

JOURNAL *of the*  
**BOSTON SOCIETY**  
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**JULY - 1963**

**VOLUME 50**

**NUMBER 3**

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**JOURNAL OF THE  
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CIVIL ENGINEERS**

**Volume 50**

**JULY, 1963**

**Number 3**

**CONTENTS**

**PAPERS AND DISCUSSIONS**

	PAGE
Final Revised and Adopted Form of Part 29 "Excavations and Foundations" of the Boston Building Code. <i>H. A. Mohr</i> . . . . .	149
Legal Aspects of Surveying. <i>Charles M. Anderson</i> . . . . .	172
Applications of Vector Algebra to Problems in Plane Surveying. <i>Joseph J. Breen</i> . . . . .	218

**OF GENERAL INTEREST**

Proceedings of the Society . . . . .	239
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Journal of Boston Society of Civil Engineers is indexed regularly by  
Engineering Index, Inc.

Copyright, 1963, by the Boston Society of Civil Engineers

Second-Class postage paid at Boston, Mass.

Published four times a year, January, April, July and October, by the Society  
47 Winter St., Boston, Massachusetts

Subscription Price \$7.00 a Year (4 Copies)  
\$1.75 a Copy

All orders must be accompanied by check

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JOURNAL OF THE  
**BOSTON SOCIETY OF CIVIL  
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Volume 50

JULY, 1963

Number 3

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**FINAL REVISED AND ADOPTED FORM OF PART  
29 "EXCAVATIONS AND FOUNDATIONS" OF  
THE BOSTON BUILDING CODE**

BY H. A. MOHR,\* *Member*

Chairman of the Technical Foundation Committee

IN VIEW of the fact that preliminary stages of the work of the Technical Foundation Committee were published in this Journal, it is appropriate and helpful to the profession to publish herewith also the final form of Part 29 which was passed by the City Council of Boston on October 1, 1962, and was approved by Mayor John F. Collins on October 3, 1962.

The Technical Foundation Committee started its work in 1954. The first draft of a revision of Part 29 was published in the January, 1959, issue of this Journal for the purpose of soliciting comments by the profession. Copies of this issue were mailed to leading foundation engineers throughout the country, requesting their critical review. Then, on February 19, 1959, before a monthly meeting of the Boston Society of Civil Engineers, an open forum discussion was held with a large attendance of engineers and contractors. Thereafter, a hearing was held in the Board of Appeals Room, City Hall Annex, specifically for the purpose of receiving comments by the pile driving contractors. The verbal comments which were made at both meetings, as well as many written comments received subsequently, were carefully studied by the Committee, and many changes were incorporated in a new revision which was completed in the spring of 1960 and published in the July, 1960, issue of this Journal. Complimentary copies of this issue were distributed at the Annual Meeting of the American Society of

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\* Consulting Engineer, Boston, Mass.

Civil Engineers held in Boston in October 1960. A session at that Convention was devoted to a presentation of various aspects of the proposed Part 29, and to an open discussion. Again the profession was requested to submit comments in writing and this Committee again considered carefully all comments received. Many suggestions were adopted in whole or in part. The Committee's final decisions represent in all instances either a unanimous opinion, or a heavy majority opinion, of the members of the Committee.

Finally, the Advisory Committee to the Mayor questioned this Committee in the course of several lengthy meetings concerning objections raised by the construction industry. Point by point each comment was discussed and the reasons given why this Committee either adopted or rejected each suggestion. The adopted revision represents the agreement on Part 29 of the two Committees.

Among the few recommendations of the Technical Committee which were not adopted were an increase in the allowable stress from 8500 to 9000 psi in Section 2913 paragraph (b)(5), and an increase from 7500 to 8000 psi in Section 2913 paragraph (c)(3).

For reference, the memberships of the Technical Foundation Committee and of the Advisory Committee are listed below.

The members of both committees have earned well-deserved thanks by the profession for the time and effort which they have devoted to this long-overdue modernization of Part 29 of the Boston Building Code.

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#### PART 29

### EXCAVATIONS AND FOUNDATIONS

#### SECTION

- 2901—EXCAVATIONS.
- 2902—GENERAL REQUIREMENTS FOR FOUNDATIONS.
- 2903—SOIL INFORMATION.
- 2904—CLASSIFICATION OF BEARING MATERIALS AND ALLOWABLE BEARING VALUES.
- 2905—FOUNDATION LOADS.
- 2906—FOUNDATION DESIGN.
- 2907—FOOTINGS AND FOUNDATION PIERS.
- 2908—DRIVEN PILES—GENERAL REQUIREMENTS.
- 2909—ALLOWABLE LOAD ON PILES.
- 2910—WOOD PILES—GENERAL REQUIREMENTS.
- 2911—PRECAST CONCRETE PILES.
- 2912—CAST-IN-PLACE CONCRETE PILES.
- 2913—STEEL AND STEEL CONCRETE PILES.
- 2914—COMPOSITE PILES.
- 2915—BEARING TESTS.
- 2916—SETTLEMENT ANALYSIS.

SECTION 2901. EXCAVATIONS.—(a) Until provision for permanent support has been made, excavations shall be properly guarded and protected by the persons causing them to be made so as to prevent such excavation from becoming dangerous, in the opinion of the commissioner, to life or limb, or to prevent adjoining soil from moving or caving, or to preserve or protect any wall, building, or structure from injury. Where necessary, excavations shall be sheet-piled, braced, or shored, and permanent excavations shall be protected by retaining walls or other permanent structures to prevent movement or caving of the adjoining soil.

(b) Structures near an excavation and owned by another than the person causing the excavation to be made shall be supported as follows:

- (1) Where an excavation is carried below the curb grade, at the common property line, or below the surface of the ground where there is no

such curb grade, the person causing such excavation to be made shall, at all times, if accorded the necessary license to enter upon the adjoining land, and not otherwise, at his own expense, preserve and protect from injury any wall, building, or structure, the safety of which may be affected by said excavation, and shall support it by proper foundations. If the necessary license is not accorded to the person making such excavation, then it shall be the duty of the owner refusing to grant such license to make such wall, building, or structure safe and to support it by proper foundations; and, when necessary for that purpose, such owner shall be permitted to enter upon the premises where such excavation is being made.

(2) Where a party wall is intended to be used by the person causing the excavation to be made, he shall, at his own expense, preserve such party wall from injury and shall support it so that the said party wall shall be safe for the purposes intended.

(c) If the person whose duty it shall be under the provisions of this section to guard and protect an excavation, or to prevent adjoining soil from moving or caving, or to preserve or protect any wall, building, or structure from injury, shall neglect or fail so to do, the commissioner may enter upon the premises, and make safe such excavation, wall, building, or other structure as provided in section 116 of Part 1.

SECT. 2902. GENERAL REQUIREMENTS FOR FOUNDATIONS.—(a) The foundations of every permanent structure shall be supported by satisfactory bearing material which shall mean:

(1) Natural deposits of rock, gravel, sand, rock flour (inorganic silt), inorganic clay, or any combination of these materials;

(2) Compacted fills which satisfy the provisions of Section 2904(a)(4);

(3) Natural deposits or artificial fills which can be changed into satisfactory bearing materials by preconsolidation with a temporary surcharge in accordance with the provisions of Section 2904(a)(5).

(b) Where footings are supported at different levels, or at different levels from footings of adjacent structures, foundation plans shall include vertical sections showing to true scale all such variations in grade. The effect of such differences in footing levels on the bearing materials shall be considered in the design.

(c) Foundations shall be constructed so that freezing temperatures will not penetrate into underlying soils that contain more than five per cent (by weight), passing a No. 200 mesh sieve. The foundations and grade beams of permanent structures, except when founded on sound rock, and except as otherwise provided in Section 2902(d), shall be carried down at least four feet below an adjoining surface exposed to natural freezing. No foundation shall be placed on frozen soil. Foundations shall not be placed in freezing weather unless adequately protected.

(d) Foundations of detached garages or similar accessory structures not exceeding eight hundred square feet in area and not over one story high, and grade beams of all structures, need not be carried more than one foot below an adjoining surface exposed to natural freezing if the underlying soil to a depth of at

least four feet beneath the surface, and extending at least four feet outside the building, is sand, gravel, cinders, or other granular materials containing not more than five per cent (by weight) passing a No. 200 mesh sieve.

(e) Foundations subject to hydrostatic uplift shall have adequate provisions to prevent heaving.

(f) Basements and cellars shall be waterproofed up to the maximum probable ground-water level. Under boilers, furnaces, and other heat-producing apparatus, suitable insulation shall be installed to protect the waterproofing against damage from heat as specified in Part 21. Foundations under heat-producing units shall be so insulated as to prevent evaporation of moisture from any underlying soil that is subject to shrinkage, and to protect the heads of wood piles against damage from heat.

SECT. 2903. SOIL INFORMATION.—(a) Before issuing a permit for the erection of a permanent structure, or for the alteration of a permanent structure that may affect its foundation, the commissioner shall be furnished with adequate soil data by the applicant. Where borings or tests are required, they shall be made at a sufficient number of locations and to such depths, and they shall be supplemented by such field or laboratory tests and engineering analysis, as are necessary in the opinion of the commissioner. When it is proposed to support the structure directly on bedrock, the commissioner may require drill holes or core borings to be made into the rock to a sufficient depth to prove that bedrock has been reached.

(b) Duplicate copies of the results obtained from all completed and uncompleted borings, plotted to true relative elevation and to scale, and of all test results or other pertinent soil data shall be filed with the commissioner.

SECT. 2904. CLASSIFICATION OF BEARING MATERIALS AND ALLOWABLE BEARING VALUES.—(a) The terms used in this section shall be interpreted in accordance with generally accepted engineering nomenclature. In addition, the following more specific definitions are used for bearing materials in the Greater Boston area:

(1) Rocks

Shale—A soft, fine-grained sedimentary rock.

Slate—A hard, fine-grained metamorphic rock of sedimentary origin.

Roxbury Puddingstone—A hard, well-cemented conglomerate.

(2) Granular Materials

Gravel—A mixture of mineral grains at least seventy per cent (by weight) of which is retained on a No. 4 mesh sieve and possessing no dry strength.

Sand—A mixture of mineral grains at least seventy per cent (by weight) of which passes a No. 4 mesh sieve and which contains not more than fifteen per cent (by weight) passing a No. 200 mesh sieve.

Coarse Sand—A sand at least fifty per cent (by weight) of which is retained on a No. 20 mesh sieve.

Medium Sand—A sand at least fifty per cent (by weight) of which passes

a No. 20 mesh sieve and at least fifty per cent (by weight) is retained on a No. 60 mesh sieve.

Fine Sand—A sand at least fifty per cent (by weight) of which passes a No. 60 mesh sieve.

Well-graded Sand and Gravel—A mixture of mineral grains which contains between twenty-five per cent and seventy per cent (by weight) passing a No. 4 mesh sieve, between ten and forty per cent (by weight) passing a No. 20 mesh sieve, and containing not more than eight per cent (by weight) passing a No. 200 mesh sieve.

### (3) Cohesive Materials

Hardpan—A glacial till that generally lies directly over bedrock and consists of a highly compacted, heterogeneous mixture ranging from very fine material to coarse gravel and boulders. It can be identified from geological evidence and from the very high penetration resistance encountered in earth boring and sampling operations.

Clay—A fine-grained, inorganic soil possessing sufficient dry strength to form hard lumps which cannot readily be pulverized by the fingers.

Hard Clay—An inorganic clay requiring picking for removal, a fresh sample of which cannot be molded by pressure of the fingers.

Medium Clay—An inorganic clay which can be removed by spading, a fresh sample of which can be molded by a substantial pressure of the fingers.

Soft Clay—An inorganic clay, a fresh sample of which can be molded with slight pressure of the fingers.

Rock Flour and Inorganic Silt—A fine-grained, inorganic soil consisting chiefly of grains which will pass a No. 200 mesh sieve, and possessing sufficient dry strength to form lumps which can easily be pulverized with the fingers.

*(Note: Dry strength is determined by drying a wet pat of soil and breaking it with the fingers.)*

### (4) Compacted Granular Fill

(a) A fill consisting of gravel, sand-gravel mixtures, coarse or medium sand, crushed stone, or slag, containing not more than five per cent (by weight) passing a No. 200 mesh sieve, shall be considered satisfactory bearing material when compacted by one of the following methods:

I. In six-inch layers, each layer with at least four coverages with the treads of a crawler-type tractor with a total weight, including equipment, of not less than fifteen tons and operated at its top speed;

II. In twelve-inch layers, with at least three coverages with the wheels of a rubber-tired roller having four wheels abreast and weighted to a total load of not less than thirty-five tons;

III. Other types of materials and other compaction equipment, such as vibrators, may be approved by the Commissioner on the basis of sufficient evidence that they will achieve compacted fills having satisfactory properties.

(b) Application of water is permitted, and for some sands may be required in order to achieve satisfactory trafficability and compaction.

(c) The Commissioner will require a competent inspector, qualified by experience and training and satisfactory to him, to be on the project at all times while fill is being placed and compacted. The inspector shall make an accurate record of the type of material used, including grain-size curves, thickness of lifts, type of compaction equipment and number of coverages, the use of water and other pertinent data. Whenever the Commissioner or the inspector questions the suitability of a material, or the degree of compaction achieved, bearing tests shall be performed on the compacted material in accordance with the requirements of Section 2915. A copy of all these records and test data shall be filed with the Commissioner.

(5) Preloaded Highly Compressible Materials

The Commissioner may allow the use of certain otherwise unsatisfactory natural soils and uncompacted fills for the support of one story structures, after these materials have been preloaded to not less than one hundred and fifty per cent of the stresses which will be induced by the structure.

The Commissioner may require the loading and unloading of a sufficiently large area, conducted under the direction of a competent engineer, approved by the Commissioner, who shall submit a report containing a program which will allow sufficient time for adequate consolidation of the material, and an analysis of the preloaded material and of the probable settlements of the structure.

(b) The maximum pressure on soils under foundations shall not exceed the allowable bearing values set forth in the following table, except when determined in accordance with the provisions of Section 2915, and in any case subject to the modifications of subsequent paragraphs of this section.

Class	Material	Allowable Bearing Value in Tons per Square Foot (*)
1	Massive igneous rocks and Roxbury Puddingstone, all in sound condition (sound condition allows minor cracks) .....	100
2	Slate in sound condition (minor cracks allowed) .....	50
3	Shale in sound condition (minor cracks allowed) .....	10
4	Residual deposits of shattered or broken bedrock of any kind except shale .....	10
5	Hardpan .....	10
6	Gravel, well-graded sand and gravel .....	5

\* The allowable bearing value given in this section, or when determined in accordance with the provisions of Section 2915, will assure that the soils will be stressed within limits that lie safely below their strength. However, such allowable bearing values for Classes 9 to 12, inclusive, do not assure that the settlements will be within the tolerable limits for a given structure.

7	Coarse sand .....	3
8	Medium sand .....	2
9	Fine sand .....	1 to 2 (‡)
10	Hard clay .....	5
11	Medium clay .....	2 (†)
12	Soft clay .....	1 (†)
13	Rock flour, inorganic silt, shattered shale, or any natural deposit of unusual character not provided for herein .....	(‡)
14	Compacted granular fill .....	2 to 5 (‡)
15	Preloaded highly compressible materials .....	(‡)

(c) The tabulated bearing values for rocks of Classes 1 to 3, inclusive, shall apply where the loaded area is on the surface of sound rock. Where the loaded area is below such surface these values may be increased ten per cent for each foot of additional depth, but shall not exceed three times the tabulated values.

(d) The allowable bearing values of materials of Classes 4 to 9, inclusive, may exceed the tabulated values by five per cent for each foot of depth of the loaded area below the minimum required in Section 2906(c), but shall not exceed twice the tabulated values. For areas of foundations smaller than three feet in least lateral dimension, the allowable design bearing values shall be one third of the allowable bearing values multiplied by the least lateral dimension in feet.

(e) The tabulated bearing values for Classes 10 to 12, inclusive, shall apply only to pressures directly under individual footings, walls, and piers; and in case structures are founded on or are underlain by deposits of these classes, the total load over the area of any one bay or other major portion of the structure, minus the weight of all materials removed, divided by the area, shall not exceed one half the tabulated bearing values. Whenever there is any doubt about the settlements of a proposed structure or the effect on neighboring structures, the commissioner shall require that the magnitude and distribution of the probable settlements be investigated as specified in Section 2916.

(f) The computed vertical pressure at any level beneath a foundation shall not exceed the allowable bearing values for the material at that level. Computation of the vertical pressure in the bearing materials at any depth below a foundation shall be made on the assumption that the load is spread uniformly at an angle of sixty degrees with the horizontal; but the area considered as supporting the load shall not extend beyond the intersection of sixty degree planes of adjacent foundations.

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† Alternatively, the allowable bearing value shall be computed from the unconfined compressive strength of undisturbed samples, and shall be taken as 1.50 times that strength for round and square footings, and 1.25 times that strength for footings with length-width ratios of greater than four; for intermediate ratios interpolation may be used.

‡ Value to be fixed by the commissioner in accordance with Sections 2915 and 2903.

SECT. 2905. FOUNDATION LOADS.—(a) The loads to be used in computing the pressure upon bearing materials directly underlying foundations shall be the live and dead loads of the structure, as specified in Part 23, including the weight of the foundations and of any immediately overlying material, but deducting from the resulting pressure per square foot the total weight of a one-square-foot column of soil, including the water in its voids, which extends from the lowest immediately adjacent surface of the soil to the bottom of the footing, pier or mat. Foundations shall be constructed so as to resist the maximum probable hydrostatic pressures.

(b) Eccentricity of loading in foundations shall be fully investigated and the maximum pressure on the basis of straight-line distribution shall not exceed the allowable bearing values.

(c) Where the pressure on the bearing material due to wind is less than one third of that due to dead and live loads, it may be neglected in the foundation design. Where this ratio exceeds one third, foundations shall be so proportioned that the pressure due to combined dead, live, and wind loads shall not exceed the allowable bearing values by more than one third.

(d) One-story structures without masonry walls and not exceeding eight hundred square feet in area may be founded on a layer of satisfactory bearing material not less than three feet thick, which is underlain by highly compressible material, provided that the stresses induced in the unsatisfactory material by the live and dead loads of the structure and the weight of any new fill, within or adjacent to the building area, will not exceed two hundred and fifty pounds per square foot.

(e) The pressures against foundation walls and other types of retaining walls shall be fully investigated. Particular attention shall be paid to restraints which may cause substantially larger earth pressures than the active earth pressure, and to the type of backfill and drainage. In addition to earth pressure, such walls shall be designed and constructed to resist hydrostatic pressures corresponding to the maximum probable ground water level.

SECT. 2906. FOUNDATION DESIGN.—(a) Foundations shall be designed to distribute to the supporting materials all vertical, horizontal and inclined loads, as specified in Section 2905, without exceeding the allowable stresses specified elsewhere in this Code for the materials of which the foundations are to be constructed.

(b) Plain concrete in foundations shall have a minimum compressive strength at twenty-eight days of two thousand pounds per square inch. Reinforced concrete in foundations shall have a minimum compressive strength of twenty-five hundred pounds per square inch at twenty-eight days.

(c) The bottom surface of any footing resting on material of Classes 4 to 15, inclusive, shall be at least eighteen inches below the lowest ground surface or the surface of a floor slab bearing directly on the soil immediately adjacent to the footing.

(d) Whenever, in an excavation, soil and ground water conditions are such that an inward or upward seepage is produced in the bearing material, special excavating methods and control of ground water shall be employed to prevent disturbance of the bearing material in the excavation or under existing structures. If there is evidence of disturbance of the bearing material, the extent of the disturbance shall be evaluated and appropriate remedial measures taken, satisfactory to the Commissioner.

SECT. 2907. FOOTINGS AND FOUNDATION PIERS.—(a) The footings of foundation walls or piers shall be of plain or reinforced concrete or other satisfactory masonry, or steel grillages. Structural steel grillage foundations shall have at least six inches of concrete cover below the bottom of the steel and shall have at least four inches of concrete cover above the steel and between the sides of the steel and the adjacent soil. Footings of wood may be used under temporary structures.

(b) A foundation pier is here defined as a structural member which extends to a satisfactory bearing material, and which may be constructed in an excavation that afterwards is backfilled by an approved method, or by filling the excavation with concrete, or which may be built by sinking an open or pneumatic caisson.

(1) The manner of construction shall be by non-displacement methods and shall permit inspection of the bearing material in place.

(2) The bases of foundation piers may be enlarged by spread footings, pedestals or belled bottoms.

(3) Bell-shaped bases shall have a minimum edge thickness of four inches. The bell roof shall slope not less than sixty degrees with the horizontal unless the base is designed in accordance with Part 26.

(4) Foundation piers may be designed as concrete columns with continuous lateral support. The unit compressive stress in the concrete at the least cross section shall not exceed twenty-two and one half per cent of the twenty-eight day strength of the concrete nor nine hundred pounds per square inch.

(5) When the center of cross section of a foundation pier at any level deviates from the resultant of all forces more than one sixtieth of its height, or more than one tenth of its diameter, it shall be reinforced as provided in Part 26. The restraining effect of the surrounding soil may be taken into account.

(6) With approval of the Commissioner, concrete may be placed through still water by means of a properly operated tremie or bottom-dump bucket.

(7) The owner shall engage a competent inspector, qualified by experience and training and satisfactory to the Commissioner, to be present at all times while foundation piers are being installed, to inspect and approve the bearing soil and the placing of the concrete. The inspector shall make a record of the type of bearing soil upon which the pier rests, of the dimensions of the pier, and of the class of concrete used in its construction. A copy of these records shall be filed in the office of the Commissioner.

SECT. 2908. DRIVEN PILES—GENERAL REQUIREMENTS.—(a) Types of pile construction not specifically provided for in this part shall meet such additional requirements as may be prescribed by the Commissioner.

(b) A detached column supported by piles shall rest upon not less than three piles, at least one of which is offset; except that for one story buildings a detached column may rest upon two piles when its axis is not more than one and one half inches off the line connecting the centers of the two piles, or upon a single pile when other than wood or wood-composite piles are used, and its axis is not more than one and one half inches off the center of the pile.

(c) A foundation wall, restrained laterally so as to ensure stability both during and after construction, may be supported by a single row of piles.

(d) The method of driving shall be such as not to impair the strength of the pile and shall meet with the approval of the Commissioner. Measurements to determine the value of "s" shall not be made immediately after the introduction of fresh cushion block material, or an interruption in the driving operation or when the pile head is shattered, broomed, crumpled, or otherwise damaged.

The cushion block, where used, shall be of hardwood with its grains parallel with the axis of the pile and be enclosed in a tight-fitting steel housing, or an approved equal. Wood chips, pieces of rope, old hose, or automobile tires and similar materials shall not be used as a cushion block.

Shattered, broomed, crumpled, or otherwise damaged pile heads shall be cut back to sound material before continuing the driving.

In case a follower is used, it shall be of steel, seasoned white oak or hickory, equipped on its lower end with a metal socket or hood suitable for encasing the pile head and to protect it from being damaged during driving.

(e) Jetted piles shall be driven to the required resistance after the flow of jet water has stopped, except as provided in Section 2909(c)(5).

(f) When piles have been damaged in driving, or driven in locations other than those indicated on the plans, or that have capacities less than required by the design, the affected pile groups and pile caps shall be investigated and if necessary, the pile groups or pile caps shall be redesigned or additional piles shall be driven to replace the defective piles.

(g) Concrete for capping piles shall be proportioned for a minimum compressive strength at twenty-eight days of at least twenty-five hundred pounds per square inch. The concrete shall extend not less than twelve inches above the pile heads and shall fill the space between and around the piles for a depth of at least three inches. The minimum horizontal distance from the edge of the pile cap to the nearest pile surface shall be six inches and there shall be at least two inches of concrete between the top of a pile and steel reinforcement.

(h) Where piles are driven through soft soil to hard bearing material providing high point resistance, the grades of all piles or pile casings previously driven or redriven shall be measured to detect uplift; and if uplift of one half inch or more occurs in any pile or pile casing, such pile or pile casing shall be

redriven to its original point elevation and thereafter to the required final driving resistance.

(i) The length of a pile below the ground surface shall be considered as a plain column with continuous lateral support. The length above the ground surface shall be designed as an unsupported column in accordance with the applicable provisions of this code.

(j) The owner shall engage a competent inspector, qualified by experience and training and satisfactory to the Commissioner, to be present at all times while piles are being driven and to inspect all work in connection with the piles. The inspector shall make an accurate record of the material and the principal dimensions of each pile, of the weight and fall of the ram, the type, size, and make of hammer, the number of blows per minute, the energy per blow, the number of blows per inch for the last six inches of driving, together with the grades at point and cut-off. A copy of these records shall be filed in the office of the Commissioner.

SECT. 2909. ALLOWABLE LOAD ON PILES.—(a) The supporting capacity of piles shall be obtained from bearing upon or embedment in bearing materials as defined in Section 2904.

(b) The allowable load on a single pile shall be limited by the requirement that such load shall not cause excessive movement of the pile relative to the soil. Satisfactory proof of this load can be obtained from load tests conducted in accordance with Section 2915. In the absence of such proof of the supporting capacity, except for the types of piles covered in Sections 2912(d) and 2913(d), the load on a single pile shall not exceed the *higher* of the two values determined in accordance with Sections 2909(c) and 2909(d).

(c) (1) The allowable load may be computed by means of the following driving formula:

$$R = \frac{1.7 E}{s + 0.1 \sqrt{\frac{w_p}{w_r}}}$$

where

R = allowable pile load in pounds

E = energy per blow in foot-pounds which for drop hammers is the product of the weight in pounds of the hammer and the height of fall in feet, and which for other types of hammers may be taken as that established by the hammer manufacturer. For batter piles, proper allowance shall be made for the resultant loss of energy.

$\frac{w_p}{w_r}$  = the ratio of the weight  $w_p$  of the pile and other driven parts to the

weight  $w_r$  of the striking part of the hammer, except that this ratio shall not be entered into the formula as less than unity.

s = the average penetration in inches per blow for the final six inches of driving, except that if an abrupt high increase in resistance is

encountered, "s" shall be taken as the average penetration per blow for the last five blows. The minimum value of "s" which may be used in the formula is five hundredths of an inch.

(2) The energy E per blow in foot-pounds delivered by the hammer shall be numerically not less than fourteen per cent of R in pounds and

$\frac{w_p}{w_r}$  shall not be greater than 3.5.

(3) The value of "s" must be determined with the hammer operating at not less than ninety per cent of the maximum number of blows per minute for which the hammer is designed.

(4) If the driving of the pile has been interrupted for more than one hour, the value of "s" shall not be determined until the pile is driven at least an additional twelve inches, except when it encounters refusal on or in a material of Classes 1 to 5, inclusive.

(5) When the constant tapered portion of a pile, including a timber pile, is driven through a layer of gravel, sand, or hard clay (Classes 6 to 10, inclusive, and Class 14) exceeding five feet in thickness, and through an underlying soft stratum, the bearing capacity shall not be determined in accordance with the driving formula, unless jetting is used during the entire driving of the tapered portion of the pile through the layer of gravel, sand, hard clay, or Class 14 material, or unless a hole is pre-excavated through said layer for each pile.

(d) The allowable load on a pile stopped in *inorganic clay as found in Greater Boston*, may be based on a friction value of five hundred pounds per square foot of embedded pile surface for a design load not to exceed twenty-two tons, or on a friction value determined from pile load tests. The embedded length shall be the length of the pile below the surface of the inorganic clay, or below the surface of immediately overlying satisfactory bearing material. The area of embedded pile surface shall be computed by multiplying the embedded length by the perimeter of the smallest circle or polygon that can be circumscribed around the average section of the embedded length of the pile. The method of determining the allowable load described in this paragraph shall not be used for a pile in which the drive-pipe is withdrawn or for piles which are driven through the clay to or into firmer bearing materials.

(e) In case piles in clusters are driven under the provisions of Section 2909(d), the allowable load shall be computed for the smaller of the following two areas: (1) the sum of the embedded pile surfaces of individual piles; (2) the area obtained by multiplying the perimeter of the polygon circumscribing the cluster at the surface of the satisfactory bearing material by the average embedded length of pile.

(f) The allowable load on a single pile installed by jacking shall not exceed one half the load applied to the pile at the completion of jacking, provided that the final load is kept constant for a period of four hours and that the settlement during that period does not exceed one twentieth of an inch.

(g) Where weaker materials underlie the bearing material into which the piles are driven, the allowable pile load shall be limited by the provision that the vertical pressures in such underlying materials produced by the loads on all piles in a foundation shall not exceed the allowable bearing values of such materials, as given in Section 2904, or determined in accordance with the provisions of Section 2915. Piles or pile groups shall be assumed to transfer their loads to the underlying materials by spreading the load uniformly at an angle of sixty degrees with the horizontal, starting at a polygon circumscribing the piles at the top of the satisfactory bearing material in which they are embedded; but the area considered as supporting the load shall not extend beyond the intersection of the sixty degree planes of adjacent piles or pile groups.

(h) Where a pile or a group of piles is placed in subsiding fill or soil, the effect of the downward frictional forces shall be given consideration in the design.

(i) The allowable bearing value of a pile shall not be limited to the value obtained by multiplying its point area by the allowable bearing value given in Section 2904.

SECT. 2910. WOOD PILES—GENERAL REQUIREMENTS.—(a) Every wood pile shall be in one piece, cut from a sound live tree, and free from defects which may materially impair its strength or durability. It shall be butt-cut above the ground swell, and shall have substantially uniform taper from butt to point. Wood piles shall measure at least six inches in smallest diameter at the point and at least ten inches in smallest diameter at the cut-off, these measurements being taken under the bark. The axis of a wood pile shall not deviate from a straight line more than one inch for each ten feet of length nor more than six inches for the entire length.

(b) The load on a wood pile shall not exceed the allowable load specified in Section 2909 and, for a pile of the minimum dimensions specified in this section, shall not exceed twelve tons for Spruce, Norway Pine, and woods of similar strength which will be referred to as Type A, nor sixteen tons for Oak, Southern Yellow Pine, and woods of similar strength which will be referred to as Type B. These loads may be increased for each full inch by which both the cut off and point diameters exceed the minima specified, by three tons for woods of Type A, but not to exceed a total load of twenty-four tons, and by four tons for woods of Type B, but not to exceed a total load of thirty tons.

(c) The load on wood piles driven to bearing on materials of Classes 1 to 5, inclusive, shall be not more than sixty per cent of that allowed in Section 2910(b).

(d) Piles shall be cut to sound wood before capping is placed.

(e) The center-to-center spacing of wood piles shall be not less than two and one half times the cut-off diameter.

(f) To avoid damage to the pile, the size of the hammer shall be such that the driving energy in foot pounds per blow shall not exceed numerically the point diameter of the pile in inches multiplied by fifteen hundred. The total driving energy in foot-pounds for six inches of penetration shall for all types of hammers

be numerically no greater than the point diameter in inches times twenty-two thousand for woods of Type A or times thirty-two thousand for woods of Type B. For the last inch of penetration the energy in foot-pounds shall not exceed numerically the point diameter in inches multiplied by six thousand. In any case driving shall be stopped immediately when abrupt high resistance to penetration is encountered.

(g) The cut-off grade for untreated wood piles shall be below the probable permanent ground-water level, and shall be subject to the Commissioner's approval.

(h) The Commissioner may require the owner to install and maintain in good condition at least one ground-water observation well within the building, which shall be accessible to the Commissioner.

(i) ADDITIONAL REQUIREMENTS FOR TREATED PILES

(1) Timber piles pressure treated with creosote or creosote-coal-tar solution, and conforming to the requirements of this section, may be cut off above permanent ground water level when used for the support of buildings not exceeding two stories in height.

(2) Before any treated piles are driven, the commissioner shall be furnished three copies of a certificate of inspection, issued by an approved independent testing laboratory, certifying that the piles were free of decay, were properly peeled and otherwise prepared before treatment; and that the method of treatment, the chemical composition and the amount of retention of the preservative conform to the requirements of this section.

(3) Treated piles shall be of Norway Pine, Southern Yellow Pine, or Douglas Fir and shall be impregnated with preservative in accordance with specifications of the American Wood Preservers' Association, as follows: C1-61, "Standard for Preservative Treatment by Pressure Processes—All Timber Products" and C3-60, "Standard for the Preservative Treatment of Piles by Pressure Processes."

(4) Piles exposed to sea water shall be Southern Yellow or Norway Pine, and the preservative used shall conform to the requirements for Grade B of P2-58, "Standard for Creosote-Coal-Tar Solutions" of the American Wood Preservers' Association. For piles not exposed to sea water, the preservative used shall conform to P1-54, "Standard for Creosote" of the American Wood Preservers' Association.

(5) The retention of preservative shall be not less than twenty pounds per cubic foot for piles exposed to sea water and not less than twelve pounds per cubic foot for other piles.

(6) After being cut to grade, the top surface of the pile shall be brush treated with not less than three heavy coatings of the treating material applied hot.

SECT. 2911. PRECAST CONCRETE PILES.—(a) Precast concrete piles shall be so proportioned, cast, cured, handled, and driven as to resist without significant cracking the stresses induced by handling and driving as well as by loads. The minimum lateral dimension of a precast concrete pile shall be twelve inches

except that the lower six feet may taper to eight inches at the point exclusive of the metal point, if used. Each pile shall be cast in one piece. The concrete shall have a minimum compressive strength of four thousand pounds per square inch. No pile shall be handled or driven until it has cured sufficiently to develop the necessary strength as shown by standard test specimens made from the same batches of concrete cured under similar conditions.

(b) Except as otherwise specified herein, piles shall be proportioned so as to satisfy the requirements of Part 26. Additional requirements for steel reinforcement are as follows: For a length equal to at least three times the minimum lateral dimension at both ends of the pile, lateral ties shall be spaced not over three inches center-to-center or an equivalent spiral shall be provided. Steel reinforcement shall be embedded in concrete forming the body of the pile a net distance of at least one and one half inches from any exposed surface and in piles exposed to sea water such coverage shall be at least three inches.

(c) The maximum water-cement ratio and the minimum cement content of the concrete for piles exposed to sea water shall be four and one half gallons per sack and eight sacks per cubic yard, respectively.

(d) The minimum spacing center-to-center of precast concrete piles shall be two and one half times the square root of the cross-sectional area at the butt.

(e) When precast concrete piles are driven to or into bearing materials of Classes 1 to 5, inclusive, or through materials containing boulders, they shall have metal tips of approved design.

(f) The load on a precast concrete pile shall not exceed the allowable load specified in Section 2909, and shall not exceed fifty tons for a pile of one square foot cross-sectional area. For piles of larger cross-section, this limit of load may be increased in proportion to increase in area, but not to exceed a total load of ninety tons.

SECT. 2912. CAST-IN-PLACE CONCRETE PILES.—(a) In this section a distinction is made between poured-concrete piles and compacted-concrete piles. A poured-concrete pile is formed by pouring concrete into a driven casing or drive-pipe that is installed in the ground either permanently or temporarily. A compacted-concrete pile is formed by placing concrete having zero slump, in small batches, and compacting each batch.

(b) All cast-in-place concrete piles shall be so made and placed as to ensure the exclusion of all foreign matter and to secure a well formed unit of full cross section. The minimum strength of concrete for cast-in-place piles shall be three thousand pounds per square inch. While placing the concrete, the casing or drive-pipe shall be free of water.

(c) Poured-Concrete Piles

(1) The diameters of metal-cased poured-concrete piles, when measured on the outside of a plain cylinder, or the outside of horizontal, helical or vertical corrugations, shall be not less than eight inches, one foot above the point, nor less than twelve inches at cut-off. The shape of the pile may be

cylindrical, or conical, or a combination thereof, or it may be a succession of cylinders of equal length, with the change in diameter of adjoining cylinders not exceeding one inch.

(2) For uncased poured-concrete piles (i.e., when no metal casing is left in the ground) the inside diameter of the drive-pipe shall be not less than fourteen and one half inches.

(3) The load on poured-concrete piles shall not exceed the allowable load specified in Section 2909, nor twenty-two and one half per cent of the twenty-eight day strength of the concrete, but not exceeding nine hundred pounds per square inch, when applied to the cross-sectional areas computed on the following bases:

I. For metal-cased piles driven to and into materials of Classes 1 to 4, inclusive, using the diameter measured one (1) foot above the point, except that when the rock is immediately overlain by a bearing stratum consisting of one or a combination of bearing materials of Classes 5 and 6, using the diameter at the surface of the bearing stratum, and as further specified in Section 2912(c)(1).

II. For metal-cased piles, driven through compressible materials, including Classes 11, 12, 13, and 15 and into a bearing stratum consisting of one or a combination of bearing materials of Classes 5 to 10, inclusive, using the diameter at the surface of the bearing stratum and as further specified in Section 2912(c)(1).

III. For uncased piles driven to or into any bearing material, using the inside diameter of the drive-pipe minus three inches.

IV. In no case shall the maximum load on a poured-concrete pile exceed ninety tons.

(4) Immediately before filling with concrete, the inside of the casing shall be thoroughly cleaned to the bottom and inspected by lowering a light bulb, or by means of a light beam. To be accepted: (a) the diameter shall not vary more than twenty per cent from the original value, (b) the point of the casing shall not deviate more than ten per cent of the length of the pile from the design alignment, and (c) the casing shall not deviate by more than four per cent of the length of the casing from a straight line connecting the midpoints of the ends of the casing. If the bottom of the casing is out of sight, the shape and alignment of the casing shall be surveyed with a suitable instrument. No load shall be allowed on a pile the casing of which shows signs of buckling.

(5) The spacing of poured-concrete piles shall be such as to ensure the preservation of the full-cross-section. The spacing center-to-center shall be not less than two and one half times the outside diameter of the drive-pipe or of the casing at midlength. No casing or drive-pipe shall be filled with concrete until all casings or drive-pipes within a radius of seven feet, or within the heave range, whichever is the greater, have been driven to the required resistance.

(d) Compacted Concrete Piles

The load on compacted concrete piles shall be limited by the provisions of

Section 2909(g), except that the circumscribing polygon shall start at the junction of the shaft and the enlarged base, and the bearing area shall be taken at planes six feet or more below said junction; and the allowable load on a compacted concrete pile shall not exceed one hundred and twenty tons. The installation of such piles shall fulfill the following listed requirements:

(1) The drive-pipe used for installing the pile shall be not less than twenty inches outside diameter.

(2) The enlarged base of the pile shall be formed on or in bearing materials of Classes 1 to 8, inclusive.

(3) The concrete shall have minimum compressive strength at twenty-eight days of four thousand pounds per square inch, shall be of zero slump, and shall be placed in batches not to exceed five cubic feet in volume.

(4) The last batch of concrete shall be driven into the enlarged base with not less than twenty blows, each of not less than one hundred and thirty thousand foot-pounds.

(5) As the drive-pipe is being withdrawn, not less than two blows of at least thirty thousand foot-pounds each shall be applied to compact each batch of concrete in an uncased shaft.

(6) An uncased shaft shall not be formed through inorganic clay or inorganic silt unless an excavation at least equal to the inside diameter of the drive-pipe is first augered through such soil, or the individual piles are located more than nine feet apart.

(7) An uncased shaft shall not be formed through peat or other organic soils.

(8) A permanent metal-cased shaft, not less than sixteen inches in diameter, shall be installed through inorganic clay or inorganic silt if requirement (6) is not fulfilled. The permanent metal casing shall be fastened to the enlarged base in such a manner that the two will not separate. The concrete may be placed in the metal casing in the same manner as for poured-concrete piles. No metal casing shall be filled with concrete until after all piles within a radius of at least nine feet have been driven. The stresses in metal-cased shafts shall not exceed nine hundred pounds per square inch on the concrete and, in addition, eight thousand five hundred pounds per square inch on the steel casing, provided that its wall thickness is at least two-tenths of an inch.

(9) The center-to-center spacing of piles shall be not less than four feet and six inches.

SECT. 2913. STEEL AND STEEL-CONCRETE PILES.—(a) At locations where steel and steel-concrete piles will be in contact with cinders, slag, organic soils, or other materials that might cause corrosion of steel, one of the following procedures shall be used:

(1) Remove all such objectionable material from within the area of the structure and replace with inorganic soil.

(2) Deduct one-eighth of an inch in thickness from all surfaces in contact with the objectionable material when computing the area of steel for

support of load. This reduction shall be applied from pile cut-off grade to a grade fifteen feet below the bottom of the objectionable material.

(3) Effectively protect the steel surface from pile cut-off grade to a grade fifteen feet below the bottom of the objectionable materials; e.g., by means of cathodic protection or by a cover of at least three inches of concrete.

At locations where steel and steel-concrete piles will be in contact with sea water, the steel from a grade ten feet below the ground surface to at least five feet above mean high tide shall be protected by at least three inches of concrete. The maximum water-cement ratio and the minimum cement content of the concrete shall be four and one half gallons per sack, and eight sacks per cubic yard, respectively.

(b) Concrete-Filled Pipe Piles

(1) Piles consisting of steel pipes and concrete-filled after driving, shall have an outside diameter of not less than ten and three quarters inches and a pipe wall thickness of at least two-tenths of an inch. The material of the pipe shall meet the requirements for Grade 2 in Specifications for Welded and Seamless Steel Pipe Piles (A252-59), of the American Society for Testing Materials. Splices shall be welded to one hundred per cent of the strength of the pipe. Pipes may be driven open-ended or closed-ended, and the provisions of the section apply to both types.

(2) After driving all pipes within a seven foot radius, and immediately before filling with concrete, the inside of the pipe shall be thoroughly cleaned to the bottom and inspected by lowering a light bulb, or by means of a light beam. To be acceptable: (a) the diameter shall not vary more than twenty per cent from the original value, (b) the point of the pile shall not deviate more than ten per cent of the length of the pile from the design alignment and (c) the pile shall not deviate by more than six per cent of the length of the pile from a straight line connecting the midpoints of the ends of the pile. If the bottom of the pile is out of sight, or cannot be seen because the pile cannot be dewatered, the shape and alignment of the pile shall be surveyed with a suitable instrument. No load shall be allowed on a pile which shows signs of buckling.

(3) Pipes shall be filled with concrete having a minimum compressive strength at twenty-eight days of three thousand pounds per square inch, and as further specified in Part 26. Concrete shall not be placed through water, except that the Commissioner may approve the use of a bottom-dump bucket for concreting a bottom section of a pile, provided that the pile is proven to be free of other materials.

(4) The center-to-center spacing of concrete-filled pipe piles shall be not less than two and one half times the outside diameter of the pipe.

(5) The load on concrete-filled pipe piles shall not exceed the allowable load determined in accordance with Section 2909, nor a load computed on the basis of stress in the concrete at twenty-two and one half per cent of the twenty-eight day strength, but not exceeding nine hundred pounds per square inch, and stress in the steel at eight thousand five hundred pounds per square

inch. nor shall the load carried by the steel on this basis exceed one half the total load on the pile.

(c) H Piles

(1) Rolled steel H or other approved sections shall meet the requirements of the Specifications for Steel for Bridges and Buildings (A7-61T) of the American Society for Testing Materials. The minimum thickness of metal shall be four tenths of an inch. If piles are spliced, the splice shall develop one hundred per cent of the strength of the section.

(2) The center-to-center spacing of such piles shall be not less than two and one half times the width of the flange or the depth of the section, whichever is the greater.

(3) The load on such piles shall not exceed the allowable load determined in accordance with Section 2909, nor a load based on stress of seven thousand five hundred pounds per square inch on the cross-section.

(d) Concrete-Filled Pipes with Steel Cores

(1) Concrete-filled pipes with steel cores may be used only when the pipes can be firmly seated in bedrock of Classes 1 or 2, and shall be of sufficient diameter to permit the inspection of the bedrock socket. Pipe shall meet the requirements stated in Section 2913(b)(1). If pipes are spliced, the splices shall be welded to develop one hundred per cent of the strength of the pipe.

(2) A socket, approximately of the inside diameter of the pipe, shall be made in bedrock of Classes 1 or 2 to a depth that will assure load transfer when computed for a bearing on the bottom surface of the socket in accordance with Section 2904 (b) and (c), acting together with a bond stress on the perimeter surface of the socket of one hundred pounds per square inch. Before placement of concrete, the socket and pipe shall be thoroughly cleaned and the rock inspected by a competent engineer or geologist satisfactory to the Commissioner. This inspection may be performed by means of an underwater television camera, the position of which is readily controllable to permit thorough inspection of the exposed rock surface in the socket.

(3) The steel core shall consist of a structural steel member. The mating ends of the sections shall be spliced so as to safely withstand the stresses to which they may be subjected. The steel core shall be centered in the steel pipe and shall rest in a layer of cement grout on the bottom of the socket.

(4) The center-to-center spacing of such piles shall be not less than two and one half times the outside diameter of the pipe.

(5) Concrete shall have a minimum compressive strength of four thousand pounds per square inch at twenty-eight days. It shall be so placed that it shall fill completely the space between the steel core and the pipe. In case the socket cannot be kept free from inflow of water, the pipe shall be filled to its top with clean water before placing the concrete.

(6) The details of the design and the installation, including the cleaning and inspection of the socket, the placement of concrete under water or in the dry, the method of centering the steel core and all other phases of the work shall be submitted to the Commissioner for approval.

(7) The load on concrete-filled pipe piles with steel cores shall not exceed the allowable load determined in accordance with the provisions of Section 2913(d)(2) nor that computed on the basis of nine hundred pounds per square inch on the area of the concrete plus eight thousand five hundred pounds per square inch on the net area of the steel pipe plus fifteen thousand pounds per square inch on the area of the steel core.

SECT. 2914. COMPOSITE PILES.—(a) A composite pile shall consist of a combination of not more than two of any of the different types of piles provided for in this part. The pile shall fulfill the requirements for each type and in addition the provisions of this section. The connection between the two types of piles shall be constructed so as to prevent their separation, to maintain their alignment, to support the load, and to be watertight where concrete must be placed subsequent to the driving. The design and the details of the connection shall be subject to the Commissioner's approval.

(b) The requirements of Section 2912(c)(4) shall apply to the entire length of a pipe-composite pile.

(c) Wood-composite piles shall not be used for support of buildings exceeding two stories in height.

(d) The center-to-center spacing shall be governed by the larger of the spacings, required in this part, for the types composing the pile.

(e) The allowable load on composite piles shall be that allowed for the weaker of the two sections. For wood-composite piles the allowable load shall not exceed eighty per cent of that allowed for the wood section alone.

SECT. 2915. BEARING TESTS.—(a) Whenever the allowable bearing value on bearing materials on single piles or groups of piles is in doubt, the Commissioner may require bearing tests to be made and the results analyzed under the direction of a competent engineer approved by the Commissioner.

(b) Before any bearing test is started, a sketch of the proposed test arrangement and an outline of the procedure to be followed shall be submitted to the Commissioner and shall have his written approval.

(c) Bearing tests shall be conducted in the presence of an inspector, qualified by experience and training, and who is satisfactory to the Commissioner. A copy of the test results obtained and a graph of the time-settlement curve for each increment of load and of the load-settlement and rebound curve for the entire test shall be submitted to the Commissioner at the completion of each test.

(d) The load shall be applied by direct weight or by means of a newly calibrated hydraulic jack. The application of the test load shall be in steps equal to not more than one half the contemplated design load, to at least twice the contemplated design load, except as provided in Section 2915(g). The unloading shall be in at least two steps, to the design load and then to zero load. During the loading cycle the contemplated design load and twice the contemplated design load shall be maintained constant for at least twenty-four hours and until settlement or rebound does not exceed two hundredths of an inch in twenty-four con-

secutive hours. The load for all other load steps including the zero load at the end of the test shall be maintained constant for a period of not less than four hours. Sufficient readings for each load step shall be made to define properly the time-deflection curve.

(e) Observation of vertical movement shall be made with dial extensometers graduated to at least one thousandth of an inch. The readings shall be sufficient in number to define the progress of the settlement or rebound and shall be referred to a beam, the ends of which rest on or are fixed to reliable supports located at least eight feet from the center of the test. In addition, the elevation of the supports shall be checked frequently with reference to a fixed benchmark. The entire measuring setup shall be protected against direct sunlight, frost action, and other disturbances that might affect its reliability. Temperature readings, both inside and outside the test enclosure, shall be made when the vertical movements are recorded.

(f) Additional Requirements for Soil Bearing Tests

(1) Bearing tests shall be applied at the elevations of the proposed bearing surfaces of the structure, except that the load may be applied directly on the surface of compacted granular material, Class 14.

(2) The excavation immediately surrounding an area to be tested shall be made no deeper than one foot above the plane of application of the test. The test plate shall be placed with uniform bearing. For the duration of the test, the material surrounding the test area shall be protected effectively against evaporation and frost action.

(3) For bearing materials of Classes 1 to 5, inclusive, the loaded area shall be not less than one square foot and for other classes not less than four square feet. For bearing materials of Classes 1 to 3, inclusive, the Commissioner may permit compression tests on rock cores to be substituted for bearing tests. Each test specimen shall have a height not less than twice its diameter.

(4) The proposed design load shall be allowed provided that the requirements of Section 2904 are fulfilled and the settlements under the design load and twice the design load do not exceed three eighths of an inch and one inch, respectively.

(g) Additional Requirements for Pile-Bearing Tests

(1) A single pile shall be load tested to not less than twice the design load. When two or more piles are to be tested as a group, the total load shall be not less than one and one half times the design load for the group.

(2) Provided that the load-settlement curve shows no sign of failure and provided that the permanent settlement of the top of the pile, after removal of all load at the completion of the test, does not exceed one half inch, the maximum design load shall be the load allowed in this part for the type of pile or one half of the maximum applied load, whichever is less.

(3) Whenever the soil conditions are such that substantial driving resistance and/or significant support of the pile test load is derived from soil strata overlying the intended bearing stratum, the results of the pile test

shall be analyzed so as to evaluate the actual support furnished by the bearing stratum.

SECT. 2916. SETTLEMENT ANALYSIS.—(a) Whenever a structure is to be supported by medium or soft clay (materials of Classes 11 and 12), the settlements of the structure and of neighboring structures due to consolidation of the clay shall be given careful consideration, particularly if there are large variations in thickness of the clay or the structure has substantial variation in net load at foundation grade. The commissioner may require a settlement analysis to be made by a competent engineer with specialized training and experience in soil mechanics in case the live and dead loads of the structure, as specified in Part 23, minus the weight of the excavation, induce a maximum stress greater than four hundred pounds per square foot at midheight of the underlying soft clay, computed by means of a procedure that is generally accepted in soil mechanics.

(b) The settlement analysis will be usually based on a computation of the net increase in stress that will be induced by the structure and realistically appraised live loads, after deducting the weight of excavated soil and other loads under which the clay was fully consolidated. The appraisal of the live loads may be based on surveys of actual live loads of existing buildings with similar occupancy. The soil compressibility data may be derived on the basis of one or more of the following data:

(1) A review of settlement records and behavior of other buildings in Greater Boston having similar subsoil profiles.

(2) Consolidation tests on undisturbed specimens with a diameter of at least two and one half inches. The report shall include a description of the method of sampling and of the quality of the samples.

(3) Consolidation test data from other projects in Greater Boston where the clay is found to be similar when compared on the basis of the natural water content and the liquid and plastic limits.

(c) Should the analysis indicate that the settlements would cause excessive stresses in the structure or would impair its usefulness, the design of the foundation and/or the superstructure shall be modified so that the anticipated settlements will be reduced to tolerable values.

## LEGAL ASPECTS OF SURVEYING

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(Presented as Lectures 1 and 2 of the Surveying and Mapping Section, B.S.C.E.,  
1963 Spring Lecture Series, March 19 and March 26, 1963)

### INTRODUCTION

A COURT of the United States Government has said in an oft-cited decision, that the term "survey of lands" means "the actual measurement of land, ascertaining the contents by running the lines and angles with compass and chain, establishing corners and boundaries, and designating the same by marking trees, fixing monuments, or referring to existing objects of notoriety on the ground, giving bearings and distances, and making descriptive field notes and plots of the work."<sup>1</sup> This is a fine definition as far as it goes. The key word here is "establishing." This is a definition of surveys of lands which create new property lines where none existed before. A competent technician with knowledge of the owner's intent and with knowledge of the applicable governmental statutes and procedures can generally do a creditable job in making this kind of a "survey of lands." If the definition had begun with the words "the relocation on the ground of property lines previously established by survey or deed and" . . . then continued on with what was quoted above, that part of land surveying which calls for the exercise of considerable judgment based on experience and legal knowledge would have been included. There's the rub in land surveying—the relocation on the ground of the lines already established by past acts of the land owners and possibly the government. As another court has said, "The real object in applying the various calls (in the deed) is to find the footsteps of the surveyor, and, when found and identified, all classes of calls must yield to them."<sup>2</sup> And a third court has said, "Parties are not bound as to boundaries determined by a resurvey, unless [that resurvey was] based on the survey originally made and the monuments erected thereunder."<sup>3</sup> For the most part, this paper will deal with those matters of legal nature with

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\* Chief Engineer, Massachusetts Land Court  
(Mass. Statutes References omit "Gen. Law. (Ter. Ed.)" and simply refer to  
chapter and section (viz. c. 1, §1)

<sup>1</sup> Winter v. United States, 30 Fed. Cas. 350.

<sup>2</sup> Miller v. Meyer, Tex. Civ. App., 190 S.W. 247.

<sup>3</sup> Day v. Stenger, 274 P. 112, 47 Idaho 253.

which the surveyor ought to be acquainted in order to be competent and efficient in relocating on the ground property lines established before he was asked to make his survey. Good field work, good mathematics and good monumentation, with adequate checks on each phase of the work, will often suffice in establishing new property lines. But the man who relocates old property lines must research and interpret prior deeds, certificates of title, takings, acts of the parties affecting boundary lines, and all other data necessary for an understanding of the intent of the parties as indicated by the title instruments, and then go into the field to hunt and search, locate and test, such evidences of prior monumentation as will fit that intent. He must weigh the relative values of what he discovers, discard that which he decides is inferior, and use the best evidence he can find to place on the ground his conclusions as to where the previously established lines are truly located.

#### CLASSIFICATION OF LEGAL ASPECTS

To my mind the matters of legal nature in which the surveyor must be interested fall into three general groupings: first, those necessary to the proper conduct of his professional employment; second, those desirable in that they help him in conducting his business efficiently; and third, those which promote better professional relationships between him and his clients, or other surveyors, or those of other professions, particularly lawyers. Under the first of these, that of proper professional employment, we might say that a surveyor is expected to be able to:

- a. Interpret an ordinary deed properly.
- b. Interpret an ordinary plan properly.
- c. Determine which governmental agencies may have taken actions affecting his survey.
- d. Trace uncomplicated titles in the Registries of Deeds, Probate Courts, or Land Court.
- e. Recognize an easement which is, or may be, an encumbrance on the property, or one which is, or may be, appurtenant to the property.
- f. Recognize a restriction on the use of a portion of the property.
- g. Recognize, and record, any feature of interest to the general public, such as natural water courses, bodies of water, and service utilities like pipe lines, telephone and power lines,

- water and sewer lines, railway tracks, etc., whether or not they have been authorized on the record by a legal document.
- h. Recognize and record any structure or land use which may constitute a trespass by or upon the client.
  - i. Understand and observe any applicable laws or regulations which may affect the making of the survey or plan, such as those of the Planning Boards, Boards of Surveys, licensing bodies, Land Court, Registries of Deeds, and Subdivision Control Law, so that the survey and plan can be approved by such agencies of the government.

Under the second of these groupings mentioned, that of business efficiency, we might say that the surveyor ought to:

- a. Have enough knowledge of the resolution of inconsistent descriptions, or incomplete descriptions, or vague descriptions, to analyze the situation in most cases and arrive at a logical solution reasonably promptly.
- b. Be able to similarly analyze inconsistent, incomplete or vague plans.
- c. Know how much information in public offices he is legally entitled to have.
- d. Know of such laws as would affect the activity of his employees, such as trespass, work laws, blue laws, nuisance, and police protection.
- e. Know enough of the regulations and procedures of such governmental bodies as the Land Court, Registries of Deeds, Building Departments, licensing agencies, Planning Boards, etc., to avoid a misguided client's request for a survey or plan which will not be usable for a reason other than the surveyor's part of the work requested.
- f. Know when to refuse to proceed without the advice or assistance of an attorney.

Under the third grouping mentioned above, it might be said that a surveyor would promote better relations with his clients, and others, if he were acquainted with:

- a. Certain additional provisions of such laws as the Subdivision Control Law and Building Laws, so that he can inform or assist his client in taking those steps where the client is expected to act.

- b. Certain fundamental laws of conveyancing, so that he can advise his client of possible or actual legal difficulties, and to suggest, perhaps, some possible solutions, coupled with the advice to see a lawyer before taking action.
- c. The background and experience of certain lawyers, so that he can recommend to his client one or more attorneys who can ably perform appropriate legal services.

In pursuing my subject, I will not try to divide the various matters to be mentioned among the three groupings. In some cases the grouping will be obvious, but in others the grouping will depend on individual opinion or upon contractual agreement. Furthermore, I am sure I have not covered the field completely. However, I believe that each matter I will touch upon is one which was considered by an engineer in the Land Court Engineering Department in connection with a plan or survey submitted to the Court, or to a plan or survey prepared by the Court.

#### THE DEED

Since nearly all property line surveying work starts with a land owner's request that the land contained in a deed to him be surveyed, it seems that a logical place to start discussing the legal aspects of surveying is with that instrument. And it seems wise to mention that a deed is always a written instrument by which title to real estate is conveyed. All conveyances have had to be evidenced by a writing since 1677, when the Statute of Frauds became law. At that time the writing was called a "Charter of Foeffment," and it commemorated the entry upon the land being conveyed of the grantor, the grantee, and the witnesses, and the passing from the grantor to the grantee, of a symbol of the possession of the land, i.e., a clod of earth, a twig of a tree, a clump of grass, a latch from a door, etc. The latter act was called the "livery of seizen," and was a practise which continued in Massachusetts until 1652 and in Maine until 1692. In 1652, Massachusetts provided that a deed plus the acknowledgment of the grantor or livery of seizen would pass title and in 1697 Massachusetts provided that a deed so acknowledged and recorded was superior to a deed not recorded, except as between the parties.<sup>4</sup> The simplicity of this action, plus the greater legal weight it carried, made livery of seizen go out of style.

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<sup>4</sup> (now) c. 183 § 4.

Title passes upon delivery of the deed to the grantee and its acceptance by him.<sup>5</sup> In the case of registered land, title passes when the deed is registered in the Land Court section of the appropriate registry of deeds.<sup>6</sup> By statute, a recorded deed is conclusively presumed to have been so delivered as to all those who are without notice of any irregularity.<sup>7</sup> For a surveyor's purposes it is necessary that he recognize a deed when he sees one. The absolutely essential ingredients are that a grantor states that he conveys to a grantee an interest in land, and that the instrument is, or is said to be, under seal, and that it be signed by the grantor and be delivered to, and accepted by, the grantee, and that both the grantor and the grantee and also the land be definitely identified. Unless the surveyor knows that one of these features is missing, he should treat the deed as valid.

The courts always try to give effect to an instrument which the parties thereto have executed. It might be a good idea to see how that court policy applies to the matter of the identification of the grantor, the grantee and the land. There is a Massachusetts case in which the name of the grantor in the deed was fictitious. However, it could be shown that a man had taken title under the fictitious name and that the same man had thereafter passed title to a new owner using that same fictitious name. Since the man who used the fictitious name could be positively identified, and since he purchased and sold under that name, there was no longer any doubt as to his identity and therefore the deed passed title effectively.<sup>8</sup> There is another Massachusetts case in which the grantee in a deed was the "South Chelmsford Hall Associates." Now ordinarily a group of associates might be large or small and always changing membership. In this case however, it was shown that the South Chelmsford Hall Associates were a small group of identified individuals who were acting together for the single purpose of erecting a hall. Since they could be definitely identified, the deed was valid to pass title.<sup>9</sup> There is a third Massachusetts case where a deed purported to convey a "spring of water" belonging to a certain person. Since the particular spring was positively identified, the deed was held to be valid in passing title to the spring and to so much land around it as was reasonably necessary for the enjoyment

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<sup>5</sup> *Maynard v. Maynard*, 10 Mass. 456; *Meigs v. Dexter*, 172 Mass. 217.

<sup>6</sup> C. 185 § 57; *Fed. Nat'l Bank v. Gaston*, 256 Mass. 471.

<sup>7</sup> C. 183 § 5; *Comm. v. Brisbois*, 281 Mass. 125.

<sup>8</sup> *Bassett v. Daniels*, 136 Mass. 547.

<sup>9</sup> *Byram v. Bickford*, 140 Mass. 31.

of the spring.<sup>10</sup> Of course, in each of these cases, it was necessary to go to court to have the identity established, but once that had been done, the deed was declared effective. These cases do bring home the fact that a deed is generally sufficient if these elements are capable of identification.<sup>11</sup>

Before leaving the matter of the form of the deed and its contents, I want to point out that a deed in the usual form, with the consideration, covenants, title references and specific dimensions and locations all spelled out, is necessary for the preservation of a marketable title. A deed should always be so carefully prepared that no one has to go to court to determine its effect. The marketability of the title does not now-a-days depend very often on the form of warranty in the deed. That is to say that since nearly all grantees obtain a legal opinion on the title status of the land being purchased before actually paying the consideration, it doesn't make much difference whether a Warranty Form or a Quitclaim Form of deed is used. The difference between them, in brief, is that the grantor in a warranty deed guarantees the title to be as described in the deed, whereas, in a quitclaim deed he guarantees the title to be as described in the deed but limits his liability to events which occurred while he owned the land.<sup>12</sup> A third type of deed, often called a "release deed," is not at all uncommon. It is used when it is desirable to have a person go on record as having no title in a particular parcel of land. The grantor conveys all his "right, title and interest" in the land. By doing so, he makes no guarantee whatsoever, that he has had any title thereto.<sup>12</sup>

#### DEED DESCRIPTIONS

The surveyor has a very definite part in preserving the marketability of the title, inasmuch as he is often called upon to prepare a description of the parcel he has surveyed. He should have in mind that three types of descriptions are in current common use, the "running description," the "bounding description" and the "description by lot number only." Both of the first two mentioned are best visualized by picturing the scrivener as being upon the ground at the lot to be described. If a running description is wanted, he would consider that he is making a circuit of the perimeter of the lot. He would first describe the point of beginning where he starts his circuit; then he would walk along the first line, describing it by giving its

<sup>10</sup> *Tinker v. Bessell*, 213 Mass. 74.

<sup>11</sup> *McHale v. Treworgy*, 325 Mass. 381; *Cassidy v. Charlestown Sav. Bank*, 149 Mass. 325.

<sup>12</sup> C. 183 §§ 10, 11; *United Sugar Co. v. Guaranty Trust Co.*, 254 Mass. 292.

direction and length and naming the abutting owner; he would then describe the point at the end of the first line, which point would also be the beginning point of the second line; then he would describe the second line as he walked along it; and so forth around the parcel, generally clockwise, describing each point and line consecutively, until he comes back to the point of beginning. If a bounding description is wanted, he would consider that he is making a circuit of the parcel by walking somewhat inside of the perimeter at all sides. At first he would picture himself as standing some distance inside the parcel at a point about midway along the first line to be described, and he would state the direction in which he is looking as he views the line, he would name the abutting owner, and he would give the length of the first line; then he would move to a second position some distance inside the parcel at a point midway along the second line to be described, and again he would state the direction in which he is looking as he views the second line, he would name the abutting owner, and he would give the length of the second line; and so on around the parcel, generally clockwise, shifting view-points for each line, until he had covered each line consecutively completely around the parcel. In a bounding description it is common to group together several lines which run in the same general direction, and to give only one direction as the "viewing" direction, and the total of all the lengths as the distance and to list the abutting owners, or, if there are a large number of them, to bound by sundry abutting owners. Examples of the two forms of descriptions, both describing the same parcel of land, are given below. (See Figure 1.)

(a running description)

. . . . a parcel of land bounded and described as follows:

Beginning at a point at the easterly intersection of A Street and B Street, which point is marked with a stone bound, thence running  
 N 45° 10' E one hundred (100.00) feet, by A Street, measuring along the southeasterly line thereof, to an iron pipe on said southeasterly line at land of Jones, thence  
 S 44° 50' E one hundred (100.00) feet, by land of said Jones, in part along the middle line of a 12'' brick partition wall, to a L. C. D. at lands of said Jones, of Brown and of Smith, thence  
 S 15° 10' W fifty (50.00) feet, by land of said Smith, to a stake, thence  
 S 75° 10' W fifty (50.00) feet, again by land of said Smith, to a fence post, thence

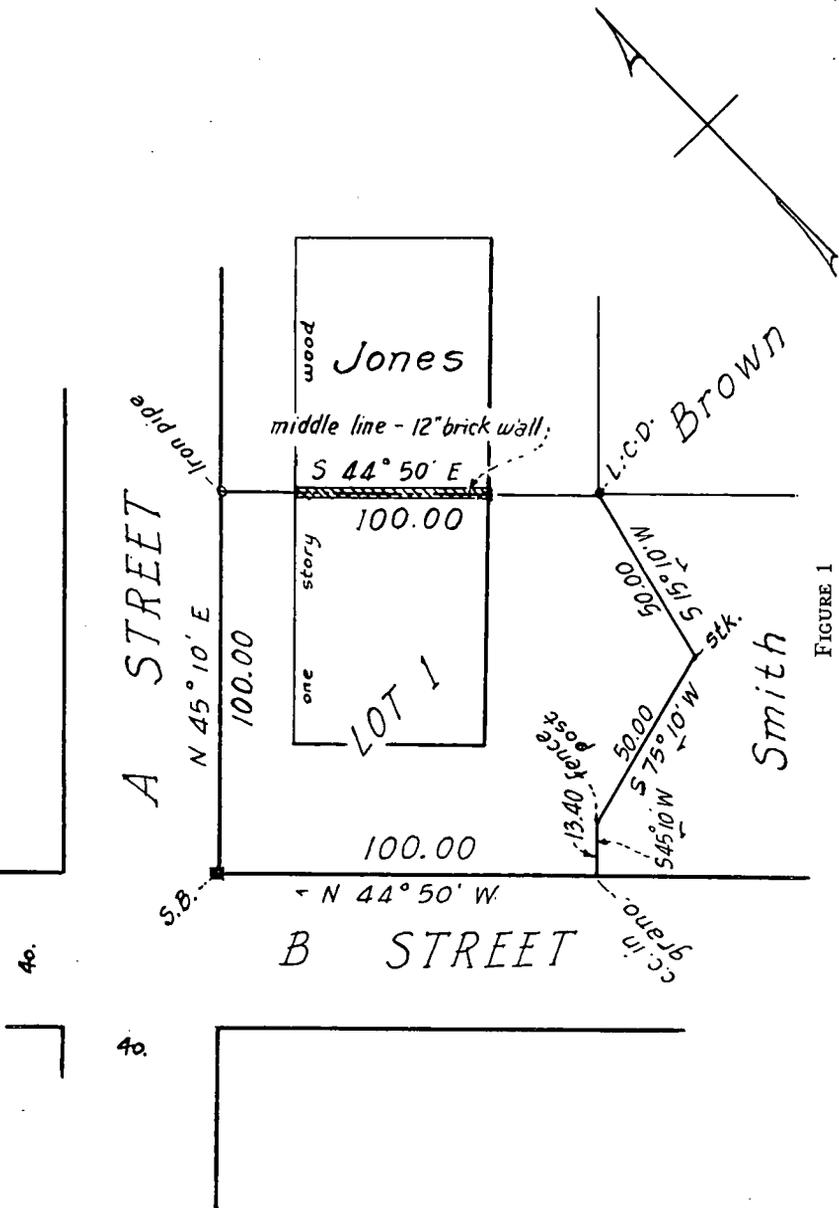


FIGURE 1

S 45° 10' W thirteen and 40/100 (13.40) feet, again by land of Smith to a "c. c. in grano." at the northeasterly line of B Street at land of said Smith, thence

N 44° 50' W one hundred (100.00) feet, by the northeasterly line of B Street, to the point of beginning.

Note that a running description can be mathematically determinable and can be effectively tied to the ground by the recited monuments. In other words it can be complete in itself. If a plan is available, it should be referred to in the same way that a bounding description incorporates the plan.

(a bounding description)

. . . . a parcel of land bounded:

Northwesterly by A Street, one hundred (100.00) feet,

Northeasterly by land of Jones, in part by a line through the middle of a 12" brick partition wall, one hundred (100.00) feet,

Southeasterly by land of Smith, by three lines totaling one hundred thirteen and 40/100 (113.40) feet, and

Southwesterly by the northeasterly line of B Street, one hundred (100.00) feet.

Said parcel is shown as Lot 1 on a plan drawn by . . . . .

Registered Land Surveyor, dated . . . . . and recorded with

. . . . . Registry of Deeds at Book . . . . . Page . . . . .

Note that a plan reference is nearly always necessary in order to make clear the exact shape and dimensions of the parcel described by a bounding description. However, when a plan is referred to, all the descriptive features thereon are incorporated in the deed, and the description portion of the deed is much more brief. Even in such a simple example as this one, the bounding description plus the plan give much more information about the lot than the running description without the plan.

A "description by lot number only" would omit the "description" portion of the deed, and include only the "plan reference" portion. Much discretion should be exercised when employing it, since an incorrect lot number, or an incorrect plan date, or an incorrect surveyor's name, might well be fatal to the conveyance. A poor scrivener can lead to a lot of trouble.

## COMMON EXPRESSIONS INDICATING TITLE

There are a large group of expressions commonly used in deeds which to the inexperienced may convey an erroneous impression concerning the ownership, or which may seem to be indefinite, but which have attained a very positive meaning under court decisions, and which therefore ought to be understood by the surveyor. Keep in mind that these interpretations may not apply in any specific instance if a contrary intent is shown by the contents of the deed as a whole. Several of such expressions commonly used are listed hereafter. A consideration of them as a group will help one to understand many of those which are not discussed here.

Such expressions as "by the street," "on the way," "along the avenue," without qualifying words, will convey title to the middle line of the street, way or avenue if the grantor had title thereto. This is true even though the distances used in the deed reach only to the sideline of the street, way or avenue.<sup>13</sup> A description consisting only of a lot number on a plan will have the same effect. On the other hand, such expressions as "by the line of the street," "on the sideline of the way," "along the southerly line of the avenue," without qualifying words, will convey to the sideline of the street, way or avenue.<sup>14</sup> Any title the grantor might have had within the street, way or avenue then remains in the grantor. These rules apply whether or not the street is public. Keep in mind that many communities have taken only easements in the process of making their streets public, while others, notably Boston, have in most cases taken the fee in the soil of the street as well. Where the whole of the fee has been taken, the deed of an abutting lot owned by an individual can convey only what was left to him, namely the land to the sideline of the street. Then, no matter which of the above expressions he uses in his deed, the land sold would be bounded by the sideline of the street, way, or avenue.

The line of reasoning used in such instances is set forth in an early case in these words (partial quote): "whenever land is bounded by other land, building, or structure, the name of which ordinarily includes the land of which it is a part . . . the side thereof . . . is the limit of the grant; but when the boundary is simply an object, . . . natural or artificial, the name of which defines (locates) a boundary

<sup>13</sup> Salem v. Salem Gas Light Co., 241 Mass. 438; Erickson v. Ames, 264 Mass. 436.

<sup>14</sup> Wood v. Culhane, 265 Mass. 555.

. . . (rather than ownership of the earth itself) . . . and yet which has width, as in the case of a river, a way, a ditch, a wall, a fence, a tree, a stake and stones, then the center of the thing . . . is the boundary. . . ."<sup>15</sup>

Similarly, expressions like "on the sea," "by the harbor," "along the bay," or "by the river," "along the brook," without qualifying words, will convey title out into the water as far as the grantor's title or private ownership extends.<sup>16</sup> The same is true where the body of water is a great pond (of more than ten acres).<sup>17</sup> On the other hand, such expressions as "by the mean high water mark of the sea," "by the high water mark of the ocean," "by the bank of the river," "by the shore of the sea," "by the edge of the pond," "by the beach," "by the flats," "by the upper edge of the beach," without other qualifying words, will convey title to the mean high water mark only.<sup>18, 19</sup> Where these latter expressions are used at salt water, the foreshore, which is the land between mean high water mark and extreme low water mark, will remain in the ownership of the grantor, if he had title thereto. Where these expressions are used at fresh water, the land between mean high water mark and either the extreme low water mark or the middle line of the stream will likewise remain in the ownership of the grantor, if he had title thereto. Here it might be well to point out that the term "extreme low water mark" means the most extreme low water contour to which the water ever will recede. Beyond the extreme low water mark the title is in The Commonwealth of Massachusetts,<sup>20</sup> or possibly, to The United States of America.<sup>21</sup>

In the Boston area, the extreme low water mark is taken to be three feet below mean low water. I believe this practice was adopted after a trial in the Land Court involving the title to certain flats in East Boston. Much evidence was presented showing tidal observations over an extended period of time, wherein it was shown that the extreme low tides ranged from about 2.3 feet below mean low water to about 2.9 feet below mean low water. It was thereupon assumed that in some instances the extreme position of the tides could be as much as three feet below the mean low water mark.

<sup>15</sup> *Boston v. Richardson*, 95 Mass. 146.

<sup>16</sup> *Burke v. Comm.*, 283 Mass. 63.

<sup>17</sup> *Paine v. Woods*, 108 Mass. 160.

<sup>18</sup> *Allen v. Wood*, 256 Mass. 343.

<sup>19</sup> *Langevin v. Fletcher*, 273 Mass. 543; *Hatch v. Dwight*, 17 Mass. 289; *Burnham v. Hoyt*, 216 Mass. 278. See ns. 16, 17 *supra* & 24 *infra*.

<sup>20</sup> *Boston v. Richardson*, 105 Mass. 351.

<sup>21</sup> *United States v. California*, 332 U.S. 19.

It should also be kept in mind that the Colonial Ordinance of 1647 fixed the outer limit of private ownership on tidal waters at a line which is one hundred rods from the mean high water mark.<sup>19</sup> This is still the law. The courts have recognized that the expression "mean high water mark" relates only to the ordinary tides, without including the extreme high tides.<sup>22</sup> Lastly, it should be noted that a natural tidal creek or channel extending through the flats (or foreshore) and flowing between mean high water mark and extreme low water mark will have the effect of fixing the limits of private ownership of the flats even though there are other flats beyond the creek or channel which are within the one hundred rod line.<sup>23</sup>

The ordinary conveyance along a water line does not call for anything more than a location of the water's edge at approximate high water, and, in some instances, the approximate low water mark on the day of the survey. These are commonly determined by a stadia location of the debris such as sea weed which settles at the mean high water mark and a stadia location of the water's edge at the time of low water. However, where the size of the fee for a license to displace tide-water, or the possible length of a proposed wharf is in question, or where the extent and location of the flats are otherwise critical, a more precise determination of the mean high water mark contour and the extreme low water mark contour is necessary. These lines would then be located by leveling from known bench marks on an established datum plane such as the Massachusetts Geodetic Survey or the City of Boston Datum Base. Where these are not available, extended tidal observations, relative to benches created for the purpose, will serve just as well. Just where the extreme low water mark is relative to the mean low water mark thus determined would be fixed by an "educated guess."

For the methods of determining the locations of the lines over flats, see a paper by Loring Jordan, Esq., in the October, 1961, issue of this Journal. These methods probably also apply to the division of the lands under the surface of the waters of a great pond out to extreme low water mark and to all the land under a small pond which is presumably owned by the upland owners.<sup>24</sup> A great pond is a

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<sup>19</sup> *Wonson v. Wonson*, 96 Mass. 71.

<sup>23</sup> *Att'y Gen. v. Boston Wharf Co.*, 78 Mass. 553; *Sparhawk v. Bullard*, 42 Mass. 95; *Tappan v. Boston Water Power Co.*, 157 Mass. 24.

<sup>24</sup> *Lynnfield v. Peabody*, 219 Mass. 322.

natural pond which is more than ten acres in area,<sup>25</sup> and the soil under the extreme low water mark thereof belongs to the commonwealth.<sup>26</sup> A great pond may be completely surrounded by land owners who will allow no trespassing, and thus be completely cut off from the general public, except by helicopter, balloon, kite or spaceship. However, if a great pond is twenty acres or more in size, the public may acquire, by a taking, an access thereto.<sup>27</sup> The use of the principles of the division of flats is not often necessary with fresh waters, since the lines are generally relatively short, and the lines over them often established by a common grantor in the process of conveying out. In the case of flowed ponds, the lines of ownership were established before the flowing took place in most instances.

Before we hop back on dry land again, I want to mention a few special examples of the principles we have mentioned; first, an island in a great pond (one located beyond the low water mark which follows the outer shore of the pond) belongs to the commonwealth unless it has been conveyed to some private party;<sup>28</sup> second, "by the dock" conveys title to the middle line thereof unless there are qualifying words;<sup>29</sup> third, "by the way" when used at the end of the way only, means "by the end of the way";<sup>30</sup> fourth, "by other land of the grantors on a passageway" conveys title to the sideline;<sup>31</sup> fifth, "by the beach" in a deed of a part of a recreational development conveys title to the limit of the sandy area above mean high water mark which each lot owner ordinarily has a right to use;<sup>32</sup> and sixth, "by the river" means "by the thread of the river" which is the middle line between the shores or banks at average high water.<sup>33</sup>

The word "about" in connection with a correct distance is meaningless, according to the courts.<sup>34</sup> This statement sets at rest a very common tendency to think that there is necessarily some flexibility in a dimension which uses the words "about" or "more or less." Whether or not the figures are approximate is to be determined by considering the intent of the parties in the light of other facts than those particular words.

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<sup>25</sup> C. 91 § 35.

<sup>26</sup> *Sprague v. Minon*, 202 Mass. 467.

<sup>27</sup> C. 91 § 18A; C. 21 § 17.

<sup>28</sup> *Att'y Gen. v. Herrick*, 190 Mass. 307.

<sup>29</sup> *Wellington v. Cambridge*, 214 Mass. 35.

<sup>30</sup> *Lefavour v. McNulty*, 158 Mass. 413.

<sup>31</sup> *Treat v. Joslin*, 139 Mass. 94.

<sup>32</sup> *Hewitt v. Perry*, 309 Mass. 100; *Lund v. Cox*, 281 Mass. 484.

<sup>33</sup> *Hopkins Academy v. Dickinson*, 63 Mass. 544.

<sup>34</sup> *Roberts v. Welsh*, 192 Mass. 278.

## DOUBLE DESCRIPTIONS

We now come to the matter of what might be said to be a conflict in descriptions within a given instrument. It is generally brought about by describing the property being conveyed by a particular description and then following that description by a deed reference or a plan reference or a general description which supposedly covers the same land. Let us consider a few cases where this problem has cropped up.

"The southerly half of my dwelling as divided by a partition wall" was used in a conveyance where the partition wall on the second floor divided the dwelling in half and also was on a line which divided the lot in half. The Court decided that the partition wall on the first floor was controlling and that the rest of the description was a type of generalized description.<sup>35</sup> This is in line with the principle that where there is a particular description by metes and bounds, and it is in conflict with another description in the same instrument which is "general" or indefinite in nature, the particular description will hold.<sup>36</sup> For instance, descriptions like "the property owned by me at —,"<sup>37</sup> "the farm where I now live,"<sup>38</sup> "the house I now live in"<sup>39</sup> will not increase nor decrease a definite, particular description by metes and bounds.<sup>40</sup>

If the metes and bounds description is definite and the secondary description reads "being the same premises in a certain deed . . ." then the metes and bounds controls since there is no apparent intention on the part of the grantor to have the deed reference control.<sup>41</sup> However, when the same expression is used, and the deed reference also contains a direction to consult that deed referred to, such as "to all of which deeds reference is to be had," then the deed will convey any extra land that is covered by the deeds which the grantor told the grantee to consult.<sup>42</sup> Yet, if the deed referred to covers less than the metes and bounds description then the deed reference will not cut down the amount of land included in the metes and bounds description.<sup>43</sup> Another expression which ties in the deed reference

<sup>35</sup> *Holbrook v. Schofield*, 211 Mass. 234.

<sup>36</sup> *Stefanick v. Fortona*, 222 Mass. 83. See n.51 infra.

<sup>37</sup> *Fitzgerald v. Libby*, 142 Mass. 235.

<sup>38</sup> *Hastings v. Hastings*, 110 Mass. 280.

<sup>39</sup> *Harvey v. Sandwich*, 256 Mass. 379; *Ansin v. Taylor*, 262 Mass. 159.

<sup>40</sup> *Crabtree v. Miller*, 194 Mass. 123.

<sup>41</sup> *Lovejoy v. Lovett*, 124 Mass. 270.

<sup>42</sup> *Foss v. Crisp*, 37 Mass. 121.

<sup>43</sup> *Whiting v. Dewey*, 32 Mass. 428.

effectively is "meaning and intending to convey and hereby conveying the land in deed. . . ." Note the expressed intention of the grantor to convey. Where a re-arrangement of the calls in a deed will eliminate its ambiguity, it is legally sound to do so.<sup>44</sup>

#### PHYSICAL MONUMENTS AND PLAN REFERENCES

In the court definition of the "survey of lands" mentioned in the first paragraph of this paper, there is a call for the monumentation on the ground of the lines established. That brings to mind the obvious truth that title to land is meaningless unless the location of that land covered by the title can be determined with certainty upon the ground. It also explains why the courts place great emphasis on the premise that "monuments control."<sup>45</sup> What does the court mean by "monuments"? It may be a highway<sup>46</sup> or the "land" of an abutter named,<sup>47</sup> even if that land of the abutter has come into his ownership by adverse possession.<sup>48</sup> Thus, you can see why it may be necessary to trace title to an abutting owner's land in order to make a given survey. Other "monuments" are natural and more or less permanent objects such as streams, rivers, trees, and the shore of the sea; others are artificial, but also tend to be more or less permanent, such as fences, walls, buildings, stakes, stones, stone or concrete monuments, or even "cleared land."<sup>49</sup> Monuments set with the concurrence of both parties after the date of the execution of the deed, will control if they were noted in the deed as "to be set."<sup>50</sup>

After monuments have been satisfied, it has been said by the courts that courses, then distances, and then area controls in that order.<sup>51</sup> However, most cases have included a statement to the effect that (these rules) are not inflexible, and they would not be followed if they would lead to a result plainly inconsistent with the intent of the parties.<sup>52</sup> Thus we have one case where it is said that courses control distances only when they definitely indicate a geometric shape was intended. . . . Otherwise they stand on an equal footing and

<sup>44</sup> *Ellis v. Wingate*, 338 Mass. 481.

<sup>45</sup> *Holmes v. Barrett*, 269 Mass. 497; *Sheppard Envelope Co. v. Arcade Malleable Iron Co.*, 335 Mass. 180. See n.51 *infra*.

<sup>46</sup> *Temple v. Benson*, 213 Mass. 128; *Daviau v. Betourney*, 325 Mass. 1. See n.51 *infra*.

<sup>47</sup> *Pickman v. Trinity Church*, 123 Mass. 1. See n.44 *supra*.

<sup>48</sup> *Percival v. Chase*, 182 Mass. 371.

<sup>49</sup> *Marvel v. Regienus*, 329 Mass. 414. See ns. 16, 46 *supra*.

<sup>50</sup> *Cleveland v. Flagg*, 58 Mass. 76.

<sup>51</sup> *Morse v. Kelley*, 305 Mass. 504.

<sup>52</sup> *Davis v. Rainsford*, 17 Mass. 207; *Holmes v. Barrett*, 269 Mass. 497.

the circumstances existing at the time would govern.<sup>53</sup> Areas seldom control.<sup>54</sup>

The practice of referring to a plan is undoubtedly growing. This is largely because so many agencies of the government and so many title examiners call for a plan or a survey. A plan has the basic advantage of being the means of recording a great deal of helpful data which can not be conveniently recited at length in a deed, but which can be incorporated fully into the deed by reference therein to the plan and by recording the plan. When referred to in a deed or Certificate of Title the plan is to be regarded as a part of the deed or the Certificate of Title, and this means that all distances and courses and monuments and other particulars shown thereon are incorporated in the title instrument.<sup>55</sup> The rules respecting monuments, courses, distances and areas apply also to plans incorporated by references in title instruments. But where the plan is inconsistent with the deed, the deed governs.<sup>56</sup>

One matter that quite often suggests itself when examining a plan is that any excess or shortage among several lots in a particular group of lots should be resolved by apportioning the excess or deficiency among the several lots. This is a valid solution but should only be applied where there is no other guide to determine the location and dimensions of each lot.<sup>57</sup> In any case it is to be applied only where the deeding out of all the lots has been by reference to the same plan, so that all stand on the same footing. This is true even though there is a wide variation in the dates of the sundry deeds out. In other jurisdictions, possession or construction along certain supposed lot lines has been held to have fixed those lines and thus relegated the shortage or excess to a definite area. The Land Court will consider whether or not there is construction or planting along any of the lines before agreeing to a solution based on an apportionment of the shortage or excess. Thus it seems necessary for the surveyor who meets this type of problem to make such measurements as will enable him to see how the various owners may have acted to assert the extent of their ownerships, before he can suggest a solution. Even though I do not know of more than one Supreme Judicial Court Decision

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<sup>53</sup> Hall v. Eaton, 139 Mass. 217.

<sup>54</sup> Holmes v. Barrett, 269 Mass. 497; Casella v. Sneirson, 325 Mass. 85.

<sup>55</sup> Walker v. Boynton, 120 Mass. 349; Dubinsky v. Cama, 261 Mass. 47; Lagorio v. Lewenberg, 226 Mass. 464; Carroll v. Hinckley, 316 Mass. 724.

<sup>56</sup> Oliver v. Kalick, 223 Mass. 252.

<sup>57</sup> Block v. Pfaff, 101 Mass. 535.

dealing with apportionment, I feel that the Court will adopt the idea of construction or occupation along individual lot lines as determinative of the area where any excess should be placed (always assuming that there is no better method of determining the parties' intent, and that no lot is deprived of his deed frontage). I feel this way because it has held in another type of case that practical considerations may be allowed to settle doubtful boundaries.<sup>58</sup>

In concluding my remarks about doubtful dimensions and inconsistent dimensions, I want to point out that in almost all cases the Court construes doubtful matters against the grantor and in favor of the grantee, unless one of the parties to the deed is the state or an agency of the state. Then the state is favored.<sup>59</sup> However, such construction is applied only in cases where the intent of the parties is not clear in the light of all the attending circumstances.<sup>60</sup>

I think it is wise to also remark at this point that the court will presume that the bounds set by a governmental agency in furtherance of a taking by, or grant to it, are the true limits of the governmental ownership. Thus the bound set on a street will control the location even though incorrectly set, provided they are not substantially outside the area taken by, or granted to, it. In connection therewith, the Land Court has decided that where the curve data and the connecting tangents of a road layout as indicated by the monuments set are not mathematically consistent, then the monuments at the beginning and the end of the curve and the radius of the curve control the lines of the street at the curve.

#### REGISTERED LAND

Up to this point we have been dealing with the deed and various questions concerning that instrument which a surveyor must, ought, or may be interested in, in the course of conducting his practice. In this state we find that perhaps ninety percent of the areas are covered, title-wise by deeds. The other perhaps ten percent of the areas of this state are registered lands which are covered by Certificates of Title issued by the Commonwealth.<sup>61</sup> The idea behind this matter of Registration of Title to land is that the condition of the title of any particular parcel of land is readily determined by an examination

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<sup>58</sup> *Stone v. Stone*, 179 Mass. 555; *Fulgenitti v. Cariddi*, 292 Mass. 321.

<sup>59</sup> *Comm. v. Roxbury*, 75 Mass. 451. See n.15 supra.

<sup>60</sup> *Coogan v. Burlin Mills*, 124 Mass. 390.

<sup>61</sup> C. 185 § 48 et seq.

of the Certificate of Title; that the description of the land is definite inasmuch as the plan incorporated into the certificate by reference is sufficiently complete to enable a surveyor to stake the land and the lines thereof upon the ground; and that the state guarantees the title and the lines. By and large I believe the idea has worked out very well. The greatest objection to the registration of land comes from those people who do not wish the Court to take time to verify the plans and changes in title desired by the owners. Most of these objectors are people selling the land. However, the Court acts as it does for the purpose of protecting buyers and successive buyers. Nevertheless, in doing so it also prevents almost completely the mis-descriptions, the conflicting descriptions, the major errors in surveying, and conveyancing, which we find in unregistered land conveyancing. This preserves the marketability of the land, a feature of direct benefit to the seller. Perhaps a brief outline of the procedure necessary to obtain the registration of title to land, and of the procedure in dealing with it after registration, is in order at this time.

The original registration proceedings are voluntary. He who wishes to register his title to his land may petition the Court on forms supplied by the Court. His petition must be accompanied by a plan of the land to which he believes he has title. The Court has prepared a pamphlet of instructions to surveyors for the making of surveys and the preparation of plans to be submitted to it. The purpose in preparing the pamphlet is to assure the Court that a recent survey has been made in accordance with the best practices of the surveying profession, and that it reports to the Court all the facts which may be of interest to those examining the title to the land and to those who may object to the proposed registration. A third paper which is filed with the petition and plan is the Assessor's certificate. On a form prepared by the Land Court, the Assessors of the community where the land is located indicate whether or not the abutting owners listed by the petitioner as adjoining his land are correct, and, if not, they report thereon the correct names of such abutters. These three papers and a fee of seventy-five dollars plus 1/10th of 1% of the assessed valuation are filed with the Recorder after the Engineering Department has indicated on the plan that it is satisfied with the plan so far as a preliminary examination of its contents goes. The case is then assigned to an examiner of title (who is a lawyer in private practise in whom the Court has confidence as to his conveyance

ability) for his report on the record title as gleaned from the Registry of Deeds and other sources, and for his opinion concerning the title. When he reports the record title appears to be satisfactory, the Court orders that a notice of the petition be published for three weeks; be posted on the land itself; and be sent by registered mail to all the known parties who may, by any possibility, be interested. If the examiner reports that he believes the title is not good, the petitioner must file a motion to proceed, in order to go ahead in face of an adverse report. Since many cases are filed because of some fault in the record title, it is common that a petitioner does move to proceed. The case then goes to publication as above.

While an answer should be filed on or before the return day set in the publication notice, an appearance by an interested party will generally preserve his right to be heard. The Court will generally allow a motion to file answer late by anyone who has a legitimate objection. If the petitioner then files a motion to set the case down for a hearing, the case will be heard, and a decision made. If no objection to the petition is filed, the judge to whom the case is assigned will read the abstract (report) of the title and order a decree, or seek other information from the petitioner, such as an affidavit of adverse possession to warrant the ordering of a decree.

When the order of decree is made, either after decision or after reading the abstract of title, the engineering department prepares a plan to accompany the decree. This plan is based on the plan which was filed with the original petition, but may vary from it considerably in order to make the decree plan conform with the judge's order, or decision, or to conform with the style and content which the Court wants in its official plans. It is numbered with the case number with the superscript "A." With the decree plan so drawn, the Recorder's office prepares the actual decree itself, incorporating the plan by reference, and the final combination is reviewed by the judge hearing the case. If all is satisfactory, the petitioner pays any additional fee required above the seventy-five dollars he paid initially, or is refunded any portion of that seventy-five dollars which remains unused, and the Court sends the decree and the plan accompanying it to the Registry of Deeds. There, the Assistant Recorder, who is the Registrar of Deeds, examines the records at the registry from the date of the examination of title as reported by the title examiner, and, if he finds there are no papers recorded since that time which affect the land in

the decree, he registers the decree and assigns a certificate number. At that point the land is registered. If he finds that some paper affecting the land in the decree has been recorded, he sends everything back to the Court for further action.

The Assistant Recorder prepares, in the name of the registered land owner, an Original Certificate of Title which he binds in a public record book, wherein all such certificates are entered numerically by certificate number. Each registry has its own numbering of certificates beginning in every case with the numeral one. Thereafter the Assistant Recorder issues to the registered owner an exact duplicate of the original Certificate of Title. This Certificate of Title is conclusive evidence of ownership of the land described therein.<sup>62</sup> In every voluntary transaction from then on, the land owner must present to the Assistant Recorder his duplicate original Certificate of Title and the paper which calls for a change therein.<sup>63</sup> Such a paper might be a deed, conveying all or a portion of the land covered by the Certificate of Title, or it might be a mortgage or lease, etc., covering all or a portion of the land described in the certificate. If the paper is an encumbrance on the property, such as a mortgage, lease, or grant of an easement, it is merely given a document number by the Assistant Recorder and filed in his office, and a memorandum thereof is entered on the encumbrance sheet of both the original and owner's duplicate Certificates of Title, and the owner's duplicate returned to him.<sup>64</sup> If the paper is an actual transfer of the land itself, such as a deed, it is given a document number and entered on the certificates in the same way. However, in this case the entry on the grantors certificate states that the certificate is cancelled as to the land described in the deed, and a new Certificate of Title made out in the name of the grantee in such a deed. Again the Assistant Recorder puts his original of this transfer certificate on record by binding it in his record book, and sends to the new owner under said deed a duplicate copy of such transfer Certificate of Title.

Whenever the owner desires to deed a portion of his land in such a way that a new property line is being created (no such line being already shown on the decree plan) he must have a new plan prepared in accordance with the Land Court instructions, which plan will show at least a new lot which the owner wishes to convey. It may show

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<sup>62</sup> C. 185 §§ 54, 62. See n.101 infra.

<sup>63</sup> C. 185 § 57 et seq.

<sup>64</sup> C. 185 § 59.

many lots.<sup>65</sup> He files that plan with the Engineering Department of the Court with a written request that a Court plan be prepared showing the new lot or lots. The filing fee for such a subdivision plan is ten dollars plus one dollar for each lot he requests to be shown. As soon as the Department can get around to it, it will prepare a Court copy thereof, in the style and with the content which the Court desires, and which has on it a statement that separate Certificates of Title may issue for specified numbered lot or lots shown thereon, and send said Court-prepared plan to the Assistant Recorder. The Assistant Recorder will merely hold that plan until a deed covering the authorized lot is presented to him for registration, whereupon he will bind the plan with the first Certificate of Title which refers to the new plan. Of course any deed out of the lot shown on the new plan will be endorsed on the grantor's outstanding certificate with a notation to the effect that the land conveyed by the document is shown on a plan filed with the grantee's Certificate of Title. The Court numbers each subdivision plan with the original registration case number combined with either a superscript letter or an affixed Arabic number. The letters are used throughout the alphabet and the numbers start with the figure 1 and proceed consecutively. In some cases there are now over two hundred such subdivision plans.

Involuntary instruments, such as takings, court orders, judgments, liens, certificates of entry, and many others, may be placed on the encumbrance sheet of any appropriate Certificate of Title without the presentation of the owner's duplicate certificate.<sup>66</sup> The registration of such papers is provided for by law. They must be considered effective by a surveyor, although they may later be cancelled by another appropriate paper or by a court order.

There are many matters which may call for a change in the outstanding Certificate of Title or the plan which is a part thereof. These changes can be accomplished by way of a supplemental petition leading to an order of the Land Court.<sup>67</sup> This matter is dealt with in more detail in the "Land Court Instructions to Engineers and Land Surveyors." A supplemental petition, for instance, is an excellent method of eliminating some of the "deadwood" which may accumulate on the encumbrance sheet and for correcting any errors in surveying or drafting which may be discovered from time to time.

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<sup>65</sup> C. 185 §§ 51, 65.

<sup>66</sup> C. 185 § 79.

<sup>67</sup> C. 185 § 114.

In summary it might be said that the act of registration of the title to land starts the title anew and with an adequate plan to describe it. The title is kept in a reasonably easy to understand format, and in a dependable summary form, by requiring that every paper, to be effective, must be endorsed thereon by a person who is responsible to the Land Court, and that every survey and plan must be verified by some agent of the Court before its use is authorized. A decree of the Land Court is conclusive on all persons, including the Commonwealth, after the appeal period of thirty days has expired, subject to certain exceptions, and the only person who can come in under that appeal period is one who can file an affidavit that, due to lack of notice, actual or otherwise, he had no chance to present his objection before decree. Those exceptions to which the decree is subject are: (1) matters not required by law to appear of record in the Registry of Deeds in order to be valid; (2) taxes within two years after they have been committed to the collector; (3) the line of a way if the certificate states it has not been determined; (4) any lease for a term not exceeding seven years; (5) any liability for assessments, etc., which attach to the land as a lien; and (6) appurtenant rights which attached to the land in the decree notwithstanding they were not registered but which shall remain appurtenant.<sup>68</sup> Other than these matters, the only way a person can open a decree is for fraud on the Court, and that is limited to a one-year period after decree, and is even further limited by the proviso that no innocent purchaser for value can lose title.<sup>69</sup>

In general then, so far as surveyors are concerned, what is contained in a Certificate of Title or referred to therein is controlling over all else except the U.S.A. Otherwise the land is subject to all legal incidents of unregistered land.<sup>70</sup> Again we have exceptions with which a surveyor should be acquainted. The first is that no title to registered land can be acquired by adverse possession or prescription, and the second, that a right of way by necessity shall not be implied under a conveyance of registered land.<sup>71</sup> The only way in which registered land can revert to an unregistered status is by foreclosure of an unregistered mortgage. This can occur only where the mortgagee of the property before registration, who refused to have

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<sup>68</sup> C. 185 § 46.

<sup>69</sup> C. 185 § 45.

<sup>70</sup> C. 185 § 77.

<sup>71</sup> C. 185 § 53.

his mortgage registered, forecloses after registration. He takes title as it was when he accepted the mortgage.<sup>72</sup>

#### ADVERSE POSSESSION AND CONTINUING TRESPASS

Having dealt with the usual forms of holding and transferring title in Massachusetts, that is, by deed or by Certificate of Title, let us now turn to other methods by which ownership in land may be transferred. Those that may be of interest to the surveyor are adverse possession, eminent domain, accretion and erosion, acquiescence, tax foreclosure, mortgage foreclosure, sales under license of Probate Court, sales on execution after judgment, and sales by a receiver in bankruptcy. Since all but the first four are more or less self explanatory as to the reasoning for them and since there ordinarily is no plan or survey problem involved, I shall limit my discussion to those four. The first of these is adverse possession.

There are seven elements which should always be present in a claim that title has passed by adverse possession.<sup>73</sup> They are that the possession was actual, adverse, open, exclusive, continuous and under a claim of right, for a period of at least twenty years and for so much longer as required to cover any period of disability of the dispossessed owner. Now what is satisfactory evidence of these factors? Some of them are largely self explanatory. For instance, actual possession means that the claimant was actually on the land and generally actually occupied the whole of the land. However, if he rents the land to a tenant, then he is constructively on the land.<sup>74</sup> Also, if he took possession under a deed, which, though void, described all of the land the limits of which are discernable upon the ground, then his actual occupation of a portion of the land is constructive occupation of the whole of the land covered by the deed. This is called occupation under "color of title."<sup>75</sup>

The requirement that the occupation be adverse or hostile to the rightful owner is designed to eliminate those situations where the adverse claimant initially moved into occupation with the permission of the rightful owner.<sup>76</sup> Such permission is considered to continue indefinitely and until there is an actual act to deny the true owner his land and which act the true owner knows of or ought to know of.

<sup>72</sup> C. 185 § 26.

<sup>73</sup> *Warren v. Bowdran*, 156 Mass. 281; *Cook v. Babcock*, 65 Mass. 206.

<sup>74</sup> *Nantucket v. Mitchell*, 271 Mass. 62; *Murphy v. Comm.*, 187 Mass. 361.

<sup>75</sup> *Dow v. Dow*, 243 Mass. 587; *Nantucket v. Mitchell*, 271 Mass. 62.

<sup>76</sup> *Robert v. Perron*, 269 Mass. 537.

The requirements that the occupation be open or notorious is designed to eliminate those situations where the acts of occupation were performed only when the true owner was absent.<sup>77</sup> However, this element does not mean that the occupation should be anything more than what is so open and obvious that the true owner, in the exercise of ordinary diligence, would discover it.

The element of exclusiveness is necessary, in order to eliminate the situation where the true owner also occupies the claimed land, some of the time, along with the claimant. It means "exclusive of the true owner." However, two people can occupy adversely for the requisite period of time and then claim joint ownership.<sup>78</sup> Continuously means without substantial breach in the period of adverse possession. An occupation of seven years, then a period of absence for a year or two followed by another period of occupation for fourteen years would not ripen into adverse possession. The break could be shorter or longer than that, the intention not to occupy being the critical feature.<sup>79</sup> However, a seasonal occupation of seasonal property may well ripen into adverse possession.<sup>80</sup> In the case of an easement or a right of way obtained by prescription, which is viewed very similarly to adverse possession, the use of a right of way during the summer season, for more than twenty years, ripened into a prescriptive right.<sup>81</sup>

Since taking title by adverse possession is a displacement of the true owner, it might be considered to be stealing land. That being so, the Courts could not recognize it until authorized to do so by statute.<sup>82</sup> And the Courts still will not recognize it unless there is evident a clear intent on the part of the claimant to claim the land as rightfully belonging to him for the whole period of adverse possession.<sup>83</sup> In order to further safeguard the true owners, the statute provided, up to 1961, that if the true owner were under a disability, i.e., a minor, or insane, or in prison, or out of the country, when he was originally dispossessed, then he had until ten years after his disability was removed to assert his true ownership.<sup>84</sup> Beginning in 1961, the same law, though applicable, is limited to a date not more than twenty-five years after the dispossession started.<sup>85</sup>

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<sup>77</sup> *Samuels v. Borrowscale*, 104 Mass. 207.

<sup>78</sup> *Joyce v. Dyer*, 189 Mass. 64.

<sup>79</sup> *Bowen v. Guild*, 130 Mass. 121.

<sup>80</sup> *Kershaw v. Zecchini*, 342 Mass. 318.

<sup>81</sup> *Mahoney v. Heebner*, 343 Mass. 770.

<sup>82</sup> C. 260 § 21 et seq.

<sup>83</sup> *Boulin v. Perreault*, 343 Mass. 329.

<sup>84</sup> C. 260 § 25.

<sup>85</sup> Acts of 1959, c. 269 § 1.

The last matter concerning adverse possession that should be mentioned here is that a number of successive occupiers of the land can "tack" their respective periods of occupation together, and if the whole makes up a period of occupation with all the necessary elements, title will pass. Such "tacking" of such periods can only be accomplished under the statute by a conveyance, or devise, or by descent, from one owner to his successor.<sup>86</sup>

A subject related to adverse possession and often confused with it, by some, is the matter of continuing trespass. In our state, a land owner has a right to the free use of all of his land under existing applicable laws; no other person has the right to deprive him of it. Thus, if another builds upon or occupies wrongfully a portion of his land, the landowner has a right to an injunction from the court to have the wrongdoer remove his construction.<sup>87</sup> This can include the removal of a building or a wall. However, the injunction will not be granted where the construction took place under a bona-fide claim of right to ownership, or an innocent mistake,<sup>88</sup> nor where the true owner knew of the trespass and failed to act soon enough.<sup>89</sup> In these cases the trespass will be allowed to continue. Note that title to the land under the trespassing structure does not pass from the true owner to the building owner. Presumably, if the true owner does not act, title will pass by adverse possession after the required period has passed. Similarly, if the true owner registers his land, or takes other steps to assert his ownership from time to time, he can prevent title from passing by adverse use.

#### EMINENT DOMAIN

Turning to the matter of eminent domain, I should first point out that there are three methods in operation in this state. The first is that employed by the federal government and commonly called "condemnation."<sup>90</sup> It is brought against the land itself and not the owners. It entitles the federal government to immediate occupation of the premises but title does not pass until damages are paid to the owners from whom it is taken.<sup>91</sup> Such a federal taking does not have to be

<sup>86</sup> *Wishart v. Knight*, 178 Mass. 356. See n.80 supra.

<sup>87</sup> *Szathmary v. B. & A. R.R. Co.*, 214 Mass. 42; *Crosby v. Blomerth*, 258 Mass. 221; *Westhampton Reservoir Recreation Corp. v. Hodder*, 307 Mass. 288; *Marcus v. Brody*, 254 Mass. 152.

<sup>88</sup> *Gray v. Howell*, 292 Mass. 400; *Lynch v. Union Institute for Savings*, 159 Mass. 306.

<sup>89</sup> *Triulzi v. Costa*, 296 Mass. 24; *Loughlin v. Wright Machine Co.*, 273 Mass. 310.

<sup>90</sup> Title 40 § 490 (12). See also 43 S. C. 689, 262 U.S. 700. *Opinion of Justices*, 297 Mass. 567. See also *Corpus Juris Secundum* vol. 29, p. 1127.

<sup>91</sup> *United States v. 40,379 sq. ft. in Newton*, 58 F. Supp. 246, D.C. (1945); *Sherwin v. Wigglesworth*, 129 Mass. 64.

recorded in the Registry of Deeds to be effective and therefore does not have to be entered on Certificate of Title either. The only good record of such takings is in the Federal District Court, where it is indexed under the name of the town by the title, "U.S. vs. — Acres of land in — (town)." A copy of the "Judgment" which is entitled as I have just indicated may be obtained and recorded on the appropriate Certificate of Title or in the appropriate registry by an owner interested in doing so.

The second eminent domain proceeding in this state is that called "Eminent Domain by Judicial Proceedings."<sup>92</sup> An order of intent and a plan showing the area to be taken is placed on record in the registry of deeds within ten days after the parties affected thereby are notified. Then, within ten days after such recording, a petition is filed in the Superior Court asking for judgment in favor of the taking authority. The Court then sends notice to all concerned and within six months renders a judgment. Title passes when judgment is obtained.

The third eminent domain proceeding in this state and the most common of them all, is called "Eminent Domain under Chapter 79" or simply "Eminent Domain."<sup>93</sup> The statutory requirements are detailed and very important to the validity of the taking. The outstanding features are that the taking authority shall prepare an order of taking which must be recorded within thirty days after the date thereof or the taking is void.<sup>94</sup> If promptly recorded, title passes to the taking authority at that time. Within two years thereafter an entry upon the land must be made for construction purposes. If this is not done then the taking is void.<sup>95</sup> Evidence of entry can be furnished by witnesses, by the production of the record of the work done, even by means of a surveyor's field notebook, or by recording a certificate of entry, as the statute allows.

Whether or not one taking agency can make an effective taking over land which had been previously taken by another taking agency is a question which the Supreme Judicial Court may have to decide shortly in the controversy between the Metropolitan District Commission and the Massachusetts Turnpike Authority. However, a statute prohibits the taking of land of a state institution, a highway, a public building or a cemetery, for a canal, railroad, or way, without the

<sup>92</sup> C. 80A.

<sup>93</sup> C. 79.

<sup>94</sup> *Radway v. Selectmen of Dennis*, 266 Mass. 329.

<sup>95</sup> *Corey v. Wrentham*, 164 Mass. 18; *Mahan v. Town of Rockport*, 287 Mass. 34.

consent of the General Court. It also prohibits the taking of a common park dedicated to public use for more than twenty years, for a canal, railroad, or way without the consent of the town or city in which the park is located. And it prohibits the taking of a park established under Chapter 45 of the General Laws for any canal, railroad, or way without the consent of the town or city park authority which has charge thereof.<sup>96</sup> An attorney general has opined that a town cannot lay out a way over the land of the Commonwealth without the consent of the General Court.<sup>97</sup> On the other hand we have a court decision that a part of land in the public use may be taken for a purpose not inconsistent<sup>98</sup> and a second decision that a park and common lands may not be taken for a purpose which is inconsistent.<sup>99</sup>

### ACCRETION AND EROSION

The third method of transferring title with which the surveyor in Massachusetts ought to be acquainted is that of accretion and erosion. In most cases this transfer in ownership is between the Commonwealth, as the owner below extreme low water mark, and the flats owner, who owns out to extreme low water mark. It is as simple a matter as stating that, as the line of extreme low water mark wanders due to natural causes, so the line of ownership changes. Similarly, where the mean high water mark is the line of ownership between the upland owner and the owner of the flats, then those ownership areas change with the natural changes in the location of the mean high water mark.<sup>100</sup> These rules hold even where the construction of a jetty has been the factor in causing the accretion or the erosion. Furthermore, the same rules hold where the state has deposited fill along the shoreline and thus built up the land so that both the location of the mean high water mark and the location of the extreme low water mark were changed.<sup>101</sup> This latter situation is unusual, inasmuch as by general rule, changes by artificial means do not work a change in ownership. The court explained that the moving force in depositing fill was the state itself, and was for public purpose, and that no actions of the adjacent land owners were moving factors in changing the shoreline.

A similar transfer of ownership can occur on a reduced scale when ownerships bound on a pond, or other inland body of water, or bound

<sup>96</sup> C. 79 § 5.

<sup>97</sup> 2 Op. Att'y Gen. 1900 P. 234.

<sup>98</sup> *Easthampton v. Hampshire County Comm.*, 154 Mass. 424.

<sup>99</sup> *Town of Needham v. Norfolk County Comm.*, 324 Mass. 293.

<sup>100</sup> *Allen v. Wood*, 256 Mass. 343.

<sup>101</sup> *Michaelson v. Silver Beach Improvement Assoc. Inc.*, 342 Mass. 251.

by the mean high water mark thereof. An even more marked transfer of ownership takes place where two adjacent properties bound by, or by the bank of, a stream. The extent of the ownership will vary as the location of the stream wanders due to natural causes.

#### ACQUIESCENCE

The last matter on the transfer of land which a surveyor should have in mind is that of acquiescence, which consists of an agreement between abutting land owners that the line between them, which cannot be correctly located from any available data, is actually in a place designated by them. A common way in which this is worked out is to have a surveyor prepare a plan showing where the agreed upon line is located, relative to some monuments in the ground, and then have both parties sign the plan as agreeing to said location as shown thereon, and recording the plan. The courts do not view this as a transfer, but merely an agreement making certain that which cannot be made certain except by agreement or arbitrary decision. If the ownership lines could have been made certain before the agreement or can be made certain afterward, the agreement would be void.<sup>102</sup> As a practical matter the courts would not raise a question unless a party in interest brought out such facts as a point in issue. However, a sure method of accomplishing the same result is to have each owner actually convey to the abutting owner all his right, title and interest in any of his land which is located on the abutter's side of the surveyed line. In such a transaction it would be wise to show the extent of each owner's land in outline, but fixing the new line in detail by metes and bounds, and monuments. The instrument would commonly be labeled an "Agreement" between the parties, but it would in fact be two deeds in one instrument, with all the usual deed formalities set forth in each grant, and all the signatures and acknowledgments at the end of the instrument.

#### PUBLIC STREETS

Often a surveyor is called upon to report whether or not a street is public. The usual method of taking care of this is to ask a community official, preferably the town or city clerk, and to accept his answer. However, it might be wise for each surveyor to be acquainted with the fact that since 1846 an accepted layout is required in order to make a street public and that layout must be in accordance with

<sup>102</sup> *Boston & Worcester R.R. Corp. v. Sparhawk*, 46 Mass. 469; *Crawford v. Roloson*, 256 Mass. 331.

the applicable statutes in order to be valid.<sup>103</sup> Before 1846 a street could become public by "dedication." This consisted of an action by the land owner offering to the public the use of the street, and an action by the public, and especially the public authorities, in using the street as though the public had accepted the offer. Such acceptance was evidenced by such acts as: repairing it, reconstructing it, placing public utilities in it, and otherwise using it as a public thoroughfare. Thus we have an exception to the general rule requiring a layout, in that what has often been called an "ancient way," may be a public street, because of extended usage for a considerable time prior to 1846.<sup>104</sup>

The present street laying-out statutes and court decisions set forth sundry requirements and interpretations which take considerable time and experience to analyze and, to my mind, do not eliminate conflicting interpretations of what is expected.<sup>105</sup> However, I believe I can best summarize the essential elements required, by stating that there must be a layout instrument accompanied by a plan which shows dimensions and boundaries of the proposed public street, which layout must be accepted after a public hearing. In the case of a county way, there does not seem to be any requirement that the layout be recorded anywhere but it logically follows that it would be on file at least in the office of the county commissioners. In the case of a town layout it is required that the layout be recorded with the town clerk and in the case of a city layout it is required that the layout be recorded with the city clerk. In the case of state highways it is required that a copy of the layout shall be filed with the various county commissioners and the various town and city clerks where the highway is located. All of these statutes respecting layouts include a section which states that if it is necessary to take land, the authority may do so under the eminent domain statute.<sup>106</sup> I deduce that the lawmakers presupposed that the easement for street purposes, or the title to the land itself, would be already in the public ownership or could readily be acquired by grant, in the majority of the cases where the street was to be made public, and thus no taking was necessary. For that reason a recording of the layout in the registry of deeds was not required. But since these lawmakers required that any taking of land outside the existing way was to be taken by eminent domain, they in effect required that the layout

<sup>103</sup> C. 84 § 23. See n.110 *infra*.

<sup>104</sup> *Comm. v. Belding*, 54 Mass. 10; *Hobbs v. Lowell*, 36 Mass. 405.

<sup>105</sup> C. 81 & c. 82.

<sup>106</sup> C. 81 § 7 & c. 82 § 7.

over land not covered by prior grants of easements should be made a part of the records at the registries of deeds by the recording of the eminent domain taking. Certainly in the case of registered land, no layout made in any portion of the land not within a street can be valid without having a taking by eminent domain or a grant for street purposes registered on the outstanding Certificates of Title.<sup>107</sup> It is my personal belief that many public street layouts include the taking of some easement or fee outside the land, or the easement for street purposes, which is owned by the layout authorities, and that in order to be effective as to those parts outside of the public control, a taking under the eminent domain statute must be made. However, my conclusions, or beliefs, are blurred by several statutes and decisions which seem to indicate otherwise.<sup>108</sup> In any reading of these, one should have in mind that the laws have changed considerably from time to time. For instance, around 1900, any layout had to be recorded in the registry of deeds in order to be valid.<sup>109</sup>

Statutes which purport to make valid all prior but unspecified invalid takings and layouts in a given town or city are probably unconstitutional.<sup>110</sup> A relocation amounts to an alteration and a discontinuance of those parts outside the newly established street lines.<sup>111</sup> An alteration alone also amounts to a discontinuance of those parts outside the newly established street lines.<sup>112</sup> A discontinuance can ordinarily be made by the same procedure as required for a layout.<sup>113</sup> Even though one statute states that a discontinuance statute does not apply to a town,<sup>114</sup> we have a decision which states that a discontinuance by a town can only be made by a vote of the town.<sup>115</sup> A discontinuance is necessary to end the "public" nature of a way.<sup>116</sup>

#### LANDINGS, PARKS, AND CEMETERIES

A street cannot be laid out below mean high water mark.<sup>117</sup> A public landing can, and often is. A public landing is not a town way

<sup>107</sup> C. 79 § 4.

<sup>108</sup> C. 82 §§ 11, 17; *City of Cambridge v. County Comm. of Middlesex*, 167 Mass. 137; *Livermore v. Norfolk County*, 186 Mass. 133; *Hyde Park v. Norfolk County Comm.*, 117 Mass. 416.

<sup>109</sup> Rev. Laws c. 48 § 97, Stat. 1898 c. 134.

<sup>110</sup> *Lorjol v. Keene*, 343 Mass. 358.

<sup>111</sup> C. 82 §§ 11, 17; *City of Cambridge v. County Comm. of Middlesex*, 167 Mass. 137.

<sup>112</sup> *Bowley v. Walker*, 90 Mass. 21; *Cohasset v. Moors*, 204 Mass. 173.

<sup>113</sup> C. 82 §§ 30, 32A; c. 81 § 12.

<sup>114</sup> C. 82 § 17.

<sup>115</sup> *Mahan v. Town of Rockport*, 387 Mass. 34.

<sup>116</sup> *Eklon v. Chelsea*, 223 Mass. 213; *Loring v. City of Boston*, 78 Mass. 209.

<sup>117</sup> *Inhabitants of Charlestown v. Middlesex County Comm.*, 44 Mass. 202; *Hunt v. Comm.*, 183 Mass. 307.

and neither town nor the county can discontinue it.<sup>118</sup> It is to be considered in the nature of a public park, apparently. A public park, which is not subject to a trust, is subject to the paramount control of the General Court.<sup>119</sup> Thus it appears that legislative permission must be obtained before any park land can be withdrawn from the use by the public as a park.<sup>120</sup> In dealing with this subject, it should be noted that all communities bounding on the sea shore must provide a public landing for the use of the public, and must file such a layout in the registry of deeds.<sup>121</sup>

Cemeteries have also assumed somewhat of a public character. That fact is indicated by a statute that prohibits the use of a burial place which is over 100 years old, for any other purpose, without the consent of the General Court.<sup>122</sup>

#### EASEMENTS

In reading the title instruments, the surveyor ought also to make note of any easements which are referred to therein. Furthermore, in making his survey in the field he should locate any evidences of easements which may affect the property, and later investigate the matter of the rights of others and of his client therein. The word "easement" is used in many instruments as being either a right another has over a given owner's land or a right which that owner may have over another's land. In order to separate the two types, I shall call the first type a "subject right" and the second type an "appurtenant right." A surveyor, however, should always keep in mind that an easement which is a subject right in his client's chain of title is an appurtenant right in the title chain of some other owner, and that this interchanged relationship applies *visa versa*. With those preliminaries, let us take a look at some of the possible situations.

An easement may be created by reservation or exception, that is, by a grantor, in the course of conveying a parcel of land, keeping a right for himself and his successors in title, to make use of a portion of the land being conveyed. This can be done either by saying so in so many words, when it is termed an expressed reservation, or by conveying under a set of circumstances such that the grantee would

<sup>118</sup> *Bennett v. Clemence*, 88 Mass. 10.

<sup>119</sup> *Lowell v. Boston*, 322 Mass. 709.

<sup>120</sup> *Brooks v. Boston*, 334 Mass. 285.

<sup>121</sup> C. 88 § 14 et seq.

<sup>122</sup> C. 114 § 17.

have, or should have, realized, that the grantor had to retain in himself a right to use some part of the land being conveyed in order to enjoy the land remaining in his name after the grant. In this latter case it is called an implied reservation. Using the plan shown in Figure 1 (p. 179) as the basis for an illustration of an expressed reservation of an easement, the following sentence might be added after a grant of Lot 1 from Smith to a grantee: "Reserving to the grantor as appurtenant to his remaining land a right of way ten feet wide over the southwesterly side of said Lot 1, along the line of B Street, from the land of the grantor to A Street."<sup>123</sup> This situation is clear enough. The surveyor would show the ten foot wide way across Lot 1 on any plan he might make for either owner. It would be a subject right as to Lot 1 and an appurtenant right as to the Smith land.

The problem in reserved easements comes in the form of the "implied" reservations. Remembering the general rule that any grant is to be construed most strictly against the grantor, it can be readily understood why a reservation probably is never implied unless it is in use by, and is absolutely necessary to, the enjoyment of the land to which it is appurtenant.<sup>124</sup> For instance, a line through a building calls for the maintenance of support and shelter,<sup>125</sup> or a line through a partition wall calls for the right to use the whole wall to support the building the grantor retains,<sup>126</sup> or if the grantor uses an obvious right of way out of his property, and has no other, it is implied that he reserves to himself the right to continue to use the right of way.<sup>127</sup> However, if the grantor can obtain a similar right for a reasonable price, he must do so.<sup>124</sup>

An easement may be created not only by reservation but also by grant, and the granted easement may also be expressed or implied. Again, the expressed easement ordinarily presents no problem to the surveyor. Using the plan shown in Figure 1 (p. 179) as the basis for an illustration of an expressed grant of an easement, the following sentence might be added after a grant of Lot 1 from Smith to a grantee: "There is granted as appurtenant to said Lot 1 a right of way ten feet wide over the northwesterly part of the grantor's land along the three lines which are respectively 50.00, 50.00, and 13.40 feet long,

<sup>123</sup> Bowen v. Conner, 60 Mass. 132.

<sup>124</sup> Carbrey v. Willis, 89 Mass. 364.

<sup>125</sup> Adams v. Marshall, 138 Mass. 228.

<sup>126</sup> Rubenstein v. Hershon, 259 Mass. 288.

<sup>127</sup> Davis v. Sykes, 254 Mass. 540.

and extending from land of Brown to B Street."<sup>128</sup> In this rather typical example, the right to travel over the land of Smith is appurtenant to Lot 1 and is sometimes said to be annexed to Lot 1. In any case it passes with any further conveyance of Lot 1.<sup>129</sup> And this is true generally whether or not it is specifically mentioned in the subsequent conveyance, so long as it can be considered in some measure to be necessary to the enjoyment of the land to which it is appurtenant.<sup>129</sup>

An expressed easement, the location of which is not set forth in the deed creating it by grant, will be located where a way already in use is located on the ground;<sup>130</sup> or where the owners together fix it on the ground;<sup>131</sup> or where one owner fixes it on the ground and the other owner acquiesces therein;<sup>132</sup> or where the courts may fix it, if the parties themselves fail to do so.<sup>131</sup> If the width of such a way is not given in the deed, it will be as wide as is convenient for all the ordinary uses for which the way was intended<sup>133</sup> at the time of the grant.<sup>130</sup> This would be for all reasonable purposes of the estate to which it is appurtenant,<sup>130</sup> unless a contrary intent is indicated.<sup>134</sup>

An implied easement is one which, though not mentioned in the deed, was a use which was open and apparent and which was being enjoyed by the grantor, and which easement is reasonably necessary for the use and enjoyment of the land being conveyed to the grantee.<sup>135</sup> Bounding at a private street either "by" or "by the line," will imply a right to the use of that street and connecting private streets to reach a public way by the most convenient (which means ordinarily the best constructed) route,<sup>136</sup> and, if in a recreational development, to get to the water or to enjoy a "beach" or "park."<sup>137</sup>

A way by necessity is similar to an implied easement either granted or reserved. It arises where one person grants to another a lot of land which would be without access to a public way if it did not have an appurtenant right over other land owned by the grantor, or, in reverse, if the land being retained by the grantor would be without access to a public street, if it did not have an appurtenant right over

<sup>128</sup> *Briggs v. Connors*, 243 Mass. 1.

<sup>129</sup> C. 183 § 15; *Dubinsky v. Cama*, 261 Mass. 47.

<sup>130</sup> *Dunham v. Dodge*, 235 Mass. 367.

<sup>131</sup> *Mahoney v. Wilson*, 260 Mass. 412.

<sup>132</sup> *Kessler v. Bowditch*, 223 Mass. 265; *Anderson v. De Vries*, 326 Mass. 127.

<sup>133</sup> *George v. Cox*, 114 Mass. 382.

<sup>134</sup> *Barrett v. Duchaine*, 254 Mass. 37.

<sup>135</sup> *Prentiss v. Gloucester*, 236 Mass. 36; *Parks v. Bishop*, 120 Mass. 340; *Baldwin v. B & M R.R.*, 181 Mass. 166.

<sup>136</sup> *Ralph v. Clifford*, 224 Mass. 58; *Driscoll v. Smith*, 184 Mass. 221.

<sup>137</sup> *Carroll v. Hinchley*, 316 Mass. 724.

the lot being sold. In either case, a way "by necessity" is absolutely essential in order to prevent a parcel of land being "landlocked."<sup>138</sup> In Massachusetts, any owner may landlock himself, if he wishes,<sup>139</sup> and any way by necessity ends as soon as the necessity ends.<sup>140</sup>

An "easement in gross" means a right to use another's land for a personal purpose, and which right is not annexed as appurtenant to any particular parcel of land. It stands alone. Probably the only type specifically approved by the Supreme Judicial Court of Massachusetts is the right to take water from a spring.<sup>141</sup> However, the Court indicated many times there may be other types.<sup>142</sup>

### PREScription AND RESTRICTIONS

An easement "by prescription" may be created by a use adverse to the land owner's complete enjoyment of his property.<sup>143</sup> This is accomplished by acts which, taken together, constitute the same assertion of right as is present in the transfer of title by adverse possession,<sup>144</sup> namely, the use of the right, which may be a right of way, for example, must be actual, adverse, open, continuous, exclusive and under a claim of right for a period of at least twenty years. What has been said of the various elements in adverse possession apply here also. Furthermore, this, also, is a "stealing" of a right in land, and is authorized by statute.<sup>145</sup> Three additional remarks ought to be added, however. The first is that, very often, prescription cannot be proved because it can be shown that the use started with the permission of the true owner.<sup>146</sup> The presumption that such permission continues must be overcome. Secondly, the word "exclusive" here does not mean to the exclusion of use by others, but only that the claimant relies on his own use exclusively.<sup>147</sup> Thirdly, the disabilities do not apply the same way, since prescription is based on the legal fiction of a presumption of a lost grant or lost deed, and any parties under disability could not have made the "lost" grant.<sup>148</sup> However, "tacking" the uses of successive owners applies here as with adverse possession.<sup>149</sup>

<sup>138</sup> *Orpin v. Morrison*, 230 Mass. 529.

<sup>139</sup> *Richards v. Attleboro R.R.*, 153 Mass. 120.

<sup>140</sup> *Rowell v. Doggett*, 143 Mass. 483.

<sup>141</sup> *Goodrich v. Burbank*, 94 Mass. 459.

<sup>142</sup> *American Tel. & Tel. Co. v. McDonald*, 273 Mass. 324.

<sup>143</sup> *Flynn v. Korsack*, 343 Mass. 15.

<sup>144</sup> *Att'y Gen. v. Revere Copper Co.*, 152 Mass. 444.

<sup>145</sup> C. 187 § 2.

<sup>146</sup> *Daw v. Lally*, 213 Mass. 578; *Ashley v. Ashley*, 70 Mass. 197.

<sup>147</sup> *Kilburn v. Adams*, 48 Mass. 33.

<sup>148</sup> *Edson v. Munsell*, 92 Mass. 557.

<sup>149</sup> *Matthys v. First Swedish Baptist Church*, 223 Mass. 544. See n.143 supra.

The surveyor, in reading deeds, often encounters a reference to restrictions. Most of such restrictions are of no particular interest to him. There are a few, however, which may affect his field work and his plan. Such would be that type of restriction which prohibits, for the purpose of preserving a view, the erection of any building, or, which limits the heights of any structure or tree growth, within a certain specified area of the land being conveyed.<sup>150</sup> Generally, these are determined by certain lines of sight from a given building or other point on the locus, or on adjoining land, or by so-called "building lines." Such restricted areas are very often of such importance that they must be shown on the surveyor's plan. Restrictions are not valid as running with the land unless they are for the benefit of the successive owners of the land specified. Certain statutes limit the effectiveness of restrictions, and therefore the surveyor ought to consult an attorney before deciding to show them on his plan.<sup>151</sup>

#### PLAN IMPLICATIONS RE EASEMENTS

What has been said about implied easements and to some extent, about implied reservations and restrictions, is particularly applicable when reading a plan.<sup>152</sup> Remembering that a plan referred to is incorporated as a part of the deed, it becomes important to determine what rights suggested by the plan may be implied as being appurtenant to the locus being surveyed.<sup>153</sup> The surveyor can be of great assistance to the lawyer and to the client by making a mental note of the features of the record plan which may be of direct benefit to an owner of land shown thereon. For instance, if the plan shows many lots which were apparently created in connection with a "beach area" shown on the plan, it may be that each lot owner has a right in the beach, and therefore the surveyor should indicate on his plan the direction of the way or street to the beach area.<sup>154</sup> Similarly, if all the streets are not constructed he should note which are in shape good enough to use conveniently and the most convenient route to a public street over such usable roads.<sup>154</sup> He may have to locate some or all of these private ways but in the majority of situations a key plan of the route might well suffice. Again he ought to seek legal advice before deciding what,

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<sup>150</sup> Peck v. Conway, 119 Mass. 546.

<sup>151</sup> C. 184 § 23; c. 294 Acts 1959.

<sup>152</sup> Oliver v. Kalick, 223 Mass. 252; Lagorio v. Lewenberg, 226 Mass. 464.

<sup>153</sup> Pearson v. Allen, 151 Mass. 79.

<sup>154</sup> Prentiss v. Gloucester, 236 Mass. 36.

if any, of such information he should show on his plan. Nothing on the record plan which can be of only indirect benefit to the grantee may be considered appurtenant to his land.<sup>155</sup>

#### ATTACKING THE TROUBLESOME PLAN

Having reviewed a number of legal points which will at least help a surveyor in understanding how the courts have thought about the problems which he has to meet from time to time, I believe it would be well to set down an orderly procedure for attacking a survey where the plan referred to is not in itself mathematically correct, or where the data on the plan does not seem to fit the facts found on the ground. Since I haven't done this before, it is likely I will omit some important point, or that the order will not be correct. I trust you will take it as a first attempt—subject to change for the better, later on.

The surveyor should hold:

1. The monuments indicated on the plan and existing undisturbed on the ground.

2. The positions of the obliterated monuments, if the surveyor has personal knowledge of the true location. Generally speaking this means knowing from his own measurements or observations where the original monuments were located relative to still existing physical features.

3. Sometimes such a relationship can be established by using what is shown on a plan, or in a record book of a governmental agency such as a "fence viewer" government engineering office, or Land Court, which agency has a duty to take and record such data. Other times it can be taken from a deceased surveyor's note book or office records, if the information is set down so that there can be no misinterpretation and if the book or records are properly authenticated. Some states consider this as a deposition by the deceased surveyor.<sup>156</sup> Nearly always, however, field notebooks are inadmissible as evidence in court without the presence of the surveyor who made them.

4. The intent of the plan as manifested by an overall study to determine how those original monuments which were found in the field compare mathematically with the data on the plan. Often the relative positions of two or three points found on the ground, will compare favorably with the relative locations on the corresponding points as

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<sup>155</sup> *Coolidge v. Dexter*, 129 Mass. 167; *Att'y Gen. v. Whitney*, 137 Mass. 450. See n.154 supra.

<sup>156</sup> *Nyston v. Lee*, 16 N.D. 561, 114 N.W. 478.

shown on the plan. By then orienting the plan work on the field work it may be disclosed that:

- a. If all the data on the plan were held as given, the layout position could then be verified by other apparently original monuments found afterwards by using a computed relation from the field traverse as run, to the record positions as computed.
  - b. That a different standard of measurements exists as between the maker of the plan and the surveyor of the new field work, and, that if certain uniform adjustments were made in all the plan dimensions, the resulting property corner locations would conform with the original monuments found in the field.
  - c. That nothing is consistent between plan and monuments found on the ground. (Thereafter one can feel free to seek another solution!)
  - d. That much of the data on the plan fits certain monuments found which, although not original monuments, may well have been set by another surveyor who, it can then be deduced, probably worked from the original monuments, or from other physical evidence left behind by the original surveyor, or original land owners.
  - e. That much of the data on the plan fits certain monumentation found in the field but which is known not to be original. However, sometimes a study of such monuments discloses where an apparent error in the plan ought to be assigned, and that this assignment is consistent with the apparent intent of every other part of the plan.
5. In interpreting a plan containing conflicting mathematical data the relative weights of the monuments, courses, distances, and areas should be observed as noted earlier in this paper.
6. Where it can be conclusively shown that an error in the plan was brought about by either erroneous drafting or erroneous mathematics, the correction of that error is the proper solution, even though it seems to place all the error in one or a few lots. Here is where an expert professional land surveyor's word is most likely to be accepted by the court at face value. In this type of situation the surveyor must be in a position to state that the error fits in one certain place, and no other, and that the correction supports all else of consequence on the plan.

7. As a last resort an apportionment may be held as indicated earlier in this paper.

8. Since each lot on a plan is on equal footing with every other lot regardless of the date of deeding, the order of the deeds out does not offer a solution very often. However, if the developer still owns some of the lots and if there is not enough land for all of the lot dimensions, then the principle of favoring the grantees over the grantors may be considered. If no grantee will be injured by giving each his dimension, the developer will have to take any deficiency.

#### RECORDS RESEARCH FOR SURVEYORS

Now that we have discussed some of the matters which should be, or could profitably be, in the surveyor's mind as he goes about his work, perhaps it would be well to follow the surveyor's steps after he has been given a deed or certificate of title, and asked to make a survey of the property covered thereby. What is his first action involving legal matters? He must search the records! A surveyor, it has been said many times, can make an accurate survey, but cannot make a correct survey, without searching the records for information bearing on the determination of the property lines. What records are to be searched? Some of them are: first, the registry of deeds, for at least sixty years back, to cull out all available descriptions of his locus, and especially plans referred to; second, the registry of deeds, for helpful descriptions and plans in the chains of title of the abutting lands; third, the registry of deeds again for any other lands in the general area which might show what other surveyors have discovered in the course of doing their work, and which may prove useful; fourth, the probate court records, if necessary to follow a chain of title, watching for such descriptions as may be in inventories and wills; fifth, the Land Court, for any registrations of land which may be controlling some of the lines of the client's land; sixth, the Massachusetts Department of Public Works, the Metropolitan District Commission, the county engineering office, the city or town engineering office, for such street lines data, or public lands property lines data, as may be either controlling or helpful; seventh, the local assessor's office, if title depends on a tax foreclosure at some stage of the title; eighth, the United States District Court if there was a condemnation, and the Navy or Army engineering departments if any such lands are involved; ninth, the Massachusetts Geodetic Survey office for information on any nearby

control or traverse points, including especially town or city line coordinates if such lines are a part of the proposed survey; and lastly, the Waterways division of the Massachusetts Department of Public Works, if town or city lines are involved and if any status of a body of water is involved.

At the registry of deeds, title can be traced either forward or backward by consulting either the grantor index or the grantee index. The use of any consolidated index available will save time. Any decrees of any court affecting the property lines should be particularly noted along with any plans which may accompany those decrees. Keep in mind that differing descriptions may be due to voluntary sale, forced sale, devise, descent, taking, adverse possession, etc., and so make a note of the grantee, the grantor and the date of the instrument. Some descriptions will be so detailed that they will suggest that some other surveyor has been at work, and that one had better look for a plan of that area. In seeking plans of other nearby areas, or of registered lands, note that some registries have a plan index, making the work of discovering such helpful plans much easier. Almost all registries have atlases which are particularly useful in determining the owners, or streets with which to start the search. Look for taking plans. These may be indexed in your record title and may not be. Furthermore, they may vary from what the engineering department having charge of those lines may have in its office.

In the various engineering departments, look for not only the layout plans, but also the work plans, and the field notes, and for locations of field points having a fixed relation to the lines established. Most engineering departments will assist in this way any surveyor who indicates that he expects to do a proper job himself and not rely on the work of the personnel at the engineering department. Here also, one may often find surveys of private streets, which will prove helpful even though not controlling. Note that certain of these "private" streets are really public layouts serving primarily a private purpose.<sup>157</sup>

The object in collecting all this information is not merely to determine the angles and distances to measure in the field, but also to determine what to look for in the way of controlling features. Generally, it is wise to make a consolidated sketch of such data for a better overall picture before going into the field.

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<sup>157</sup> C. 82 § 21; Davis v. Smith, 130 Mass. 113; Denham v. Bristol Cty. Comm., 108 Mass. 202.

## ORDER OF PRECEDENCE OF RESEARCH DATA

Which of any conflicting data obtained by this research will control? First, any decree of the United States Courts. Second, any decree of a Massachusetts court, having in mind that a Land Court Certificate of Title and the accompanying Land Court Plan are such a decree. Third, eminent domain takings, properly made. Fourth, data which favors the Commonwealth in any takings by, or conveyances to or from, it, especially if supplemented by surveys and plans. Fifth, the actual town or city lines as fixed between town corners, when referred to in deeds by the unqualified words "town line" or "city line" or when referred to in a deed after foreclosure for failure to pay real estate taxes.<sup>158</sup> Often however, there are qualifying words such as "by the town line by land of John Doe" or "being all the land described in (another deed referred to)" where the land is described as being the abutting owner and where it appears from the deed that the grantor intended to divest himself of the whole of the parcel which he owned. There is an exception to the general rule however, in the situation where everyone concerned, even the public officials, considered an erroneous line to be the true town line. However, here, the obvious intent of the parties controls.<sup>158</sup>

The Commonwealth's Superior Courts and Supreme Court and Land Court have authority to issue decrees, generally in equity, whereby title to land may be established or transferred, or a particular line of ownership fixed upon the ground. Any such decree should be recorded to become effective as to a purchaser who otherwise may not have any knowledge of the decree. The Land Court also has exclusive jurisdiction of the registration of title to land as mentioned before in this paper and of the confirmation of title to land and the foreclosure of the rights of redemption after sale for the non-payment of real estate taxes. One can see why it is necessary to ask the type of decree obtained, whenever an owner states that he has a decree of the Land Court. Confirmation decrees merely establish the title to a particular parcel of land in a specific owner at a specific moment. It goes no further than that, and the Court does not retain jurisdiction over the land beyond that moment. Where Registration has been obtained, the Land Court does retain jurisdiction thereafter forever (with the single exception of land subject to foreclosure of an unregistered mortgage).

In all courts, there is a card index of the cases filed, indexed by

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<sup>158</sup> Land Court Case 28983, Ruth H. McLaughlin, Petitioner.

the names of the plaintiffs, or petitioners, and also by the names of the respondents, or defendants. In all courts there are docket books in which each case is entered in numerical order according to the number given to the case at the time of the original filing. Each separate action is given a separate number. At the Land Court, all subsequent matters having to do with the land registered in a certain case are given that original case number with an affix "s" indicating supplemental to the original case, except the subdivision plans are numbered as noted previously in this paper. All papers which are docketed are available to the public for examination as is all other data required by the court's instruction. As a practical matter, everything which can be of help to a surveyor is available to him at the Land Court along with whatever assistance we can give him. I suppose the same is true in most public offices.

#### SUNDRY STATUTES OF INTEREST TO SURVEYORS

There are a few statutes which are of particular interest to a surveyor. Most of them contribute very little toward his day-to-day tasks, but they may come in handy for a special situation. The first of these is Chapter 97 of the General Laws (Ter. Ed.) which deals exclusively with the surveying of land. It calls for the establishment of meridian stones, the testing of the compass, the use of a standardized tape, and the recognition of the Massachusetts Coordinate System. The next such statute is that providing for the mandatory registration of engineers and land surveyors, Chapter 112 Sections 81D through 81T.

Section 36 of Chapter 131 provides for the measurement of the area of a great pond by the Massachusetts Department of Public Works, Waterways Division (provided someone pays for it) and also states that "No arm or branch shall be included as a part of such a pond unless it is at least one foot deep and fifty feet wide." This may be helpful in determining where to draw the line in describing a boundary on a pond. Section 34 sets forth the public character of a great pond. A court case describes these rights thus:—"Fishing, fowling, boating, bathing, skating, riding on the ice, taking water for domestic purposes, agricultural purposes, or uses in the arts, cutting and taking ice, are all lawful to all abutters on the pond or to those who can obtain lawful access."<sup>159</sup>

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<sup>159</sup> C. 131 § 34.

Section 75G of Chapter 164 provides that a natural gas line company must provide to the land owner an accurate plan suitable for recording or registration, showing the exact location of the pipe line easement with reference to the bounds and boundaries of the land. Section 1 of Chapter 86 provides for the setting of monuments at all angles and other termini of public streets, and points out that it can be done "by setting stone or concrete bounds with lead plugs etc., or if that is impracticable, then by a heap of stones, a living tree, a permanent rock, a corner of a building or other permanent bound." This section also provides a penalty on the governmental agency which fails to comply after being requested to do so.

Section 22 of Chapter 81 provides that adverse possession by a private party will not avail as to any land within a state highway and Section 3 of Chapter 86 makes the same provision as to all other public roads . . . (since May 26, 1917).<sup>160</sup> However, the public can make out a case of adverse possession or use, as against land owners, under Section 2 of Chapter 86 where it is provided that buildings or fences existing for twenty years or more and fronting on ways, streets, training fields, burying places, etc. which have been appropriated for public use, determine the lines thereof, if the lines cannot be made certain otherwise.

Chapter 240, Sections 19-26 provides for the determination of lines over flats and Section 12 of Chapter 42 provides for the determination of lines between towns, districts and cities and counties. Section 4 of Chapter 1 provides that the Massachusetts Department of Public Works shall inspect all state lines monuments and maintain the same, and by Section 7 of Chapter 42 that Department shall approve all changes in town or city lines, and the monumentation thereof. This section includes a 1962 provision that a registered land surveyor must do the work.<sup>161</sup> The same Department, under Sections 13 and 14 of Chapter 91 has charge of all licenses to occupy tide water or great pond areas and under Section 18A has authority to lay out ways providing access to great ponds and tide waters, and, under Section 34, authority to establish harbor lines.

Once in a while a surveyor will run across an unrecorded plan which has been referred to in certain recorded instruments. Such a plan, if it were on record, would clarify matters which, without it,

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<sup>160</sup> *Driscoll v. Essex Cty. Comm.*, 268 Mass. 162.

<sup>161</sup> Acts 1962, c. 157.

would be somewhat in doubt. Chapter 36, Section 13B, provides a method whereby the plan can be put on record even though it does not comply with the usual requirements for recording. The subdivision control law, contained in Chapter 41, at Sections 81A-81GG, provides for endorsements by the planning boards, or boards of survey, when each plan has met those particular requirements.

Fences and fence-viewers are the subject of Chapter 49, Sections 1 through 22. Here we find that the adjoining land owners are jointly responsible for the maintenance of fences . . . and the statute describes fences as being "4 feet high, in good repair, and made of rails, timber, boards, iron or stone, or, brooks, rivers, ponds, creeks, ditches, hedges, or, other things which the viewer considers equivalent." A fence-viewer's designation of a property line is final until a court decides the matter.<sup>162</sup>

Finally it should be noted that there are a number of criminal and civil statutes of which a surveyor and his field crew should be aware. We find penalties assigned for: wrongfully claiming that one has a degree,<sup>163</sup> digging up or obstructing a sidewalk;<sup>164</sup> involuntary trespass;<sup>165</sup> voluntary trespass;<sup>166</sup> destruction of a property marker;<sup>167</sup> destruction of a fence enclosing land;<sup>168</sup> opening bars and gates in fences;<sup>169</sup> cutting or injuring trees, shrubs, or growth standing for any useful purpose;<sup>170</sup> cutting or injuring trees, shrubs, or growth on land of another;<sup>171</sup> similar cutting or injuries to growth in a public place or way;<sup>172</sup> injury of a fruit tree, forest tree or other malicious mischief on a Sunday;<sup>173</sup> picking the plants of the wild azalea, the wild orchid, or the cardinal flower;<sup>174</sup> a foreign-born person picking wild flowers or berries in Barnstable or Plymouth Counties between April 1 and December 1 without a permit;<sup>175</sup> carrying away stones, turf, mould, fruit, berries, grapes, grass, hay, corn, ferns, flowers, shrubs, on Sunday, or at night, or while in disguise;<sup>176</sup> and, in case you have

<sup>162</sup> C. 49 § 14. See n.49 supra.

<sup>163</sup> C. 266 § 89.

<sup>164</sup> C. 83 § 25; c. 81 § 21.

<sup>165</sup> C. 242 § 8.

<sup>166</sup> C. 266 § 120.

<sup>167</sup> C. 266 § 94.

<sup>168</sup> C. 266 § 105.

<sup>169</sup> C. 266 § 114.

<sup>170</sup> C. 87 § 11.

<sup>171</sup> C. 242 § 7.

<sup>172</sup> C. 87 § 12.

<sup>173</sup> C. 266 § 131.

<sup>174</sup> C. 266 § 116A.

<sup>175</sup> C. 266 § 116.

<sup>176</sup> C. 266 § 113.

any harmonica-playing rodmen, a town may prohibit the playing of a hand organ in a public way!<sup>177</sup>

#### FINANCIAL LIABILITY

Is the surveyor financially liable to his client for his work even though he has not guaranteed it? I believe the answer is "yes," but I do not recall ever having read a Massachusetts case stating so. I do recall having read a case in one of the states in the northwest part of this country, which case stated that a surveyor is liable (in contract, I believe) for not performing his work with the same degree of skill which he has held himself out as being able to perform, and not performing his work with that degree of skill which is exercised generally by others in the same profession and in the same area. My own opinion is that a surveyor would not legally be responsible for most of the legal matters I have outlined in this paper. I believe he would be responsible for all technical measurements, calculations, and drafting, and for the first grouping of uncomplicated legal matters which I made in the early part of this paper. In this connection, it may be of interest to note that a California court has taken judicial notice of the fact that a rodman or chainman is not a surveyor.<sup>178</sup>

#### FUNCTION OF SURVEYORS

In actual practice, the surveyor is performing as a technician in turning his angles and measuring his distances and making his computations and drafting, but he is acting like a lawyer or judge when making his decision as to what information is controlling, and thus arriving at his conclusions concerning the true location of the property lines. It seems to me that in the vast majority of cases, two capable surveyors will arrive at compatible conclusions when given the job of determining a specific property line. This speaks well for the profession. From my post at the Land Court, it appears that the majority of questionable conclusions come from those surveyors who have not searched the record thoroughly or who have not had the knowledge or the patience to weigh the relative values of the information they had to work with. I believe that a mental picture of the way the courts have settled some of the vexing property line questions, enables the

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<sup>177</sup> C. 85 § 10.

<sup>178</sup> *Severance v. Ball*, 93 Cal. App. 56, 268 P. 1068.

surveyor to think better in the same terms as the lawyer or judge, and thus arrive at a better conclusion more quickly.

Yet the surveyor should keep in mind that there is one place where he cannot expound on his knowledge of legal matters—in the court room. There, he can only recite the story of the facts which he discovered in the field and tell how and why he used some of those facts and discarded others. He cannot tell which principles of law he believes are controlling. The courts reserve for themselves the exclusive right to determine which rule of law applies. The lawyers are in the position of weighing the matter from a legal point of view and do not like to be told by a surveyor that certain legal principles control. The lawyer is carrying the burden in the court room and must play the role his way. However, I believe all lawyers do appreciate hearing why a surveyor came to his conclusion, even when he includes an inconspicuous reference to a legal precedent or principle. Even a court will listen to an opinion of a surveyor, if it is well founded upon knowledge of discovered facts. I know of only one case in Massachusetts where this matter came up. In that case the Supreme Judicial Court decided that it was proper to allow a surveyor to give his opinion as to where the property line was located, since it was “evident that the surveyor had sufficient knowledge of all the relevant conveyances. . . .”<sup>174</sup> His research must have been good and his understanding of what he had discovered must have been apparent.

In another state, it has been held that if a surveyor made the survey or assisted in making the survey, he could: (a) explain the manner of locating points; (b) illustrate by charts and plans, which he prepared from his actual knowledge, the manner of placing those points; (c) otherwise explain orally, his plan, provided he limited himself to statements of fact, and did not give conclusions; (d) interpret another surveyor’s marks on a substantially correct plan; (e) interpret data which is not what he surveyed, provided his own work verified that data; (f) give the opinion or conclusion provided it is based on facts he discovered and recorded.<sup>179</sup> Similarly, a judge in the Land Court recently told me that, to him, the most important man in the surveying firm is the man who actually was in the field and can speak from personal observation, and the second most important man in the surveying firm is the office man who actually supervised the

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<sup>179</sup> *Hodges v. Sanderson*, 213 Ala. 563, 105 So. 652.

particular survey with but brief visits to the field. He stated that either, or both, of these men is expected to tell of the facts he found in the field and why he felt that the description of the title instruments fits those facts which he found.

#### CONCLUSION

This brings us back to the beginning again: The surveyor's role in resurveying or relocating property lines is acceptably played if: he digs out the facts from the record title and from the field; he weighs them all in the light of his knowledge of both surveying and conveying; he arrives at a conclusion; and he stakes out that conclusion upon the ground. He can then testify, in court if necessary, to those facts upon which he based his lines, with a reasonable expectation that his work will be accepted as being not only accurate, but also correct.

## APPLICATIONS OF VECTOR ALGEBRA TO PROBLEMS IN PLANE SURVEYING

BY JOSEPH J. BREEN,\* *Junior Member*

(Presented at a meeting of the Surveying & Mapping Section, B.S.C.E., held on April 3, 1963)

### SYNOPSIS

This paper presents a review of vector algebra and the application of this method to some common problems in plane surveying.

### INTRODUCTION

Vector algebra is a method that is often overlooked when performing computations in plane surveying. Many times problems can be simplified by utilizing the properties of vectors. Today many of the universities are using vector algebra in courses in engineering mechanics and so in the future civil engineering graduates should be able to apply this tool to other areas such as surveying. Persons who are now engaged in the practice of surveying will find vector algebra a tool that will supplement the existing methods of analytical geometry in the solution of plane surveying problems.

### BASIC VECTOR ALGEBRA

A vector is defined to be any quantity that possesses magnitude, sense and direction. This differs from a scalar quantity in that a scalar can be completely defined by its magnitude. For example, in surveying, any side of a traverse can be represented by a vector since its length (magnitude), bearing (direction), and sense (N.W. or S.E.) completely define the line. If any one of these quantities is missing in a measurement then it cannot be represented by a vector.

A vector can be directly related to any coordinate system as will be shown in the examples.

A vector quantity (force, velocity, traverse-side) is usually denoted by a letter with a bar over the letter ( $\bar{A}$ ) and graphically by an arrow with a head showing direction and length showing the magnitude (see Figure 1).

There are four basic algebraic operations that can be applied to

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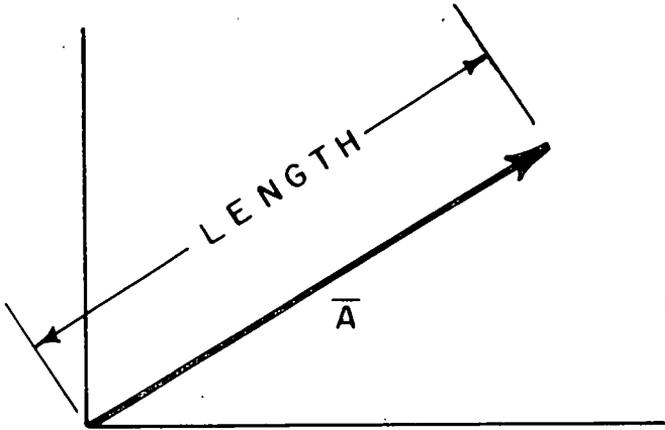


FIG 1

vectors. They are addition, subtraction, dot product and cross product. The following is a description of each of these operations:

(a) Addition

Addition is defined as the sum of two vectors  $\bar{A}$  and  $\bar{B}$ , denoted by  $\bar{A} + \bar{B}$ . Graphically, the sum is the vector with its initial point at

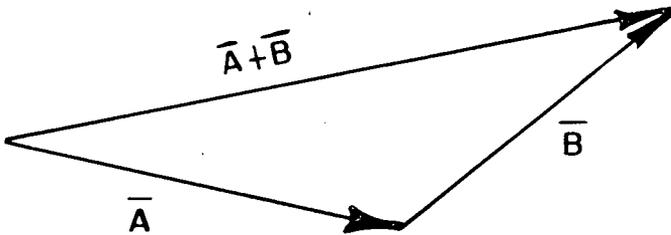


FIG 2

the initial point of  $\bar{A}$  and its terminal point at the terminal point of  $\bar{B}$  where the terminal point of  $\bar{A}$  coincides with the initial point of  $\bar{B}$  (see Figure 2).

The laws of addition are both commutative and associative.

That is, these laws state that a vector sum is completely independent of the order of addition.

$$\text{Commutative Law } \bar{A} + \bar{B} = \bar{B} + \bar{A} \quad (\text{where } \bar{A} \text{ and } \bar{B} \text{ are free vectors}) \quad (1)$$

$$\text{Associative Law } (\bar{A} + \bar{B}) + \bar{C} = \bar{A} + (\bar{B} + \bar{C}) \quad (2)$$

(See Figure 3.)

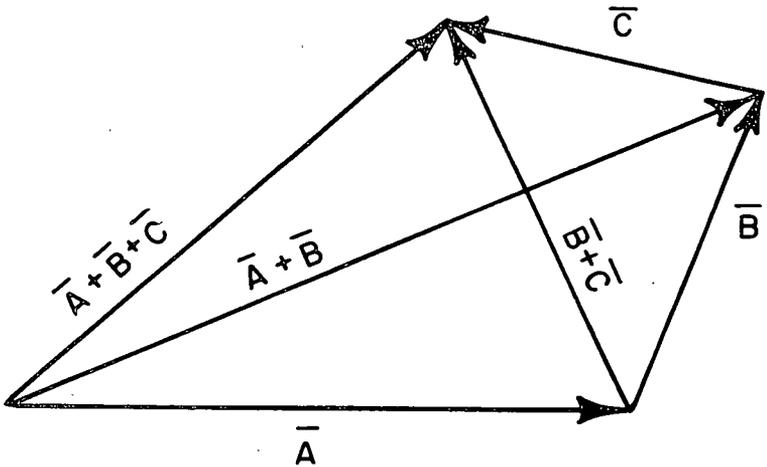


FIG 3

(b) Subtraction

Subtraction is defined by

$$\bar{A} - \bar{B} = \bar{A} + (-\bar{B}) \quad (3)$$

and is the inverse of addition.  $\bar{A} - \bar{B}$  is the vector that is obtained by reversing the sense of vector  $\bar{B}$  and proceeding as in addition (see Figure 4).

Before discussing the two product operations it will be convenient to establish a coordinate system that, with a slight modification, can be changed to any plane system.

A conventional North-South coordinate system is shown in Figure 5.

A unit vector in the X direction is denoted by  $i$  and in the Y direc-

tion by  $j$ . This could correspond to an East and North direction in a traverse.

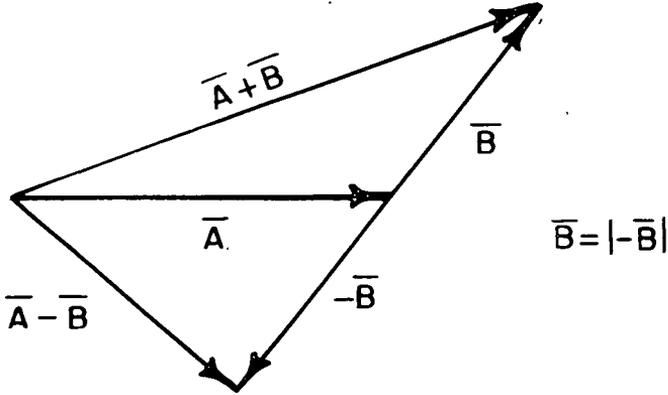


FIG 4

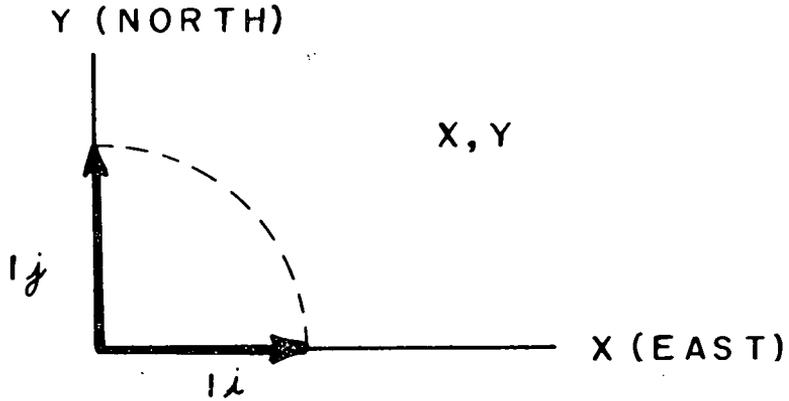


FIG 5

Any vector in this coordinate system can be written in the form

$$\vec{A} = (A_x)i + (A_y)j \quad (4)$$

where  $A_x$  corresponds to the *magnitude* of the projection of  $\vec{A}$  on the X axis and  $A_y$  to the *magnitude* of the projection of  $\vec{A}$  on the Y axis (see Figure 6).

Let  $\alpha$  be the angle from the positive X axis to  $\bar{A}$ , and  $\beta$  the angle from the positive Y axis to  $\bar{A}$ .

The magnitude of a vector  $\bar{A}$  is denoted by  $|\bar{A}|$ .

It follows that

$$A_x = |\bar{A}| \cos \alpha \quad (5)$$

and

$$A_y = |\bar{A}| \cos \beta \quad (6)$$

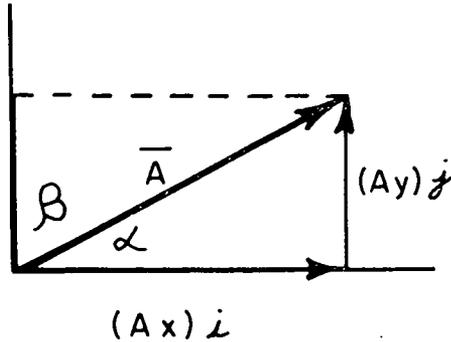


FIG 6

It should be noted that the expressions for  $A_x$  and  $A_y$  are obtained from trigonometry and as expressed here they are not vector quantities but represent the magnitude of the projection of  $\bar{A}$  on the X and Y axes.

Cosine  $\alpha$  and cosine  $\beta$  are called the direction cosines of  $\bar{A}$  and are usually denoted by the letters  $l$  and  $m$  respectively. The following is a very useful property of the direction cosines.

$$l^2 + m^2 = 1 \quad (7)$$

A unit vector in the direction of  $\bar{A}$  can be represented by the following expression

$$\bar{A}_1 = \cos \alpha i + \cos \beta j \quad (8)$$

This unit vector completely defines the direction of vector  $\bar{A}$

$$\bar{A} = (A_x)i + (A_y)j = |\bar{A}| (\cos \alpha i + \cos \beta j) \quad (9)$$

Vector  $\bar{A}$  can now be expressed in alternate forms. Equation (9) states that the  $\bar{A}$  vector is equal to the magnitude of  $\bar{A}$  times a unit vector in the direction of  $\bar{A}$ . As an example consider the following problem: (See Figure 7).

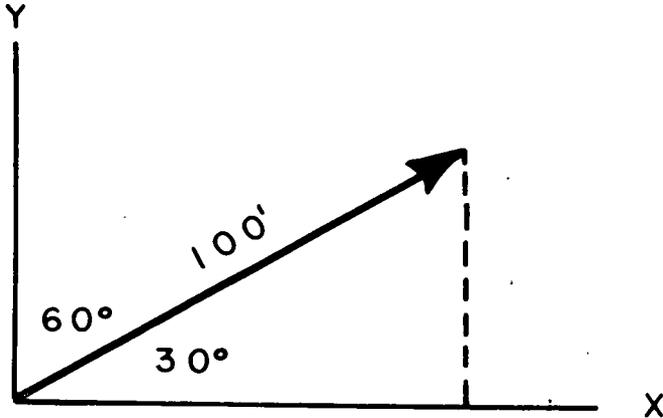


FIG 7

Given  $A = 100$  feet

$$\alpha = 30^\circ$$

$$\beta = 60^\circ$$

Therefore  $l = \cos \alpha = .866$

$$m = \cos \beta = .500$$

$$l^2 + m^2 = 1$$

$$(0.500)^2 + (0.866)^2 = 1$$

$$\bar{A} = 100 (0.866i + .500j)$$

$$\bar{A} = 86.6i + 50.0j$$

Or,  $\bar{A} = 100$  times a unit vector in the direction of  $\bar{A}$

The absolute magnitude of any vector is found by trigonometry to be the following

$$|\bar{A}| = \sqrt{(A_x)^2 + (A_y)^2} \quad (10)$$

By dividing  $\bar{A}$  by its magnitude, a unit vector in the direction of  $\bar{A}$  will be obtained

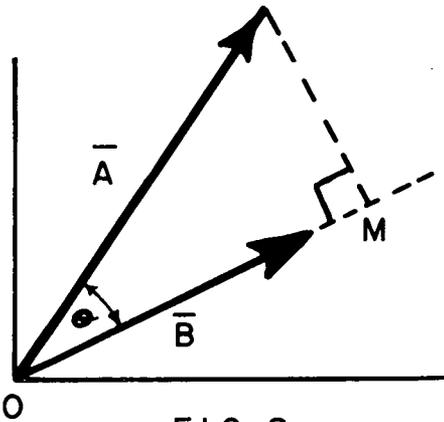
$$\bar{A}_1 = \frac{\bar{A}}{|\bar{A}|} = \frac{A_x}{\sqrt{(A_x)^2 + (A_y)^2}} i + \frac{A_y}{\sqrt{(A_x)^2 + (A_y)^2}} j \quad (11)$$

(c) Dot Product

The dot product of two vectors  $\bar{A}$  and  $\bar{B}$  is defined by

$$\bar{A} \cdot \bar{B} = |\bar{A}| |\bar{B}| \cos \theta \quad (12)$$

where  $\theta$  is the acute angle between  $\bar{A}$  and  $\bar{B}$  (see Figure 8).



$$|OM| = |\bar{A}| \cos \theta$$

FIG 8

This operation is also known as the scalar or inner product. Physically it represents the projection of vector  $\bar{A}$  onto vector  $\bar{B}$  and this result multiplied by the magnitude of vector  $\bar{B}$ . If vector  $\bar{B}$  is a unit vector (magnitude = 1) then  $\bar{A} \cdot \bar{B}_1 = |\bar{A}| \cos \theta$  which is the projection of  $\bar{A}$  in the direction of  $\bar{B}$ . This particular problem arises many times in surveying where it is desired to know the offsets and angles from a given point to a survey line. It is also very useful in the solution of triangles.

From the basic definition of a dot product, the following properties are obtained. Let  $i$  represent a unit vector in the X direction and  $j$  a unit vector in the Y direction. Then it follows that

$$\begin{aligned}
 i \cdot i &= |i| |i| \cos 0^\circ = 1 \\
 j \cdot j &= |j| |j| \cos 0^\circ = 1 \\
 i \cdot j &= |i| |j| \cos 90^\circ = 0
 \end{aligned}
 \tag{13}$$

This principle can now be extended to any two vectors. Let two vectors  $\bar{A}$  and  $\bar{B}$  be represented by

$$\bar{A} = A_x i + A_y j$$

and

$$\bar{B} = B_x i + B_y j$$

The dot product of  $\bar{A}$  and  $\bar{B}$  is found in the following manner

$$\bar{A} \cdot \bar{B} = (A_x i + A_y j) (B_x i + B_y j) \tag{14}$$

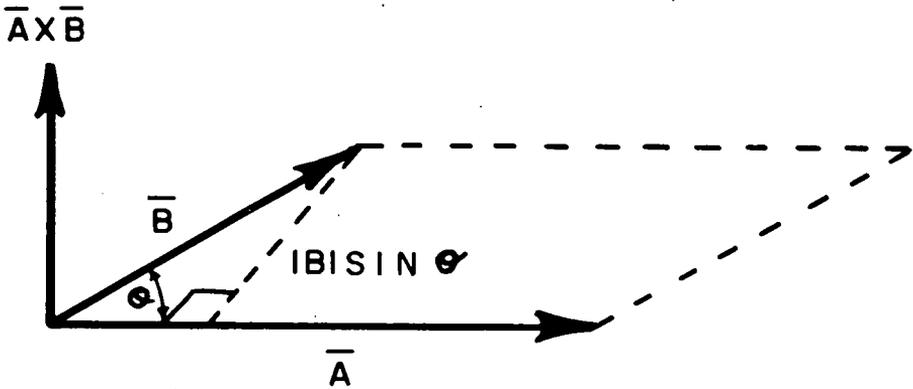


FIG 9

By direct expansion

$$\bar{A} \cdot \bar{B} = (A_x i) \cdot (B_x i) + (A_x i) \cdot (B_y j) + (A_y j) \cdot (B_x i) + (A_y j) \cdot (B_y j)$$

Since  $i \cdot i = 1$  and  $i \cdot j = 0$ , the above expression can be simplified to the following form

$$\bar{A} \cdot \bar{B} = A_x B_x + A_y B_y \tag{15}$$

(d) Cross Product

The cross product of two vectors  $\bar{A}$  and  $\bar{B}$  is defined by

$$\bar{A} \times \bar{B} = |\bar{A}| |\bar{B}| \sin \theta k$$

and is a vector quantity. Physically it represents the area formed by a parallelogram with sides A and B (see Figure 9).

It should be noted that the resulting vector  $k$  is normal to the plane of  $\bar{A}$  and  $\bar{B}$  and its sense determined by the conventional right hand rule.

The cross product operation is not commutative

$$\bar{B} \times \bar{A} \neq \bar{A} \times \bar{B}$$

but

$$\bar{B} \times \bar{A} = -\bar{A} \times \bar{B}$$

That is, the resulting normal vector changes sense but it is always oriented perpendicular to the plane of  $\bar{A}$  and  $\bar{B}$ . Since  $\bar{A} \times \bar{B} = |\bar{A}| |\bar{B}| \sin \theta k$  (where  $k$  is a unit vector normal to the plane of  $\bar{A}$  and  $\bar{B}$ ), it follows that

$$i \times i = |i| |i| \sin 0^\circ k = 0$$

and

$$i \times j = |i| |j| \sin 90^\circ k = 1k$$

since

$$\bar{A} \times \bar{B} = -\bar{B} \times \bar{A}$$

then

$$i \times j = -j \times i = k$$

This definition can now be applied to any two vectors  $\bar{A}$  and  $\bar{B}$ .

Given 2 vectors  $\bar{A} = A_x i + A_y j$  and  $\bar{B} = B_x i + B_y j$  the cross product ( $\bar{A} \times \bar{B}$ ) is found in the following manner

$$\bar{A} \times \bar{B} = (A_x i + A_y j) \times (B_x i + B_y j)$$

By expanding the right side of this equation term by term

$$\bar{A} \times \bar{B} = A_x i \times B_x i + A_x i \times B_y j + A_y j \times B_x i + A_y j \times B_y j$$

or

$$\bar{A} \times \bar{B} = A_x B_y k - A_y B_x k$$

The same result would be obtained by solving the following determinate

$$\begin{vmatrix} A_x A_y 0 \\ B_x B_y 0 \\ i j k \end{vmatrix} = A_x B_y k - A_y B_x k$$

The principles of vector algebra will now be applied to a few typical surveying problems.

(A) Given a line OA with point O at the origin and point A at coordinates (4,3) determine the perpendicular distance from point B (5,1) to line OA (see Figure 10).

The following vectors can be written for sides OA and OB

$$\overline{OA} = 4i + 3j$$

and

$$\overline{OB} = 5i + j$$

A unit vector in the direction of OA is

$$\overline{OA}_1 = \frac{\overline{OA}}{|\overline{OA}|} = \frac{4i + 3j}{\sqrt{4^2 + 3^2}}$$

or

$$\overline{OA}_1 = .8i + .6j$$

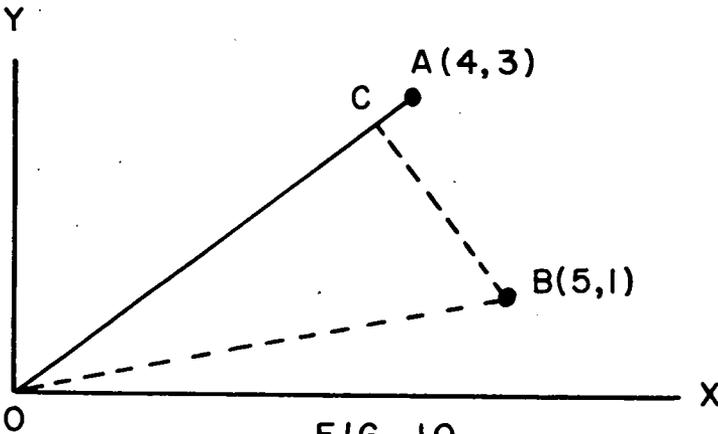


FIG 10

By using the dot product operation it can be seen that

$$\begin{aligned}\overline{OB} \cdot \overline{OA}_1 &= |\overline{OC}| \\ |\overline{OC}| &= (5i + j) \cdot (.8i + .6j) \\ |\overline{OC}| &= 4.0 + 0.6 = 4.6'\end{aligned}$$

OC vector can now be determined because the magnitude of  $\overline{OC}$  times a unit vector in the direction of  $\overline{OC}$  is  $\overline{OC}$  vector

$$\begin{aligned}\overline{OC} &= |\overline{OC}| \overline{OA}_1 \\ \overline{OC} &= (4.6) (.8i + .6j) \\ \overline{OC} &= 3.68i + 2.76j\end{aligned}$$

By applying the law of addition to triangle OBC it can be seen that

$$\overline{BC} = \overline{BO} + \overline{OC}$$

$$\overline{BC} = (-5i - j) + (3.68i + 2.76j)$$

or 
$$\overline{BC} = -1.32i + 1.76j$$

The magnitude of BC is now determined

$$|\overline{BC}| = \sqrt{(-1.32)^2 + (1.76)^2}$$

$$|\overline{BC}| = 2.20'$$

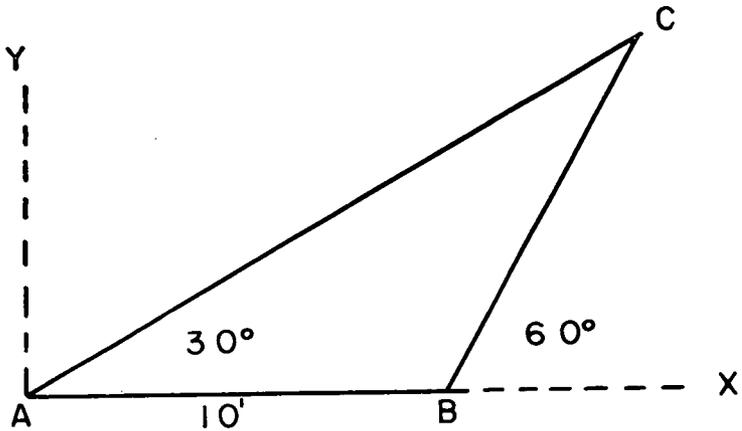


FIG 11

(B) Given one side and two angles of triangle ABC, determine the magnitude of sides BC and AC (see Figure 11).

For convenience choose side AB as the X axis. Unit vectors in the direction of AC and BC are

$$\overline{AC}_1 = .866i + .500j$$

$$\overline{BC}_1 = .500i + .866j$$

By applying the law of addition to triangle ABC considering each side as a vector, it can be seen that

$$\overline{AC} + \overline{CB} = \overline{AB}$$

Note that  $\overline{BC} = -\overline{CB}$ , that is, the sense of  $\overline{BC}$  is opposite to that of  $\overline{CB}$

$$\text{or} \quad AC (.866i + .500j) + CB (-.500i - .866j) = 10i$$

The coefficients of the  $i$  vector on the left side of the equation can then be equated to the coefficients of the  $i$  vector on the right side. The same can be said for the  $y$  components ( $j$ ).

The following scalar equations can be written

$$(a) \quad .866AC - .500CB = 10$$

$$(b) \quad .500AC - .866CB = 0$$

Solving these equations simultaneously will yield from (b)

$$|\overline{AC}| = \frac{.866CB}{.500}$$

then substituting this result in (a) yields

$$.866 \frac{.866CB}{.500} - .500CB = 10$$

$$\text{or} \quad 1.50CB - .500CB = 10$$

$$\text{or} \quad CB = 10'$$

$$\text{and} \quad AC = \frac{.866}{.500} (10) = 17.32'$$

(C) A rather common problem is one in which it is required to determine the coordinates on the intersection of two straight lines.

Given a line  $AB$  with  $A$  at coordinates  $(10,10)$ ,  $B$  at coordinates  $(40,50)$ , and an intersecting line  $CD$  with the coordinates of  $C$  at  $(30,15)$  and a bearing of  $N30^\circ W$  towards  $D$ . Compute the coordinates of the intersection and the distance from point  $A$  to the point of intersection. Let  $E$  denote the point of intersection. (See Figure 12).

A unit vector in the direction of  $AB$  is obtained as follows

$$\overline{AB} = 30i + 40j$$

$$|\overline{AB}| = \sqrt{30^2 + 40^2} = 50$$

$$\overline{AB}_1 = \frac{\overline{AB}}{|\overline{AB}|} = \frac{30i}{50} + \frac{40j}{50}$$

$$\text{or} \quad \overline{AB}_1 = .6i + .8j$$

A unit vector in the direction of CD can be found directly from the bearing of line CD

$$\overline{CD}_1 = -.500i + .866j$$

The following equation can now be written for triangle AEC

$$\overline{AE} + \overline{EC} = \overline{AC}$$

Substituting the values for AE, EC, and AC in this equation

$$AE (.6i + .8j) + EC (+.500i - .866j) = 20i + 5j$$

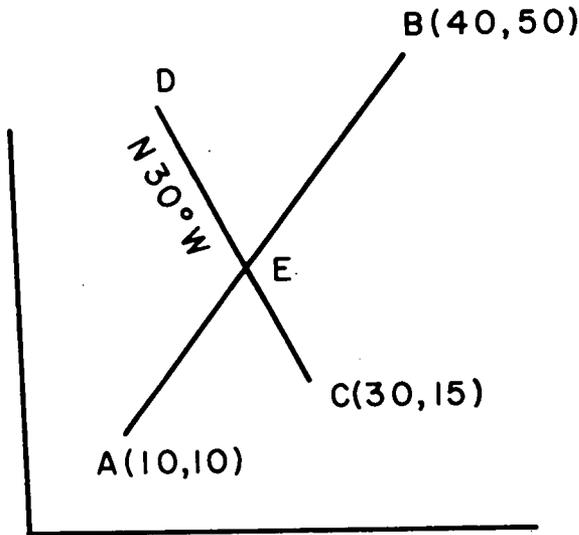


FIG 12

Reducing this to scalar form yields

$$a) .6AE + .5EC = 20$$

and

$$b) .8AE - .866EC = 5$$

Solving (a) and (b) simultaneously

$$\begin{array}{r} .520AE + (.866)(.5)EC = 17.32 \\ .400AE - (.500)(.866)EC = 2.50 \\ \hline .920AE \qquad \qquad \qquad = 19.82 \end{array}$$

gives

$$AE = 21.54 \text{ ft.}$$

Knowing distance AE one can now compute AE vector

$$\overline{AE} = |\overline{AE}| \overline{AE}_1 = 21.54 (.6i + .8j)$$

or

$$\overline{AE} = 18.92i + 17.13j$$

The coordinates of E are then obtained by adding the i component of AE to the X coordinate of point A and the j component to the Y coordinate of point A, thus

$$X = 10 + 18.92 = 28.92$$

and

$$Y = 10 + 17.13 = 27.13$$

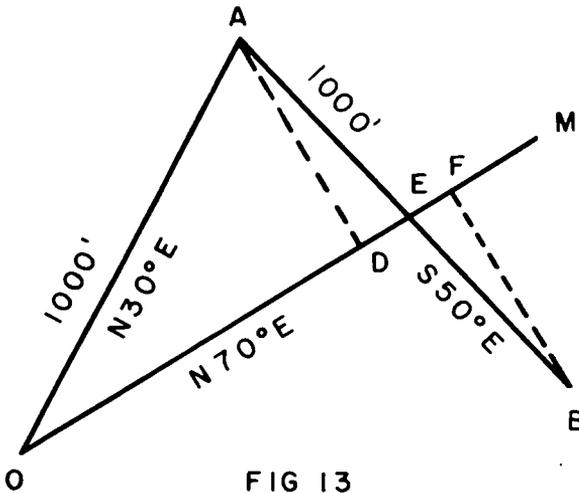


FIG 13

By using methods of analytical geometry it would have been necessary to write the general equations of lines AB and CD and then solve them simultaneously for X and Y. The problem of intersecting straight lines can be greatly simplified by using vectors.

The dot product operation can also be applied to a problem such as the one shown in Figure 13. Given an existing highway base line OAB, determine the distance OC and OE (projections of OA and AB on line OM).

A unit vector can be written in the direction of OM

$$OM_1 = \cos 20^\circ i + \cos 70^\circ j$$

or

$$OM_1 = .9392i + .3420j$$

From the data shown in Figure 13 the vectors OA and AB can be found

$$OA = 1000.000 (.5000i + .8660j)$$

$$AB = 1000.000 (.7660i - .6438j)$$

The distances OD and OF are

$$OD = OA \cdot OM_1$$

$$OD = (500.00i + 866.00j) \cdot (.939i + .3420j)$$

$$OD = 765.77$$

and since  $OB = OA + AB$

$$OF = (OA + AB) \cdot OM_1$$

$$OF = (500.00i + 866.00j + 766.00i - 643.80j) \cdot (.9392i + .3420j)$$

$$OF = (1266.00i + 222.20j) \cdot (.9392i + .3420j)$$

$$OF = 1265.02'$$

By applying the law of addition to triangle OAD it is also possible to determine the point of intersection of line OM with AB as was illustrated in the previous problem.

Consider the problem of determining the coordinates of the intersection of a straight line and a circle. Given a 50 foot radius circle with its center at coordinates (100, 100) and a straight line AB, A at coordinates (160, 170) and B at (110, 40). Determine the coordinates of the intersection of the straight line and the circle. (See Figure 14).

Let N represent the point of intersection.

First, a unit vector is found in the direction of AB in the following manner

$$\overline{AB} = -50i - 130j$$

$$|\overline{AB}| = \sqrt{50^2 + 130^2} = 139.28'$$

$$\overline{AB}_1 = -\frac{50}{139.28}i - \frac{130}{139.28}j$$

or 
$$\overline{AB}_1 = -.3590i - .9334j$$

Next the projection of AO on line AB can be computed by means of the dot product

$$|\overline{AM}| = AO \cdot AB_1$$

$$|\overline{AM}| = (-60i - 70j) \cdot (-.3590i - .9334j)$$

or 
$$|\overline{AM}| = (-60)(-.3590) + (-70)(-.9334)$$

$$|\overline{AM}| = 86.88'$$

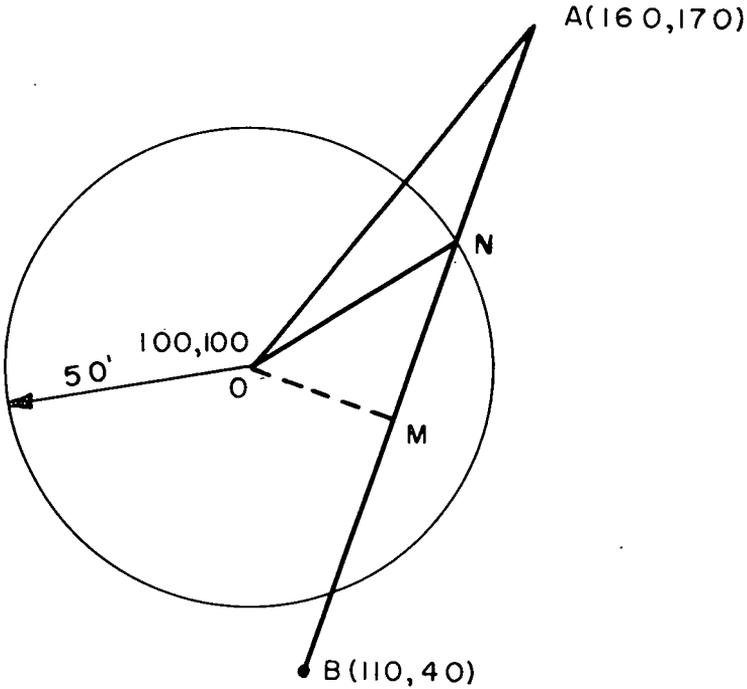


FIG 14

By applying the law of addition to triangle AOM it can be seen that

$$\overline{OM'} = \overline{OA} + \overline{AM}$$

or 
$$\overline{OM} = (60i + 70j) + 86.88 (-.3590i - .9334j)$$

which reduces to

$$\overline{OM} = 28.81i - 11.09j$$

In the right triangle OMN

$$|\overline{OM}|^2 + |\overline{MN}|^2 = |\overline{ON}|^2$$

$$|\overline{MN}| = \sqrt{|\overline{ON}|^2 - |\overline{OM}|^2}$$

$$|\overline{MN}| = \sqrt{(50.00)^2 - \left(\sqrt{(28.81)^2 + (11.09)^2}\right)^2}$$

$$|\overline{MN}| = \sqrt{2500.00 - 830.02 - 122.29} = \sqrt{1547.69}$$

$$|\overline{MN}| = 39.34'$$

The distance AN can now be found

$$|\overline{AN}| = |\overline{AM}| - |\overline{MN}|$$

$$|\overline{AN}| = 86.88' - 39.34'$$

or

$$|\overline{AN}| = 47.54'$$

Next AN vector can be computed and the coordinates of point N can be obtained by adding the components of AN vector to the coordinates of point A.

$$\overline{AN} = |\overline{AN}| \overline{AB}_1$$

$$\overline{AN} = (47.54) (-.3590i - .9334j)$$

$$\overline{AN} = -17.07i - 44.37j$$

The coordinates of point N are then

$$X = 160 - 17.07 = 142.83$$

and

$$Y = 170 - 44.37 = 125.63$$

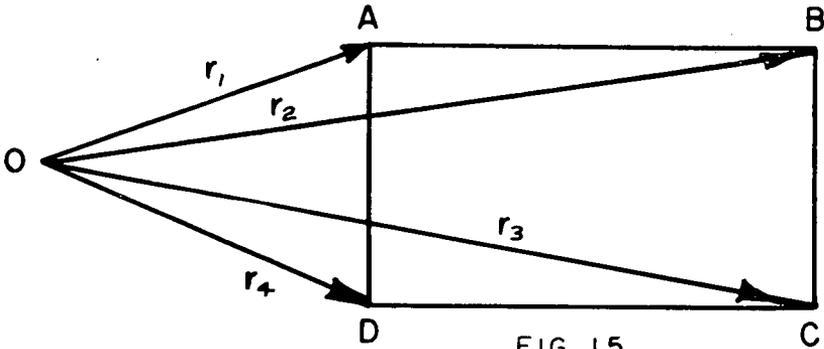
#### AREA COMPUTATION

The cross product was defined by equation (16). This definition can be extended to find the area of any closed figure that is made up of straight lines. Consider the problem of finding the area of figure ABCD by means of the cross product. (See Figure 15).

First select any point "O" (outside the figure). From point "O" draw the vectors  $\overline{OA}$ ,  $\overline{OB}$ ,  $\overline{OC}$  and  $\overline{OD}$  to the corners of figure ABCD. It can be seen that

$$\text{Area ABCD} = \text{Area OABCD} - \text{Area OAD}$$

Since the cross product of any two vectors is numerically equal



to twice the area contained between the two vectors, the area of the triangles OAB, BOC, COD and DOC can be found.

$$\text{Area of } \triangle AOB = \frac{\overline{OA} \times \overline{OB}}{2}$$

$$\text{Area of } \triangle BOC = \frac{\overline{OB} \times \overline{OC}}{2}$$

$$\text{Area of } \triangle COD = \frac{\overline{OC} \times \overline{OD}}{2}$$

$$\text{Area of } \triangle DOC = \frac{\overline{OD} \times \overline{OA}}{2}$$

$$\text{Area ABCD} = \frac{\overline{OA} \times \overline{OB}}{2} + \frac{\overline{OB} \times \overline{OC}}{2} + \frac{\overline{OC} \times \overline{OD}}{2} + \frac{\overline{OD} \times \overline{OA}}{2}$$

The last term in this expression will actually be a negative value since

$$\overline{OD} \times \overline{OA} = -\overline{OA} \times \overline{OD}$$

It should be noted that vector products must be taken in order around the figure and if "O" is outside the figure, the last vector ( $\overline{OD}$ ) must be crossed with the first vector ( $\overline{OA}$ ) in order to subtract the area OAB.

If point "O" is selected at any corner of the traverse, then it is only necessary to cross the vectors drawn from point O to the other points of the traverse going either clockwise or counterclockwise around the figure. (See Figure 16.)

Given the closed traverse ABCDEFGHJ as shown in Figure 17 select any point, say J, as point "O."

Next the vectors from point "O" to all other points in the traverse can be written

$$\overline{OA} = \overline{r_1} = 5j$$

$$\overline{OB} = \overline{r_2} = 11i + 5j$$

$$\overline{OC} = \overline{r_3} = 11i + 2j$$

$$\overline{OD} = \overline{r_4} = 15i + 2j$$

$$\overline{OE} = \overline{r_5} = 15i - 2j$$

$$\overline{OF} = \overline{r_6} = 19i - 5j$$

$$\overline{OG} = \overline{r_7} = 8i - 5j$$

$$\overline{OH} = \overline{r_8} = 8i$$

$$\text{Area} = \frac{1}{2} (\overline{r_1} \times \overline{r_2} + \overline{r_2} \times \overline{r_3} + \overline{r_3} \times \overline{r_4} + \overline{r_4} \times \overline{r_5} + \overline{r_5} \times \overline{r_6} + \overline{r_6} \times \overline{r_7} + \overline{r_7} \times \overline{r_8})$$

$$\overline{r_1} \times \overline{r_2} = (5j) \times (11i + 5j) = -55k$$

$$\overline{r_2} \times \overline{r_3} = (11i + 5j) \times (11i + 2j) = -33k$$

$$\overline{r_3} \times \overline{r_4} = (11i + 2j) \times (15i + 2j) = -8k$$

$$\overline{r_4} \times \overline{r_5} = (15i + 2j) \times (15i - 2j) = -60k$$

$$\overline{r_5} \times \overline{r_6} = (15i - 2j) \times (19i - 5j) = -37k$$

$$\overline{r_6} \times \overline{r_7} = (19i - 5j) \times (8i - 5j) = -55k$$

$$\overline{r_7} \times \overline{r_8} = (8i - 5j) \times (8i) = +40k$$

$$\text{Area} = \frac{1}{2} (208) = 104$$

The area can also be found from geometry to be

$$5 \times 11 = 55$$

$$4 \times 2 = 8$$

$$5 \times 7 = 35$$

$$\frac{1}{2} (4 \times 3) = \frac{6}{104}$$

The cross product can be used to derive the expression for finding the area of any figure by the coordinate method. However, by utilizing the cross product definition it can be seen that a better understanding

of the principle can be obtained and it is not necessary to remember a rule. The DMD method places a restriction as to which point one selects for an initial point. However, with the cross product any point can be selected, even one that is not on the traverse line.

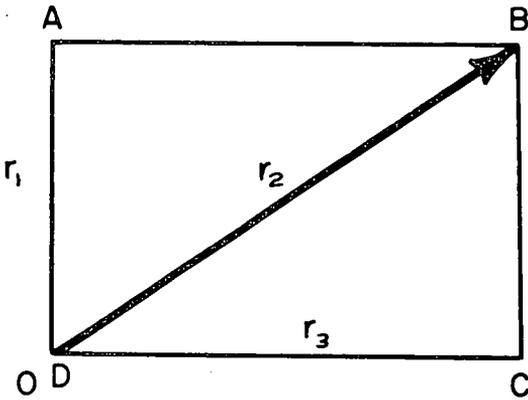


FIG 16

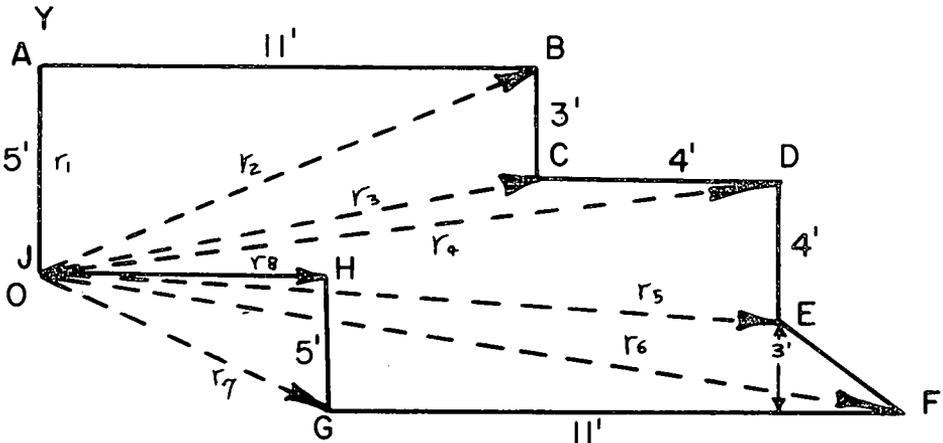


FIG 17

There are many other problems in surveying that can be solved by vector methods. A closed traverse must satisfy the condition that the sum of the vectors around the traverse be equal to zero. Vectors can also be extended to three dimensional problems such as determin-

ing the elevation and distance of a point from a triangulation baseline.

With the increasing use of digital computers in civil engineering, vectors have been receiving much attention in the solution of problems. N-Dimensional vector space is a general concept that can be used in the solution of simultaneous equations. In N-Dimensions however, it is impossible to have a physical picture of a vector. A surveying course appears to be an excellent place to present the necessary physical picture, even more so than a course in applied mechanics. It illustrates the logical approach to geometric problems and in many ways simplifies mathematical calculations. For the practicing surveyor, vectors are another tool to supplement geometry, trigonometry and analytical geometry in the solution of everyday problems.

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# OF GENERAL INTEREST

## PROCEEDINGS OF THE SOCIETY

### MINUTES OF MEETING

#### Boston Society of Civil Engineers

MAY 8, 1963:—A Joint Meeting of the Boston Society of Civil Engineers with the Structural, Hydraulics and Construction Sections was held this evening at the United Community Services Building, 14 Somerset Street, Boston, Mass., and was called to order by President John F. Flaherty, at 7:00 P.M.

President Flaherty stated that the Minutes of the previous meeting held March 21, 1963 would be published in a forthcoming issue of the Journal and that the reading of those Minutes would be waived unless there was objection.

The Secretary announced the names of applicants for membership in the Society and that the following had been elected to membership April 18, 1963:—

*Grade of Member*—Libby S. Albanese, Alphonso J. Binda,\* William R. Buckley, William F. Coates, Jr.; Matthew R. McInerny, William Moy,\* Ronald G. Perry, George F. Poland, Wallace G. Sanborn,\* Robert W. Simonds, Ernest T. Williams, Jr.

President Flaherty announced that this was a Joint Meeting with the Structural, Hydraulics and Construction Sections and called upon the Chairmen of those sections to conduct any necessary business at this time.

\* Transfer from Grade of Junior

President Flaherty then turned the meeting over to Dr. Harl P. Aldrich, Jr., Chairman of the Structural Section, who introduced the speakers of the evening. Capt. J. E. Rehler, CEC, U.S. Navy, Frank L. Lincoln, Fay, Spofford & Thorndike, Inc., and Mr. A. F. Watts, A. S. Wickstrom, Inc., gave a most interesting illustrated talk on "Reconstruction of Portsmouth Dry Dock, No. 3."

A discussion period followed the talk.

Sixty-five members and guests attended the dinner preceding the meeting and 90 members and guests attended the meeting.

The meeting adjourned at 9:10 P.M.

CHARLES O. BAIRD, JR., *Secretary*

### CONSTRUCTION SECTION

MARCH 27, 1963:—A regular scheduled meeting of the Construction Section was held on this date at the Society Rooms following a well attended dinner gathering at the Smorgasbord Restaurant. Mr. Leonard Tucker acted as Chairman pro tem in the absence of Mr. James P. Archibald, Jr.

By a simple and unanimous vote the following officers were elected for the ensuing year:

<i>Chairman</i>	James P. Archibald, Jr.
<i>Vice Chairman</i>	Leonard W. Tucker
<i>Clerk</i>	Herman G. Protze

*Advisory  
Committee*

Frank J. Heger, Jr.  
Robert A. Bierweiler  
Harold S. Gillis, Jr.

Mr. Charles L. Guild, President of C. L. Guild Construction Company delivered a dynamically interesting illustrated talk on "Sonic Pile Driving." He discussed present uses and future applications of this process, and dramatically indicated the relative efficacy of the method via colored motion pictures. The rapid penetration is due to the fact that the sonic method utilizes all of the energy put into the process.

Piles are driven at a fundamental frequency (*i.e.*, at half wave length). The sound impulse is an elastic wave in matter and here the oscillation is created by properly revolving weights. The resulting tensile and compression stresses are lower than for conventional methods of driving.

Formulas have been developed for sonic pile driving based upon empirical comparisons with normal type piles. Formulas also are to be developed for end bearing and friction piles.

Sonic piles have been utilized on 20 jobs to date with dramatic results. In general, driving takes one twentieth of the time as for conventional piles! Sonic piles show approximately 50% less settlement than similar straight conventional piles. Transmitted vibration to adjacent structures during driving is amazingly less. Extraction is simple and rapid. Damage to piles during driving is less with the sonic method.

Fees for driving sonic and conventional piles are the same; the saving is in the time.

A question period followed the talk. The meeting started at 7:00 P.M. and

ended at 8:00 P.M., and was attended by 128 members and guests.

HERMAN G. PROTZE, *Clerk*

## STRUCTURAL SECTION

APRIL 10, 1963:—A regular meeting of the Structural Section was held at the Society Rooms on this date.

Dr. Howard Simpson of Simpson, Gumpertz and Heger gave a talk entitled "The 1963 A.C.I. Building Code." Dr. Simpson is a member of A.C.I. Committee #318 which is responsible for completely rewriting the code. The last time this was done was in 1920.

Dr. Simpson's purpose was to outline the scope of the new code, to emphasize the philosophy of those who formulated it, and to point out the approach which should be made on the part of designers using it. In addition, he pointed out some important changes in the new code.

The interest of the committee was to set guide posts for the designer. The code is not a textbook and is not expected to cover all situations. The fruits of research in the concrete field are incorporated in the new code. This generally leads to more sophisticated or complicated mathematics. Because the state of knowledge is much more advanced than before, lower safety factors are felt justified.

Throughout, the philosophy has been to avoid over-stressing which causes a sudden catastrophic failure. Rather, the mode of failure would be ductile. Attendance was 125 and the meeting adjourned at 8:45 P.M.

DONALD T. GOLDBERG, *Clerk*

## SURVEYING & MAPPING SECTION

JANUARY 16, 1963:—A regular meeting of the Surveying & Mapping Section

was held on this date at the Society Rooms.

The meeting was called to order by Chairman Richard D. Raskind promptly at 7:00 P.M.

The Minutes of the previous meeting were read and accepted.

There was no introduction of old or new business.

Chairman Raskind introduced Dr. Lloyd Thompson of the Cambridge Air Force Research Station, Terrestrial Science Laboratory, who spoke on "The Status of Gravity Measurement Techniques."

There was a brief question and answer period after the lecture.

Twelve members attended the meeting.

Meeting adjourned at 9:00 P.M.

JOSEPH A. BODIO, *Clerk*

## ADDITIONS

### *Members*

Libby S. Albanese, 57 I Street, So. Boston, Mass.

Alphonso J. Binda, 16 Campbell St., Stoneham, Mass.

William R. Buckley, 4 Carmine Ave., Foxboro, Mass.

William F. Coates, 3 Stagecoach Road, Holliston, Mass.

Edward J. Comeau, 103 Beal Road, Waltham 54, Mass.

William J. Le Messurier, 711 Boylston St., Boston, Mass.

Matthew R. McInerny, Merritt-Chapman-Scott Corp., 260 Madison Ave., New York, N.Y.

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William Moy, 401 Norfolk Street, Dorchester, Mass.

George F. Poland, Box 125, R.D. #2, Granville, N.Y.

Wallace G. Sanborn, 2401 N. Alexander Dr., Baytown, Texas.

Robert W. Simonds, 207 Main Street, Woburn, Mass.

Ernest T. Williams, Jr., 20 Peach Street, Braintree, Mass.

### *Junior*

Guenther Wilhelm, 1412 Montgomery Ave., New York 53, N.Y.

## DEATHS

Steven R. Berke, June 6, 1963.

Henry F. Dolliver, June 5, 1963.

Edwin A. Taylor, June, 1963.

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	PAGE
LISTED ALPHABETICALLY . . . . .	ii

## INDEX TO ADVERTISERS

BEACON PIPING Co., 200 Freeport St., Dorchester 22, Mass. . . . .	ix
BERKE MOORE Co., Inc., 8 Newbury St., Boston . . . . .	vii
BOSTON BLUE PRINT Co., Inc., 777 Boylston St., Boston . . . . .	vi
FLETCHER, H. E., Co., West Chelmsford, Mass. . . . .	Inside front cover
HEFFERNAN PRESS, 35B New St., Worcester . . . . .	xi
HEINRICH COMPANY, CARL, 711 Concord Ave., Cambridge . . . . .	x
MAKEPIECE, B. L., INC., 1266 Boylston St., Boston . . . . .	xi
NEW ENGLAND CONCRETE PIPE CORP., Newton Upper Falls, Mass. . . . .	vi
PIPE FOUNDERS SALES CORP., 131 State Street, Boston . . . . .	vii
PORTLAND CEMENT ASSOCIATION, 22 Providence St., Boston, Mass. . . . .	viii
RAYMOND CONCRETE PILE Co., 147 Medford St., Charlestown . . . . .	ix
SAN-VEL CONCRETE, Littleton . . . . .	ix
TOMASELLO CORPORATION, 25 Huntington Ave., Boston . . . . .	vi
UNITED STATES PIPE AND FOUNDRY COMPANY, 250 Stuart St., Boston . . . . .	x
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WEST END IRON WORKS, Cambridge . . . . .	x

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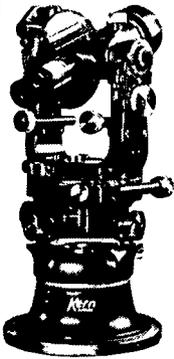
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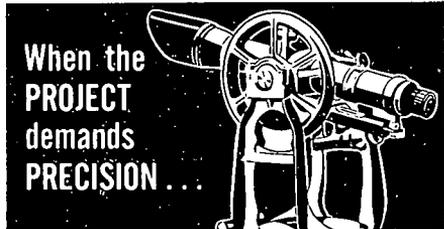
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