RESERVOIR SEDIMENTATION SURVEYS IN THE DEPARTMENT OF THE U.S. ARMY

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NOTE ON AUTHOR

Omega H. SHAMBLIN was born 6 June 1909 at Delhi, La. He attended Louisiana State University 1926-27.

He has been employed by the Department of the Army, U.S. Army Engineer District, Vicksburg, Corps of Engineers, Vicksburg, Miss., since 1929, with the exception of a brief period of service in the U.S. Navy during World War II. As Chief of the Survey Branch, he has been in charge of basic survey, mapping and stream-gauging activities for the District since 1947.

GENERAL

To determine the rate of silting in reservoirs, the U. S. Army Engineer District, Vicksburg, uses a system of permanently marked ranges which are usually established either during or immediately after construction of the dam. These ranges are surveyed periodically to obtain comparative profiles which indicate the rate of silting. Figure 1 is a range layout for one of the reservoirs.

PREVIOUS SURVEY METHODS

Prior to 1950 the permanent ranges were established and profiled by conventional direct-levelling survey methods before the reservoirs were filled. The original range layouts were to third-order accuracy. (Horizontal position closure 1/5 000). (Vertical closure 0.05 ft $\sqrt{\text{length of loop in miles}}$).

Resurveys of these ranges were made by direct levelling and taped distances on the portions of the ranges above the water surface and by lead-line soundings below the water surface. Horizontal positions for the soundings were determined by visual signals from the sounding boat as it travelled along each range line and by turning angles to the boat at each sounding with a transit at a convenient location on the shore.

This method was used for a resurvey of Sardis Reservoir in North Mississippi, in 1943. The results of the underwater surveys were not

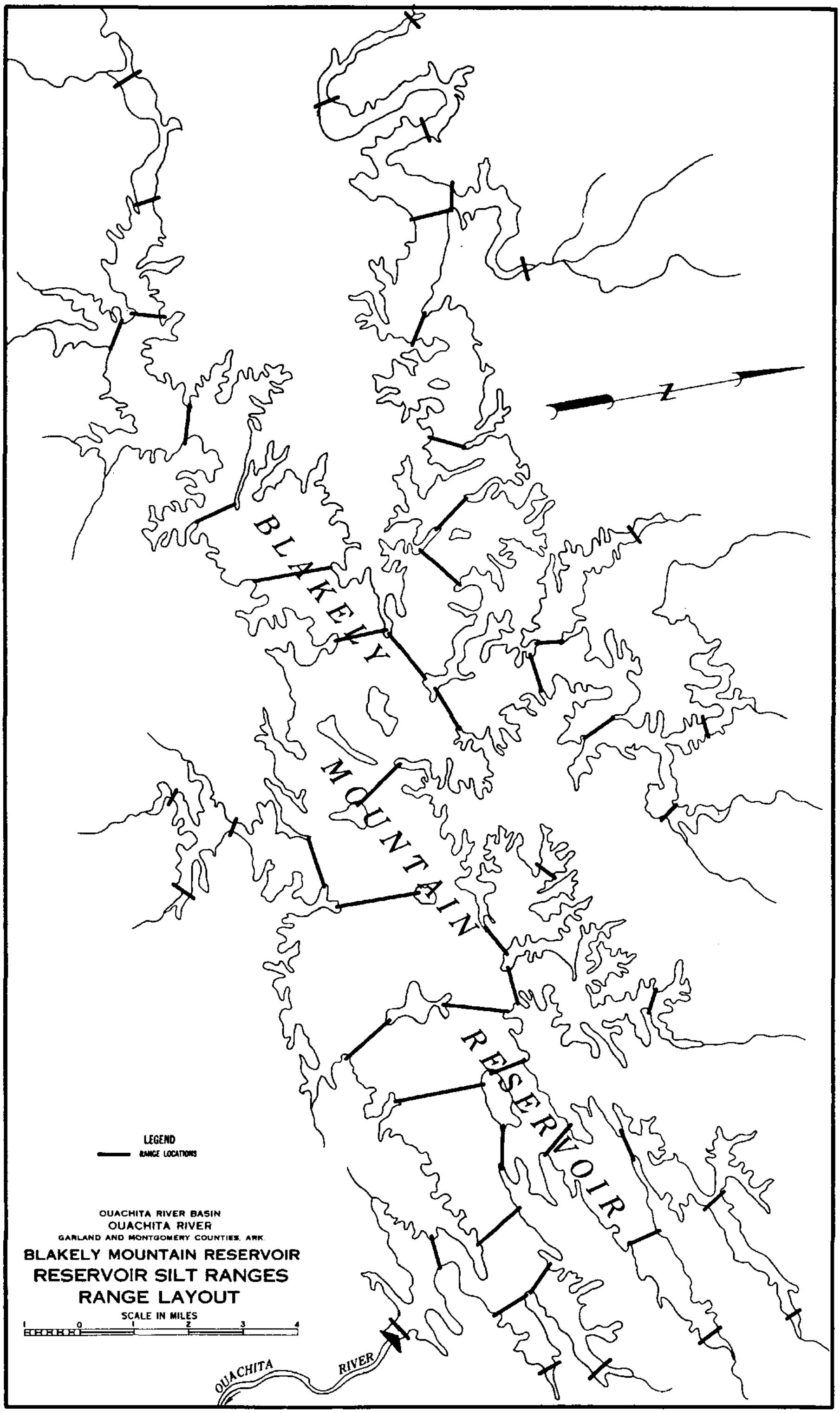

Fig. 1. — Blakely Mountain Reservoir — Range Layout

considered satisfactory because of the errors in the horizontal position of each sounding and the inability to determine the top of the silt deposit with the sounding weight. These inaccurate results caused the Vicksburg District to search for a more reliable survey method.

IMPROVED METHOD FOR RESURVEYS

During the period 1946 to 1947, a new procedure for the underwater survey was developed and pilot models of specialized equipment were made. This improved survey method was first used during a resurvey of Arkabutla Reservoir, also in North Mississippi, in 1947-1948. The results of this survey proved that the new method would produce results which were considerably more accurate than the methods previously used.

In brief, the improved method consisted of stretching a wire on range across the reservoir. A calibrated distance-measuring wheel travelling along this wire measured distances simultaneously as the depths were obtained with a supersonic depth recorder. Alignment directions were transmitted to the sounding-boat operator, by radio, from the transitman located at a point on the range as the boat proceeded along the range.

IMPROVED METHOD OF SURVEYS FOR ESTABLISHING AND PROFILING RANGES

Before the construction of Blakely Mountain Dam, in West Central Arkansas, it was evident that conventional surveys for establishing and profiling the permanent-range system in the rugged and mountainous terrain in which the reservoir was located would be unduly expensive. It was therefore decided to :

(*a*) delay establishing the permanent ranges until after water was impounded in the reservoir,

(*b*) eliminate expensive traverse in the mountains by locating the permanent-range markers by ties to aerial photographs,

(*c*) use the water surface of the lake as a datum plane to eliminate the need for direct levelling for vertical control, and

(*d*) use the improved method developed for resurveys in making the initial underwater survey of the permanent ranges.

A summary description of this survey is as follows :

Horizontal control

Horizontal positions of the permanent-range markers were obtained by ties to aerial photographs. This eliminated traverse tie lines between ranges and ties to existing control.

Vertical control

The water surface in the reservoir was used as a datum plane for establishing elevations on the permanent-range markers. In determining the datum plane for the water surface in the reservoir, several gauges were located at strategic points around the reservoir. These gauges were tied to existing first-and second-order benchmarks and were read twice daily during the period of the survey. It was found that water-surface fluctuations were constant at all gauges and that the differences in water-surface elevations at the various gauges were never more than two-tenths of a foot. This eliminated the necessity for level tie lines between ranges and ties to existing control.

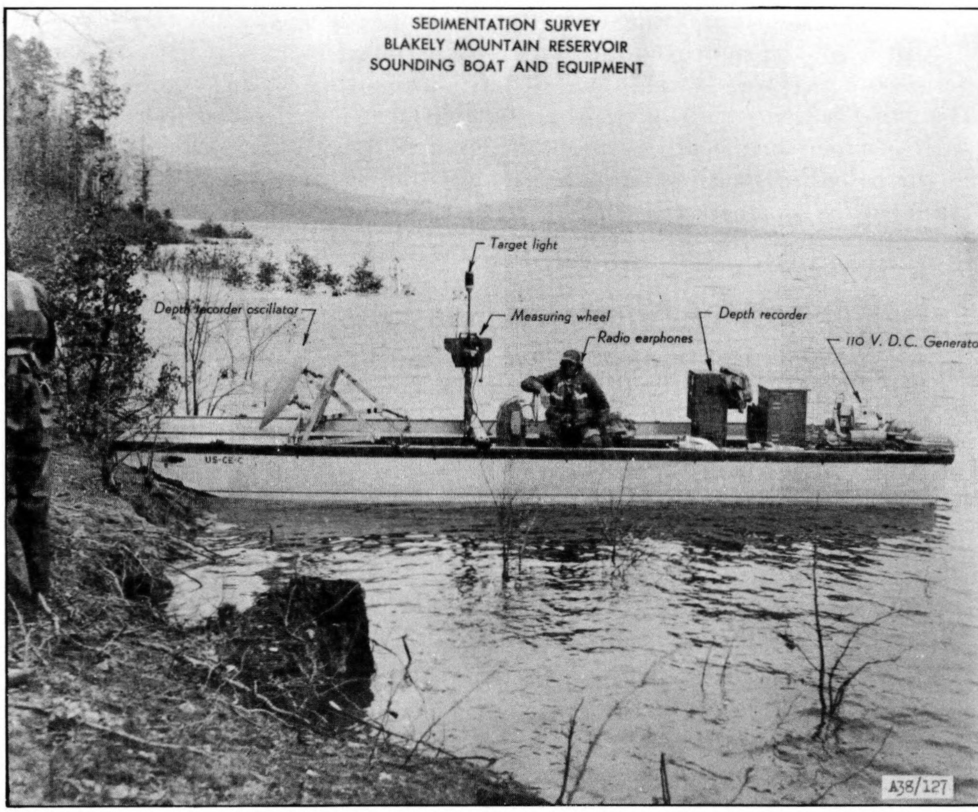

Fig. 2. — Sounding Boat and Equipment

Range profiles

The portions of all ranges above the reservoir level were traversed and profiled by conventional direct-levelling survey methods. The underwater portion of each range was profiled by the improved method as described below :

Special Equipment

Special equipment needed for this operation includes :

(1) Supersonic Depth Recorder. The depth recorder used on this survey was manufactured commercially. (See figure 2). The specifications on the outboard oscillator were :

Sound frequency	14 Kc/s
Beamwidth	not exceeding 30 degrees
Sounding rate	200 per minute
Theoretical accuracy	3 inches in 150 feet

(2) Distance Wire and Reel. The distance wire used was 0.059-inch-diameter steel piano wire. This wire was stored on a specially built, powered reel having a drum diameter of 9 inches. (See figure 3).

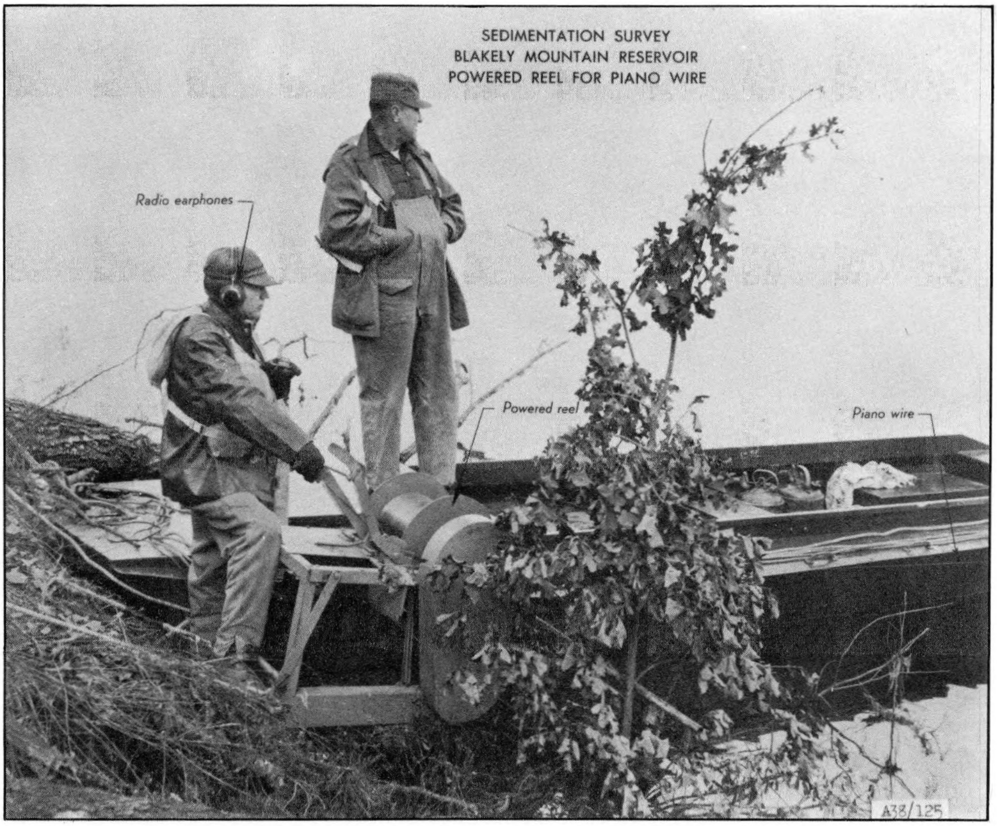

Fig. 3. — Powered Reel for Piano Wire

(3) Measuring Wheel. The distances across the lake were measured with a specially built measuring wheel having a circumference (at the centre of the wire) of two feet. (See figure 4). An attached counter registered the revolutions of the wheel. A cam and microswitch on the counter

actuated a switch in the depth recorder to automatically make a *fix mark* on the depth-recorder scroll at intervals of twenty feet. The wire encircled the wheel to provide a maximum of friction and prevent slippage. (See figure 5). The measuring wheel was mounted in the sounding boat directly over the depth-recorder oscillator. A light was mounted on the measuring wheel to serve as a target when, because of wind and rough water during the day, it became necessary to operate at night.

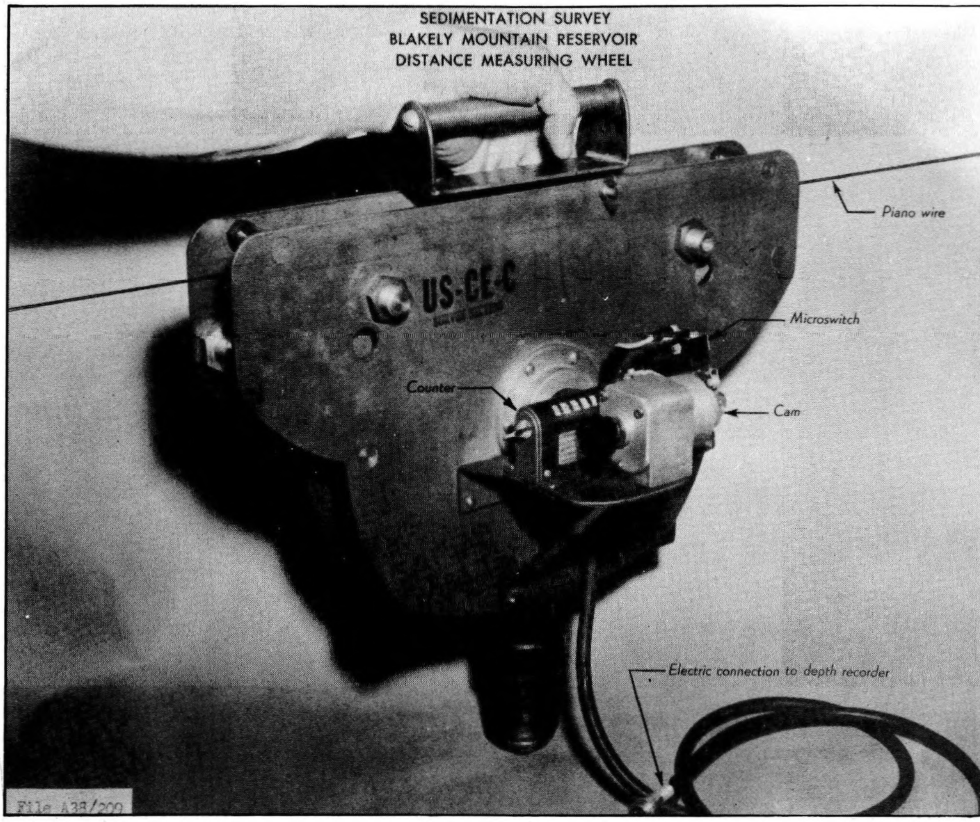

Fig. 4. — Distance-Measuring Wheel

(4) Radios. Transceiver radios having 0.75-watt transmitters were used for communication between the transitman, distance-reel operator and boat operator. (See figure 6).

(5) Wire Splicer. A compressed-sleeve-type wire splicer was used for repairing breaks in the distance wire.

Method for Underwater Surveys

(1) Stretching Wire on Range. A transit was set up on line at a point near one end of the range where the transitman had an unobstructed view of the range. The powered distance-wire reel was placed on range near

the water's edge close to the transit. The loose end of the distance wire was then towed by boat across the lake and securely fastened at a point on range on the opposite bank. While towing the wire across the lake, radioed directions from the transitman guide the boat operator in keeping the boat on the range alignment. After the wire had been secured on the opposite bank, the wire was placed in an eye on a vertical post at the bow of the boat and the boat was then run back toward the transitman to place the wire on the exact range alignment. As the boat made this return trip, the

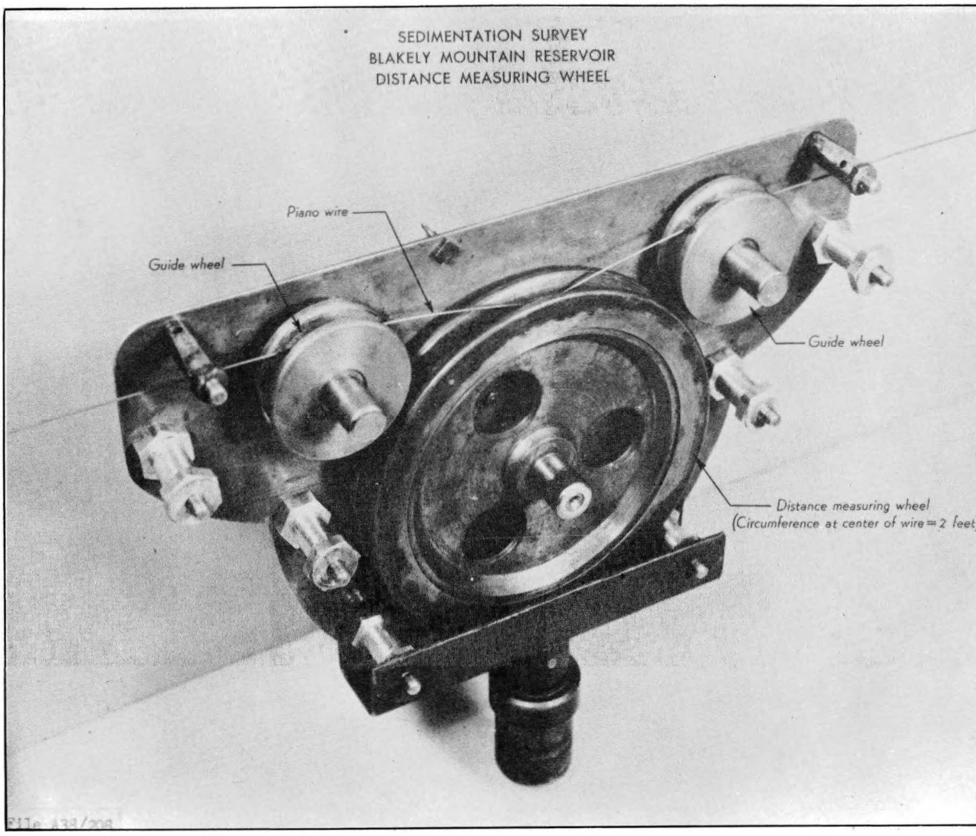

Fig. 5. — Distance-Measuring Wheel

slack was taken up and buoys were fastened on the wire at approximate 300 foot intervals. These floats holding up the wire reduce sag and the resulting errors in distance. Radioed alignment directions from the transitman to the boat operator were also given on this return trip. After the distance wire had been placed on range, the depth-recorder outboard oscillator was placed under the sounding boat, the boat was moved onto the range and the wire was threaded around the measuring wheel. The wire was then drawn taut and securely fastened at a point on the range.

(2) Sounding the Range. To establish a reference point for the sounding boat on the range stationing, the boat was securely held at a point on

the distance wire and the range station at the measuring wheel was determined by a taped distance from a known station on the range. (See figure 7). Before the sounding boat was moved from this point, the counter was set at zero and the cam was set under the microswitch to make the first *fix mark* on the depth-recorder chart. Then as the boat moved forward on the range, the cam would strike the microswitch at twenty-foot intervals, automatically causing a *fix mark* to be made on the depth-recorder chart. The buoys on the wire furnished an approximate indication of alignment

Fig. 6. — Transitman at Point on Range

which enabled the boat operator to better evaluate the transitman's radioed directions for maintaining a true course. On the sounding run, it was necessary to remove and replace each buoy on the wire as the boat passed each buoy location. (See figure 8 for sounding boat in operation on range). When the sounding boat reached the opposite side of the reservoir, the counter reading represented the distance across the lake. The profile was extended from this point in the usual manner with levels and taped distances. Before recovering the distance wire, the tension was released and the buoys removed. The powered reel made recovery of the wire more rapid and less laborious than by hand.

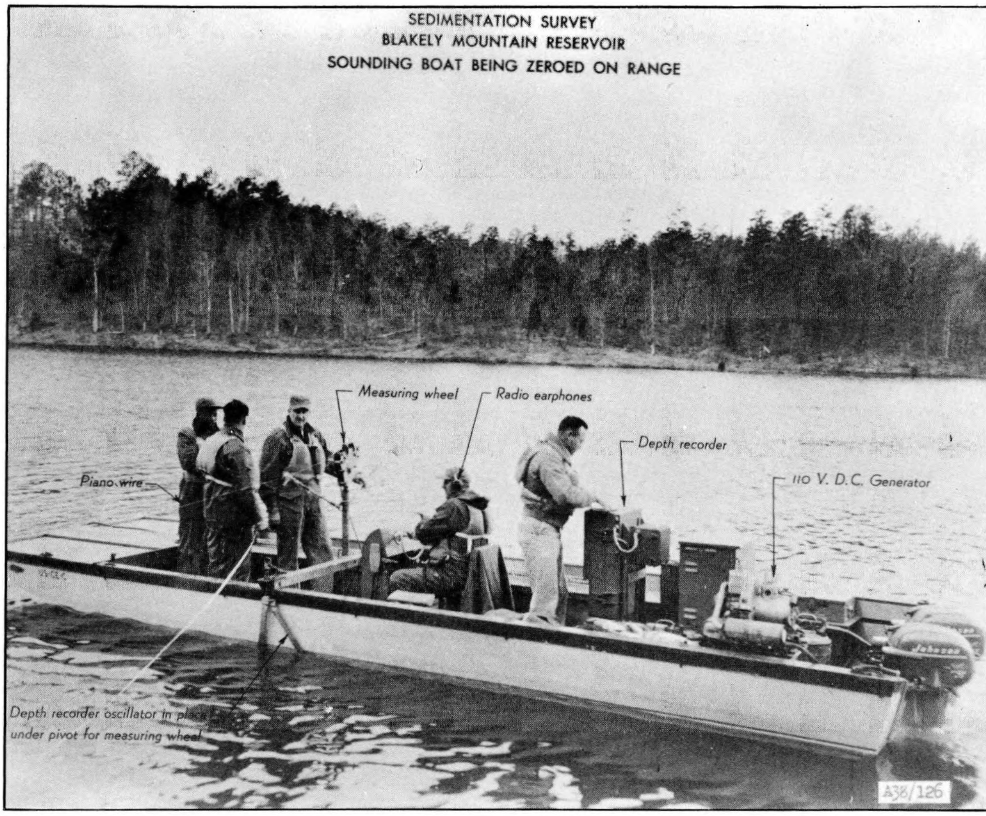

Fig. 7. — Sounding Boat Being Zeroed on Range

RESULTS

Ranges up to 20 000 feet have been profiled by this method. In accuracy tests on a 6 000-foot taped course, the distances obtained by the distance-measuring wheel consistently agreed with the taped distances to the closest foot over the entire course and at numerous intermediate points. Under actual working conditions on ranges previously taped before the reservoir was filled, the measuring-wheel distances across the lake agreed with the original taped distances within $\pm$ 2 feet on distances up to 13 600 feet.

In establishing and profiling the ranges by this method, it was considered necessary to conduct certain tests to determine if the depth-recorder survey would yield data which could be compared with direct-levelling surveys. Also, it was desirable to determine the effect of standing submerged timber in the reservoir pool upon the soundings.

To resolve these questionable points, several of the Blakely Mountain Reservoir ranges in the timbered areas were cleared to a width of twenty-five feet. These ranges were profiled by direct levelling before the reservoir was filled. Certain other ranges in the timbered areas were not cleared

Fig. 8. — Range Sounding

and were also profiled by direct levelling. These same ranges were resurveyed with the improved method after the reservoir was filled. Figure 9 is a chart comparing tests on one range.

A comparison of plotted results from surveys by both the direct-levelling and improved methods indicates that :

(1) In Arkabutla Reservoir in depths up to 23 feet, the soundings had an accuracy of $\pm$ 0.5 foot.

(2) On test ranges in Blakely Mountain Reservoir where the original survey was made by direct levelling and a check profile was run with the depth recorder, the soundings had a general accuracy of $\pm$ 1.0 foot in depths up to 155 feet on the valley bottom, flat shelves and on relatively flat slopes. However, due to the mountainous terrain where steep underwater slopes were present on or immediately adjacent to the range, the depth-recorder soundings were influenced by echoes rebounding from these steep slopes and did not give the true depth directly underneath the sounding boat. Also, the depth recorder tends to smooth out sharp irregularities on the profile in deep water. These inaccuracies are inherent in the depth finder and are controlled by the beamwidth of the oscillator.

(3) On test ranges in Blakely Mountain Reservoir, in check profiles obtained by the depth recorder over profiles previously surveyed by depth

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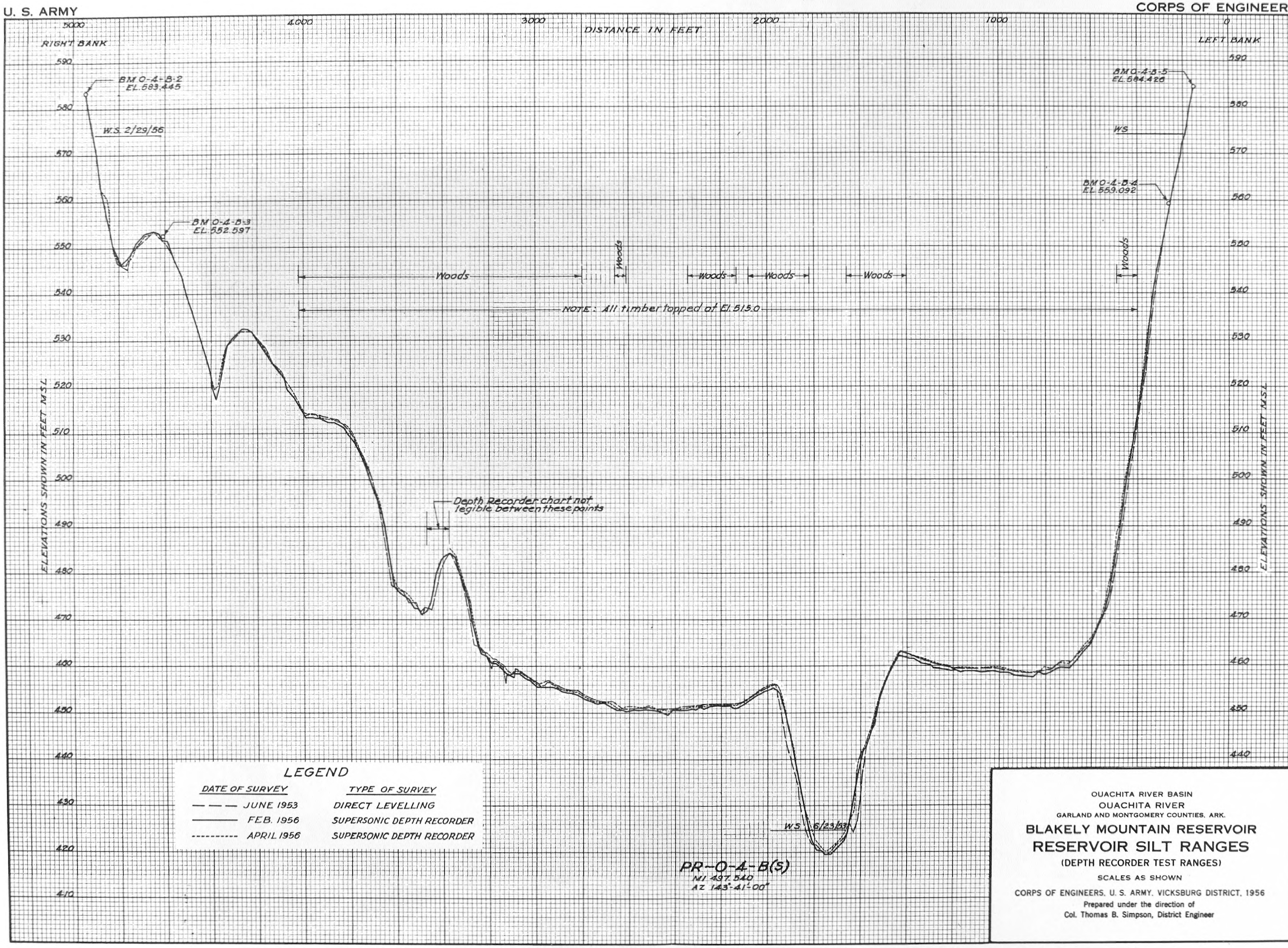

Fig. 9. — Depth-Recorder Test Ranges

recorder, practically no differences were noted on the steep slopes and the differences in the profiles on the valley bottom were ± 1.0 foot in depths up to 180 feet.

CONCLUSIONS

(1) The establishment of the original permanent-range system by the improved method was completed at a considerable saving in funds.

(2) The improved method produces results well within the accuracy of other field methods available. This is especially true in deep water and on long ranges.

(3) In terrain where steep underwater slopes are present, office adjustment will be required if the range profiles from this method are to be compared with direct-levelling profiles.

(4) Good results are obtained when the original profile and the resurvey are both made with the improved method at comparable water stage. In these instances, the effect of echoes from steep slopes can be ignored because these inaccuracies are relative and are present to the same extent in both profiles.

(5) Comparison of the depth-recorder profiles with direct-levelling profiles on ranges in cleared and wooded areas did not indicate any appreciable effect of submerged, standing timber on the depth-recorder soundings.

(6) This improved method can be successfully used for slack-water surveys on any reasonably calm body of water.