

DEPARTMENT OF THE INTERIOR  
Hubert Work, Secretary

U. S. GEOLOGICAL SURVEY  
George Otis Smith, Director

Bulletin 766

SPIRIT LEVELING IN CALIFORNIA  
1896-1923

C. H. BIRDSEYE  
CHIEF TOPOGRAPHIC ENGINEER



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WASHINGTON  
GOVERNMENT PRINTING OFFICE  
1925



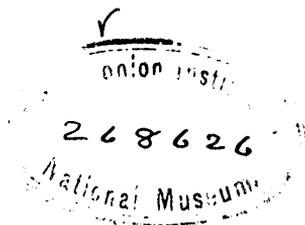
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## EXPLANATORY NOTE

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The results of spirit leveling given in this bulletin are arranged by "degree quadrangles," each covering one degree of latitude and longitude, in geographic order beginning at the southeast corner of the State. A diagram showing the area included is given for each degree quadrangle. After the matter covering degree quadrangles  $38^{\circ}$ - $39^{\circ}$ ,  $122^{\circ}$ - $123^{\circ}$ , and  $38^{\circ}$ - $39^{\circ}$ ,  $123^{\circ}$ - $124^{\circ}$ , was printed large errors in the adjustment of the level lines were found which make further field work necessary to determine the proper correction. This matter, including Figures 41 and 42, has accordingly been omitted. At the end of the bulletin is given a list of approximate elevations obtained from various sources.

# SPIRIT LEVELING IN CALIFORNIA, 1896-1923

C. H. BIRDSEYE, Chief Topographic Engineer

## INTRODUCTION

*Cooperation.*—The State of California contributed financially to most of the level work done in Sacramento, Salinas, and San Joaquin valleys. Nearly all the expense of the United States Geological Survey's work done in 1922 and 1923 in Los Angeles County was borne by that county. The expense of the work done in other parts of the State was paid mainly from appropriations made for the United States Geological Survey, the United States Coast and Geodetic Survey, and the Corps of Engineers, United States Army.

*Previous publications.*—The results of spirit leveling done in California from 1896 to 1910 have been published by the United States Geological Survey in Bulletins 342 and 481, and these results and those of later work in the State are included in this report. The elevations given are reckoned from mean sea level and in general are in accord with the precise-level lines run by the United States Coast and Geodetic Survey.

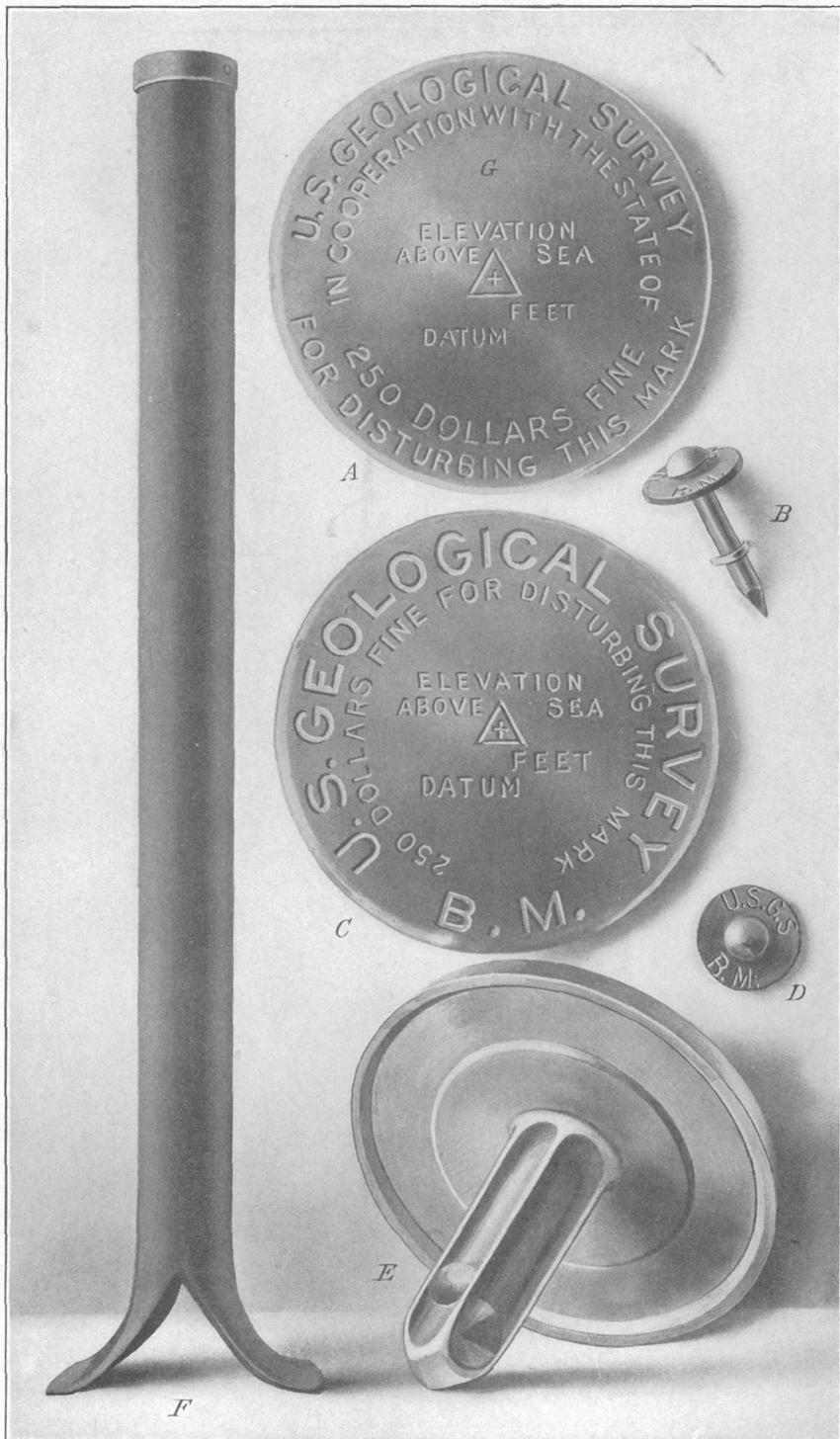
*Personnel.*—The field work was done by the engineers of the Geological Survey named in the bulletin in connection with the matter showing the elevations determined. The office work, which involves the adjustment of the field notes to the data on record in the Geological Survey, was done by D. H. Baldwin under the supervision of E. M. Douglas, topographic engineer. The matter was compiled for publication by S. S. Gannett, geographer.

*Classification of elevations.*—The elevations shown are classified as precise or primary, according to the methods employed in their determination. For precise lines instruments and rods of the highest grade are used, each line is run both forward and backward, and every precaution is taken to guard against error. The allowable divergence in feet between a line run forward and one run backward is represented by the formula  $0.017 \sqrt{D}$ , in which  $D$  is the distance in miles between bench marks. For primary lines standard  $Y$  levels are used; lines are run in circuits or are closed on precise-level lines, with an allowable closing error in feet represented by the formula  $0.05 \sqrt{D}$ , in which  $D$  is the length of the circuit in miles, the work being done with sufficient care to maintain this standard. For levels of both classes careful office adjustments are made, the small outstanding errors being distributed over the lines.

*Bench marks.*—The standard bench marks used by the United States Geological Survey prior to 1920 were of two forms. One, still in use, is a circular bronze or aluminum tablet (*C* and *E*, Pl. I),  $3\frac{1}{2}$  inches in diameter and one-quarter of an inch thick, having a 3-inch stem, which is cemented into a hole drilled in solid rock or in the wall of some public building, a bridge abutment, or other substantial masonry structure. The other form (*F*, Pl. I), which was used where masonry or rock was not available, consists of a hollow wrought-iron post  $3\frac{1}{2}$  inches in outer diameter and 4 feet in length, which was set about 3 feet in the ground. The bottom was spread out to a width of 10 inches in order to get a firm bearing. An aluminum-bronze cap was riveted upon the top of the post. A third style of bench mark with abbreviated lettering (*B* and *D*, Pl. I) is used for unimportant points. This consists of a special copper nail,  $1\frac{1}{2}$  inches long, driven into a wooden structure through a copper washer seven-eighths of an inch in diameter. The tablets as well as the caps on the iron posts and the washer are appropriately lettered, and cooperation with States is indicated (*G*, Pl. I). Since 1920 concrete posts having a bronze tablet in the top have been used instead of iron posts.

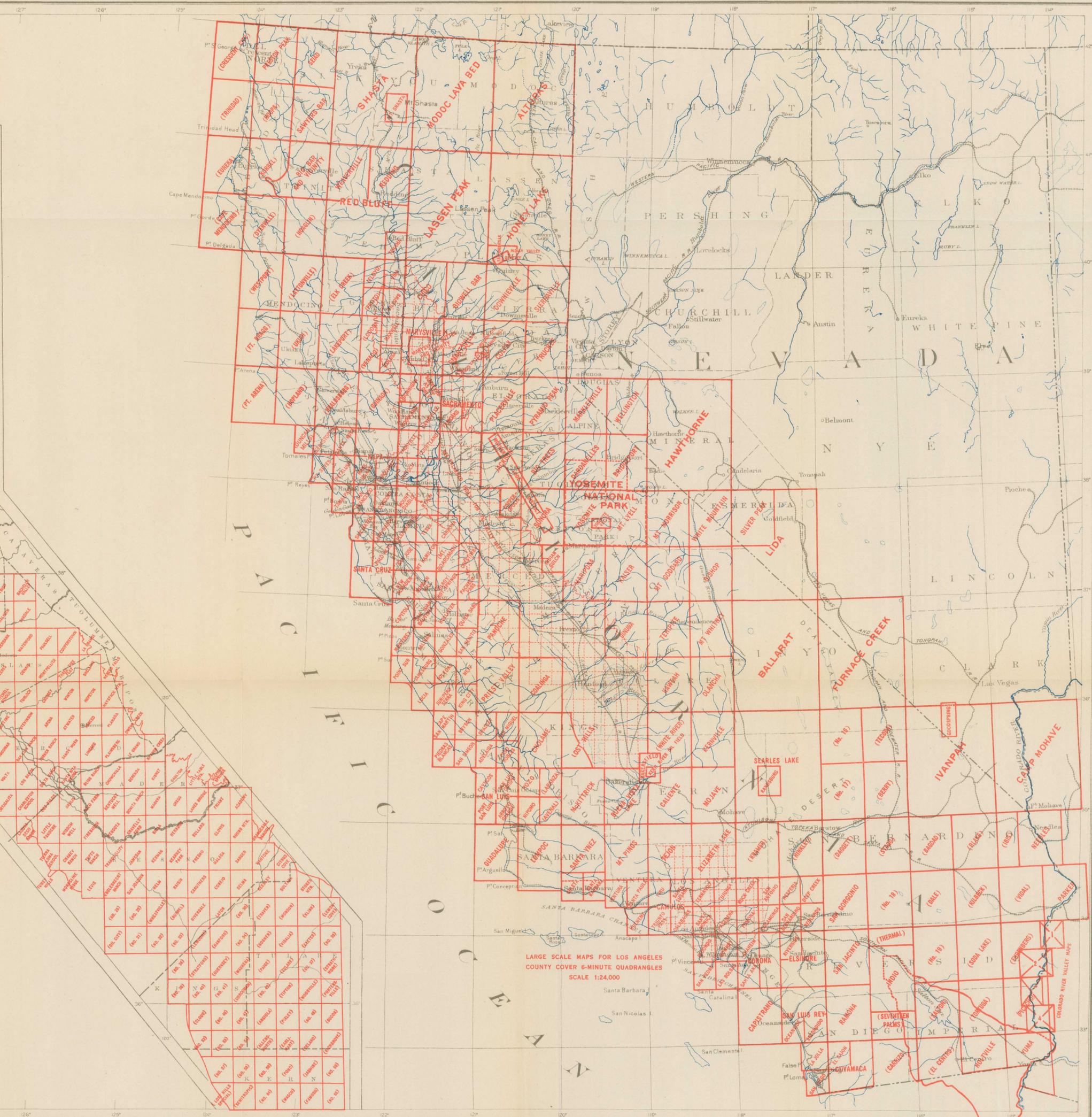
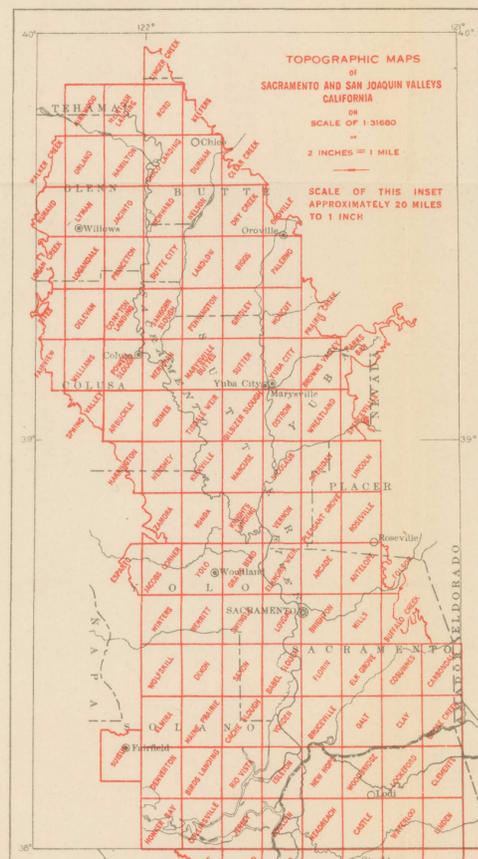
The numbers stamped on the bench marks described in the following pages represent the elevations to the nearest foot as determined by the levelman. These numbers are stamped with  $\frac{3}{8}$ -inch steel dies on the tablets or post caps, to the left of the word "feet." The office work, which includes the reduction of the elevations to mean sea level, may so change some of the figures that the markings stamped are 1 or 2 feet in error. It is assumed that engineers and others who have occasion to use the bench-mark elevations will apply to the Director of the United States Geological Survey, at Washington, D. C., for the adjusted elevations and will use the elevations marked only for identification. The present practice of the United States Geological Survey and the United States Coast and Geodetic Survey is to defer the stamping of elevations on bench marks until after the office adjustment has been completed. When the levelman establishes a bench mark he stamps on it a serial number, the year, and his initial letter, for identification only.

*Datum.*—All elevations determined by the United States Geological Survey and the United States Coast and Geodetic Survey are measured from mean sea level, which is the level the surface of the sea would assume if all disturbing influences of tide, current, and wind were removed. Mean sea level is thus the average of all the hourly heights of the tide; it differs somewhat from mean tide level, which is the average of the high and low water. It is determined from observations made by means of tidal gages placed at stations where the height of the water is not affected by local con-



## GEOLOGICAL SURVEY BENCH MARKS

*A*, Tablet used in cooperating States. The State name is inserted at *G*  
*B* and *D*, Copper temporary bench mark, consisting of a nail and copper washer  
*A*, *C*, and *E*, Tablets for stone or concrete structures  
*F*, Iron post used where there is no rock



TOPOGRAPHIC MAPS PUBLISHED

MAPS OF SAME REGION ON TWO SCALES  
 TWO-MILE SCALE (1:125,000)  
 ONE-MILE SCALE (1:62,500)

QUADRANGLES FOR WHICH NO MAPS ARE PUBLISHED

INDEX MAP OF CALIFORNIA SHOWING GEOGRAPHIC POSITIONS OF QUADRANGLES

Scale 1:250,000

APPROXIMATELY 40 MILES TO 1 INCH

0 25 50 75 100 MILES

ditions, such as are due to long narrow bays, rivers, and like features. To obtain even approximately correct results these observations must extend over at least one lunar month, and if great accuracy is desired they must extend over several years. At ocean stations the half-tide level and the mean sea level usually differ but little. It is assumed that there is no difference between the mean sea levels determined from observations made in the Atlantic Ocean, the Gulf of Mexico, and the Pacific Ocean.

The elevations shown on some bench marks that lie far from the sea have been determined not by means of lines run to them from sea level by Government engineers but by means of lines run by those engineers from inland datum points fixed by railroad, municipal, or other engineers. On such a bench mark the datum point used is indicated by letters or a word stamped after the word "datum," the meaning of which is shown in the text. The elevations thus provisionally adopted are corrected from time to time as the Government precise-level lines are extended.

*Index map.*—The accompanying index map of the State of California (Pl. II) shows the geographic positions and the relations of the quadrangles in which leveling work has been done. Maps of these quadrangles (except those whose names are inclosed in parentheses, which have not been mapped) may be purchased from the United States Geological Survey at 10 cents each. A discount of 40 per cent is allowed on an order amounting to \$5 at the retail price.