Survey Security Through Photogrammetry

D. E. WINSOR, Design Engineer, U.S. Bureau of Public Roads, Denver

In view of the magnitude of the projected national highway program, it is becoming increasingly more important to exercise some sort of informational security on projected highway routing. In some instances it has been noted that conventional survey methods have generated speculation to the extent that the projected highway route was rendered economically prohibitive because of commercial encroachment. To insulate against such speculation, photogrammetry affords an ideal solution.

Even with the use of photogrammetry, ground control parties may alert the more persistent speculators to the fact that some sort of development is anticipated, even though this work does not offer much information as to specific location. To preclude this type of speculation, an engineer and one or two assistants can make a reconnaissance of the area to locate property corners, section corners, or existing survey markers, from which subdivisions have been made. On the day and the approximate hour of the flight to obtain low-level photography, two men familiar with the project can target the control corners for easy identification and remove the targets as soon as the flight has been accomplished.

From this low-level photography, accurate planimetric maps can be developed. From county records, descriptions of property tracts within the affected area are obtained. Through stereoscopic study of the photograph, the final highway routing can then be determined and projected upon the completed map. Likewise, the right-of-way requirements can be ascertained and computed in the manner and accuracy required by law.

To produce a comprehensive right-of-way map, the work manuscript is then reprojected on a controlled mosaic of convenient size against matching images. The centerline, right-of-way line, and property lines are outlined on this mosaic using white acetate tape in widths ranging from $\frac{1}{32}$ in. to $\frac{1}{8}$ in., as desired, for emphasis. This mosaic is then reproduced on a film autopositive. Inexpensive photoprints in any desired quantity are then available to the right-of-way negotiators. In this manner, speculation as to the projected development can be precluded, because security can be maintained up to the day that engineers accompany the negotiators to the field for acquisition of right-of-way.

● **TO PRECLUDE** speculation and controversy during reconnaissance surveys to determine highway routes, photogrammetry is an ideal tool. In view of the magnitude of the projected national highway program, it is becoming increasingly important to exercise some sort of informational security on projected highway routing. In some instances it has been noted that conventional survey methods have generated speculation to the extent that the projected highway route was rendered economically prohibitive because of commercial encroachment. To insulate against such speculation, proper and full use of photogrammetry in determining and comparing feasible route alternatives affords an ideal solution.

Even with the use of photogrammetry in making large-scale preliminary surveys of the best routes, ground control crews may alert the more persistent speculators to the fact that some sort of development is contemplated. Ground work performed by a field reconnaissance investigation group or by a survey party establishing control for making the preliminary survey by photogrammetric methods does not offer much information as to exact or specific location. However, work on the ground that

NAME AND ADDRESS	DATE	BOOK	PAGE	LEGAL DESCRIPTION OF PROPERTY
Mary Esther Fenton	7/8/47	840	347	Beginning at a point which bears South 24° 03' East 914.0 feet from the Northwest corner of Section 35, Township 5 North, Range 73 West of the 6th P. M. ; and which bears North 67° 56' East 490.0 feet from a point on the section line South 64° 34' West 1023.25 feet of the Northwest corner of said Section 35, thence South 67° 56' West 38.3 feet, thence South 16° 39' East 958.8 feet to the center line of the Big Thompson River, thence along said River center line North 30° 01' East 42.2 feet, thence North 07° 27' West 322.0 feet, thence North 77° 12' East 264.4 feet, thence leaving said River North 16° 46' West 637.9 feet, thence South 72° 34' West 306.4 feet to point of beginning. (Warranty Deed) Excepting right of way conveyed to The Department of Highways State of Colorado November 3, 1955, recorded in Book 1006 at Page 525, Larimer County Records.
The Department of Highways, State of Colorado	11/3/55	1006	525	A parcel of land in the Northwest Quarter of Section 35, Township 5 North, Range 73 West of the 6th P. M. described as follows: Beginning at a point on the west property line from which point the Northwest corner of Section 35, Township 5 North, Range 73 West, bears North 21° 40' 30" West, a distance of 940.4 feet; 1. Thence, along the arc of a curve to the right, having a radius of 2,835.0 feet, a distance of 143.5 feet, the chord of which arc bears North 71° 31' East, a distance of 143.4 feet; 2. Thence, North 72° 58' East, a distance of 201.0 feet to a point on the east property line; 3. Thence, North 16° 46' West, a distance of 30.0 feet; 4. Thence, South 72° 58' West, a distance of 201.1 feet; 5. Thence, along the arc of a curve to the left, having a radius of 2,865.0 feet, a distance of 143.3 feet, the chord of which arc bears South 71° 32' West, a distance of 143.3 feet; 6. Thence, South 16° 46' East, a distance of 30.0 feet, more or less, to the point of beginning. (Special Warranty Deed). Above tract contains 0.237 acres, more or less, of which 0.179 acres are in the present road on November 1955.

Figure 1. Typical right-of-way description.

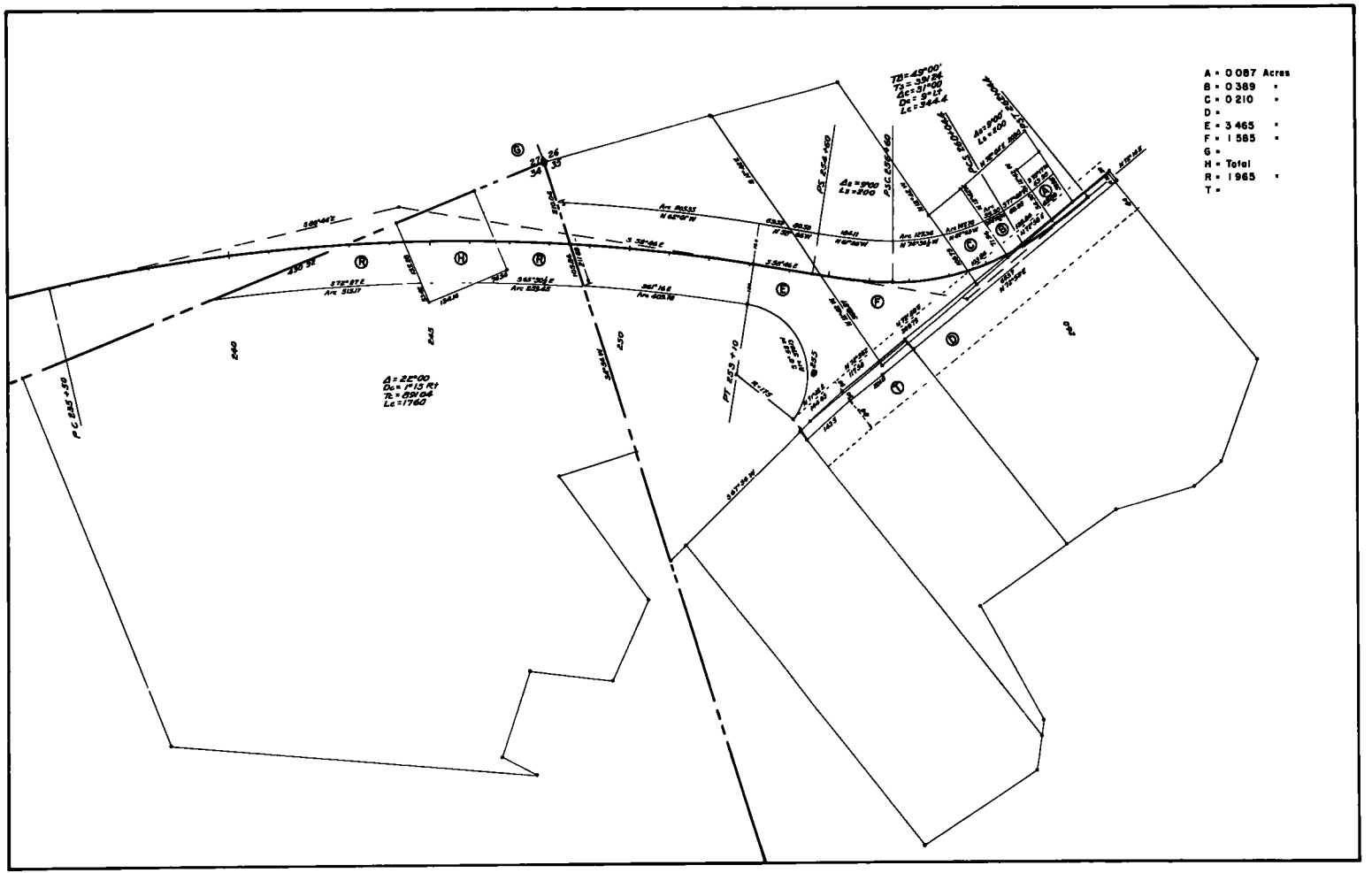


Figure 2. Typical right-of-way map.

would indicate development is contemplated in the area may create some speculation or cause premature ill will before the economics or feasibility of the routing have been determined and made public. To preclude this type of speculation and to avoid unwarranted concern by property owners and business establishments, routing can be refined to specific corridors without the exposure of the work performance by parties within the area. To accomplish this end, large-scale accurate planimetric and topographic maps can be compiled by photogrammetric methods using as control the pre-established land and subdivision corners.

The first step in this procedure is to obtain descriptions of the land tracts in the affected area from the county records. Using the key corner or corners from which these descriptions are based, the entire area is computed and plotted on a coordinate grid using bearings and distances of the recorded deeds.

Figure 1 is a copy of the recorded description of a tract within this area. Figure 2 represents the results of the first step. Small errors in closure of the original survey are apparent. Using the layout as a guide, a trip to the area is made to determine the possibility of photographic identification of some of the property ownership corners. It is essential that images of at least three corners be identified or targeted for each stereoscopic pair of the photographed strip. It may be found that in some instances key property ownership corners are difficult to identify even on large-scale photography. To overcome this handicap, arrangements are made to target these corners on the ground. About one hour before the area is photographed, portable targets are unobtrusively placed over the corners and removed as soon as the plane passes over.

Through stereoscopic study of the photographs, images of the corners or the photographic targets can be identified for horizontal control of the photographs. Factors affecting highway location on the selected route to be surveyed are determined at this time. Using hand-made radial or slotted templet methods or stereoscopic plotting equipment, all pertinent features can be brought into map position.

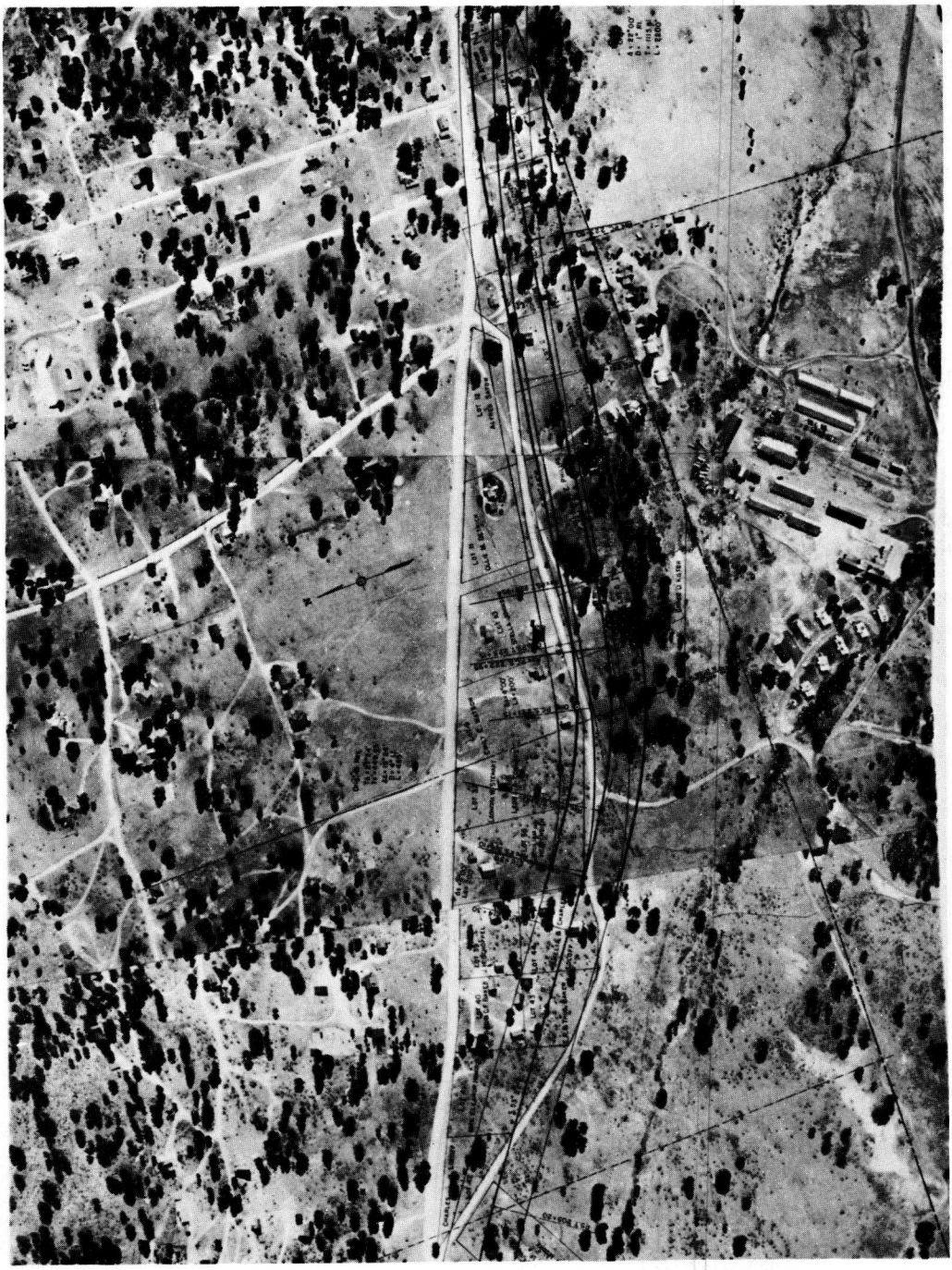
To further control the stereoscopic pairs (termed models) for mapping topographic features, a theodolite may be inconspicuously set up on an identifiable spot or object on the ground for which the image is seen on the photographs.

From this set up, vertical angles are read to four other identifiable objects appearing in the outer quadrants of the model. In orienting the photographs in a photogrammetric instrument for topographic mapping, the exact differences in elevation and horizontal distance are of central interest. With the use of photographic trigonometry, these differences are easily determined. Once the model is oriented in the vertical plane and properly adjusted to scale, the topographic features may be plotted to true elevation or to relative assumed elevations, depending upon the index available and used.

Figure 3 depicts a proposed intersection through highly desirable commercial property as developed by the photogrammetric methods described. On this project, the ownership descriptions also delineated right-of-way previously purchased for the connecting highway. This afforded a positive tie as to stations and bearings on this previously constructed project.

After the proposed centerline has been plotted on the planimetric map, the desired right-of-way areas may be accurately calculated and right-of-way descriptions prepared. To assemble a comprehensive map for use by negotiators, the property lines, centerline, and right-of-way are transferred to a controlled photographic mosaic using acetate tape or other means of delineating the project limits. The mosaic may then be rephotographed on autopositive film. Using this film, dry photographic prints of any quantity can be readily and cheaply processed. Both negotiators and property owners are enthusiastic over this method of presenting a true picture of the proposed development, and it has proved to be invaluable in appraisal and acquisition of right-of-way. Where it becomes necessary to resort to condemnation, this method of presentation will show the court the details of the area to be taken in a form that can be easily understood.

Figure 4 illustrates a portion of the final right-of-way map with parcels numbered



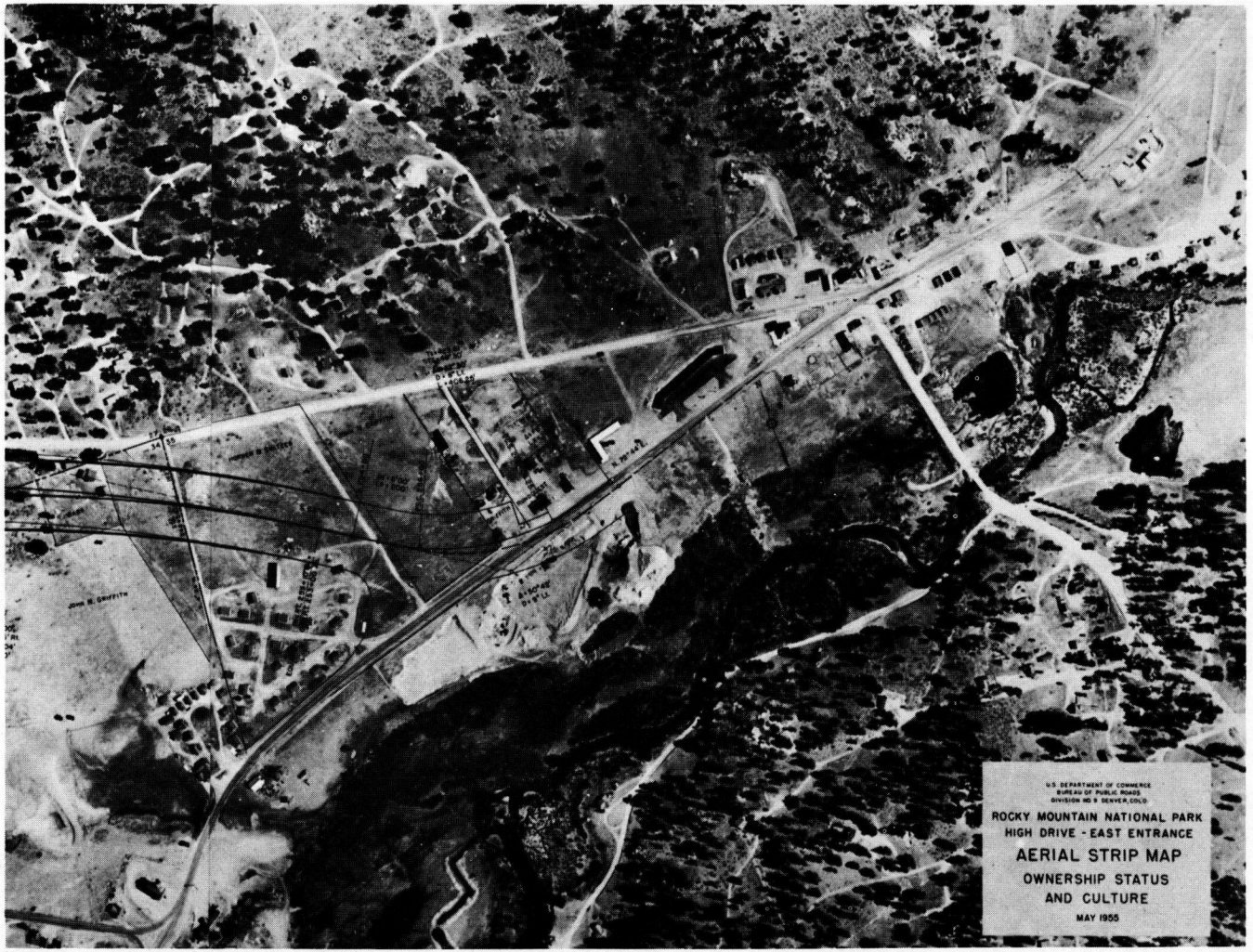


Figure 3. Aerial strip map; ownership status and culture.


1036
1025
CHARLES B. & AGNES M. CARIGNAN
BECK
GIMAR
JACK
DETRICK
N

Figure 4. Aerial strip map; ownership status and culture.

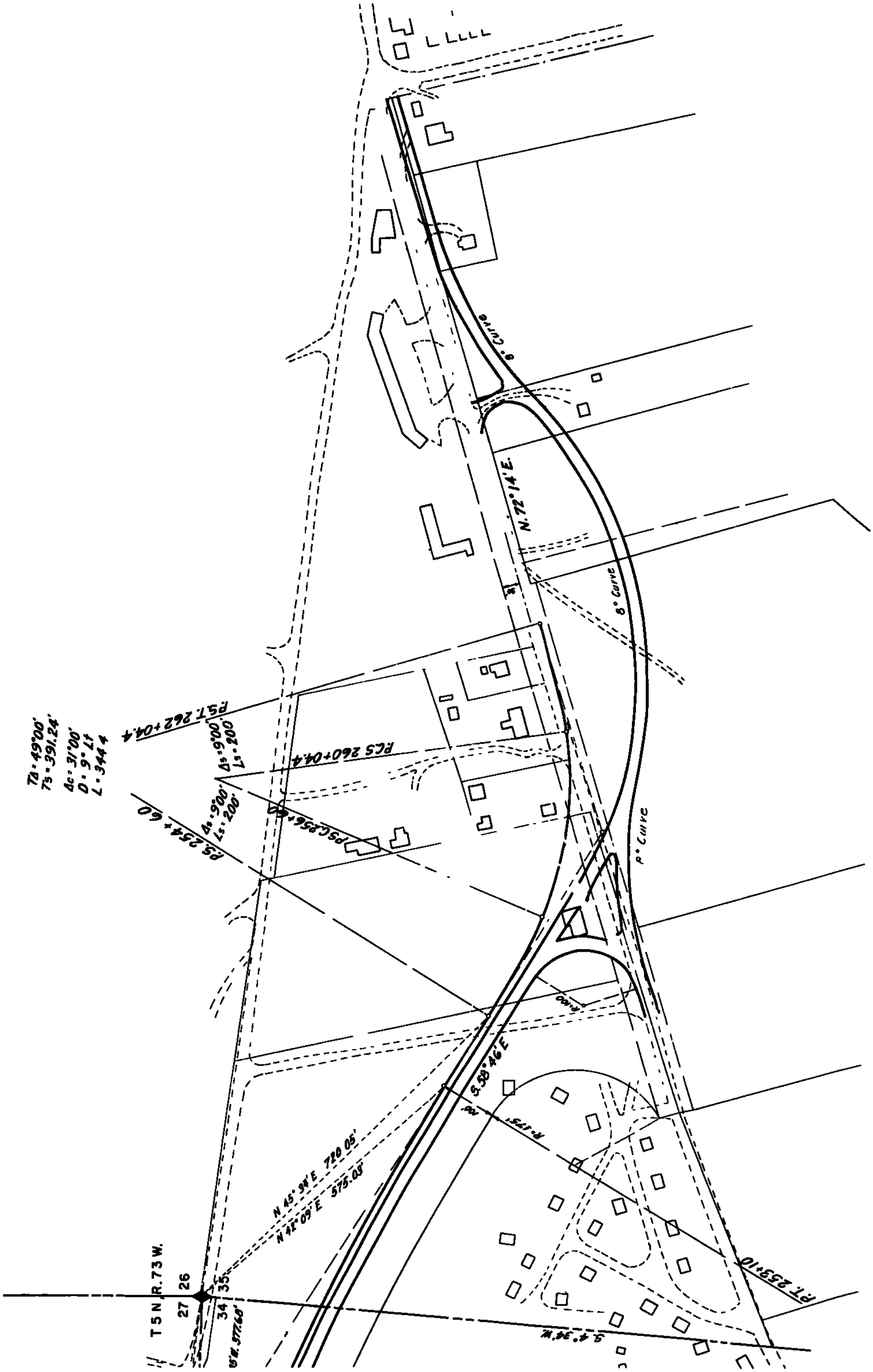

N. 72° 14' E.
S. 58° 46' E.
8° Curve
8° Curve
T 5 N. R. 73 W.
27
26
34
35
N 45° 34' E 720.05'
N 42° 09' E 575.03'
P.T. 253+10
P.S. 254+60
P.S.C. 256+60
P.C.S. 260+04.4
P.S.T. 262+04.4
Δs = 9°00'
Ls = 200'
Δc = 31°00'
L = 344.4

Figure 5.

for easy reference as to ownership. Following this prescribed procedure, speculation can be precluded, because it is entirely possible to maintain security up to the day negotiation begins for procurement of rights-of-way.

Figure 5 illustrates the final layout for field staking. To reach this plateau, less than 8 hours of actual field work has been performed by three men.