.7		2.9		1.3		
		V(E/I/)		5		5		6		9		
		NO(E/IJ/)		19500		30000		19500		30000		
		AVE(E/IJ/)		55.6		33.8		52.0		14.7		
		SD(E/IJ/)		7.2		3.0		5.4		2.2		
		V(E/IJ/)		13		9		10		15		

TABLE 32. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE HOFFN2(44).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1746			36.6	6			44.7	7	1000	1	
2	160980	1752	44.9	11			49.3	8			1000	1	
3	160980	1758			36.3	7			49.0	9	500	1	
4	160980	1851	43.9	10			49.4	7			500	1	
5	160980	1854			34.7	6			47.0	8	500	1	
6	190980	1819	47.4	11			48.3	6			500	0	RESOAKED
7	190980	1822			35.9	8			45.4	11	1000	1	
		NO(E/I/)		2		4		2		4			
		AVE(E/I/)		44.4		35.9		49.3		46.5			
		SD(E/I/)		.7		.8		.1		1.9			
		V(E/I/)		2		2		0		4			
		NO(E/IJ/)		1500		3000		1500		3000			
		AVE(E/IJ/)		44.6		36.0		49.3		46.0			
		SD(E/IJ/)		4.8		2.6		3.8		4.4			
		V(E/IJ/)		11		7		8		10			

TABLE 33. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE SKF2.5(45).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1730			86.8	4			61.9	7	1000	1	
2	160980	1736	99.3	10			91.3	10			1000	1	
3	160980	1742			87.7	4			64.7	6	500	1	
4	160980	1835			85.5	5			60.1	7	1000	1	
5	160980	1840	98.2	7			88.0	6			1000	1	
6	160980	1846			85.6	5			60.4	7	500	1	
7	160980	2138	99.9	11			86.3	8			1000	1	
8	160980	2143			87.6	4			65.2	7	500	1	
9	170980	955	89.8	15			81.7	10			1000	1	
10	170980	1001			74.2	4			56.3	9	1000	1	
11	170980	1007	88.0	8			82.7	6			500	1	
12	180980	1122	100.0	5			78.7	5			1000	1	
13	180980	1129			81.0	4			56.4	9	1000	1	
14	190980	1459			86.2	4			58.4	8	4000	1	
15	190980	1520	101.0	7			83.0	6			1500	1	
16	190980	1529			86.8	4			55.9	7	500	1	
	NO(E/I/)		7		9		7		9				
	AVE(E/I/)		96.6		84.6		84.5		59.9				
	SD(E/I/)		5.4		4.4		4.3		3.5				
	V(E/I/)		6		5		5		6				
	NO(E/IJ/)		7000		10000		7000		10000				
	AVE(E/IJ/)		97.5		84.6		84.5		59.1				
	SD(E/IJ/)		10.1		5.2		7.5		5.3				
	V(E/IJ/)		10		6		9		9				

TABLE 34. MEASUREMENTS OF ECHO ENERGY IN QD-UNITS FOR SPHERE CMP2.5(46).

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	2149			107.0	11			43.4	16	1000	0	DRY
2	160980	2155	41.8	29			71.7	19			1000	0	DRY
3	160980	2221	19.5	25			68.4	11			500	1	
4	160980	2225			105.0	5			30.1	13	500	1	
5	180980	1137			100.0	4			27.0	13	500	1	
6	180980	1142	17.0	17			64.1	5			1000	1	
7	180980	1148			100.0	5			29.1	10	1000	1	
8	180980	1420	16.8	17			64.6	5			1000	1	
9	180980	1427			103.0	4			30.3	9	1000	1	
	NO(E/I/)		3		4		3		4				
	AVE(E/I/)		17.8		102.0		65.7		29.1				
	SD(E/I/)		1.5		2.4		2.4		1.5				
	V(E/I/)		8		2		4		5				
	NO(E/IJ/)		2500		3000		2500		3000				
	AVE(E/IJ/)		17.4		101.8		65.2		29.3				
	SD(E/IJ/)		3.5		5.0		4.7		3.4				
	V(E/IJ/)		20		5		7		11				

TABLE 35. MEASUREMENTS OF REVERBERATION IN QD-UNITS FROM THE SPHERE-INTEGRATION VOLUME.

			ECHO SOUNDER										
			EK-38		EK-50		EY-M		EK-120				
NO	DATE	TIME	E	V	E	V	E	V	E	V	NPING	WT	COMMENT
1	160980	1631			.085	103			.120	102	1000	0	
2	160980	1636	.30	104			.11	120			1000	0	
3	170980	1221	3.84	75			3.25	69			500	0	
4	170980	1225	2.83	66			3.62	62			500	0	
5	170980	1229			.055	109			.075	104	500	0	
6	170980	1233	3.24	57			2.16	52			500	0	
7	170980	1716	.170	153			.048	132			500	0	
8	170980	1719			.65	478			.41	648	500	0	
9	170980	1742			.14	123			.13	231	1500	0	
10	170980	1751	.990	221			.068	180			1500	0	
11	180980	1501	.22	104			.12	207			500	0	JELLYFISH
12	180980	1647	13.0	74			27.8	25			500	0	FISH
13	180980	1738	3.55	124			2.71	210			2000	0	
14	180980	1750			.16	106			.34	91	2000	0	
15	190980	904	1.15	148			.61	208			500	0	
16	190980	907			.22	55			.46	54	500	0	
17	190980	1631			.039	126			.170	82	500	0	JELLYFISH
18	190980	1634	.130	115			.054	281			500	0	
19	190980	1753			.047	135			.110	87	500	0	
20	210980	1241	.33	82			.14	76			500	0	
21	210980	1245			.14	67			.18	62	1000	0	
22	210980	1251	.200	89			.062	109			500	0	
23	210980	1334			.028	115			.033	108	1000	0	
24	210980	1525			.037	130			.033	123	1000	0	
25	210980	1531	.1200	134			.0087	321			1000	0	
26	230980	1326	.330	86			.080	110			1000	0	
27	230980	1334			.12	77			.14	80	1000	0	
28	230980	1413			.039	121			.067	101	1000	0	
29	230980	1419	.140	123			.035	191			1000	0	
30	230980	2042			1.07	432			.49	761	1500	0	FISH
31	230980	2050	13.60	225			9.38	233			1500	0	FISH
32	230980	2058	16.9	230			14.9	206			5000	0	FISH
33	230980	2134			19.4	170			10.2	192	1000	0	FISH
34	260980	1654			.14	318			.46	354	500	0	
35	260980	1658	2.00	110			2.49	100			500	0	
36	260980	1729	214.0	244			176.0	132			1000	0	BUBBLES
37	260980	1735			.45	108			.37	87	1500	0	
38	300980	939	.65	138			.25	124			1500	0	WARMUP
39	300980	949			.057	82			.220	78	2000	0	
40	300980	959	.380	101			.085	147			1500	0	
41	300980	1135			.040	111			.032	107	500	0	
42	300980	1138	.130	115			.037	155			500	0	
43	300980	1725	.17	109			.18	146			500	0	
44	300980	1728			.042	131			.054	108	500	0	

TABLE 36. SUMMARY OF STATISTICS OF ECHO ENERGY FROM SPHERES MEASURED WITH THE EK-38 ECHO SOUNDER.

	------ E/I/(QD-UNITS) -----				----- E/IJ/(QD-UNITS) -----			
SPHERE(NO)	AVE	SD	V	M	AVE	SD	V	N
CU35A (1)	29.89	.82	3	11	29.89	4.88	16	5500
CU35B (2)	31.27	.30	1	4	31.36	3.69	12	3500
CU35B-(3)	28.91	11.05	38	13	28.91	12.29	42	6500
CU35C+(4)	31.97	.40	1	3	31.97	4.07	13	3000
CU35C-(5)	28.73	2.18	8	3	28.73	8.03	28	1500
CU40 (6)	38.07	1.97	5	4	38.02	5.53	15	2500
CU45 (7)	87.32	2.58	3	6	87.42	9.19	11	4000
CU50A (8)	114.83	5.67	5	6	114.83	9.78	9	3000
CU50B (9)	108.78	13.25	12	6	108.78	14.56	13	3000
CU50C+(10)	82.60	1.62	2	4	82.60	5.85	7	2000
CU50C (11)	111.30	11.11	10	4	114.20	13.58	12	3000
CU60 (12)	153.75	5.19	3	4	152.50	11.12	7	3000
STL60A(21)	95.43	1.96	2	7	95.46	8.79	9	4500
STL60B(22)	92.34	2.50	3	8	93.48	7.45	8	13000
STL99 (23)	240.55	21.82	9	11	241.00	23.80	10	16500
AS130 (24)	548.83	17.87	3	6	543.67	36.91	7	4500
RS130 (25)	499.30	27.93	6	10	505.24	36.05	7	10500
SS130 (26)	295.87	19.34	7	8	292.23	23.00	8	6500
AL60 (31)	80.09	10.04	13	7	85.68	9.08	11	18500
BRS60T(32)	219.27	8.62	4	11	219.91	19.90	9	11000
BRS60 (33)	207.70	5.31	3	10	207.73	14.32	7	5500
NYL60 (34)	105.08	12.38	12	17	103.87	14.35	14	11500
ZN60 (35)	144.46	3.73	3	13	143.78	12.87	9	9000
SKF1.5(41)	19.55	.52	3	4	19.48	3.54	18	3000
SKF2A (42)	62.68	1.71	3	5	62.68	7.19	11	6000
SKF2B (43)	55.77	2.74	5	27	55.64	7.25	13	19500
HOFFN2(44)	44.40	.71	2	2	44.57	4.78	11	1500
SKF2.5(45)	96.60	5.35	6	7	97.53	10.08	10	7000
CMP2.5(46)	17.77	1.50	8	3	17.42	3.53	20	2500
CU35 (81)	30.26	.95	3	15	30.46	4.51	15	9000
CU50 (82)	111.68	10.07	9	16	112.61	13.09	12	9000
STL60 (83)	93.78	2.70	3	15	93.99	7.86	8	17500

TABLE 37. SUMMARY OF STATISTICS OF ECHO ENERGY FROM SPHERES MEASURED WITH THE EK-50 ECHO SOUNDER.

	----- E/I/(QD-UNITS) -----				----- E/IJ/(QD-UNITS) -----			
SPHERE(NO)	AVE	SD	V	M	AVE	SD	V	N
CU35A (1)	43.92	1.99	5	12	44.04	4.20	10	7000
CU35B (2)	44.75	.77	2	4	44.75	2.58	6	2000
CU35B-(3)	48.67	9.76	20	13	48.67	10.04	21	6500
CU35C+(4)	38.45	.07	0	2	38.43	2.31	6	1500
CU35C-(5)	43.73	3.39	8	3	43.73	3.82	9	1500
CU40 (6)	29.50	.66	2	3	29.50	2.06	7	1500
CU45 (7)	61.88	1.50	2	11	61.20	3.90	6	31500
CU50A (8)	80.07	3.19	4	8	80.07	4.63	6	4000
CU50B (9)	80.26	3.35	4	7	80.26	4.63	6	3500
CU50C+(10)	85.00	3.00	4	4	85.00	4.28	5	2000
CU50C (11)	79.32	5.02	6	5	79.32	5.94	7	2500
CU60 (12)	25.50	.39	2	4	25.50	1.76	7	2000
STL60A(21)	92.07	2.35	3	7	91.79	4.90	5	4500
STL60B(22)	94.79	2.32	2	9	94.83	4.59	5	5000
STL99 (23)	248.75	32.46	13	12	258.00	43.42	17	26500
AS130 (24)	127.83	5.56	4	6	127.78	10.18	8	4500
RS130 (25)	320.25	60.25	19	8	305.00	35.83	12	22000
SS130 (26)	360.30	9.27	3	10	361.27	16.19	4	7500
AL60 (31)	123.50	1.29	1	4	123.50	6.23	5	3000
BRS60T(32)	108.73	4.38	4	15	108.45	5.94	5	11000
BRS60 (33)	106.10	4.18	4	10	105.82	5.78	5	5500
NYL60 (34)	68.09	4.53	7	17	64.29	5.55	9	23500
ZN60 (35)	93.94	4.65	5	15	92.96	6.10	7	11000
SKF1.5(41)	24.07	1.06	4	4	24.07	2.31	10	4000
SKF2A (42)	39.61	2.37	6	7	39.67	3.35	8	6500
SKF2B (43)	34.06	1.71	5	28	33.76	2.96	9	30000
HOFFN2(44)	35.87	.83	2	4	36.00	2.56	7	3000
SKF2.5(45)	84.60	4.38	5	9	84.61	5.23	6	10000
CMP2.5(46)	102.00	2.45	2	4	101.83	5.00	5	3000
CU35 (81)	44.12	1.78	4	16	44.20	3.91	9	9000
CU50 (82)	79.95	3.57	4	20	79.95	5.00	6	10000
STL60 (83)	93.60	2.65	3	16	93.39	4.97	5	9500

TABLE 38. SUMMARY OF STATISTICS OF ECHO ENERGY FROM SPHERES MEASURED WITH THE EY-M ECHO SOUNDER.

	E/I/(QD-UNITS)				E/IJ/(QD-UNITS)			
SPHERE(NO)	AVE	SD	V	M	AVE	SD	V	N
CU35A (1)	32.55	1.57	5	11	32.55	3.82	12	5500
CU35B (2)	32.25	1.56	5	4	32.27	2.85	9	3500
CU35B-(3)	31.24	5.66	18	13	31.24	7.20	23	6500
CU35C+(4)	59.60	1.40	2	3	59.60	4.75	8	3000
CU35C-(5)	31.70	1.76	6	3	31.70	5.64	18	1500
CU40 (6)	57.17	1.39	2	4	57.46	3.91	7	2500
CU45 (7)	25.05	1.36	5	6	24.85	3.13	13	4000
CU50A (8)	107.17	3.82	4	6	107.17	6.19	6	3000
CU50B (9)	118.00	4.15	4	6	118.00	6.62	6	3000
CU50C+(10)	138.50	4.12	3	4	138.50	6.21	4	2000
CU50C (11)	118.75	9.43	8	4	123.17	13.24	11	3000
CU60 (12)	103.75	1.71	2	4	103.83	5.72	6	3000
STL60A(21)	70.66	1.65	2	7	70.66	4.98	7	4500
STL60B(22)	61.51	1.52	2	8	61.18	3.83	6	13000
STL99 (23)	382.00	110.20	29	11	383.09	106.20	28	16500
AS130 (24)	488.67	20.98	4	6	493.89	45.87	9	4500
RS130 (25)	844.50	55.84	7	10	820.29	73.04	9	10500
SS130 (26)	840.50	59.21	7	8	846.69	68.05	8	6500
AL60 (31)	48.24	3.59	7	7	45.61	4.69	10	18500
BRS60T(32)	177.91	21.13	12	11	172.14	22.10	13	11000
BRS60 (33)	182.20	8.05	4	10	181.91	12.19	7	5500
NYL60 (34)	26.77	6.29	23	17	27.22	6.62	24	11500
ZN60 (35)	48.44	5.67	12	13	49.30	6.92	14	9000
SKF1.5(41)	5.89	.29	5	4	5.92	1.15	19	3000
SKF2A (42)	41.14	6.09	15	5	40.30	6.68	17	6000
SKF2B (43)	51.46	2.87	6	27	51.99	5.40	10	19500
HOFFN2(44)	49.35	.07	0	2	49.33	3.79	8	1500
SKF2.5(45)	84.53	4.26	5	7	84.55	7.55	9	7000
CMP2.5(46)	65.70	2.35	4	3	65.16	4.72	7	2500
CU35 (81)	32.47	1.52	5	15	32.44	3.48	11	9000
CU50 (82)	114.12	7.71	7	16	116.11	11.41	10	9000
STL60 (83)	65.78	4.96	8	15	63.62	5.86	9	17500

TABLE 39. SUMMARY OF STATISTICS OF ECHO ENERGY FROM SPHERES MEASURED WITH THE EK-120 ECHO SOUNDER.

	E/I/(QD-UNITS)				E/IJ/(QD-UNITS)			
SPHERE(NO)	AVE	SD	V	M	AVE	SD	V	N
CU35A (1)	39.12	5.71	15	12	39.87	7.10	18	7000
CU35B (2)	37.95	4.33	11	4	37.95	5.17	14	2000
CU35B-(3)	37.64	5.10	14	13	37.64	6.52	17	6500
CU35C+(4)	33.95	.35	1	2	33.87	3.51	10	1500
CU35C-(5)	41.43	4.60	11	3	41.43	5.56	13	1500
CU40 (6)	8.62	.86	10	3	8.62	1.38	16	1500
CU45 (7)	.46	.06	13	11	.44	.22	51	31500
CU50A (8)	34.09	8.13	24	8	34.09	8.25	24	4000
CU50B (9)	15.01	2.22	15	7	15.01	2.85	19	3500
CU50C+(10)	34.05	1.13	3	4	34.05	2.59	8	2000
CU50C (11)	23.90	4.60	19	5	23.90	5.15	22	2500
CU60 (12)	113.25	5.91	5	4	113.25	9.87	9	2000
STL60A(21)	22.54	3.21	14	7	22.92	3.95	17	4500
STL60B(22)	4.06	.69	17	9	4.04	1.12	28	5000
STL99 (23)	242.00	44.86	19	12	261.74	49.04	19	26500
AS130 (24)	424.17	88.28	21	6	441.78	94.70	21	4500
RS130 (25)	82.49	32.84	40	8	57.90	27.81	48	22000
SS130 (26)	463.60	55.27	12	10	480.20	55.58	12	7500
AL60 (31)	9.65	.38	4	4	9.58	1.68	17	3000
BRS60T(32)	24.38	20.31	83	15	23.75	19.17	81	11000
BRS60 (33)	13.86	1.11	8	10	13.78	2.33	17	5500
NYL60 (34)	159.76	19.34	12	17	147.57	17.93	12	23500
ZN60 (35)	9.01	1.76	20	15	8.81	2.19	25	11000
SKF1.5(41)	21.92	2.22	10	4	21.92	3.11	14	4000
SKF2A (42)	20.81	4.50	22	7	19.86	5.69	29	6500
SKF2B (43)	14.91	1.33	9	28	14.67	2.20	15	30000
HOFFN2(44)	46.52	1.91	4	4	46.03	4.42	10	3000
SKF2.5(45)	59.92	3.52	6	9	59.14	5.25	9	10000
CMP2.5(46)	29.12	1.51	5	4	29.32	3.35	11	3000
CU35 (81)	38.82	5.28	14	16	39.44	6.77	17	9000
CU50 (82)	24.86	10.11	41	20	24.86	10.24	41	10000
STL60 (83)	12.15	9.70	80	16	12.99	9.84	76	9500

Table 40. Relative and absolute measures of backscattering cross sections SB observed with the EK-38 echo sounder.

SPHERE (NO)	SB/SB (CU35)	SB (CM**2)	SB/SGEOM	TS (DB)
CU35A (1)	0.988	11.5	1.191	-40.4
CU35B (2)	1.034	12.0	1.246	-40.2
CU35B- (3)	0.956	11.1	1.152	-40.5
CU35C+ (4)	1.056	12.3	1.274	-40.1
CU35C- (5)	0.950	11.0	1.145	-40.6
CU40 (6)	1.258	14.6	1.161	-39.3
CU45 (7)	2.886	33.5	2.105	-35.7
CU50A (8)	3.795	44.0	2.242	-34.6
CU50B (9)	3.595	41.7	2.124	-34.8
CU50C+ (10)	2.730	31.7	1.613	-36.0
CU50C (11)	3.678	42.7	2.173	-34.7
CU60 (12)	5.081	58.9	2.085	-33.3
STL60A (21)	3.154	36.6	1.294	-35.4
STL60B (22)	3.051	35.4	1.252	-35.5
STL99 (23)	7.949	92.2	1.198	-31.3
AS130 (24)	18.137	210.4	1.585	-27.8
RS130 (25)	16.500	191.4	1.442	-28.2
SS130 (26)	9.778	113.4	0.855	-30.4
AL60 (31)	2.647	30.7	1.086	-36.1
BRS60T (32)	7.246	84.1	2.973	-31.7
BRS60 (33)	6.864	79.6	2.816	-32.0
NYL60 (34)	3.473	40.3	1.425	-34.9
ZN60 (35)	4.774	55.4	1.959	-33.6
SKF1.5 (41)	0.646	7.5	0.657	-42.2
SKF2A (42)	2.071	24.0	1.185	-37.2
SKF2B (43)	1.843	21.4	1.055	-37.7
HOFFN2 (44)	1.467	17.0	0.840	-38.7
SKF2.5 (45)	3.192	37.0	1.169	-35.3
CMP2.5 (46)	0.587	6.8	0.215	-42.7
CU35 (81)	1.000	11.6	1.206	-40.3
CU50 (82)	3.691	42.8	2.180	-34.7
STL60 (83)	3.099	36.0	1.271	-35.4

Table 41. Relative and absolute measures of backscattering cross sections SB observed with the EK-50 echo sounder.

SPHERE (NO)	SB/SB (CU35)	SB (CM**2)	SB/SGEOM	TS (DB)
CU35A (1)	0.995	22.5	2.338	-37.5
CU35B (2)	1.014	22.9	2.382	-37.4
CU35B- (3)	1.103	24.9	2.591	-37.0
CU35C+ (4)	0.871	19.7	2.047	-38.0
CU35C- (5)	0.991	22.4	2.328	-37.5
CU40 (6)	0.669	15.1	1.202	-39.2
CU45 (7)	1.402	31.7	1.993	-36.0
CU50A (8)	1.815	41.0	2.089	-34.9
CU50B (9)	1.819	41.1	2.094	-34.9
CU50C+ (10)	1.926	43.5	2.217	-34.6
CU50C (11)	1.798	40.6	2.069	-34.9
CU60 (12)	0.578	13.1	0.462	-39.8
STL60A (21)	2.087	47.2	1.668	-34.3
STL60B (22)	2.148	48.5	1.717	-34.1
STL99 (23)	5.637	127.4	1.655	-29.9
AS130 (24)	2.897	65.5	0.493	-32.8
RS130 (25)	7.258	164.0	1.236	-28.8
SS130 (26)	8.165	184.5	1.390	-28.3
AL60 (31)	2.799	63.3	2.237	-33.0
BRS60T (32)	2.464	55.7	1.970	-33.5
BRS60 (33)	2.405	54.3	1.922	-33.6
NYL60 (34)	1.543	34.9	1.233	-35.6
ZN60 (35)	2.129	48.1	1.702	-34.2
SKF1.5 (41)	0.546	12.3	1.082	-40.1
SKF2A (42)	0.898	20.3	1.001	-37.9
SKF2B (43)	0.772	17.4	0.861	-38.6
HOFFN2 (44)	0.813	18.4	0.907	-38.3
SKF2.5 (45)	1.917	43.3	1.368	-34.6
CMP2.5 (46)	2.312	52.2	1.650	-33.8
CU35 (81)	1.000	22.6	2.349	-37.5
CU50 (82)	1.812	40.9	2.086	-34.9
STL60 (83)	2.121	47.9	1.696	-34.2

Table 42. Relative and absolute measures of backscattering cross sections SB observed with the EY-M echo sounder.

SPHERE (NO)	SB/SB (CU35)	SB (CM**2)	SB/SGEOM	TS (DB)
CU35A (1)	1.002	19.2	2.000	-38.1
CU35B (2)	0.993	19.1	1.982	-38.2
CU35B- (3)	0.962	18.5	1.920	-38.3
CU35C+ (4)	1.836	35.2	3.663	-35.5
CU35C- (5)	0.976	18.7	1.948	-38.3
CU40 (6)	1.761	33.8	2.691	-35.7
CU45 (7)	0.772	14.8	0.931	-39.3
CU50A (8)	3.301	63.4	3.228	-33.0
CU50B (9)	3.634	69.8	3.554	-32.6
CU50C+ (10)	4.266	81.9	4.171	-31.9
CU50C (11)	3.658	70.2	3.577	-32.5
CU60 (12)	3.196	61.4	2.170	-33.1
STL60A (21)	2.176	41.8	1.478	-34.8
STL60B (22)	1.895	36.4	1.287	-35.4
STL99 (23)	11.766	225.9	2.935	-27.5
AS130 (24)	15.051	289.0	2.177	-26.4
RS130 (25)	26.011	499.4	3.763	-24.0
SS130 (26)	25.888	497.1	3.745	-24.0
AL60 (31)	1.486	28.5	1.009	-36.4
BRS60T (32)	5.480	105.2	3.721	-30.8
BRS60 (33)	5.612	107.7	3.811	-30.7
NYL60 (34)	0.825	15.8	0.560	-39.0
ZN60 (35)	1.492	28.6	1.013	-36.4
SKF1.5 (41)	0.181	3.5	0.306	-45.6
SKF2A (42)	1.267	24.3	1.200	-37.1
SKF2B (43)	1.585	30.4	1.502	-36.2
HOFFN2 (44)	1.520	29.2	1.440	-36.3
SKF2.5 (45)	2.604	50.0	1.578	-34.0
CMP2.5 (46)	2.024	38.9	1.227	-35.1
CU35 (81)	1.000	19.2	1.996	-38.2
CU50 (82)	3.515	67.5	3.437	-32.7
STL60 (83)	2.026	38.9	1.376	-35.1

Table 43. Relative and absolute measures of backscattering cross sections SB observed with the EK-120 echo sounder.

SPHERE (NO.)	SB/SB (CU35)	SB (CM**2)	SB/SGEOM	TS (DB)
CU35A (1)	1.008	36.0	3.738	-35.4
CU35B (2)	0.977	34.9	3.627	-35.6
CU35B- (3)	0.969	34.6	3.597	-35.6
CU35C+ (4)	0.874	31.2	3.245	-36.0
CU35C- (5)	1.067	38.1	3.960	-35.2
CU40 (6)	0.222	7.9	0.631	-42.0
CU45 (7)	0.012	0.4	0.027	-54.7
CU50A (8)	0.878	31.3	1.596	-36.0
CU50B (9)	0.387	13.8	0.703	-39.6
CU50C+ (10)	0.877	31.3	1.595	-36.0
CU50C (11)	0.616	22.0	1.119	-37.6
CU60 (12)	2.917	104.1	3.683	-30.8
STL60A (21)	0.581	20.7	0.733	-37.8
STL60B (22)	0.105	3.7	0.132	-45.3
STL99 (23)	6.233	222.5	2.891	-27.5
AS130 (24)	10.925	390.0	2.938	-25.1
RS130 (25)	2.125	75.8	0.571	-32.2
SS130 (26)	11.941	426.3	3.212	-24.7
AL60 (31)	0.249	8.9	0.314	-41.5
BRS60T (32)	0.628	22.4	0.793	-37.5
BRS60 (33)	0.357	12.7	0.451	-39.9
NYL60 (34)	4.115	146.9	5.196	-29.3
ZN60 (35)	0.232	8.3	0.293	-41.8
SKF1.5 (41)	0.565	20.2	1.768	-37.9
SKF2A (42)	0.536	19.1	0.944	-38.2
SKF2B (43)	0.384	13.7	0.676	-39.6
HOFFN2 (44)	1.198	42.8	2.111	-34.7
SKF2.5 (45)	1.543	55.1	1.740	-33.6
CMP2.5 (46)	0.750	26.8	0.846	-36.7
CU35 (81)	1.000	35.7	3.711	-35.5
CU50 (82)	0.640	22.9	1.164	-37.4
STL60 (83)	0.313	11.2	0.395	-40.5

TABLE 44. TIME HISTORY OF ACOUSTIC MEASUREMENTS OF SPHERES AND NOISE.

				ECHO SOUNDER									
				EK-38		EK-50		EY-M		EK-120			
NO	DATE	TIME	NAME(CODE)	E	V	E	V	E	V	E	V	NPING	COMMENT
1	160980	1537	SKF2A (42)			41.6	6			21.9	13	1000	
2	160980	1544	SKF2A (42)	65.3	11			49.1	8			1000	
3	160980	1550	SKF2A (42)			41.9	8			22.2	13	500	
4	160980	1557	SKF2B (43)			35.2	7			15.3	15	1000	
5	160980	1603	SKF2B (43)	55.5	9			57.2	6			1000	
6	160980	1609	SKF2B (43)			35.9	7			16.4	12	500	
7	160980	1614	BRS60T(32)			112.2	4			60.0	8	1000	
8	160980	1620	BRS60T(32)	230.3	6			171.5	4			1000	
9	160980	1626	BRS60T(32)			112.7	3			62.1	8	500	
10	160980	1631	NOISE (99)			.085	103			.120	102	1000	
11	160980	1636	NOISE (99)	.30	104			.11	120			1000	
12	160980	1643	SKF2B (43)	54.8	12			57.0	7			1000	
13	160980	1650	SKF2B (43)			35.4	8			15.4	14	500	
14	160980	1656	BRS60T(32)			114.0	4			59.2	7	500	
15	160980	1700	BRS60T(32)	226.4	6			170.5	4			2500	
16	160980	1714	SKF2A (42)	61.2	11			46.3	10			1000	
17	160980	1720	SKF2A (42)			40.9	6			23.0	12	1000	
18	160980	1730	SKF2.5(45)			86.8	4			61.9	7	1000	
19	160980	1736	SKF2.5(45)	99.3	10			91.3	10			1000	
20	160980	1742	SKF2.5(45)			87.7	4			64.7	6	500	
21	160980	1746	HOFFN2(44)			36.6	6			44.7	7	1000	
22	160980	1752	HOFFN2(44)	44.9	11			49.3	8			1000	
23	160980	1758	HOFFN2(44)			36.3	7			49.0	9	500	
24	160980	1803	SKF2B (43)			34.9	7			15.8	14	1000	
25	160980	1808	SKF2B (43)	55.2	11			55.3	10			1000	
26	160980	1814	SKF2B (43)			35.4	8			15.9	14	500	
27	160980	1819	BRS60T(32)			110.6	4			35.5	12	1000	
28	160980	1825	BRS60T(32)	226.1	5			155.9	5			1000	
29	160980	1830	BRS60T(32)			108.9	3			32.4	10	500	
30	160980	1835	SKF2.5(45)			85.5	5			60.1	7	1000	
31	160980	1840	SKF2.5(45)	98.2	7			88.0	6			1000	
32	160980	1846	SKF2.5(45)			85.6	5			60.4	7	500	
33	160980	1851	HOFFN2(44)	43.9	10			49.4	7			500	
34	160980	1854	HOFFN2(44)			34.7	6			47.0	8	500	
35	160980	1901	SKF2B (43)			33.3	8			14.4	12	14000	
36	160980	2020	SKF2B (43)	56.0	15			53.6	13			1000	

TABLE 44. (CONTINUED)

37	160980	2029	SKF2A (42)	62.7	12			36.1	11			2000	
38	160980	2042	SKF2A (42)			40.1	7			10.7	17	1500	
39	160980	2053	BRS60T(32)			105.10	5			9.53	14	1000	
40	160980	2059	BRS60T(32)	212.5	6			150.9	5			1000	
41	160980	2105	BRS60T(32)			105.6	4			10.0	13	500	
42	160980	2110	SKF2B (43)			35.5	9			12.3	15	1000	
43	160980	2118	BRS60T(32)			107.3	4			13.6	14	1500	
44	160980	2126	BRS60T(32)	211.8	6			149.3	6			1500	
45	160980	2138	SKF2.5(45)	99.9	11			86.3	8			1000	
46	160980	2143	SKF2.5(45)			87.6	4			65.2	7	500	
47	160980	2149	CMP2.5(46)			106.7	11			43.4	16	1000	DRY
48	160980	2155	CMP2.5(46)	41.8	29			71.7	19			1000	DRY
49	160980	2202	BRS60T(32)	185.8	11			158.7	13			500	DRIED
50	160980	2206	BRS60T(32)			122.90	10			2.25	29	2000	DRIED
51	160980	2217	BRS60T(32)	209.5	9			207.8	6			500	DRIED
52	160980	2221	CMP2.5(46)	19.5	25			68.4	11			500	
53	160980	2225	CMP2.5(46)			105.3	5			30.1	13	500	
54	160980	2229	BRS60T(32)			118.80	4			7.22	18	500	
55	160980	2233	BRS60T(32)	234.1	24			219.8	19			500	
56	160980	2239	SKF1.5(41)	19.30	26			5.47	16			500	
57	160980	2242	SKF1.5(41)			28.9	46			26.1	27	500	
58	170980	913	SKF1.5(41)	22.10	23			6.99	44			2500	
59	170980	927	SKF1.5(41)			25.4	9			21.5	13	1000	
60	170980	933	SKF1.5(41)	20.20	12			6.13	18			500	
61	170980	938	SKF2B (43)	60.5	8			54.3	7			1000	
62	170980	944	SKF2B (43)			35.2	6			15.3	11	1000	
63	170980	950	SKF2B (43)	59.8	12			53.9	11			500	
64	170980	955	SKF2.5(45)	89.8	15			81.7	10			1000	
65	170980	1001	SKF2.5(45)			74.2	4			56.3	9	1000	
66	170980	1007	SKF2.5(45)	88.0	8			82.7	6			500	
67	170980	1015	SKF1.5(41)	19.70	16			5.95	21			1000	
68	170980	1020	SKF1.5(41)			22.8	8			19.0	10	1000	
69	170980	1029	BRS60T(32)			105.5	5			12.6	16	1000	
70	170980	1035	BRS60T(32)	218.6	5			188.6	5			1000	
71	170980	1041	BRS60T(32)			104.0	4			12.4	13	500	
72	170980	1047	SKF2B (43)			30.9	6			12.8	12	500	
73	170980	1050	SKF2B (43)	55.6	9			51.2	10			500	
74	170980	1056	BRS60T(32)	212.8	5			184.8	6			500	
75	170980	1100	BRS60T(32)			103.20	4			9.24	18	500	

TABLE 44. (CONTINUED)

76	170980	1105	SKF2A (42)			35.6	5			22.9	13	1000		
77	170980	1111	SKF2A (42)	63.1	8			36.9	11			1000		
78	170980	1117	SKF2A (42)			37.1	5			21.7	14	500		
79	170980	1221	NOISE (99)	3.84	75			3.25	69			500		
80	170980	1225	NOISE (99)	2.83	66			3.62	62			500		
81	170980	1229	NOISE (99)			.055	109			.075	104	500		
82	170980	1233	NOISE (99)	3.24	57			2.16	52			500		
83	170980	1236	SKF2B (43)	55.5	20			50.2	21			500		
84	170980	1240	SKF2B (43)			32.5	10			14.5	12	500		
85	170980	1243	SKF2B (43)	54.2	17			49.5	19			500		
86	170980	1249	BRS60T(32)	209.5	13			191.1	12			500		
87	170980	1253	BRS60T(32)			106.4	5			16.0	13	500		
88	170980	1258	AL60 (31)			121.10	13			5.78	40	1000	NH4-1	
89	170980	1303	AL60 (31)	94.1	14			48.3	14			1000	NH4-1	1258
90	170980	1309	AL60 (31)			118.10	3			9.44	17	500	NH4-1	1258
91	170980	1313	AL60 (31)	91.5	10			48.6	9			500	NH4-1	1258
92	170980	1317	ZN60 (35)	100.9	15			48.9	13			1000	NH4-5	
93	170980	1323	ZN60 (35)			119.70	4			6.56	19	1000	NH4-5	1317
94	170980	1328	ZN60 (35)	123.9	9			53.5	10			500	NH4-5	1317
95	170980	1333	SKF2B (43)	52.5	12			50.2	8			500		
96	170980	1337	SKF2B (43)			35.2	8			14.5	18	500		
97	170980	1340	STL60B(22)			113.30	17			1.51	46	1000	NH4-10	
98	170980	1346	STL60B(22)	86.3	12			43.4	9			1000	NH4-10	1340
99	170980	1352	STL60B(22)			97.50	4			2.46	27	500	NH4-10	1340
100	170980	1356	STL60A(21)			66.9	8			14.8	20	1000	NH4-3	
101	170980	1401	STL60A(21)	111.9	11			46.9	7			1000	NH4-3	1356
102	170980	1407	STL60A(21)			81.0	4			17.1	12	500	NH4-3	1356
103	170980	1416	NYL60 (34)			71.7	6			154.9	6	1500	NH4-5	
104	170980	1425	NYL60 (34)	114.9	7			35.9	13			1000	NH4-5	1416
105	170980	1431	NYL60 (34)			67.9	5			148.0	5	500	NH4-5	1416
106	170980	1436	SKF2B (43)			33.8	9			15.1	14	500		
107	170980	1439	SKF2B (43)	54.5	12			50.9	8			500		
108	170980	1445	BRS60T(32)	211.3	8			184.9	5			1000		
109	170980	1451	BRS60T(32)			107.9	5			12.0	15	1000		
110	170980	1500	BRS60T(32)			108.8	3			13.9	12	500		
111	170980	1503	BRS60T(32)	220.5	7			190.2	6			500		
112	170980	1508	AL60 (31)	91.2	6			44.4	8			500		
113	170980	1512	AL60 (31)			125.50	4			9.55	17	1000		
114	170980	1519	ZN60 (35)			94.90	5			7.75	19	1000		

TABLE 44. (CONTINUED)

115	170980	1524	ZN60 (35)	142.7	7			54.3	7			2000	
116	170980	1535	ZN60 (35)			92.90	4			8.84	16	500	
117	170980	1539	STL60B(22)			93.80	5			4.55	20	500	
118	170980	1542	STL60B(22)	89.8	9			60.1	7			500	
119	170980	1545	STL60B(22)			93.50	5			4.93	22	500	
120	170980	1548	STL60B(22)	90.2	6			61.7	6			500	
121	170980	1552	STL60A(21)	95.5	12			72.0	10			1000	
122	170980	1558	STL60A(21)			91.3	6			26.2	11	1000	
123	170980	1605	NYL60 (34)			62.2	8			146.5	5	1000	
124	170980	1611	NYL60 (34)	109.2	8			24.5	10			1000	
125	170980	1617	SKF2B (43)	56.0	12			51.2	8			500	
126	170980	1620	SKF2B (43)			32.5	15			15.0	15	500	
127	170980	1624	SKF2B (43)	52.1	13			49.0	7			1500	
128	170980	1635	BRS60 (33)	202.9	7			185.9	3			500	
129	170980	1639	BRS60 (33)			102.2	4			12.2	13	500	
130	170980	1644	STL99 (23)			251.6	5			267.1	9	1000	
131	170980	1649	STL99 (23)	207.3	10			352.4	6			500	
132	170980	1654	NYL60 (34)	109.8	10			26.2	11			500	
133	170980	1657	NYL60 (34)			63.2	6			164.3	6	500	
134	170980	1701	SKF2B (43)			34.9	12			15.8	16	500	
135	170980	1705	SKF2B (43)	54.6	11			53.2	7			1500	
136	170980	1716	NOISE (99)	.170	153			.048	132			500	
137	170980	1719	NOISE (99)			.65	478			.41	648	500	
138	170980	1742	NOISE (99)			.14	123			.13	231	1500	
139	170980	1751	NOISE (99)	.990	221			.068	180			1500	
140	170980	1801	SKF2A (42)	61.1	13			37.3	10			1000	
141	170980	1807	SKF2A (42)			40.1	8			23.3	11	1000	
142	170980	1814	SKF1.5(41)			24.0	9			23.1	10	1000	
143	170980	1820	SKF1.5(41)	19.70	35			6.53	41			1000	FISH
144	170980	1828	SKF1.5(41)			24.1	9			24.1	11	1000	
145	170980	1833	SKF1.5(41)	19.00	18			6.02	19			1000	
146	170980	1843	NYL60 (34)			62.2	7			140.9	8	14000	
147	170980	2001	NYL60 (34)			59.8	4			123.0	4	1000	
148	170980	2010	NYL60 (34)	109.2	7			22.1	10			1000	
149	170980	2146	STL99 (23)	235.0	6			350.9	6			10000	
150	170980	2245	STL99 (23)			236.3	1			246.7	7	14000	
151	180980	749	AL60 (31)	87.0	9			44.8	9			14000	
152	180980	915	AL60 (31)	86.8	6			46.7	7			2000	
153	180980	1035	AL60 (31)			122.10	3			9.36	15	1000	

TABLE 44. (CONTINUED)

154	180980	1046	ZN60	(35)			90.40	4			8.46	16	500	
155	180980	1050	ZN60	(35)	144.5	5			.0	0			500	EY-M OFF
156	180980	1105	ZN60	(35)			87.90	5			8.15	16	2000	
157	180980	1115	ZN60	(35)	136.8	8			45.6	6			1000	
158	180980	1122	SKF2.5	(45)	100.2	5			78.7	5			1000	
159	180980	1129	SKF2.5	(45)			81.0	4			56.4	9	1000	
160	180980	1137	CMP2.5	(46)			100.5	4			27.0	13	500	
161	180980	1142	CMP2.5	(46)	17.0	17			64.1	5			1000	
162	180980	1148	CMP2.5	(46)			100.5	5			29.1	10	1000	
163	180980	1154	SKF2B	(43)			31.9	7			15.2	12	1000	
164	180980	1201	SKF2B	(43)	54.4	8			49.7	6			1000	
165	180980	1210	STL60B	(22)	94.0	8			60.9	6			9000	
166	180980	1255	STL60B	(22)			95.20	4			3.90	23	1000	
167	180980	1302	STL60A	(21)			90.3	4			22.3	11	1000	
168	180980	1308	STL60A	(21)	95.6	10			69.3	6			1000	
169	180980	1315	BRS60	(33)	208.3	5			179.2	3			1000	
170	180980	1321	BRS60	(33)			103.4	4			13.0	12	1000	
171	180980	1328	NYL60	(34)			62.5	5			144.3	5	1000	
172	180980	1334	NYL60	(34)	118.7	6			22.1	8			1000	
173	180980	1342	STL99	(23)	246.2	5			345.4	3			1000	
174	180980	1348	STL99	(23)			236.6	3			250.1	6	1000	
175	180980	1355	ZN60	(35)			91.90	4			8.51	16	1000	
176	180980	1401	ZN60	(35)	144.3	6			49.2	6			1000	
177	180980	1407	ZN60	(35)			92.80	4			8.96	16	1500	
178	180980	1416	ZN60	(35)	144.1	7			48.2	6			500	
179	180980	1420	CMP2.5	(46)	16.8	17			64.6	5			1000	
180	180980	1427	CMP2.5	(46)			102.7	4			30.3	9	1000	
181	180980	1436	AL60	(31)			109.00	12			8.66	51	1000	
182	180980	1441	AL60	(31)	34.1	27			17.5	48			1000	JELLYFISH
183	180980	1447	AL60	(31)	31.2	16			14.4	53			500	JELLYFISH
184	180980	1501	NOISE	(99)	.22	104			.12	207			500	JELLYFISH
185	180980	1507	AL60	(31)	30.6	71			24.1	38			1000	JELLYFISH
186	180980	1647	NOISE	(99)	13.0	74			27.8	25			500	FISH
187	180980	1738	NOISE	(99)	3.55	124			2.71	210			2000	
188	180980	1750	NOISE	(99)			.16	106			.34	91	2000	
189	180980	1802	AL60	(31)	36.9	52			27.4	32			500	
190	180980	1805	AL60	(31)			52.4	21			14.6	37	500	
191	180980	1809	BRS60	(33)			106.3	5			14.1	17	500	
192	180980	1813	BRS60	(33)	210.4	8			182.5	5			500	

TABLE 44. (CONTINUED)

193	180980	1817	SKF2B (43)	65.3	26			54.7	10			500	
194	180980	1820	SKF2B (43)			36.9	9			15.7	21	500	
195	180980	1825	STL99 (23)			222.0	5			221.1	6	500	
196	180980	1828	STL99 (23)	229.7	6			325.6	4			500	
197	180980	1832	AL60 (31)	40.5	30			29.9	26			2500	
198	180980	1900	RS130 (25)			295.2	7			45.2	29	14000	
199	180980	2023	RS130 (25)	544.9	4			863.0	3			1000	
200	180980	2029	RS130 (25)			261.3	3			67.7	12	500	
201	180980	2035	AS130 (24)			121.3	5			398.9	14	1000	
202	180980	2040	AS130 (24)	559.6	5			498.7	11			1000	
203	180980	2047	AS130 (24)			128.6	3			395.7	5	500	
204	180980	2059	SS130 (26)			366.0	4			517.3	4	2000	
205	180980	2110	SS130 (26)	271.2	5			957.2	3			1000	
206	180980	2117	SS130 (26)			380.9	3			563.1	4	500	
207	180980	2122	STL60A(21)			92.0	5			24.7	12	500	
208	180980	2126	STL60A(21)	98.9	7			71.1	5			500	
209	180980	2131	STL60B(22)	93.8	6			63.3	6			1000	
210	180980	2137	STL60B(22)			97.60	4			4.39	20	500	
211	180980	2145	RS130 (25)			322.9	4			98.3	24	1000	
212	180980	2151	RS130 (25)	505.1	4			783.0	5			500	
213	180980	2157	AS130 (24)	520.3	7			507.2	7			1500	
214	180980	2205	AS130 (24)			132.1	10			594.4	5	1000	
215	180980	2212	SKF2B (43)			35.8	23			16.4	23	5000	FISH
216	180980	2250	SKF2B (43)	60.0	24			53.4	17			5000	FISH
217	180980	2318	AL60 (31)	63.0	34			28.3	29			500	
218	190980	904	NOISE (99)	1.15	148			.61	208			500	
219	190980	907	NOISE (99)			.22	55			.46	54	500	
220	190980	911	SKF2B (43)			36.8	5			17.7	14	500	
221	190980	915	SKF2B (43)	58.1	10			54.8	6			1000	
222	190980	920	SKF2B (43)			36.2	6			17.7	15	500	
223	190980	924	NYL60 (34)			68.2	4			169.1	6	500	
224	190980	928	NYL60 (34)	112.2	7			29.4	8			500	
225	190980	933	RS130 (25)	498.1	6			867.8	8			1000	
226	190980	938	RS130 (25)			328.8	6			77.0	30	1500	
227	190980	947	RS130 (25)	522.4	4			912.4	2			1000	
228	190980	955	AS130 (24)	553.1	3			507.1	9			500	
229	190980	958	AS130 (24)			129.8	6			438.4	12	1000	
230	190980	1007	SS130 (26)			358.9	2			507.7	4	1500	
231	190980	1014	SS130 (26)	292.7	6			830.4	2			2000	

TABLE 44. (CONTINUED)

232	190980	1027	RS130 (25)	517.7	4			859.7	8			500	
233	190980	1030	RS130 (25)			312.1	5			119.0	22	2000	JELLYFISH
234	190980	1041	NYL60 (34)			67.3	3			184.7	4	500	
235	190980	1045	NYL60 (34)	112.6	6			25.2	8			500	
236	190980	1050	STL99 (23)	235.5	6			355.0	4			500	
237	190980	1053	STL99 (23)			252.1	2			271.7	5	500	
238	190980	1057	STL99 (23)			251.6	2			249.0	4	500	
239	190980	1104	STL99 (23)			251.1	2			259.5	4	500	120T.1BW10
240	190980	1108	STL99 (23)			248.6	3			616.2	3	500	120T1.BW10
241	190980	1112	STL99 (23)	111.0	4			372.6	2			500	38T.3BW3
242	190980	1117	STL99 (23)	110.6	6			372.6	2			500	38T.6BW1
243	190980	1121	STL99 (23)	129.9	6			374.6	2			1000	38T1.BW1
244	190980	1132	NYL60 (34)	112.4	8			24.5	9			500	
245	190980	1135	NYL60 (34)			70.2	5			194.3	6	500	
246	190980	1139	SKF2B (43)			35.0	6			16.2	15	500	
247	190980	1144	SKF2B (43)	56.3	10			51.9	6			1000	
248	190980	1151	RS130 (25)	510.7	3			770.9	4			3000	
249	190980	1207	RS130 (25)			315.1	3			145.8	6	1000	
250	190980	1214	NYL60 (34)			70.3	4			179.8	5	500	
251	190980	1217	NYL60 (34)	112.0	5			24.6	10			500	
252	190980	1346	NYL60 (34)	112.5	5			22.1	10			500	
253	190980	1349	NYL60 (34)			.00	0			172.50	6	1000	EK-50 OFF
254	190980	1356	SKF2B (43)			.00	0			15.20	14	500	EK-50 OFF
255	190980	1359	SKF2B (43)			34.2	6			15.4	15	500	
256	190980	1403	SKF2B (43)	56.1	8			51.2	6			500	
257	190980	1408	ZN60 (35)	144.8	11			52.5	12			500	
258	190980	1411	ZN60 (35)			91.9	7			13.7	20	500	
259	190980	1415	NYL60 (34)			71.0	4			165.0	5	500	MOVED 8CM E
260	190980	1418	NYL60 (34)	105.3	6			21.6	9			500	MOVED 8CM E
261	190980	1422	NYL60 (34)	110.6	7			22.8	8			500	
262	190980	1425	NYL60 (34)			72.7	4			176.1	5	500	
263	190980	1429	BRS60 (33)			113.5	3			14.9	17	500	
264	190980	1432	BRS60 (33)	212.1	5			185.5	4			500	
265	190980	1436	STL60A(21)	95.2	6			72.7	6			500	
266	190980	1439	STL60A(21)			97.2	3			26.0	11	500	
267	190980	1444	STL60B(22)			99.40	4			5.00	24	500	
268	190980	1447	STL60B(22)	95.9	7			63.6	6			500	
269	190980	1451	NYL60 (34)	112.6	5			21.2	9			500	
270	190980	1454	NYL60 (34)			73.1	4			176.0	5	500	

TABLE 44. (CONTINUED)

271	190980	1459	SKF2.5(45)			86.2	4			58.4	8	4000	
272	190980	1520	SKF2.5(45)	101.1	7			83.0	6			1500	
273	190980	1529	SKF2.5(45)			86.8	4			55.9	7	500	
274	190980	1534	NYL60 (34)			71.2	4			156.4	7	500	
275	190980	1539	NYL60 (34)	109.3	5			21.6	8			500	
276	190980	1543	BRS60 (33)	211.1	4			187.5	4			500	
277	190980	1547	BRS60 (33)			109.7	3			14.9	18	500	
278	190980	1552	CU35A (1)			42.5	12			41.1	12	1000	
279	190980	1558	CU35A (1)	30.4	18			31.7	10			500	
280	190980	1602	CU35B (2)	31.2	12			34.1	8			1000	
281	190980	1607	CU35B (2)			45.6	6			43.5	10	500	
282	190980	1611	CU40 (6)			30.40	16			8.94	25	1000	JELLYFISH
283	190980	1618	CU40 (6)	37.8	17			58.6	7			1000	
284	190980	1624	CU45 (7)	84.1	11			27.3	11			500	
285	190980	1628	CU45 (7)			63.40	5			.76	48	500	
286	190980	1631	NOISE (99)			.039	126			.170	82	500	JELLYFISH
287	190980	1634	NOISE (99)	.130	115			.054	281			500	
288	190980	1637	CU50A (8)	111.5	6			108.4	4			500	
289	190980	1641	CU50A (8)			84.2	4			23.4	11	500	
290	190980	1644	CU50A (8)			83.5	3			23.3	8	500	
291	190980	1648	CU50B (9)			83.1	4			13.8	13	500	
292	190980	1652	CU50B (9)	96.3	7			121.7	2			500	
293	190980	1655	CU50C+(10)	81.2	8			142.6	4			500	
294	190980	1659	CU50C+(10)			87.4	4			33.0	7	500	
295	190980	1703	CU50B (9)			82.5	4			12.8	14	500	
296	190980	1706	CU50B (9)	89.4	7			120.7	3			500	
297	190980	1710	CU50C+(10)	81.3	6			141.2	3			500	
298	190980	1713	CU50C+(10)			87.6	4			34.1	8	500	
299	190980	1717	CU50A (8)			82.0	4			36.9	9	500	
300	190980	1721	CU50A (8)	112.6	7			108.5	3			500	
301	190980	1724	CU50A (8)			81.7	4			37.6	11	500	
302	190980	1727	CU50B (9)			83.9	4			13.7	12	500	
303	190980	1731	NYL60 (34)			71.2	4			148.7	5	500	
304	190980	1734	NYL60 (34)	109.0	4			21.7	7			500	
305	190980	1738	ZN60 (35)	96.1	12			40.3	8			500	RESOAKED
306	190980	1742	ZN60 (35)			93.30	3			9.94	14	500	
307	190980	1749	CU45 (7)			64.50	4			.59	49	500	
308	190980	1753	NOISE (99)			.047	135			.110	87	500	
309	190980	1757	BRS60 (33)			108.7	3			13.7	14	500	

TABLE 44. (CONTINUED)

310	190980	1800	BRS60 (33)	207.8	6			187.8	4			500	
311	190980	1805	ZN60 (35)	147.9	5			35.7	10			500	
312	190980	1808	ZN60 (35)			101.7	4			10.2	16	500	
313	190980	1812	CU35A (1)			46.3	6			39.8	10	500	
314	190980	1815	CU35A (1)	30.0	11			34.6	6			500	
315	190980	1819	HOFFN2(44)	47.4	11			48.3	6			500	RESOAKED
316	190980	1822	HOFFN2(44)			35.9	8			45.4	11	1000	
317	190980	1828	SKF2B (43)			34.8	5			14.6	15	500	
318	190980	1831	SKF2B (43)	54.9	9			51.8	6			500	
319	190980	1836	STL99 (23)	243.8	5			354.0	2			500	
320	190980	1839	STL99 (23)			249.5	3			253.8	5	1000	
321	210980	1241	NOISE (99)	.33	82			.14	76			500	
322	210980	1245	NOISE (99)			.14	67			.18	62	1000	
323	210980	1251	NOISE (99)	.200	89			.062	109			500	
324	210980	1255	SKF2B (43)	55.3	10			50.8	10			500	
325	210980	1259	SKF2B (43)			33.6	9			14.7	14	500	
326	210980	1303	CU35A (1)			43.4	6			32.2	9	500	
327	210980	1306	CU35A (1)	30.7	13			31.9	8			500	
328	210980	1310	CU35B (2)	30.9	10			30.6	7			500	
329	210980	1313	CU35B (2)			44.0	6			33.1	9	500	
330	210980	1318	CU40 (6)			29.60	8			7.78	15	500	
331	210980	1321	CU40 (6)	39.7	11			55.7	5			500	
332	210980	1325	CU45 (7)	89.5	10			24.9	10			500	
333	210980	1328	CU45 (7)			61.60	5			.49	45	1000	
334	210980	1334	NOISE (99)			.028	115			.033	108	1000	
335	210980	1340	CU50A (8)			76.6	5			33.1	8	500	
336	210980	1343	CU50A (8)	125.6	7			104.2	3			500	
337	210980	1347	CU50B (9)	117.5	8			115.8	4			500	
338	210980	1350	CU50B (9)			77.3	5			15.7	11	500	
339	210980	1354	CU50C+(10)			81.5	4			33.5	6	500	
340	210980	1357	CU50C+(10)	83.4	5			134.9	2			500	
341	210980	1401	SKF2B (43)	55.1	7			48.4	6			500	
342	210980	1404	SKF2B (43)			32.5	5			14.2	11	500	
343	210980	1408	STL60A(21)			90.5	5			17.9	12	500	
344	210980	1412	STL60A(21)	96.4	6			67.8	4			500	
345	210980	1416	STL60B(22)	94.1	6			59.2	4			500	
346	210980	1419	STL60B(22)			93.50	5			3.18	24	500	
347	210980	1422	STL60B(22)			92.00	4			3.23	23	500	
348	210980	1427	STL99 (23)			233.8	3			196.4	7	500	

TABLE 44. (CONTINUED)

349	210980	1430	STL99 (23)	241.5	4			346.4	3			500	
350	210980	1435	SS130 (26)	279.3	4			729.0	7			500	SOAP-5
351	210980	1439	SS130 (26)			349.4	4			411.9	7	500	
352	210980	1443	AS130 (24)			114.0	10			302.1	13	500	SOAP-3
353	210980	1446	AS130 (24)	562.4	6			459.0	11			500	
354	210980	1450	NYL60 (34)	78.5	8			41.7	7			500	
355	210980	1454	NYL60 (34)			72.9	4			155.2	5	500	
356	210980	1458	BRS60 (33)			102.2	4			12.7	12	500	
357	210980	1502	BRS60 (33)	216.6	5			167.7	3			500	
358	210980	1506	NYL60 (34)	82.6	7			37.7	10			500	
359	210980	1509	NYL60 (34)			70.6	4			151.5	5	500	
360	210980	1513	SKF2B (43)			32.6	7			12.7	15	500	
361	210980	1516	SKF2B (43)	57.9	20			47.9	7			500	
362	210980	1521	CU45 (7)			61.40	4			.53	45	500	
363	210980	1525	NOISE (99)			.037	130			.033	123	1000	
364	210980	1531	NOISE (99)	.1200	134			.0087	321			1000	
365	210980	1538	SKF2B (43)	54.6	6			47.3	5			500	
366	210980	1541	SKF2B (43)			32.9	6			13.7	13	500	
367	210980	1545	CU45 (7)			60.80	6			.42	47	3000	
368	210980	1602	CU45 (7)	86.3	9			23.3	11			1000	
369	210980	1608	CU45 (7)			61.50	6			.43	50	5000	
370	210980	1645	CU45 (7)			59.90	5			.42	52	5000	
371	210980	1712	STL99 (23)			346.0	3			350.3	4	5000	
372	210980	1741	STL99 (23)	298.2	5			712.6	3			1500	
373	210980	1753	SKF2B (43)	54.3	8			47.4	6			500	
374	210980	1756	SKF2B (43)			32.4	8			13.2	16	500	
375	210980	1801	CU35A (1)			41.1	6			29.7	7	500	
376	210980	1804	CU35A (1)	28.5	14			29.3	8			500	
377	210980	1808	NYL60 (34)	88.5	9			34.1	12			2000	
378	210980	1819	NYL60 (34)			66.6	4			135.3	4	500	
379	210980	1824	STL99 (23)			244.0	3			188.3	6	1000	
380	210980	1830	STL99 (23)	230.2	7			347.1	4			500	
381	230980	1326	NOISE (99)	.330	86			.080	110			1000	
382	230980	1334	NOISE (99)			.12	77			.14	80	1000	
383	230980	1341	CU35A (1)			42.6	5			34.4	7	500	
384	230980	1344	CU35A (1)	30.7	12			32.8	7			500	
385	230980	1349	CU35B (2)	31.4	12			32.9	10			500	
386	230980	1352	CU35B (2)			45.2	6			38.5	8	500	
387	230980	1356	CU40 (6)			30.10	6			8.58	11	500	

TABLE 44. (CONTINUED)

388	230980	1359	CU40 (6)	39.4	11			58.1	6			500
389	230980	1403	CU45 (7)	90.0	9			25.5	12			500
390	230980	1407	CU45 (7)			64.10	4			.58	43	1000
391	230980	1413	NOISE (99)			.039	121			.067	101	1000
392	230980	1419	NOISE (99)	.140	123			.035	191			1000
393	230980	1425	CU50A (8)	110.9	7			104.7	5			500
394	230980	1428	CU50A (8)			77.7	4			45.3	6	500
395	230980	1437	CU50B (9)			77.6	4			15.4	11	500
396	230980	1441	CU50B (9)	121.8	5			114.5	4			500
397	230980	1445	CU50C+(10)	84.5	8			135.2	5			500
398	230980	1449	CU50C+(10)			83.5	4			35.6	7	500
399	230980	1453	SKF2B (43)			32.7	7			14.3	15	500
400	230980	1456	SKF2B (43)	55.1	6			48.9	5			500
401	230980	1500	CU35A (1)	30.1	10			31.4	7			500
402	230980	1503	CU35A (1)			42.8	5			37.3	7	500
403	230980	1508	CU35B (2)			44.2	4			36.7	10	500
404	230980	1511	CU35B (2)	31.6	12			31.4	7			1500
405	230980	1521	CU35C+(4)	32.4	12			59.6	9			1000
406	230980	1526	CU35C+(4)			38.5	6			34.2	11	500
407	230980	1531	CU60 (12)			26.0	7			113.9	6	500
408	230980	1534	CU60 (12)	159.7	4			103.5	4			500
409	230980	1539	BRS60 (33)	206.5	6			173.4	4			500
410	230980	1542	BRS60 (33)			104.9	4			14.2	12	500
411	230980	1547	NYL60 (34)			73.3	5			171.9	4	500
412	230980	1550	NYL60 (34)	86.8	9			33.6	8			500
413	230980	1555	STL60B(22)	92.0	9			61.0	7			500
414	230980	1558	STL60B(22)			94.50	4			3.75	29	500
415	230980	1602	STL60A(21)			91.8	6			19.8	16	500
416	230980	1606	STL60A(21)	93.4	7			70.9	4			500
417	230980	1610	STL99 (23)	237.9	4			365.9	3			500
418	230980	1613	STL99 (23)			240.3	3			220.3	5	500
419	230980	1617	RS130 (25)			451.8	8			71.1	12	500
420	230980	1621	RS130 (25)	463.9	4			918.1	3			500
421	230980	1626	AS130 (24)	533.8	6			465.6	8			500
422	230980	1630	AS130 (24)			133.8	8			356.6	5	500
423	230980	1638	SS130 (26)			363.4	6			415.3	6	500
424	230980	1643	SS130 (26)	282.0	6			836.0	7			1000
425	230980	1650	AL60 (31)	77.7	8			47.8	7			500
426	230980	1654	AL60 (31)			122.6	9			10.2	21	500

TABLE 44. (CONTINUED)

427	230980	1701	ZN60 (35)			92.60	3			7.32	21	500	
428	230980	1705	ZN60 (35)	147.3	6			51.7	6			500	
429	230980	1713	CU35C+(4)	31.6	14			58.2	8			1000	
430	230980	1721	CU35C+(4)			38.4	6			33.7	10	1000	
431	230980	1729	CU35C+(4)	31.9	12			61.0	6			1000	
432	230980	1737	CU60 (12)	155.9	5			106.5	5			500	
433	230980	1745	CU60 (12)			25.6	7			107.3	6	500	
434	230980	1750	ZN60 (35)			89.70	4			6.94	18	500	
435	230980	1754	ZN60 (35)	143.8	7			51.9	6			500	
436	230980	1759	AL60 (31)	84.5	7			47.9	8			500	
437	230980	1802	AL60 (31)			124.20	4			9.49	17	500	
438	230980	1808	AS130 (24)			120.6	5			360.9	7	500	
439	230980	1811	AS130 (24)	564.1	6			494.3	4			500	
440	230980	1817	RS130 (25)	478.8	5			836.7	9			500	
441	230980	1822	RS130 (25)			305.8	3			108.3	12	500	
442	230980	1826	SS130 (26)			364.8	5			444.1	7	500	
443	230980	1829	SS130 (26)	293.8	5			864.3	8			500	
444	230980	1835	STL60A(21)	93.0	9			70.8	6			500	
445	230980	1838	STL60A(21)			91.4	4			20.9	12	500	
446	230980	1844	STL60B(22)			93.60	4			3.60	23	500	
447	230980	1846	STL60B(22)	88.9	9			62.3	7			500	
448	230980	1854	CU45 (7)			61.20	7			.49	51	14000	
449	230980	2011	CU45 (7)	89.2	12			25.2	13			1000	
450	230980	2016	CU45 (7)			60.30	8			.51	53	500	
451	230980	2023	STL99 (23)			220.6	5			190.4	9	1000	
452	230980	2029	STL99 (23)	242.0	8			347.5	5			500	
453	230980	2034	ZN60 (35)	141.5	6			48.5	8			500	
454	230980	2038	ZN60 (35)			89.70	5			8.79	15	500	
455	230980	2042	NOISE (99)			1.07	432			.49	761	1500	FISH
456	230980	2050	NOISE (99)	13.6	225			9.4	233			1500	FISH
457	230980	2058	NOISE (99)	16.9	230			14.9	206			5000	FISH
458	230980	2134	NOISE (99)			19.4	170			10.2	192	1000	FISH
459	230980	2141	RS130 (25)			338.1	7			67.2	30	500	
460	230980	2145	RS130 (25)	452.0	7			872.0	11			500	
461	230980	2148	RS130 (25)			345.1	3			58.6	24	3000	
462	260980	1324	CU35A (1)	30.1	21			34.4	14			500	
463	260980	1327	CU35A (1)			47.1	9			47.7	11	1000	
464	260980	1333	CU35B-(3)			58.3	6			41.8	10	500	TILT 20
465	260980	1337	CU35B-(3)	15.8	30			36.8	14			500	TILT 20

TABLE 44. (CONTINUED)

466	260980	1341	CU35C-(5)	30.5	41			33.0	25			500	TILT 10
467	260980	1344	CU35C-(5)			43.1	6			45.6	9	500	TILT 10
468	260980	1348	CU50A (8)			79.0	6			42.6	11	500	
469	260980	1352	CU50A (8)	112.7	9			113.8	7			500	
470	260980	1356	CU50B (9)	118.7	10			122.2	8			500	
471	260980	1400	CU50B (9)			81.9	4			19.5	15	500	
472	260980	1404	CU50C (11)			82.8	5			29.3	12	500	
473	260980	1407	CU50C (11)	113.0	8			119.2	6			500	
474	260980	1412	CU35A (1)			45.5	8			41.9	11	500	
475	260980	1415	CU35A (1)	30.0	19			34.1	14			500	
476	260980	1419	CU35B-(3)	11.6	28			35.7	13			500	TILT 10
477	260980	1422	CU35B-(3)			57.5	5			44.8	11	500	TILT 10
478	260980	1426	CU35B-(3)			38.4	6			37.7	10	500	TILT 90
479	260980	1429	CU35B-(3)	38.6	19			25.4	21			500	TILT 90
480	260980	1433	CU35B-(3)	23.4	22			37.0	13			500	TILT 0
481	260980	1436	CU35B-(3)			56.6	6			42.1	11	500	TILT 0
482	260980	1440	CU35A (1)			42.3	7			43.3	11	500	
483	260980	1443	CU35A (1)	30.7	23			33.4	15			500	
484	260980	1447	CU35B-(3)	38.3	23			25.9	21			500	TILT 90
485	260980	1450	CU35B-(3)			38.6	6			39.5	11	500	TILT 90
486	260980	1454	CU50C (11)			78.8	6			22.6	16	500	
487	260980	1525	CU50C (11)			85.6	5			27.3	14	500	
488	260980	1529	CU50C (11)	120.0	10			132.5	9			1500	
489	260980	1538	AL60 (31)	68.2	20			54.0	17			500	
490	260980	1541	AL60 (31)			174.80	7			8.42	35	500	
491	260980	1545	ZN60 (35)			104.50	5			7.36	29	500	
492	260980	1548	ZN60 (35)	148.5	9			55.2	12			500	
493	260980	1552	BRS60 (33)	204.2	11			195.7	12			500	
494	260980	1555	BRS60 (33)			109.7	4			15.7	18	500	
495	260980	1559	CU35A (1)			46.3	12			46.7	15	500	
496	260980	1603	CU35A (1)	33.2	36			37.9	33			500	
497	260980	1606	CU35B-(3)	41.4	33			28.7	35			500	TILT 90
498	260980	1609	CU35B-(3)			41.4	17			42.5	16	500	TILT 90
499	260980	1614	AL60 (31)			88.70	12			5.65	49	500	
500	260980	1654	NOISE (99)			.14	318			.46	354	500	
501	260980	1658	NOISE (99)	2.00	110			2.49	100			500	
502	260980	1702	ZN60 (35)	142.4	18			38.7	26			500	
503	260980	1705	ZN60 (35)			99.9	6			11.5	26	500	
504	260980	1708	ZN60 (35)	143.1	10			49.4	11			500	

TABLE 44. (CONTINUED)

505	260980	1729	NOISE (99)	214.0	244			175.7	132			1000	BUBBLES
506	260980	1735	NOISE (99)			.45	108			.37	87	1500	
507	300980	939	NOISE (99)	.65	138			.25	124			1500	WARMUP
508	300980	949	NOISE (99)			.057	82			.220	78	2000	
509	300980	959	NOISE (99)	.380	101			.085	147			1500	
510	300980	1008	CU35A (1)	29.0	10			32.7	9			500	
511	300980	1011	CU35A (1)			44.9	7			41.6	11	500	
512	300980	1015	CU35B-(3)			55.9	6			41.4	9	500	TILT 5
513	300980	1018	CU35B-(3)	24.9	10			35.9	7			500	TILT 5
514	300980	1023	CU35C-(5)	29.4	12			32.4	9			500	TILT 10
515	300980	1027	CU35C-(5)			47.4	6			42.2	9	500	TILT 10
516	300980	1031	CU35B-(3)			59.0	6			39.5	8	500	TILT 45
517	300980	1034	CU35B-(3)	9.99	20			35.10	8			500	TILT 45
518	300980	1039	CU35B-(3)	39.9	8			24.3	9			500	TILT 90
519	300980	1042	CU35B-(3)			39.2	5			34.7	8	500	TILT 90
520	300980	1046	CU35C-(5)			40.7	6			36.5	12	500	TILT 90
521	300980	1050	CU35C-(5)	26.3	15			29.7	12			500	TILT 90
522	300980	1055	ZN60 (35)	151.6	11			48.8	9			500	
523	300980	1058	ZN60 (35)			95.20	6			8.70	20	500	
524	300980	1102	BRS60 (33)			101.0	6			13.2	16	500	
525	300980	1106	BRS60 (33)	197.6	7			178.1	5			500	
526	300980	1110	AL60 (31)	48.4	36			48.5	21			500	
527	300980	1113	AL60 (31)			164.50	10			6.61	32	500	
528	300980	1120	CU60 (12)			25.3	6			120.6	9	500	
529	300980	1123	CU60 (12)	148.6	7			101.9	5			500	
530	300980	1128	CU45 (7)	84.8	9			24.1	11			500	
531	300980	1131	CU45 (7)			62.00	5			.45	44	500	
532	300980	1135	NOISE (99)			.040	111			.032	107	500	
533	300980	1138	NOISE (99)	.130	115			.037	155			500	
534	300980	1141	CU40 (6)	35.4	13			56.3	7			500	
535	300980	1145	CU40 (6)			28.80	6			9.49	15	500	
536	300980	1148	CU50C (11)			72.9	4			17.5	10	500	
537	300980	1152	CU50C (11)	95.2	9			111.6	5			500	
538	300980	1155	CU50A (8)	115.4	7			103.9	5			500	
539	300980	1158	CU50A (8)			75.9	5			30.5	9	500	
540	300980	1203	CU50B (9)			75.5	5			14.2	14	500	
541	300980	1206	CU50B (9)	108.7	6			113.0	4			500	
542	300980	1210	CU50C (11)	117.2	6			111.7	6			500	
543	300980	1213	CU50C (11)			76.5	4			22.8	10	500	

TABLE 44. (CONTINUED)

544	300980	1218	CU35B-(3)			37.5	6			31.4	10	500	TILT 90
545	300980	1221	CU35B-(3)	38.5	14			24.4	10			500	TILT 90
546	300980	1228	CU35B-(3)	29.9	17			35.9	8			500	TILT 0
547	300980	1231	CU35B-(3)			57.5	9			34.0	12	500	TILT 0
548	300980	1236	CU60 (12)			25.1	7			111.0	8	500	
549	300980	1239	CU60 (12)	150.3	8			104.0	6			1500	
550	300980	1249	SS130 (26)	278.8	5			829.9	5			500	
551	300980	1253	SS130 (26)			359.3	2			390.8	11	500	
552	300980	1302	RS130 (25)			265.0	4			65.0	13	1500	
553	300980	1310	RS130 (25)	498.8	10			760.6	4			2000	
554	300980	1323	AL60 (31)	65.2	12			52.1	13			500	
555	300980	1327	AL60 (31)			124.70	10			8.19	34	500	
556	300980	1334	SS130 (26)			366.8	4			433.0	10	500	TURNED 90
557	300980	1337	SS130 (26)	275.1	10			763.2	6			1000	TURNED 90
558	300980	1344	CU35B-(3)	28.5	17			36.7	11			500	TILT 0
559	300980	1347	CU35B-(3)			56.1	6			29.8	15	500	TILT 0
560	300980	1353	CU35B-(3)			36.7	6			30.1	15	500	TILT 90
561	300980	1357	CU35B-(3)	35.1	13			24.3	13			500	TILT 90
562	300980	1401	CU35A (1)	28.6	19			31.7	14			500	
563	300980	1404	CU35A (1)			42.2	8			33.7	13	500	
564	300980	1408	SS130 (26)			356.2	5			433.4	9	500	
565	300980	1412	SS130 (26)	302.3	6			741.5	7			500	
566	300980	1725	NOISE (99)	.17	109			.18	146			500	
567	300980	1728	NOISE (99)			.042	131			.054	108	500	
568	300980	1735	SS130 (26)			355.0	6			456.0	7	500	
569	300980	1739	SS130 (26)	322.0	4			824.0	5			500	
570	300980	1742	SS130 (26)	323.8	7			841.6	5			500	
571	300980	1745	SS130 (26)			350.2	3			496.8	3	500	
572	300980	1750	SKF2B (43)			30.6	9			13.6	16	500	
573	300980	1756	SKF2B (43)	51.6	8			48.0	6			500	

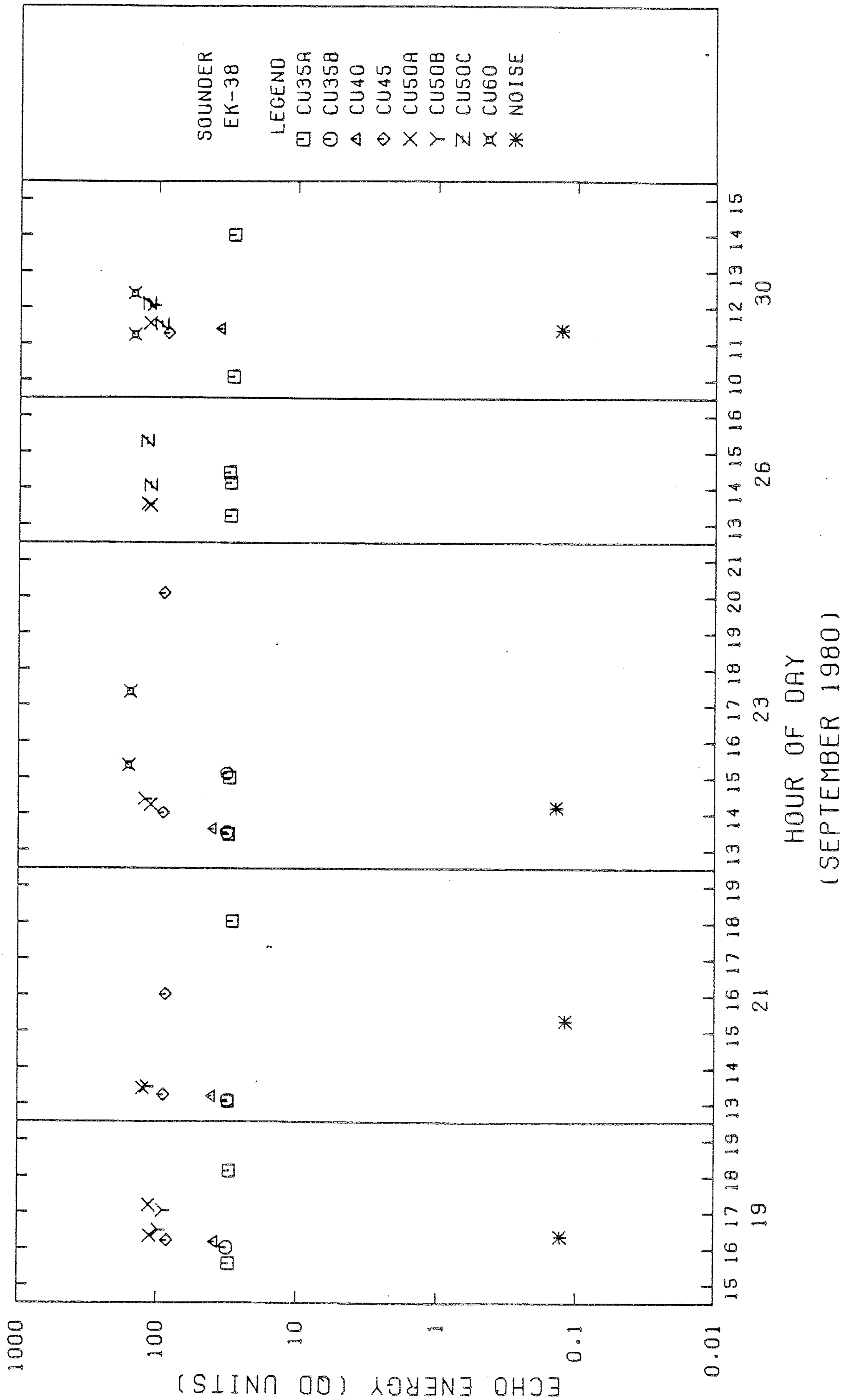


Fig. 8. Echo energy or backscattering cross sections in QD-units of eight copper spheres measured with the EK-38 echo sounder.

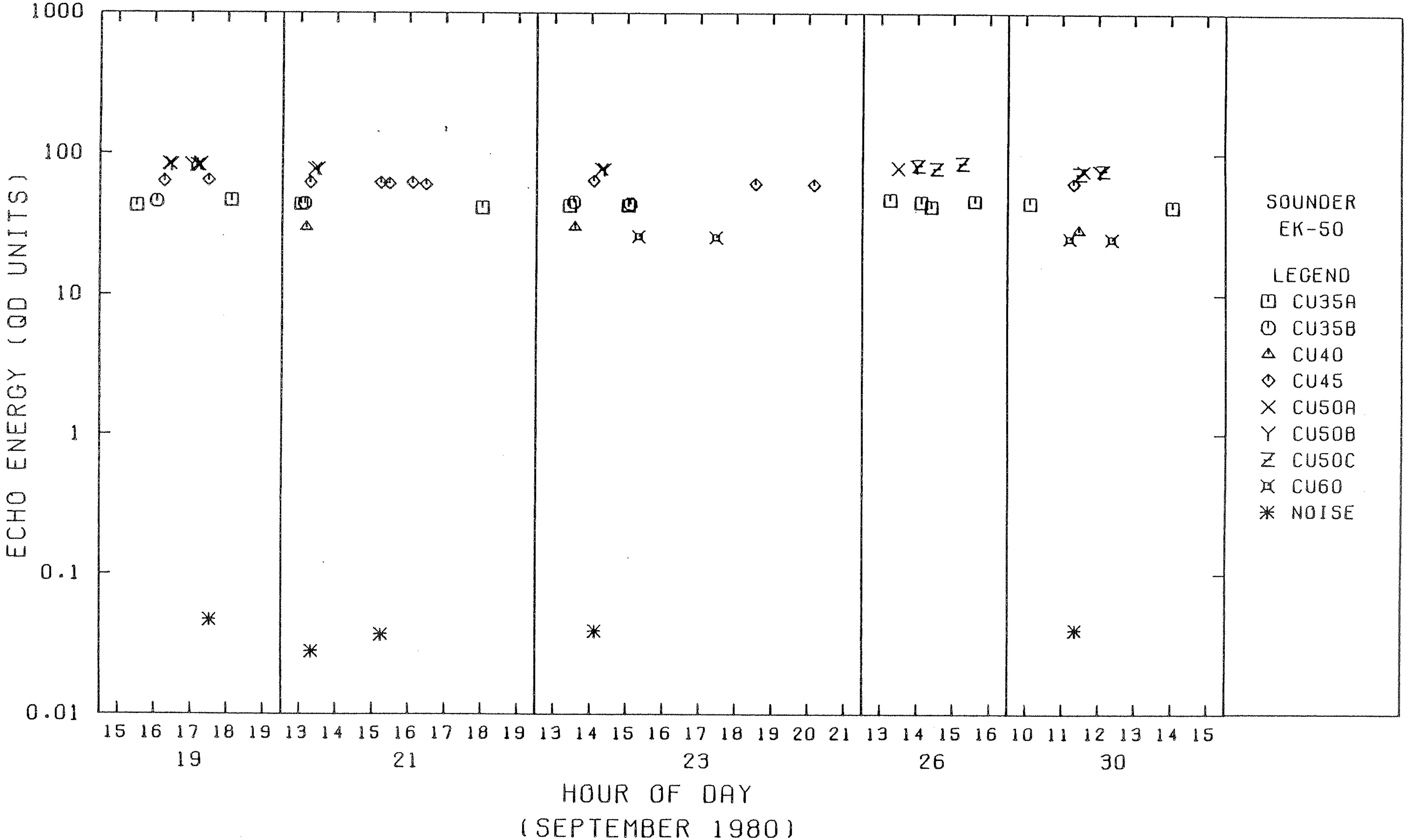


Fig. 9. Echo energy or backscattering cross sections in QD-units of eight copper spheres measured with the EK-50 echo sounder.

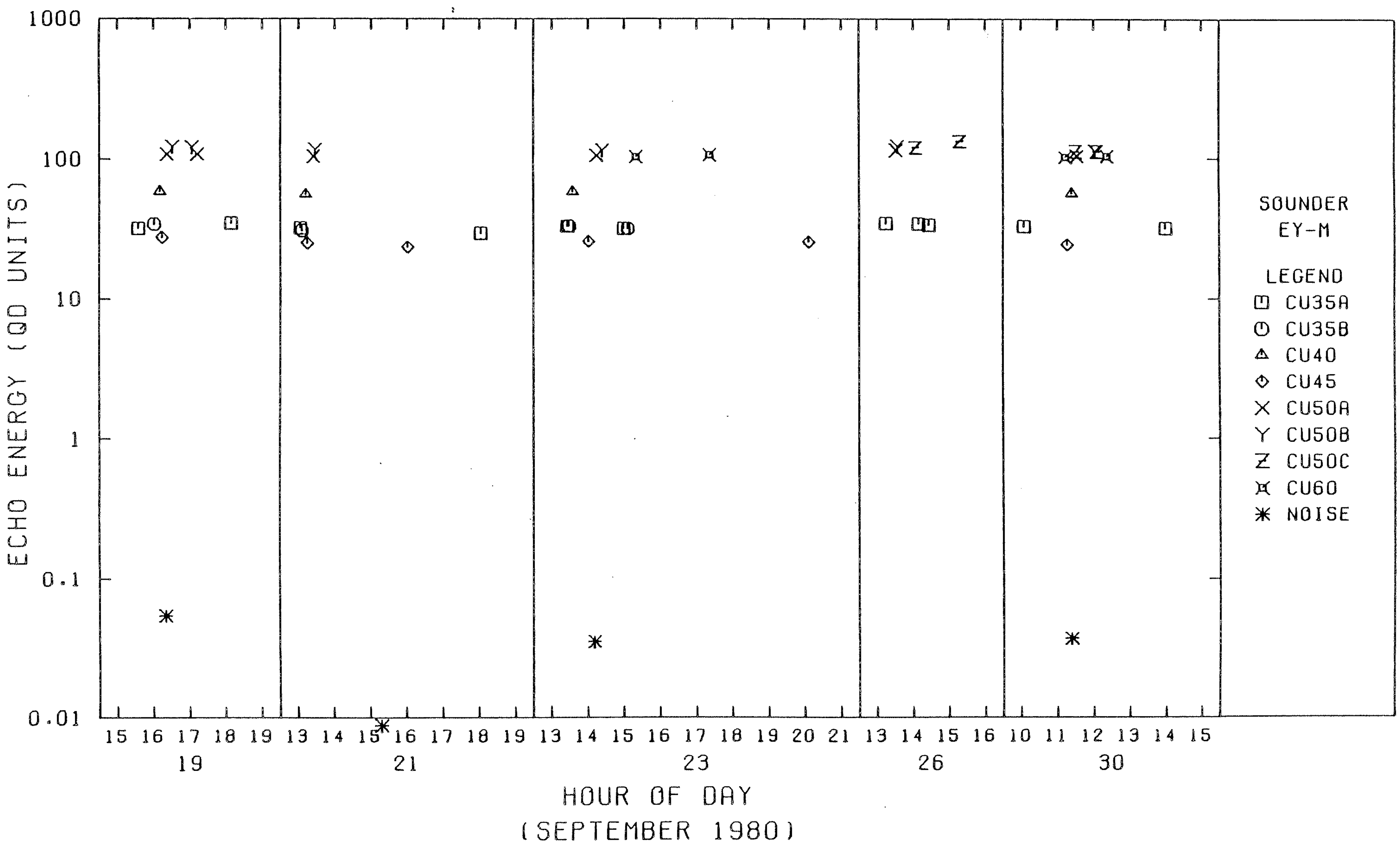


Fig. 10. Echo energy or backscattering cross sections in QD-units of eight copper spheres measured with the EY-M echo sounder.

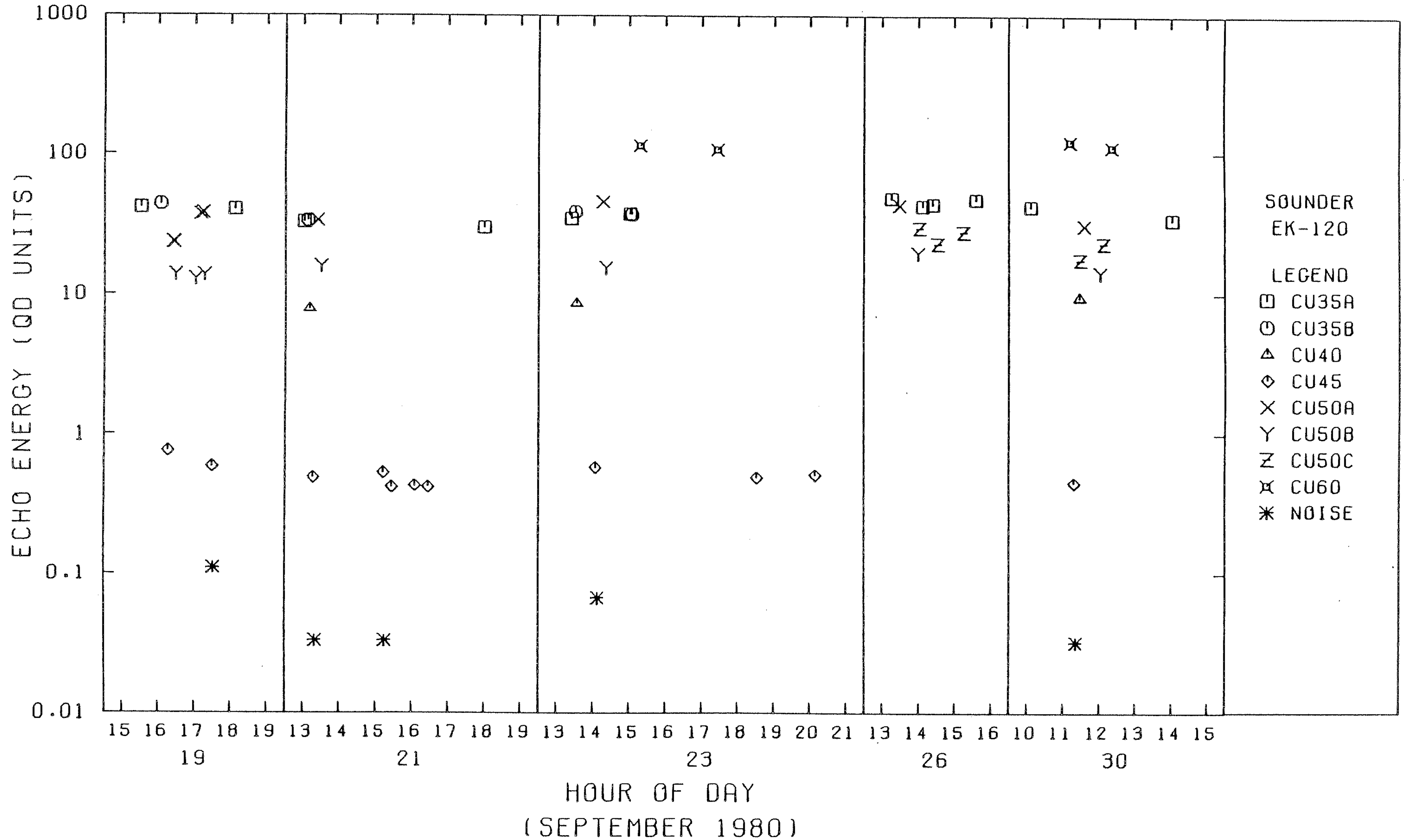


Fig. 11. Echo energy or backscattering cross sections in QD-units of eight copper spheres measured with the EK-120 echo sounder.

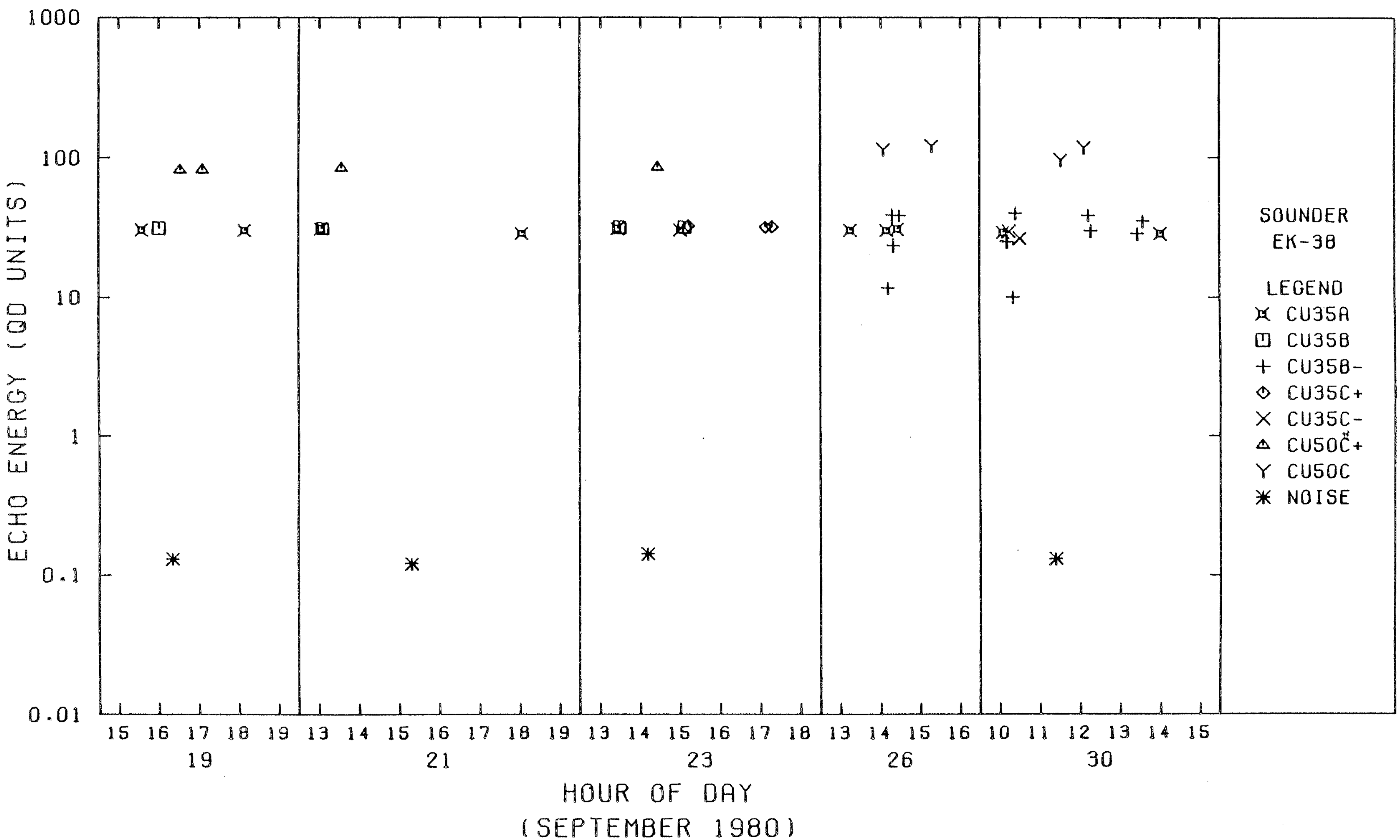


Fig. 12. Echo energy or backscattering cross sections in QD-units of seven copper spheres measured with the EK-38 echo sounder.

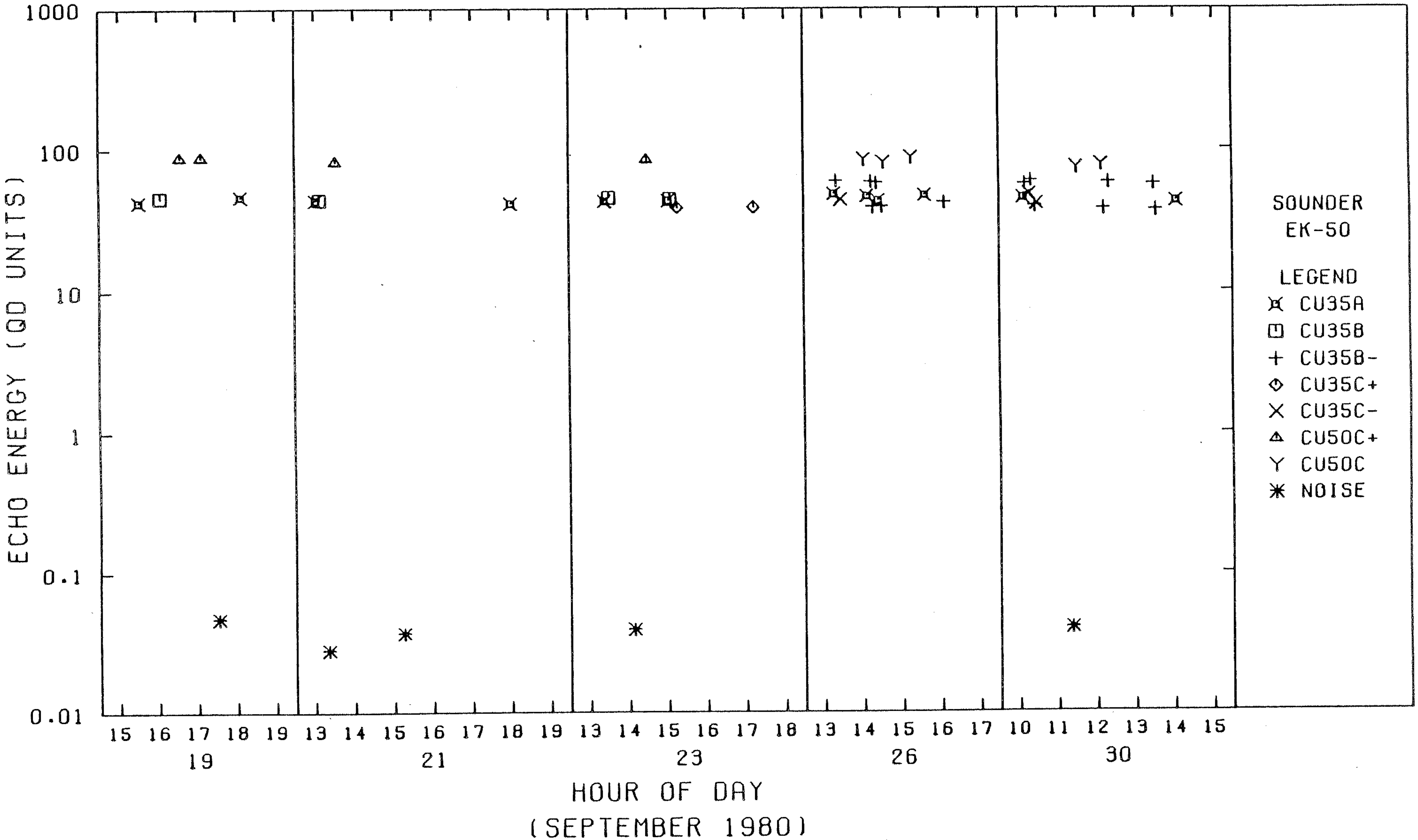


Fig. 13. Echo energy or backscattering cross sections in QD-units of seven copper spheres measured with the EK-50 echo sounder.

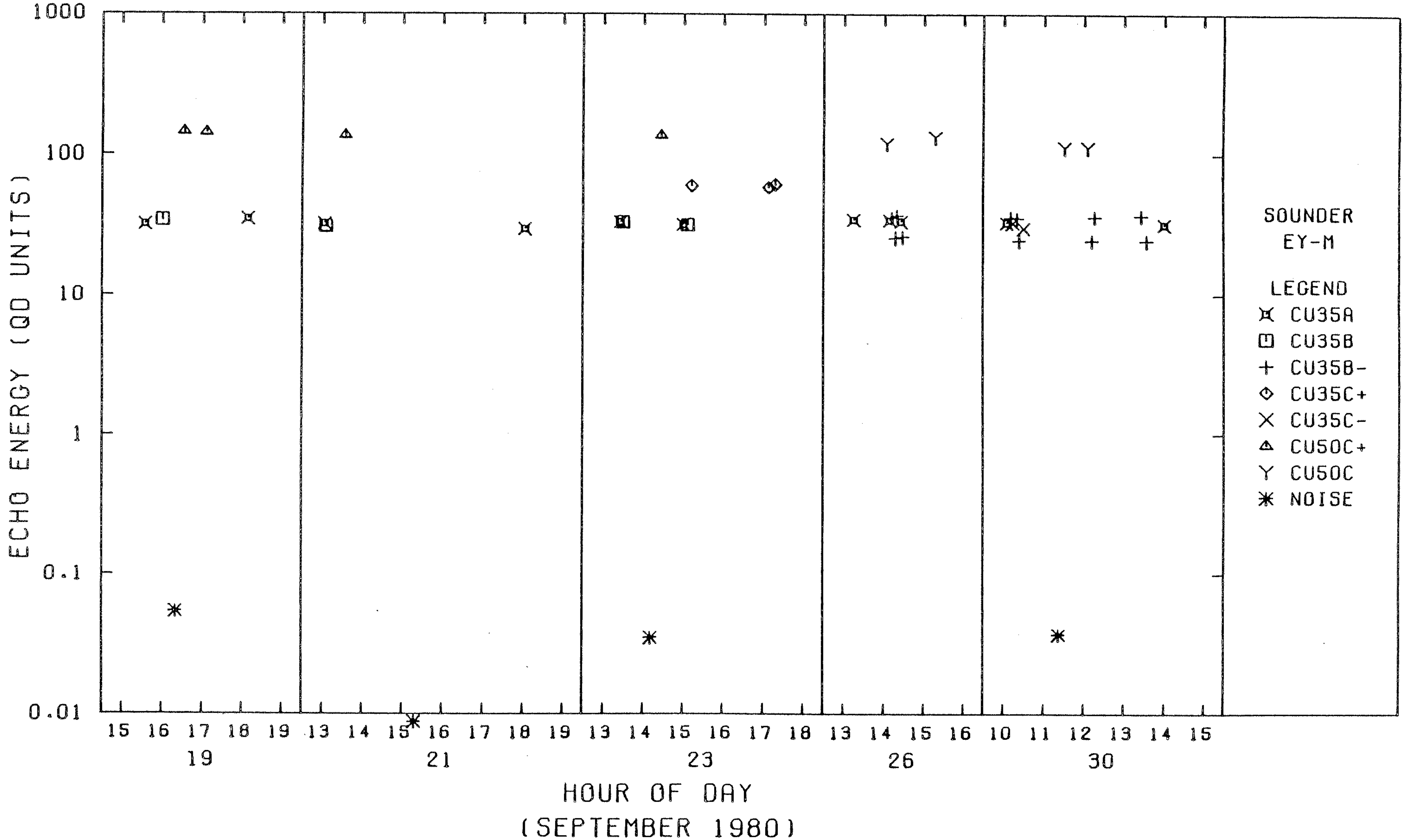


Fig. 14. Echo energy or backscattering cross sections in QD-units of seven copper spheres measured with the EY-M echo sounder.

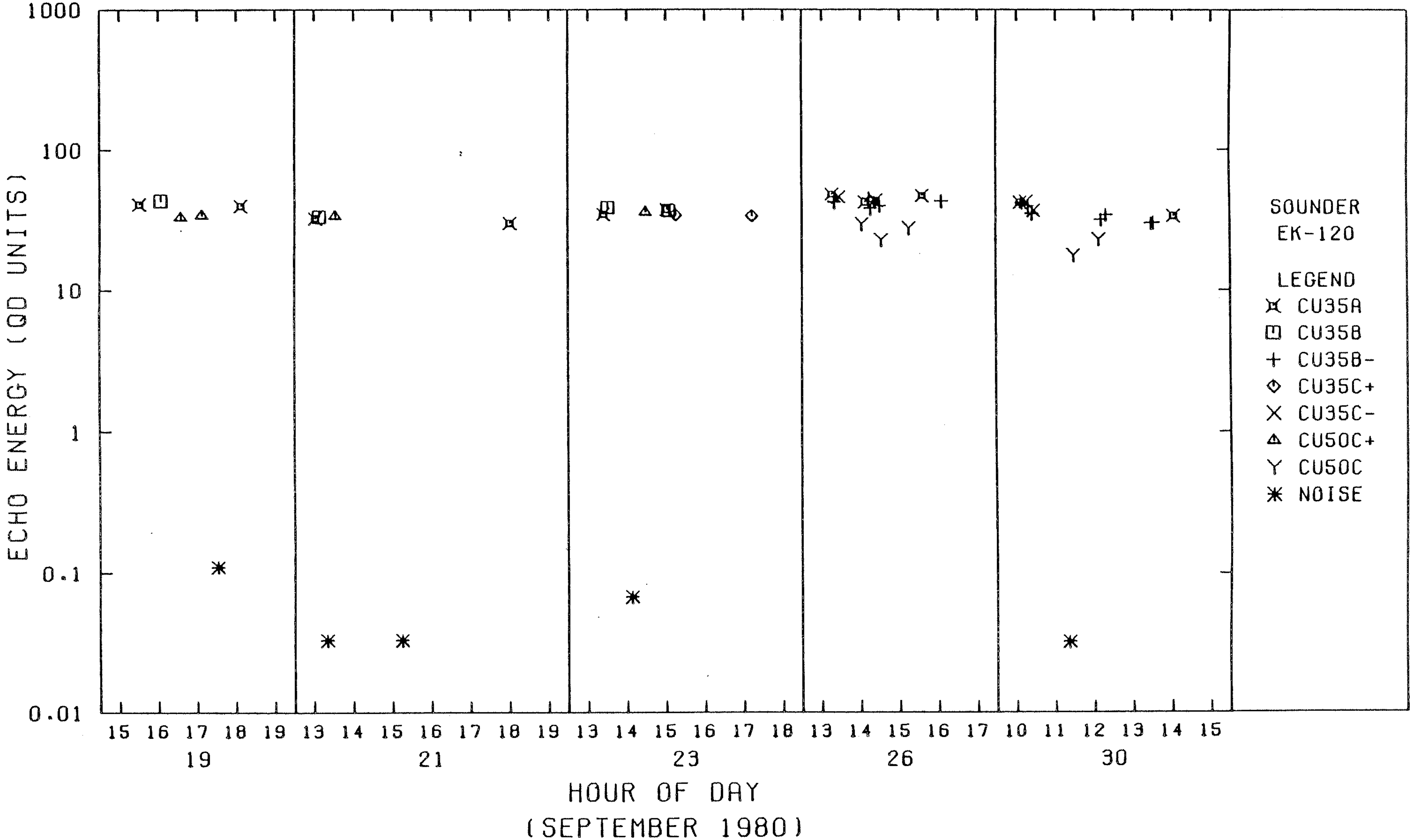


Fig. 15. Echo energy or backscattering cross sections in QD-units of seven copper spheres measured with the EK-120 echo sounder.

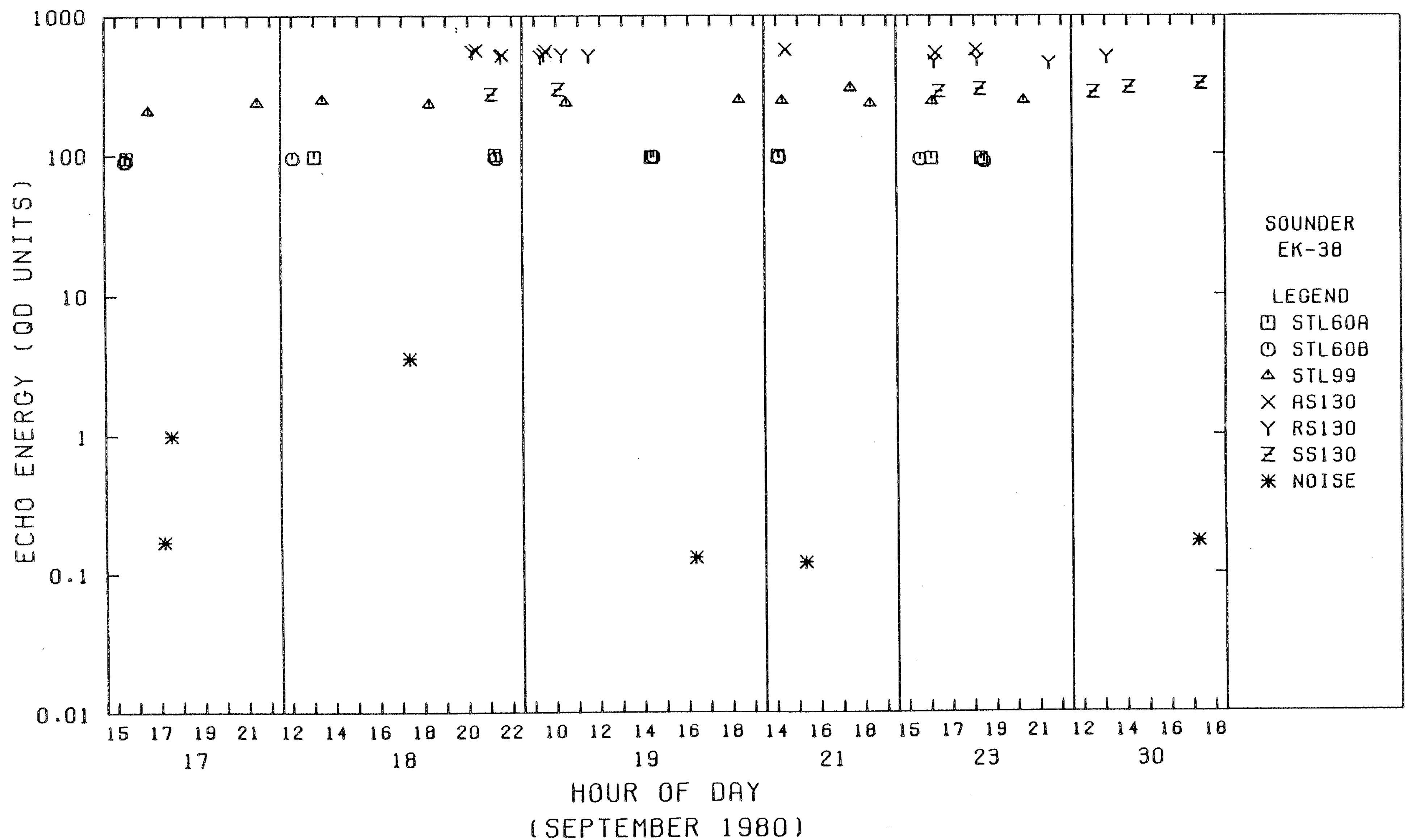


Fig. 16. Echo energy or backscattering cross sections in QD-units of six steel spheres measured with the EK-38 echo sounder.

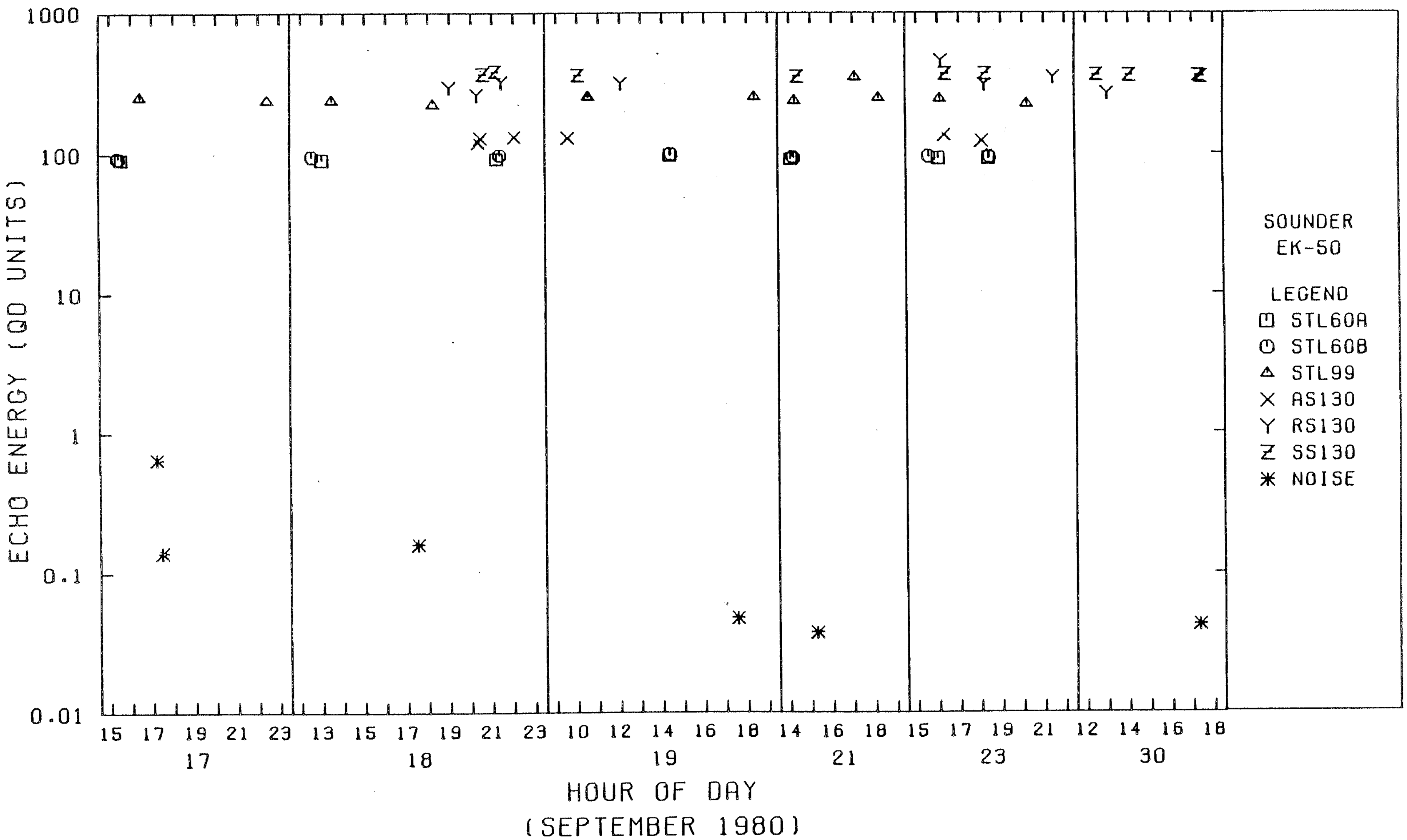


Fig. 17. Echo energy or backscattering cross sections in QD-units of six steel spheres measured with the EK-50 echo sounder.

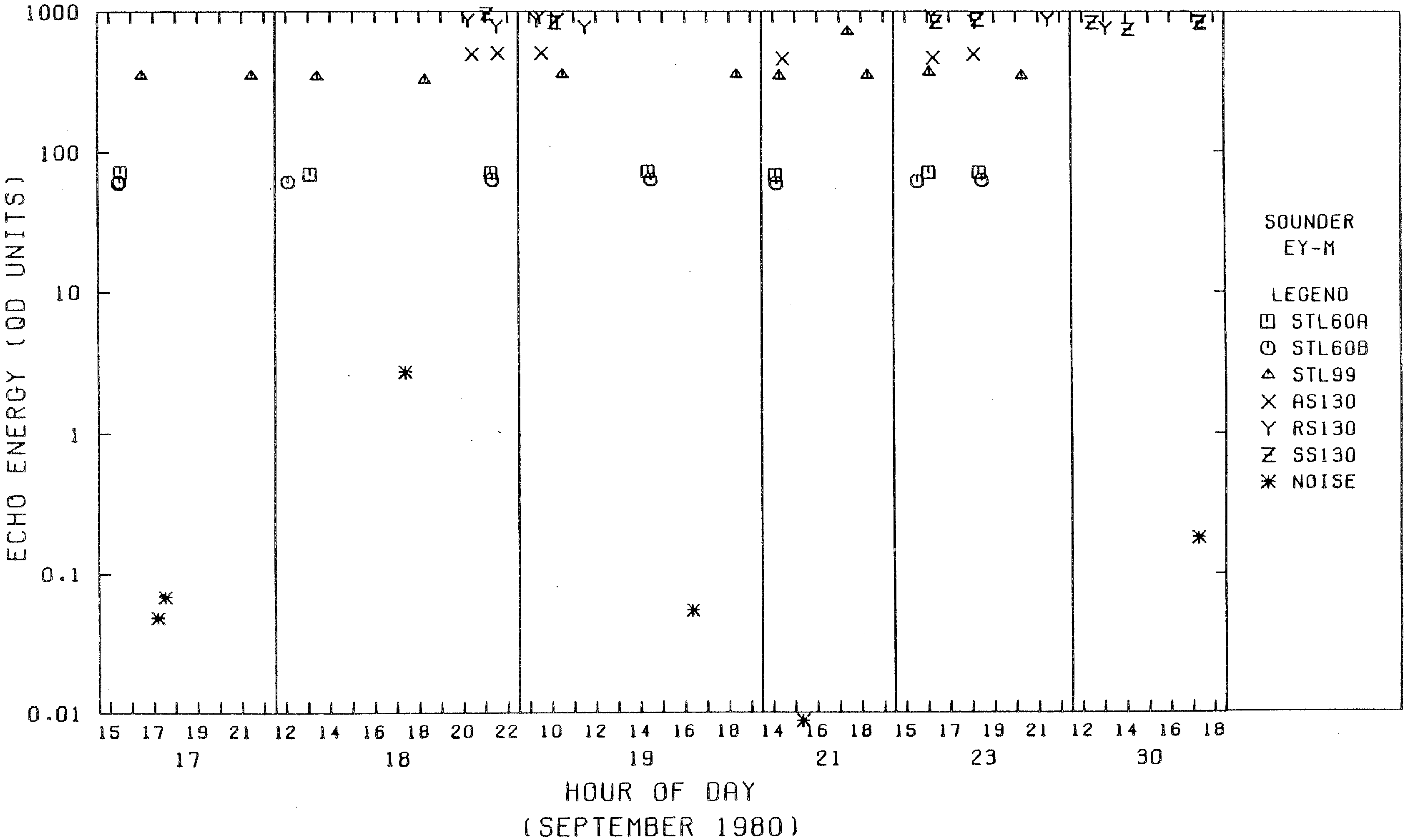


Fig. 18. Echo energy or backscattering cross sections in QD-units of six steel spheres measured with the EY-M echo sounder.

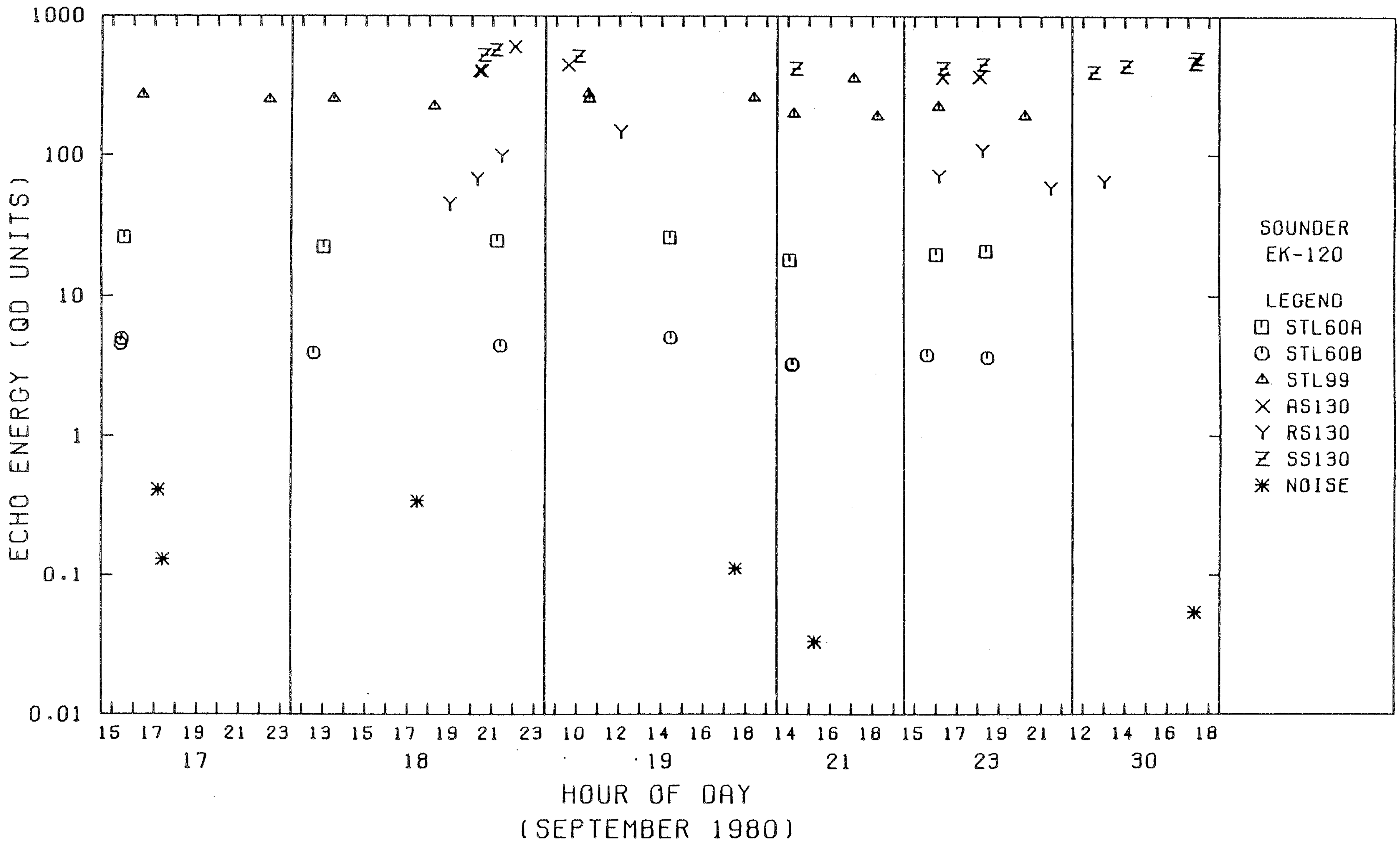


Fig. 19. Echo energy or backscattering cross sections in QD-units of six steel spheres measured with the EK-120 echo sounder.

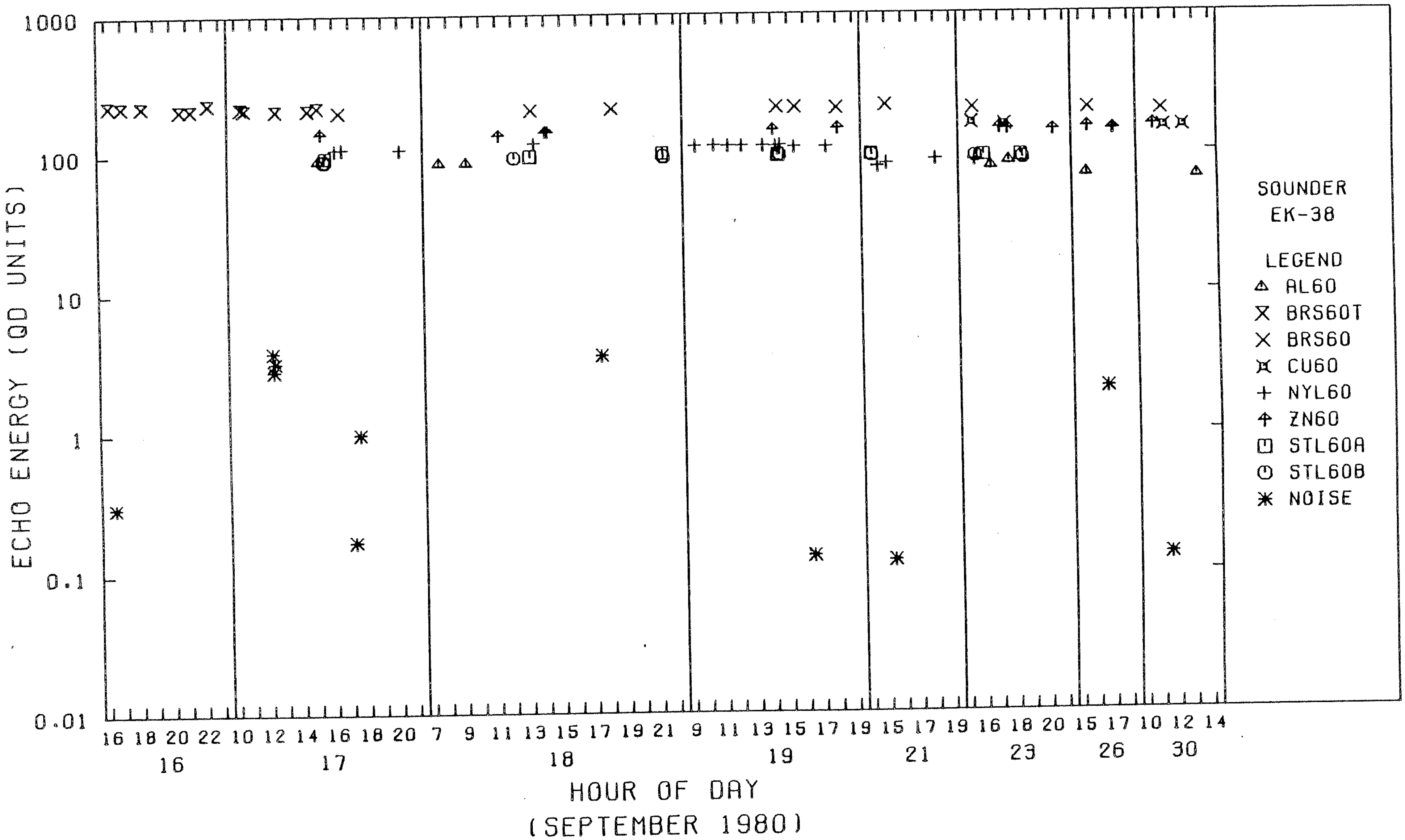


Fig. 20. Echo energy or backscattering cross sections in QD-units of eight 60 mm-diameter spheres measured with the EK-38 echo sounder.

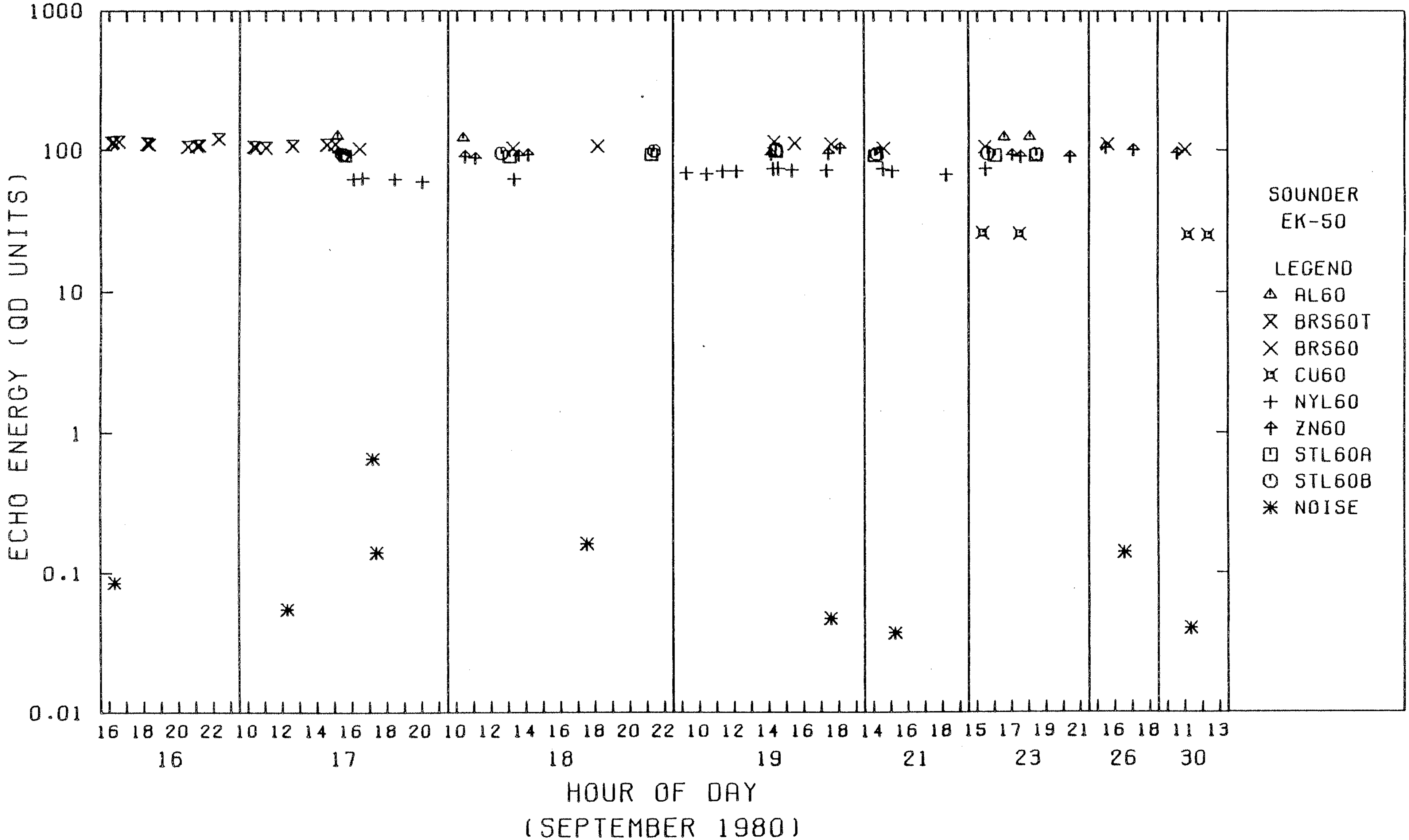


Fig. 21. Echo energy or backscattering cross sections in QD-units of eight 60 mm-diameter spheres measured with the EK-50 echo sounder.

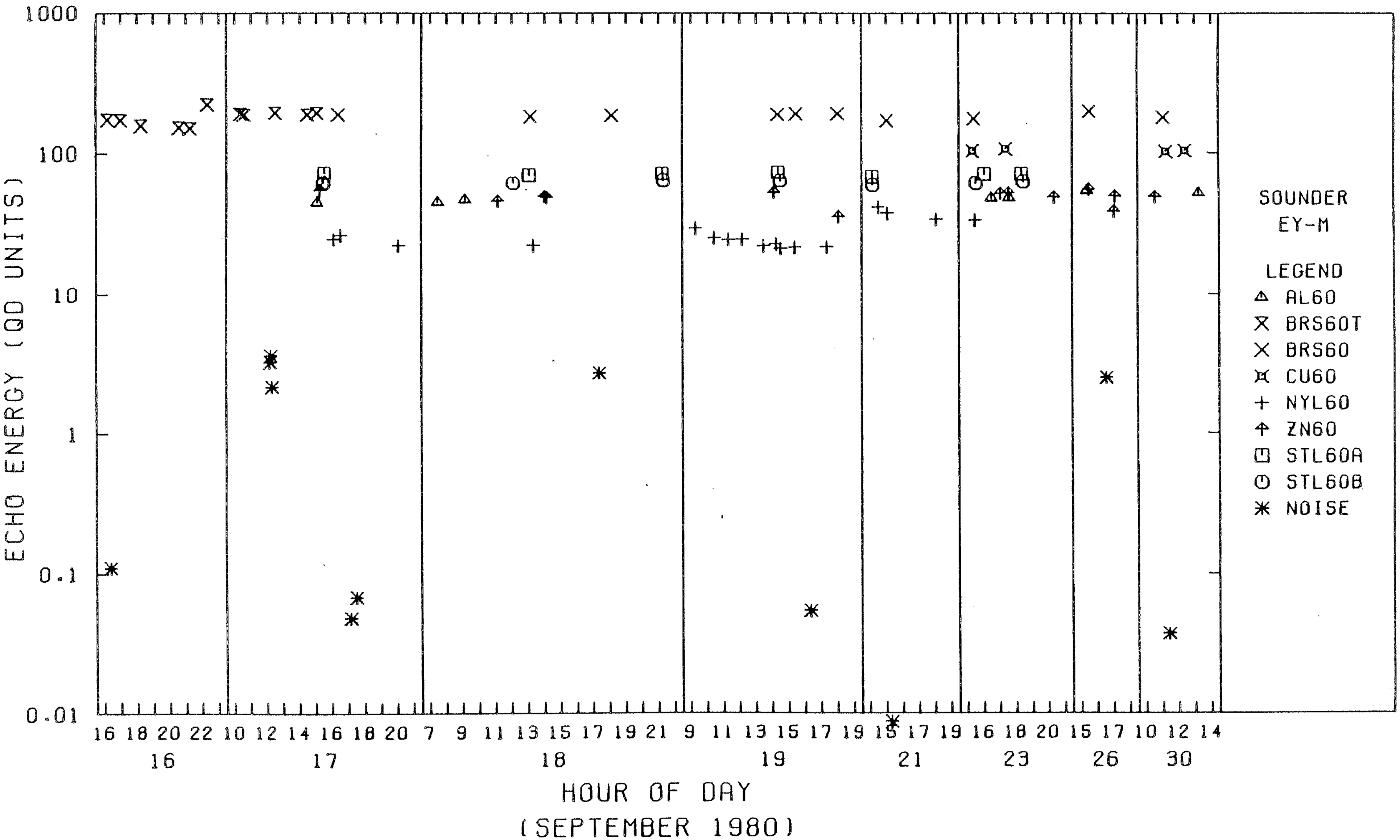


Fig. 22. Echo energy or backscattering cross sections in QD-units of eight 60 mm-diameter spheres measured with the EY-M echo sounder.

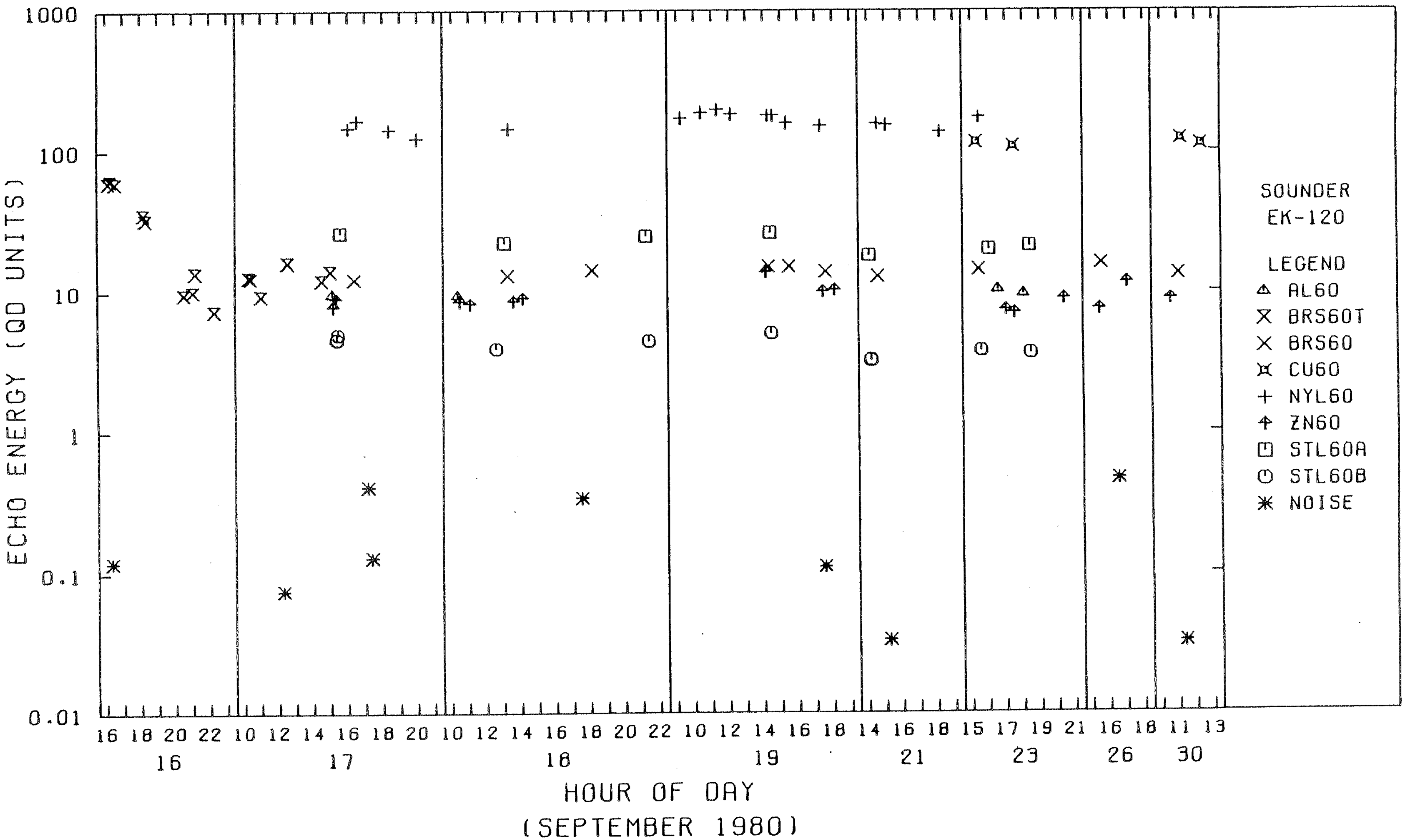


Fig. 23. Echo energy or backscattering cross sections in QD-units of eight 60 mm-diameter spheres measured with the EK-120 echo sounder.

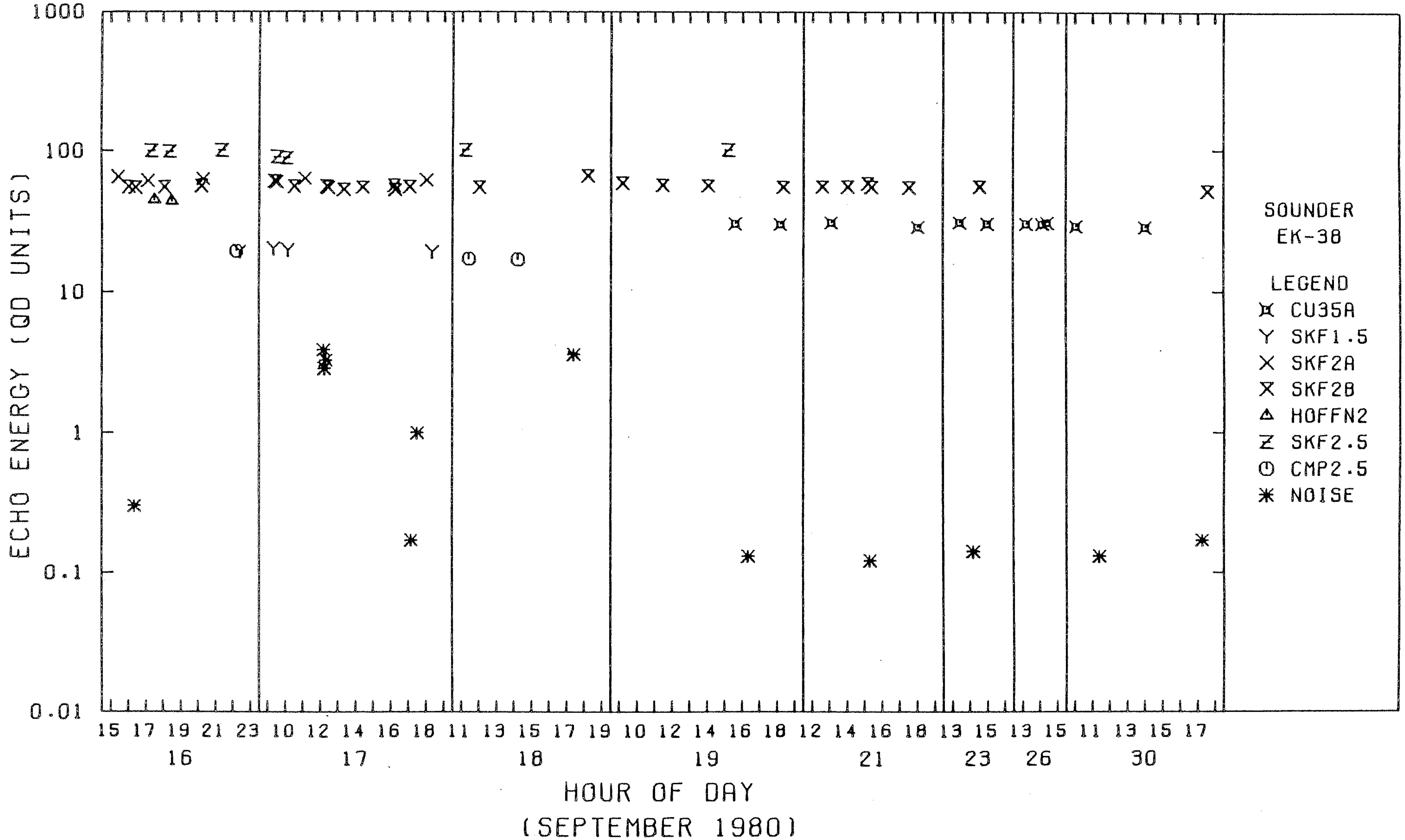


Fig. 24. Echo energy or backscattering cross sections in QD-units of six steel ball-bearings and a 35 mm-diameter copper sphere measured with the EK-38 echo sounder.

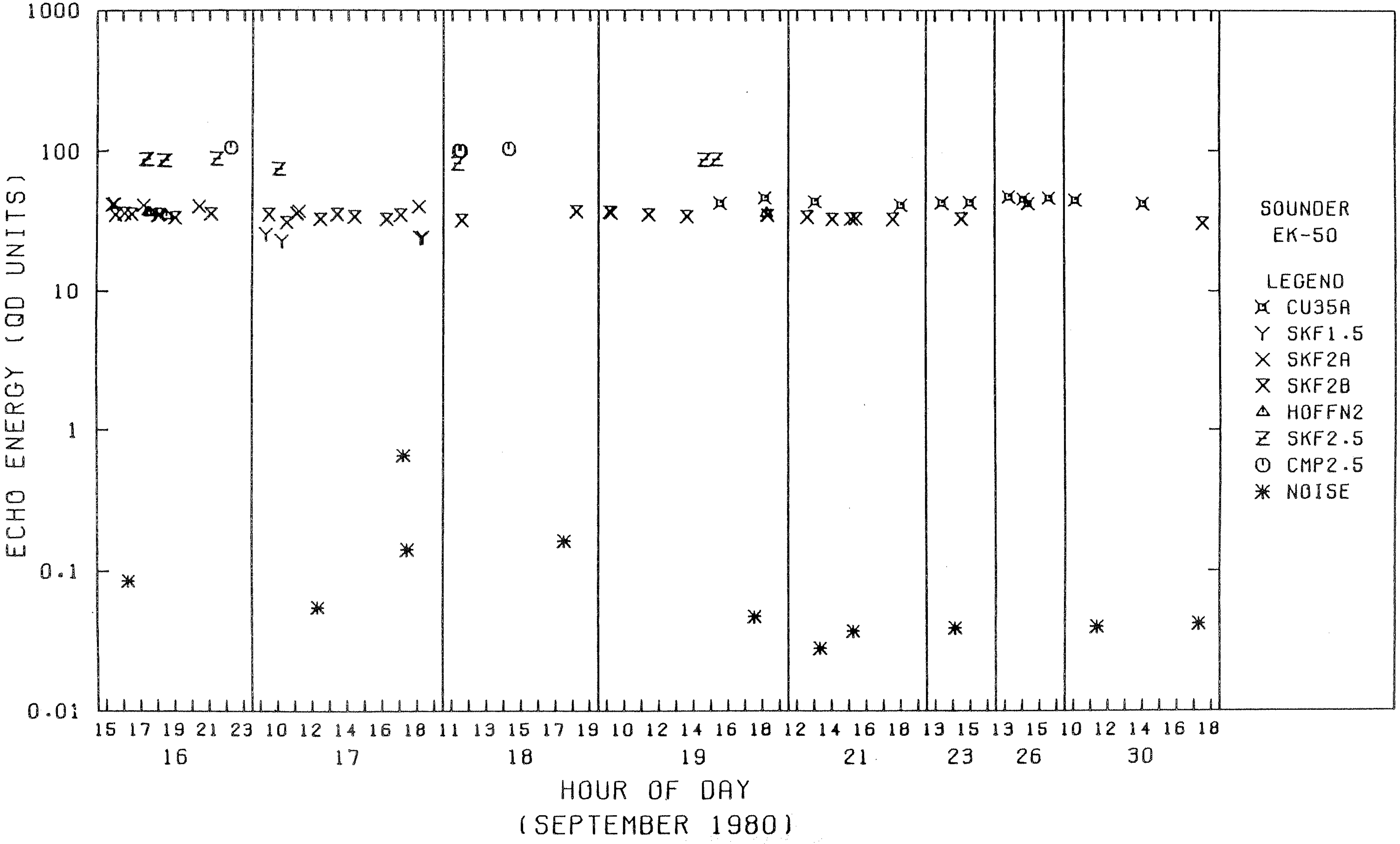


Fig. 25. Echo energy or backscattering cross sections in QD-units of six steel ball-bearings and a 35 mm-diameter copper sphere measured with the EK-50 echo sounder.

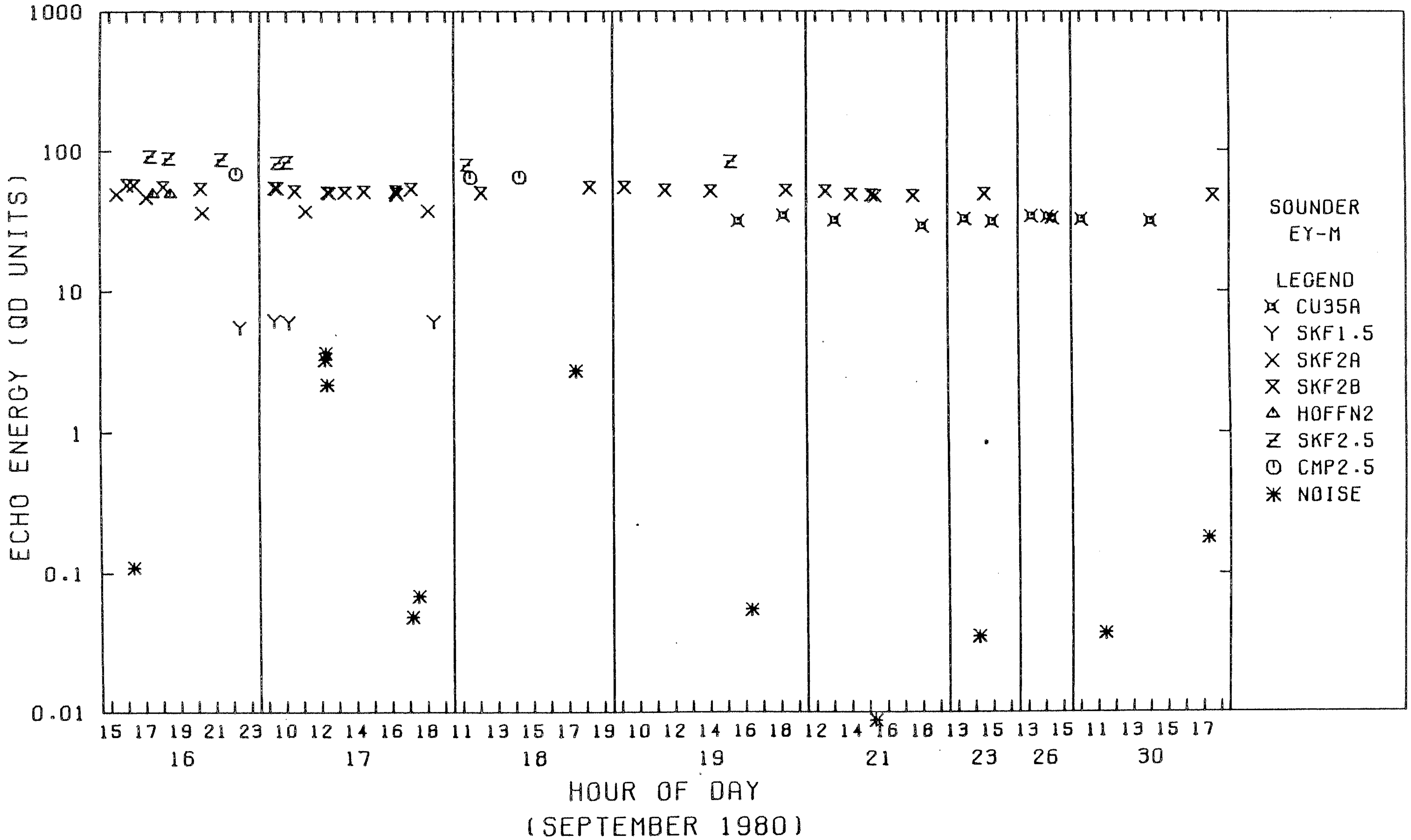


Fig. 26. Echo energy or backscattering cross sections in QD-units of six steel ball-bearings and a 35 mm-diameter copper sphere measured with the EY-M echo sounder.

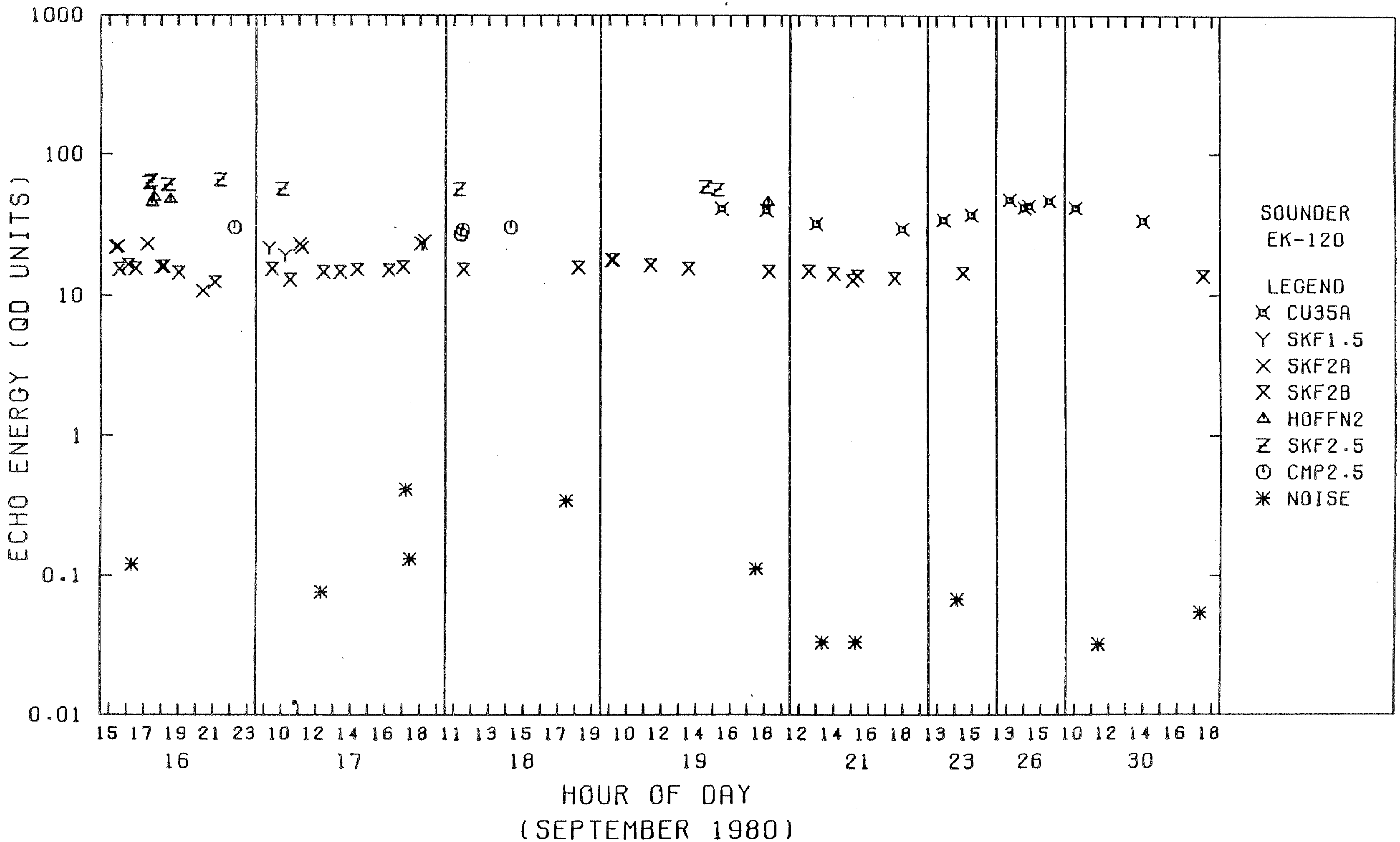
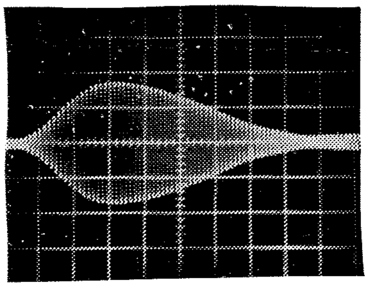
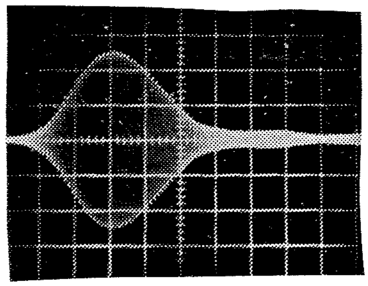


Fig. 27. Echo energy or backscattering cross sections in QD-units of six steel ball-bearings and a 35 mm-diameter copper sphere measured with the EK-120 echo sounder.

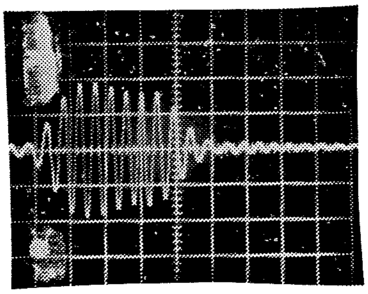
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

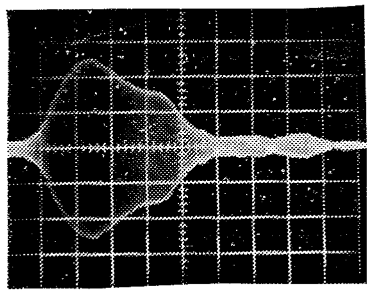
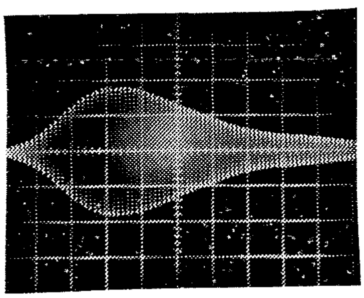
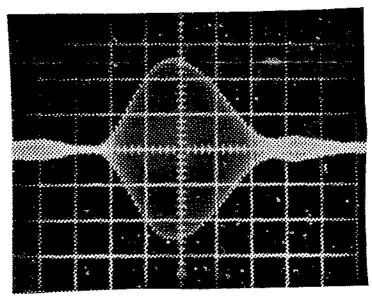


Fig. 28. Echo waveforms from sphere CU35A. Heading sequences: echo sounder, abscissa and ordinate scale sizes.

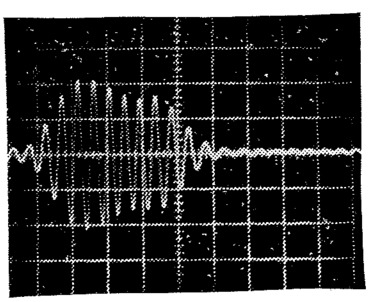
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

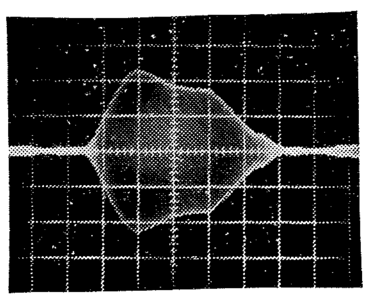
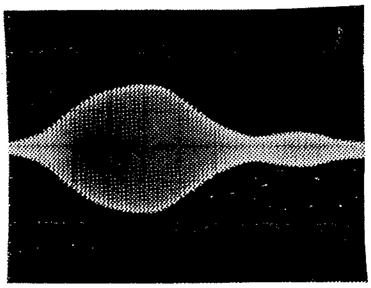
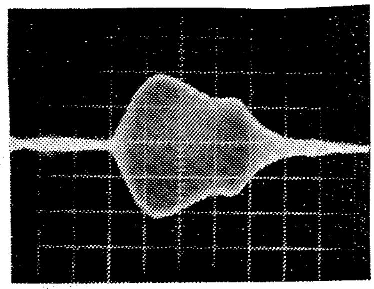


Fig. 29. Echo waveforms from sphere CU35B. Heading sequences: echo sounder and scale sizes.

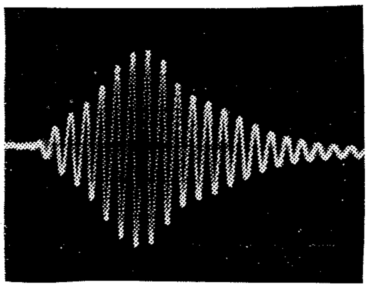
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

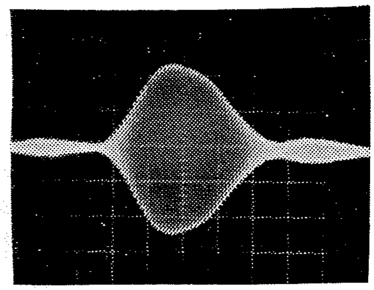
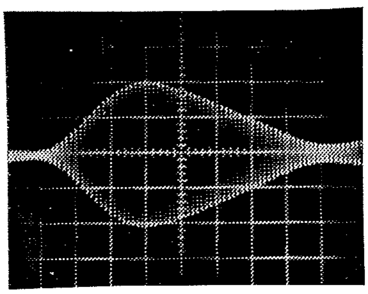
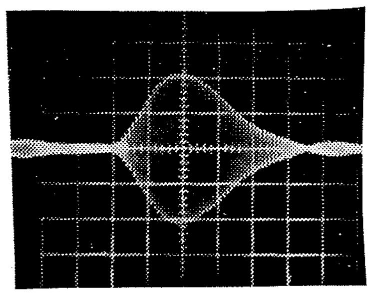


Fig. 30. Echo waveforms from sphere CU35C+. Heading sequences: echo sounder and scale sizes.

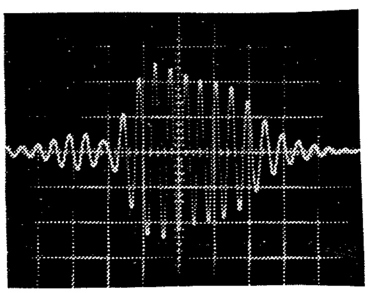
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.02 v

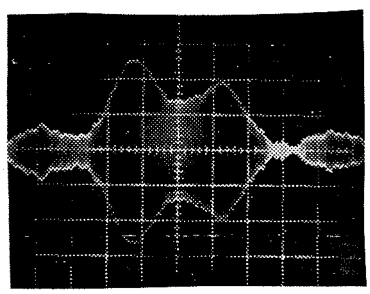
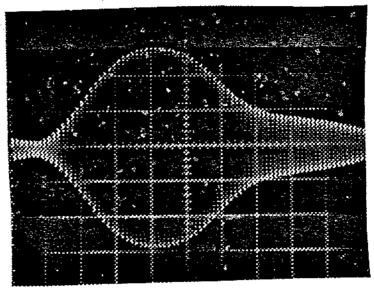
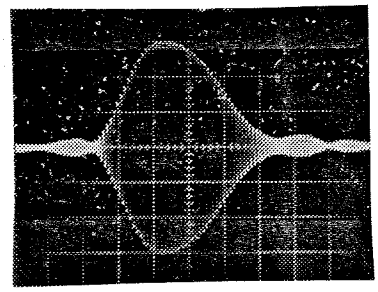


Fig. 31. Echo waveforms from sphere CU40. Heading sequences: echo sounder and scale sizes.

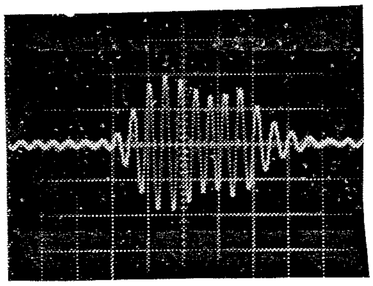
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

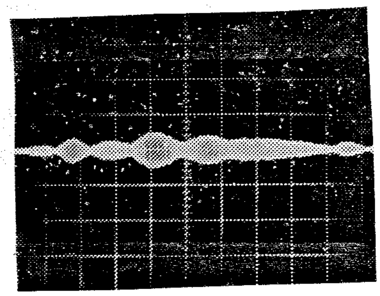
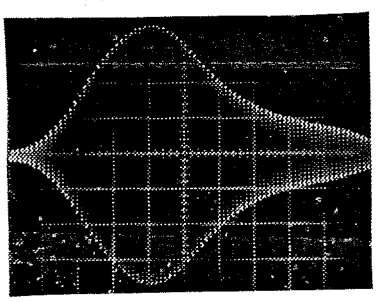
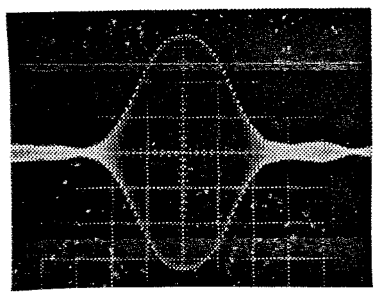


Fig. 32. Echo waveforms from sphere CU45. Heading sequences: echo sounder and scale sizes.

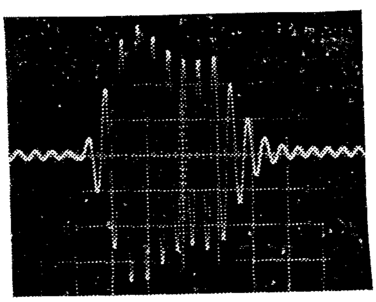
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

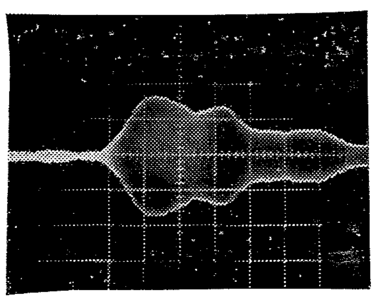
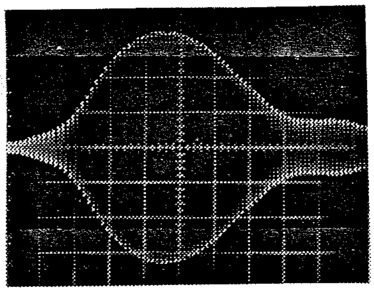
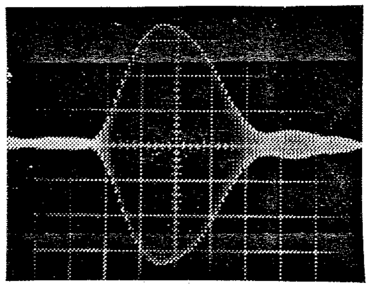


Fig. 33. Echo waveforms from sphere CU50A. Heading sequences: echo sounder and scale sizes.

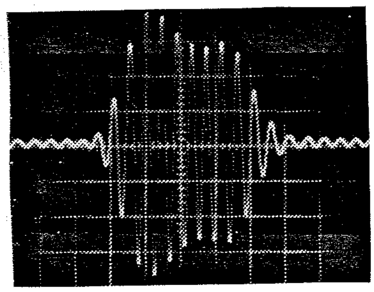
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

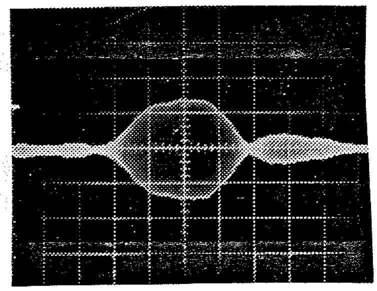
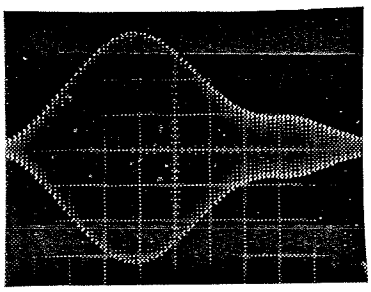
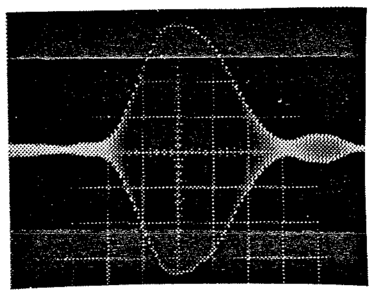


Fig. 34. Echo waveforms from sphere CU50B. Heading sequences: echo sounder and scale sizes.

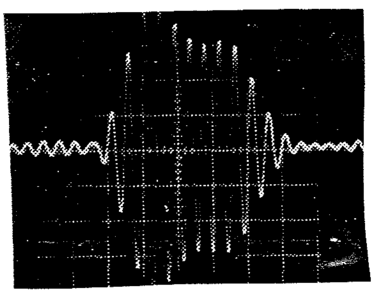
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

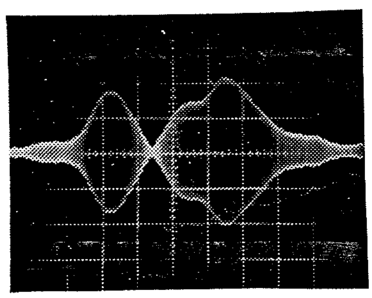
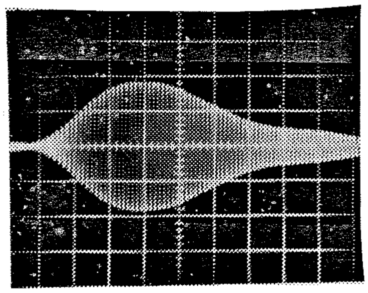
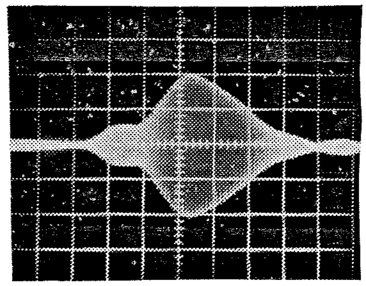


Fig. 35. Echo waveforms from sphere CU50C+. Heading sequences: echo sounder and scale sizes.

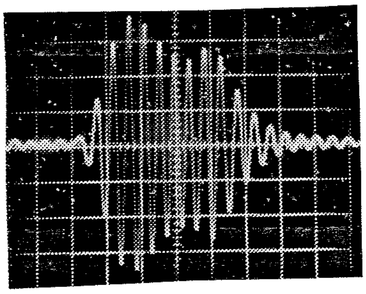
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.1 v

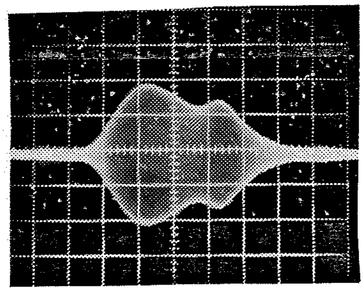
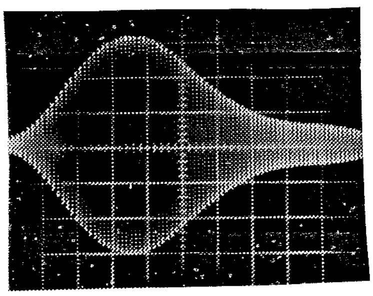
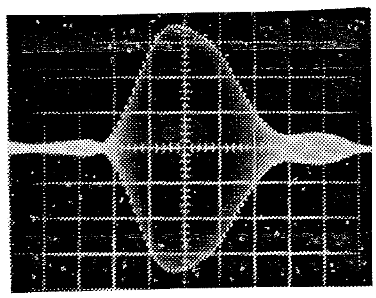


Fig. 36. Echo waveforms from sphere CU60. Heading sequences: echo sounder and scale sizes.

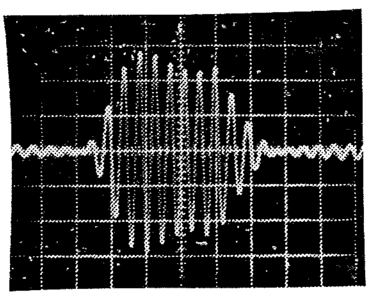
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

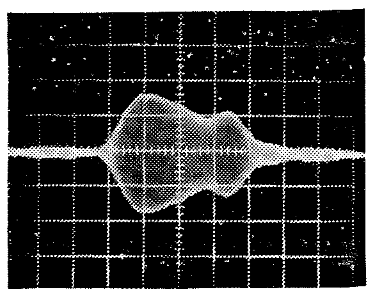
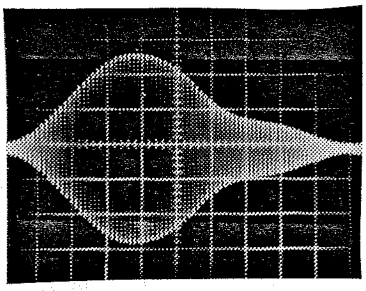
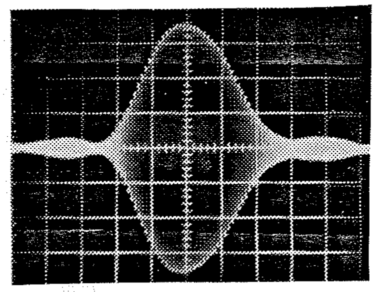


Fig. 37. Echo waveforms from sphere STL60A. Heading sequences: echo sounder and scale sizes.

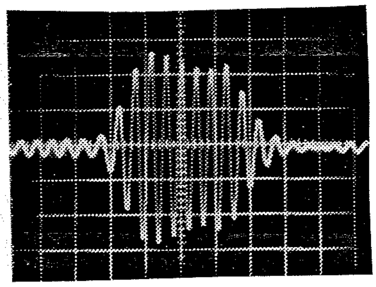
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.02 v

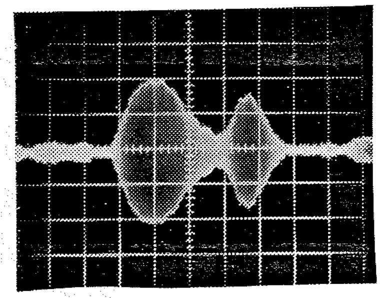
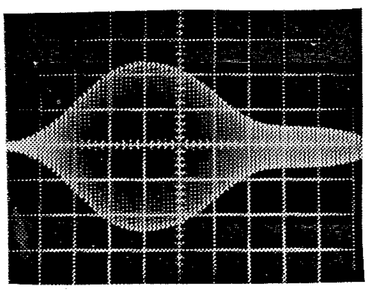
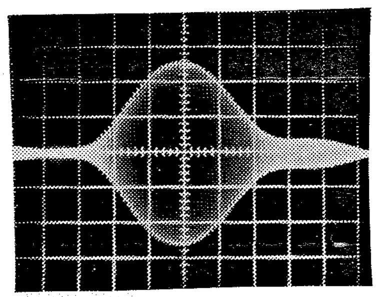


Fig. 38. Echo waveforms from sphere STL60B. Heading sequences: echo sounder and scale sizes.

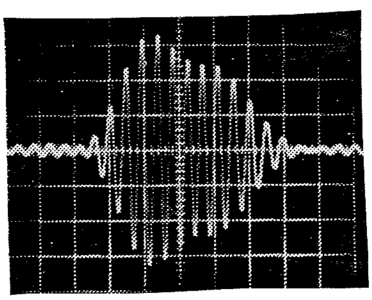
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.1 v



(c) EY-M 0.2 ms 0.1 v



(d) EK-120 0.2 ms 0.1 v

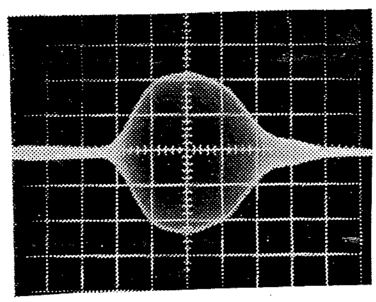
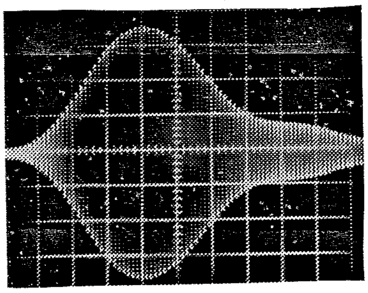
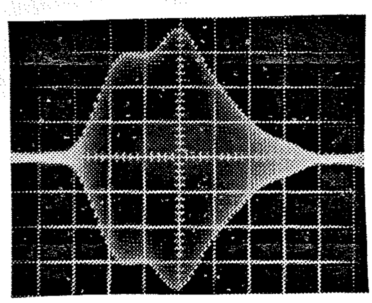


Fig. 39. Echo waveforms from sphere STL99. Heading sequences: echo sounder and scale sizes.

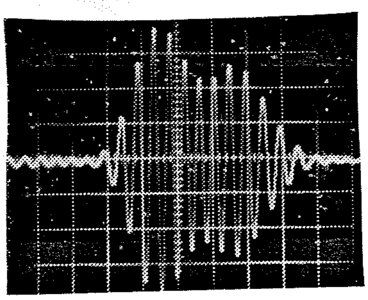
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.1 v



(d) EK-120 0.2 ms 0.1 v

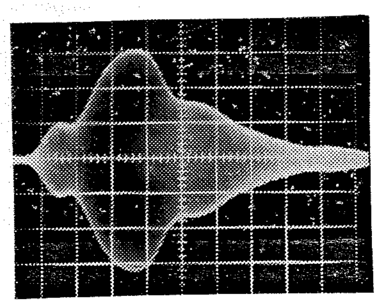
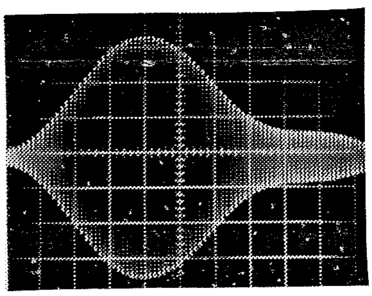
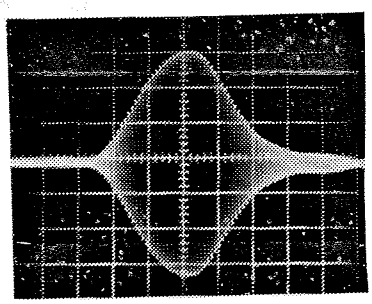


Fig. 40. Echo waveforms from sphere AS130. Heading sequences: echo sounder and scale sizes.

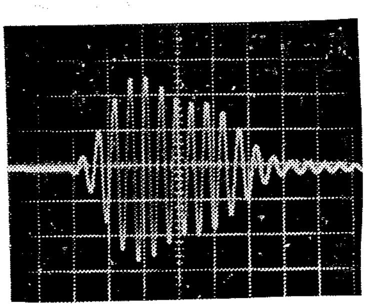
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.1 v



(c) EY-M 0.2 ms 0.2 v



(d) EK-120 0.2 ms 0.05 v

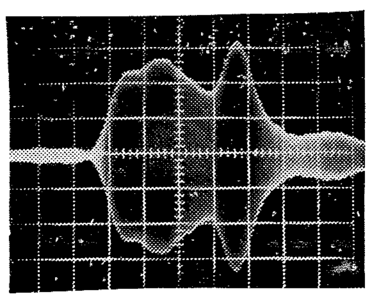


Fig. 41. Echo waveforms from sphere RS130. Heading sequences: echo sounder and scale sizes.

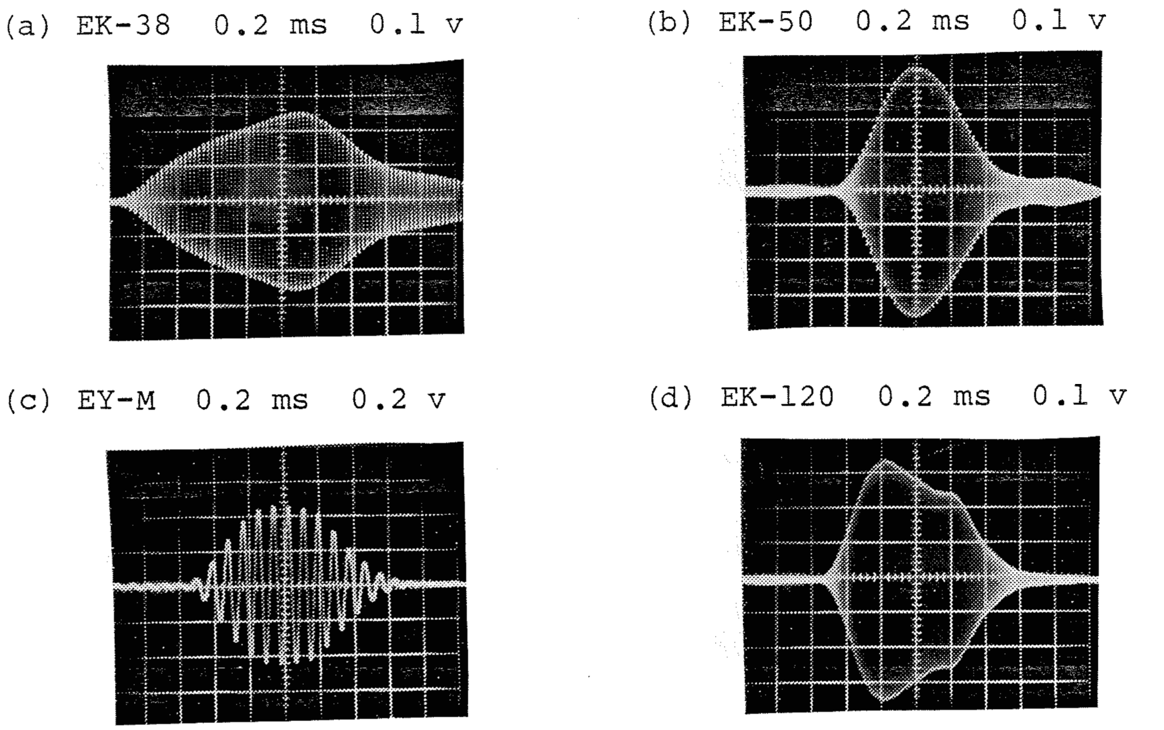


Fig. 42. Echo waveforms from sphere SS130. Heading sequences: echo sounder and scale sizes.

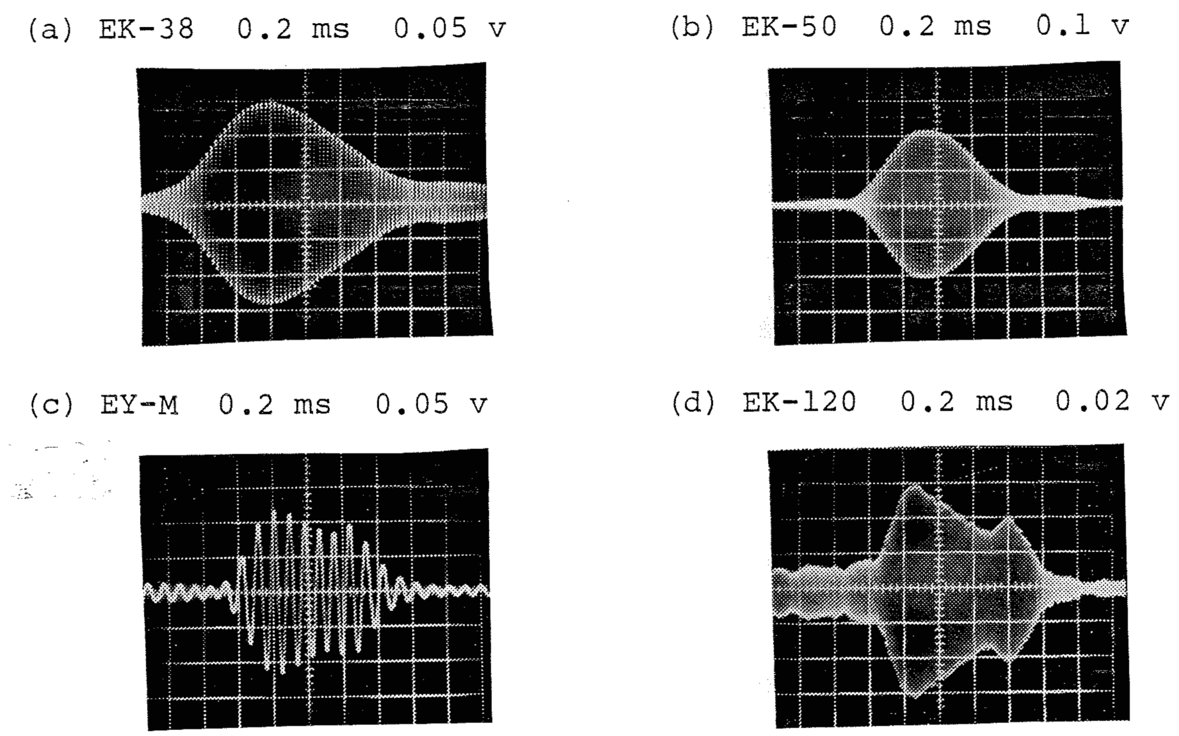
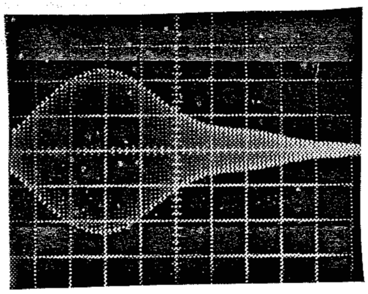
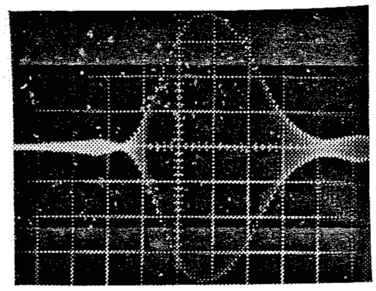


Fig. 43. Echo waveforms from sphere AL60. Heading sequences: echo sounder and scale sizes.

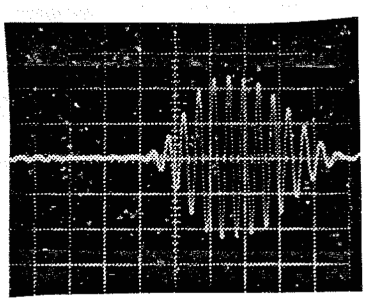
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.1 v



(d) EK-120 0.2 ms 0.05 v

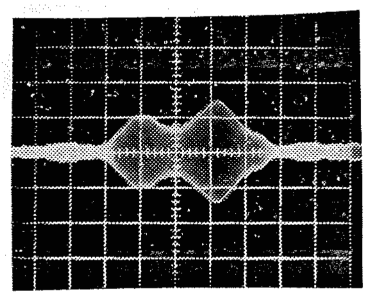
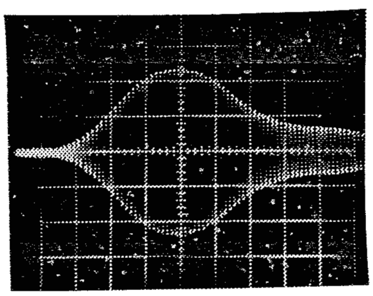
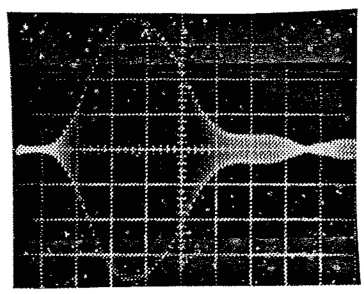


Fig. 44. Echo waveforms from sphere BRS60T. Heading sequences: echo sounder and scale sizes.

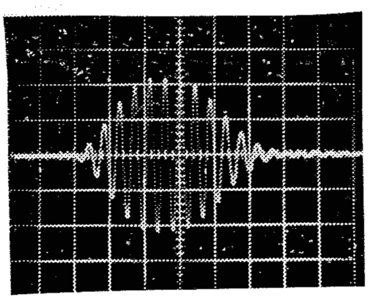
(a) EK-38 0.2 ms 0.1 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.1 v



(d) EK-120 0.2 ms 0.05 v

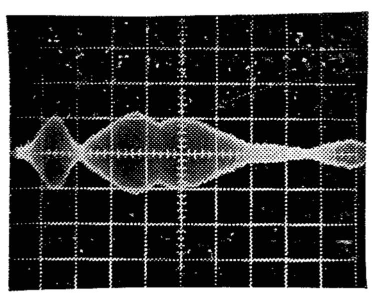


Fig. 45. Echo waveforms from sphere BRS60. Heading sequences: echo sounder and scale sizes.

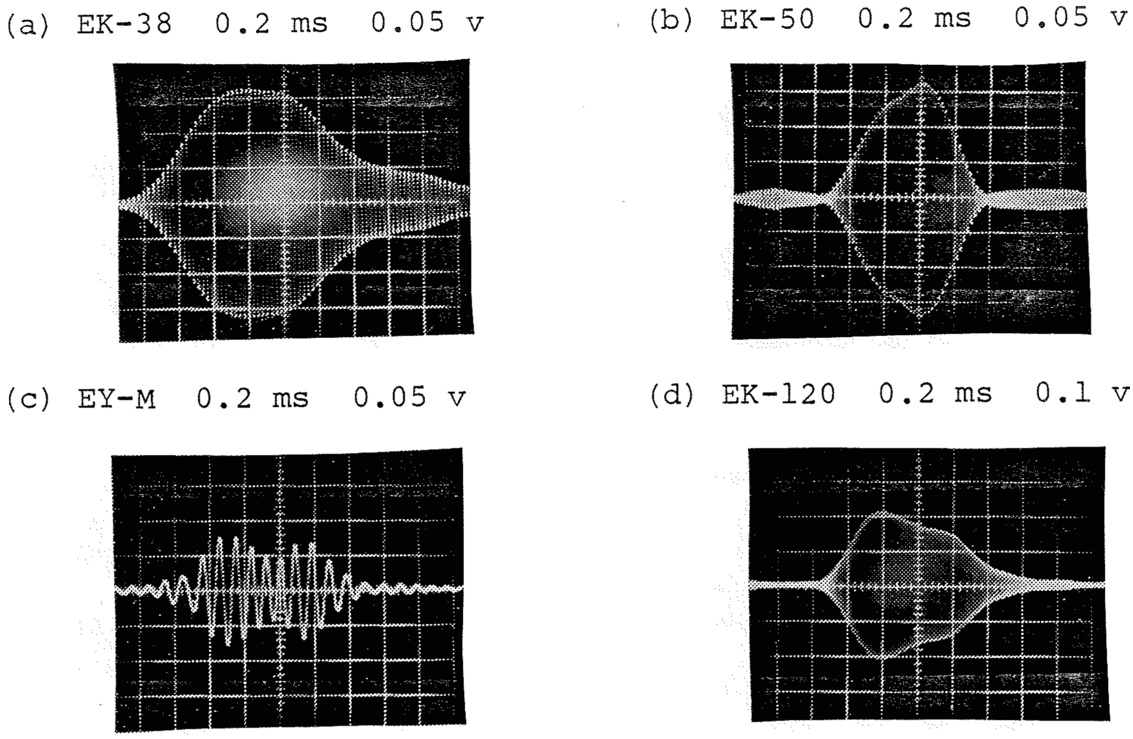


Fig. 46. Echo waveforms from sphere NYL60. Heading sequences: echo sounder and scale sizes.

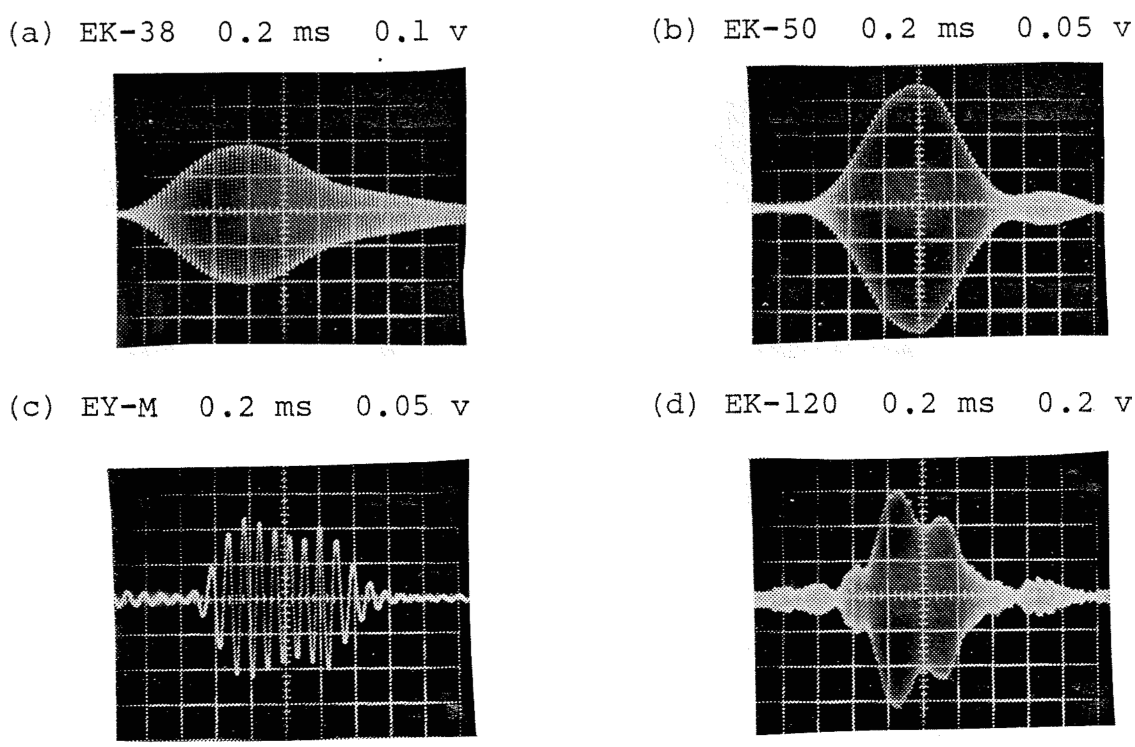
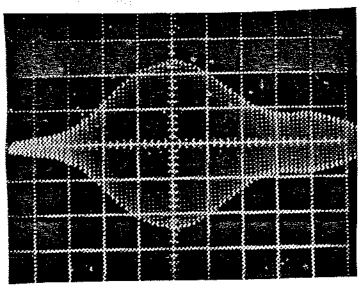
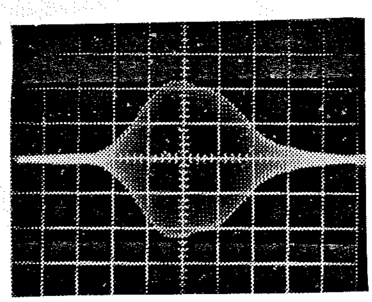


Fig. 47. Echo waveforms from sphere ZN60. Heading sequences: echo sounder and scale sizes.

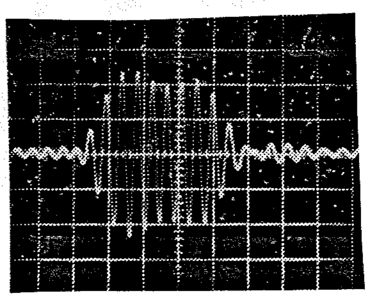
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

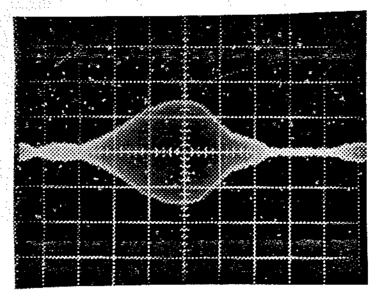
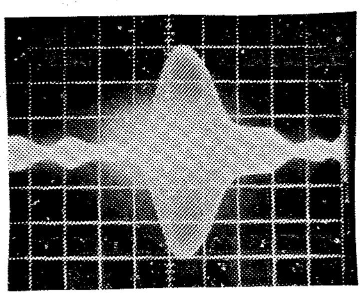
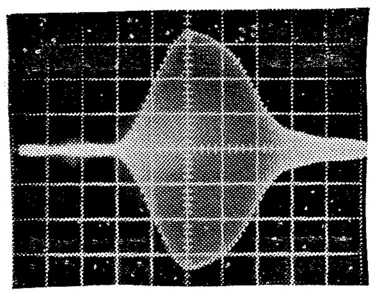


Fig. 48. Echo waveforms from sphere SKF2B. Heading sequences: echo sounder and scale sizes.

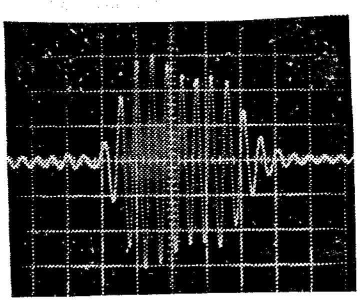
(a) EK-38 0.2 ms 0.05 v



(b) EK-50 0.2 ms 0.05 v



(c) EY-M 0.2 ms 0.05 v



(d) EK-120 0.2 ms 0.05 v

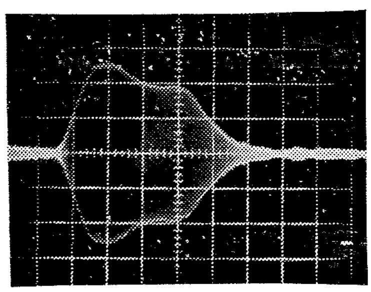
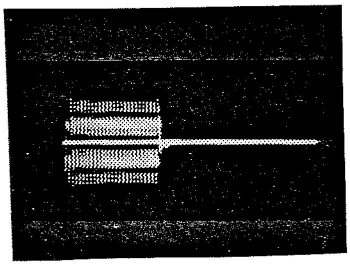
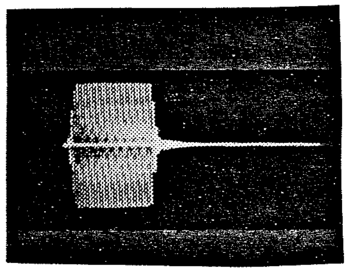


Fig. 49. Echo waveforms from sphere SKF2.5. Heading sequences: echo sounder and scale sizes.

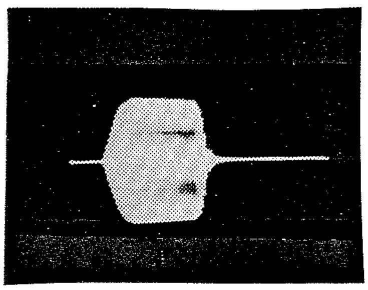
(a) EK-38 0.2 ms 5 v



(b) EK-50 0.2 ms 10 v



(c) EY-M 0.2 ms 5 v



(d) EK-120 0.2 ms 10 v

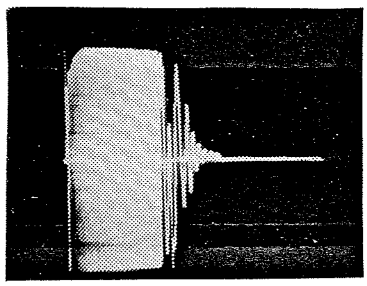


Fig. 50. Transmit signals of four echo sounders. Heading sequences: echo sounder and scale sizes.

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