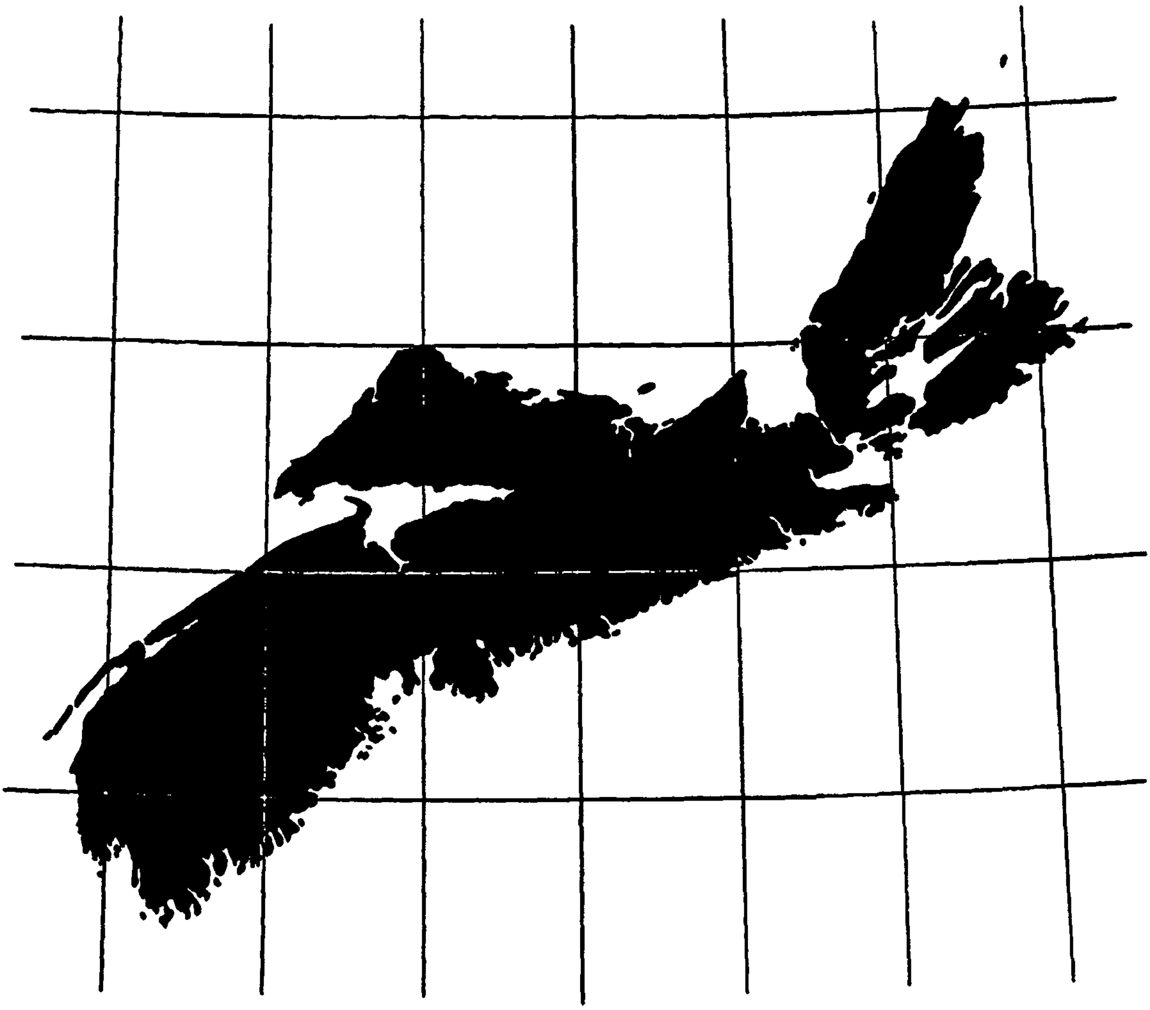
The NOVA SCOTIAN SURVEYOR



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WALTER E. SERVANT
President

H. B. ROBERTSON
Secretary-Treasurer

R. E. MILLARD
Editor

Address all communications to P. O. Box 1541, Halifax, Nova Scotia

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Plane Co-ordinates For Surveyors

By J. E. LILLY, Dominion Geodesist

Presented at the fifty-third Annual Meeting of the Canadian Institute of Surveying, Ottawa, Feb., 1960; as reported in *The Canadian Surveyor*

We have been hearing a good deal about plane co-ordinates and their use by land surveyors. It may be well to consider the whole question of co-ordinates and the problems involved in applying plane co-ordinates to the earth's surface.

Any co-ordinate system is a means of locating a point relative to a reference frame. In survey operations involving large areas, the usual co-ordinates are latitude and longitude, the axes being the equator and the meridian through Greenwich. Since the points in question are assumed to lie on a surface, in this case the sea-level surface of the earth, only two co-ordinates are required. Thus the latitude and longitude of any point locate the position of the vertical line through the point, while the location of the point in space requires also the height of the point above sea-level. At present we are concerned only with horizontal co-ordinates, except in so far as heights affect horizontal distances.

In general, geodetic computations of horizontal control refer to points on the sea-level surface, or in respect to any one station refer to the point at which the vertical line through the station pierces that surface. It follows that, since vertical lines converge towards the centre of the earth, any distance measured between points situated above sea-level in greater than the sea-level distance and must be corrected to sea-level before being used to compute latitude and longitude. If the two points are not at the same height the measured distance must also be corrected for slope; this slope correction is very commonly understood and applied in survey operations. The sea-level correction is less commonly considered, but it becomes increasingly important as the accuracy of measurements increase. The correction is directly proportional to height above sea-level, and amounts to about one part in 10,000 for a height of 2,000 feet.

For many years, surveys of small areas have been computed on the assumption that the earth's surface is a plane. Slope corrections have been applied to compensate for irregularities in the physical surface, but no account has been taken of sea-level correction or of the curvature of the earth's surface. Such a method of computation is entirely satisfactory for a small area. At a distance of 10 miles from the origin, the error in distance introduced by neglect of curvature is only about one part in 1,000,000, which is completely negligible. The error introduced by the neglect of correction to sea-level is much larger than this, but usually is not serious. As is well known, if astronomic observations are to be used to control bearings, a correction for convergence must be applied, of the order of one minute for each mile of easting or westing.

The present interest in plane co-ordinates is not concerned with local schemes applicable to very small areas, but with schemes that may be applied to rather large areas, so that the positions of geodetic and other control points may be expressed in plane co-ordinates. Small local surveys may then be connected to these control surveys and hence to each other on a uniform basis and any necessary computations may be carried out by simple methods, without recourse to the involved procedures of geodetic computations. In setting up such a system it is necessary to establish a general relationship with a one-to-one correspondence between points on the plane and points on the earth's surface; that is to say, within the area covered by the system there must be one and only one point on the plane corresponding to each point on the earth, and similarly there must be one and only one point on the earth corresponding to each point on the plane. Also, lengths and angles as represented on the plane should not be very different from the corresponding quantities on the earth's surface.

The word "projection" is frequently used in connection with plane co-ordinate systems, and perhaps this word should be defined and explained. For present purposes, a projection is a representation on a plane of a portion of the earth's surface. It is essential that a one-to-one correspondence be maintained between points on the earth and points on the projection. Distortion is unavoidable. Projections may be designed to preserve certain characteristics, such as area, or shape, or azimuth of lines radiating from a central point, but all these characteristics cannot be preserved in a single projection. The most desirable type of projection for purposes of local surveys is a conformal projection, which preserves the shape of all very small areas. For short lines, angles on the projection are equal to the corresponding angles on the earth, but since in general straight lines on the earth do not project into straight lines on the plane the same equality does not hold for long lines. For lines of measurable length angular distortions are small, usually of the order of a few seconds or less for 20-mile lines.

It is also necessary to have a clear understanding of the term "scale factor". The scale factor may be defined as the ratio of the length of the straight line joining two nearby points on the plane to the length of the geodetic line joining the corresponding points on the earth's surface. Note that this definition is expressed in terms of two nearby points. To determine the scale factor for a fixed point P, we may select a second point Q, determine the geographical and plane co-ordinates of both points, and thence compute the length of the line PQ on the plane and on the earth's surface and the ratio of these two lengths. If we repeat these computations, using the same point P and a different point Q', we will probably get a different value on this ratio. If we choose a series of points Q', all lying on the line PQ but getting closer to P, the value of the ratio will approach a limiting value as Q' approaches P. Strictly the scale factor for P in the direction PQ is the limiting value of this ratio. If, now, we repeat this whole operation, using the same point P and a point R such that PR lies in a different direction from PQ, we will obtain the scale factor for P in the direction of PR. If the projection is not conformal, these two values of the scale factor will probably be different. The essential characteristic of a conformal projection is a scale factor which, at any point, is the same in all directions.

The three most satisfactory projections for our purposes are the Transverse Mercator, the Lambert Conformal Conic and the Stereographic. These three projections are suitable for different areas and under different circumstances.

A cylindrical projection, of which the Transverse Mercator is one example, may be visualized by imagining a cylinder tangent to the earth. Obviously the line of tangency is the same on the earth and on the cylinder. Furthermore, lines near this tangent line almost coincide on the cylinder and on the earth, so that they may be mapped to the cylinder with very little distortion. The cylinder may then be unrolled, and we have a small part of the earth's surface represented on a plane. If the cylinder is tangent along the equator, we have essentially the Mercator Projection. If the cylinder is tangent along a meridian, we have the Transverse Mercator Projection. If the cylinder is tangent along a great circle oblique to the equator, we have an oblique projection. The transverse Mercator Projection is suitable for areas extending north and south with very little east-west extent. In practice a secant cylinder is frequently employed instead of a tangent cylinder. This gives two parallel lines of zero scale error, with a scale factor less than unity between these lines and greater than unity outside them.

The Universal Transverse Mercator projection (usually referred to as UTM) is very commonly used, especially for military purposes. A standard UTM zone covers a strip of territory extending over 6 degrees of longitude and almost indefinitely north and south. Central meridians of the zones are 6 degrees apart and each zone may be extended rather more than 3 degrees on each side of the central meridian, to provide a reasonable overlap between zones. The scale factor is constant along a line parallel to the central meridian, is 0.9996 at the central meridian, is exactly 1.0000 at 180 kilometres east or west, and becomes 1.0003 at 240 kilometres east or west (at the approximate limits of the zone in latitude 45°). If field work is being conducted at an accuracy at which an error of one part in 2500 is not negligible, all measured lengths (after correction for slope and for height above sea-level) must be multiplied by the scale factor before being used in plane co-ordinate computations. Conversely, computed lengths must be divided by the scale factor before being laid out on the ground.

The scale error could be reduced by reducing the width of the zone. It was pointed out by Mr. W. V. Blackie in the October number of The Canadian Surveyor that, if we reduce the zone width to 3 degrees, we may reduce the scale error at the central meridian to one part in 10,000. The scale error would then diminish to zero at 90 km. from the central meridian, and beyond this point would increase to one part in 10,000 at about 128 km. from the meridian. Thus the effective width of zone would be 256 km., or 160 miles. This is equivalent to about 3° 15' of longitude in latitude 45°, or 3°30' in latitude 50°. Zones with central meridians spaced at intervals of 3° of longitude would have an overlap, in latitude 45°, of about 40 km. or 25 miles.

A conic projection may be visualized by imagining a cone tangent to the earth along a parallel of latitude. Here again a narrow strip of the earth's surface on either side of the tangent parallel may be mapped to the cone with very little distortion, and the cone may be developed into a plane. This type of projection is suitable for an area with a great east-west dimension and very little north-south extent. In this case also a secant zone is usually employed, this giving two parallels with zero scale error.

The Lambert Conformal Conic projection is of this type, with true scale along two selected parallels of latitude. Between these parallels the scale factor is less than unity, while to the north and south it is greater than unity. Fifteen years ago the Geodetic Survey prepared a plane co-ordinate system based on this projection for the province of Prince Edward Island. The two standard parallels are in latitude 46°09'53" and 46°50'. The projection covers a total range in latitude of 1° 10' or about 80 miles, and the extreme values of scale factor are 0.9999830 and 1.0000349. Thus the maximum scale error is about one part in 30,000. If we are willing to accept a maximum scale error of one part in 10,000, we may use a Lambert projection over a range in latitude of 160 miles.

Another possibility is the mapping of the earth's surface on a plane tangent to the surface. This type of projection is suitable for a small area which is approximately square or circular. The Stereographic projection is a perspective projection of this type, points being projected from the earth to the plane by means of straight lines emanating from the opposite end of the diameter of the earth from the point of tangency of the plane. In practice a secant plane may be used.

On the Sterographic projection the scale error varies only with the distance from a central point, which would normally be the true origin of plane co-ordinates. Thus the scale may be made true along a specified circle about the origin; within this circle the scale factor will be less than unity, while outside it is greater than unity. A year ago the Geodetic Survey devised a plane co-ordinate system for New Brunswick, based on this projection. The circle of true scale has a radius of 75 miles, the scale factor at the origin is 0.999912, and the scale factor 140 miles from the origin (just beyond the extreme limits of the province) is 1.000223. For all points within 110 miles of the origin the scale error does not exceed one part in 10,000, and at the extreme limits of the province is about one part in 5,000.

Earlier in this paper it was stated that by the use of plane co-ordinates "any necessary computations may be carried out by simple methods without recourse to the involved procedures of geodetic computations". Nevertheless it should always be remembered that the representation of the earth's surface on a plane is a distortion, and if our survey is of any great extent, observed lengths and angles should be converted to the corresponding plane values before computations are carried out. This is of special importance if the survey lies in a location where the scale error is comparatively large.

We recently had occasion to adjust a small triangulation network near Moncton, New Brunswick. The results were to be expressed in New Brunswick plane co-ordinates. The extent of the network was about 8 miles north and south, and 16 miles east and west. The average scale error for the whole area was about one part in 30,000. We made 5 adjustments of this network in order to test various methods of treatment.

The network was first adjusted by our standard geodetic method, and the positions of stations determined in latitude and longitude. These values were then converted to plane co-ordinates. This adjustment was accepted as correct, and was used as a standard against which to compare the results of less rigorous methods. Four plane adjustments were made, which may be designated A, B, C, and D.

In adjustment A the measured lengths were corrected for slope and for height above sea-level, but no correction was made for scale error. The measured angles likewise were accepted without correction. The maximum error in the resulting co-ordinates was 1.5 feet. In adjustment B all sea-level lengths were corrected by means of the average scale factor for the area, the angles remaining uncorrected In this case the maximum error was 1.1 feet. In adjustment C the lengths were retained as in B, and corrections were applied to the angles to convert them to angles on the plane. This reduced the maximum error to 0.5 foot. Finally, in adjustment D each length was corrected by its own scale factor, and angles were retained as in C. In this case all errors were less than 0.1 foot.

The errors or discrepancies just discussed are purely mathematical, and should all be zero if the computational methods are rigorously correct,. These errors have no connection with the accuracy of the field survey. Regarding this question of accuracy, we sometimes hear such an expression as "We want the co-ordinates to be accurate within 6 inches". Just what is the meaning of this expression "accurate within 6 inches"? Presumably the meaning is something like this: "There is a true value of the co-ordinates of a station marker, and the adopted value, determined by a survey, must lie within 6 inches of this true value." The accuracy of a value determined by survey depends on many things, including the accuracy of location of the point from which the survey starts, the care exercised and instruments used in carrying out the survey, and the distance over which the survey must be carried. Let us consider these three points separately.

We may assume that the true co-ordinates of the starting point of our survey are known exactly, without error. It must be emphasized that this assumption can be true of only one point in any co-ordinate system. In establishing the system, we may arbitrarily choose one station marker and decide that this point shall be the origin of co-ordinates, or that the co-ordinates of this point shall have specified values. Then the co-ordinates of all other points must be determined by measurement from this initial point, and since no measurements are perfect the true co-ordinates of these other points cannot be determined exactly. Furthermore if our fixed initial station marker is subsequently destroyed, it cannot be re-located perfectly, since such location involves measurement (itself imperfect) from a point whose location is not known exactly. Thus in establishing the co-ordinates of a new point, we may or may not be able to start our survey from a point whose position is known exactly, and in any case there is not more than one such point in the entire co-ordinate system.

It is scarcely necessary to emphasize the importance of careful survey methods and good instruments. It is obvious that very precise results cannot be obtained by means of a one-minute transit and a kinked steel tape. It is perhaps less obvious that even first-order geodetic instruments and methods yield results which are less than perfect.

The greatest obstacle to the attainment of a "co-ordinate accuracy of 6 inches" lies in the fact that co-ordinates are determined by the survey of distances, and long distances cannot be determined as accurately as short distances. The accuracy of a survey covering a large area is best expressed in terms of the error that may be expected in the length and azimuth of a line joining any two points of the survey. In first-order geodetic work, the surveyed length of a line may sometimes be in error by as much as one part in 50,000 (or one foot in 10 miles), and perhaps the average error would be one part in 100,000. Thus if our co-ordinate system extends for 100 miles, even if the starting point of our survey is a point whose co-ordinates are known exactly, the co-ordinates of the terminal point may well be in error by 5 feet or more. But if the control survey is properly executed, the co-ordinates of all points in the vicinity of the terminal station will be in error by approximately the same amount, so that the lengths and azimuths of lines joining these points will be correct to the specified order of accuracy.

Now a few words about the establishment of a plane co-ordinate system. The prime requirement of a useful system is a sufficient density of control points, marked on the ground; the expression of positions in plane co-ordinates is comparatively trivial. The establishment of a system of control points should start with a skeleton network, established to first-order geodetic accuracy. With the skeleton firmly established, additional points may be established by less rigorous methods. The general plan should be to fill in additional points between the points of the skeleton, rather than to establish independent small areas of control around the main stations. Accumulation of small errors is inevitable in the establishment of an area of control, but if the area includes three or four points of superior accuracy, which are accepted as correct, these small errors may be properly distributed by adjustment. If, on the other hand, small separate areas of control are built up, clashes are bound to occur when these areas eventually come together.

There are various methods of filling in additional points between those of the geodetic skeleton. If possible, this subsidiary work should be surrounded by first-order control rather than being extended from such control. Ideally the first-order skeleton should be broken down by second-order methods, either triangulation or traverse, and this second-order net should again be broken down to the final required density of control points by third-order methods. It may sometimes be desirable to omit the intermediate step, and to work directly to the final required density from the geodetic skeleton. The whole concept is to fill in between control points rather than to build up from one or two such points. It is not good practice, for example, to establish a group of points by means of triangles standing on a single base, or even by pairs of triangles standing on two adjacent bases. It is better that nearby points be directly connected to each other either by a series of small triangles or by traverse. If the method of traversing is used, each traverse should originate and terminate on a control point, and the traverses should be interlocking in order to prevent a bad swing between control points.

To summarize, plane co-ordinates provide a simple means of carrying out survey computations, but they inevitably involve distortion. If the scale error is not to exceed one part in 10,000, one plane co-ordinate system is available suitable for a north-south band 160 miles wide; another for an east-west band of the same width; and a third for a circular area 220 miles in diameter. For high accuracy, corrections must be applied to measured quantities before these quantities are used in plane co-ordinate computations. A high density of control points marked on the ground is essential to a satisfactory plane co-ordinate system. Subsidiary control points should be added to a first-order skeleton network by means of triangulation or traverse, and these subsidiary surveys should be extended from one main control point to another and adjusted accordingly rather than being extended outward from one or two such points.

COLLOQUIUM NEWS

From *The Canadian Surveyor*

The recent Colloquium on Survey Education which was fully reported in the January issue of The Canadian Surveyor, was only the beginning, it is hoped, of a series of events that will result in a greatly improved standard of education for surveyors and a wider recognition of surveying as a profession. We intend to keep our readers informed of these events as they happen and it is likely that frequent references to the Colloquium will appear in the pages of this journal.

During the recent fifty-third annual meeting of the Canadian Institute of Surveying Mr. S. G. Gamble, Chairman of the Education Committee, presented a report in which he dealt extensively with the Colloquium. At the conclusion of this report Mr. Gamble read an extract from a letter from Professor S. H. deJong and then called on Mr. Angus Hamilton to report on the plans to continue the work of the Colloquium. After Mr. Hamilton had given his report discussion from the floor was invited, and this discussion will be covered briefly in the Annual Report issue. Mr. Gamble's report, Professor deJong's comments and Mr. Hamilton's report now follow in the order given.

Report of Education Committee

By S. G. GAMBLE, Chairman

Since this is the first time that the Education Committee has been called upon to present a report to the Annual Meeting I shall first take a few moments to remind you of some of the more important events in its short and comparatively peaceful life. I shall then say a few words about our main activity during 1959, the Colloquium on Survey Education.

At our 50th Annual Meeting in 1957 Dr. L. E. Howlett gave a paper entitled "Distance Measurements" in which he described the prototype tellurometer he and the late Mr. W. H. Miller had seen the previous spring in South Africa. After explaining the intricacies of this new measuring device in terms surveyors could understand, he proceeded to take us to task for our lack of fundamental education.

Dr. Howlett concluded with the suggestion that we approach one of the local universities and attempt to interest them in setting up a degree course in surveying.

The Institute was quick to take up this challenge and no sooner had Colonel Smith vacated the presidency than he was asked to chair the newly formed Education Committee. Colonel Smith made several attempts to interest the universities in survey education, but, apparently, they were either unable or not prepared to move into our field at that time.

In July 1957 number of The Canadian Surveyor an informative article by Mr. J. T. Blachut was published entitled "Is a special Education in Surveying necessary?"

At our annual meeting the following year Professor Syb deJong spoke to us on "Education of Surveyors and Photogrammetrists", pointing out the alarming rate at which survey instruction was decreasing at universities.

At last year's annual meeting we heard about education in surveying at Laval University from Professor L. Z. Rousseau, and Mr. Hamilton organized an informal education group luncheon. The interest in this gathering was so great that it almost sabotaged the Over 50 Club luncheon.

The inevitable result of these outstanding papers and other efforts by the Education Committee was that the Institute had begun to take a real interest in survey education.

When I accepted the honour and responsibility of the chairmanship of this Committee, I found that my predecessor, Mr. Angus Hamilton, had already set the wheels in motion for increased activity in 1959. Amongst other things, he had tentatively arranged with the Editorial Committee to devote one number of the journal to articles on survey education. The hope was expressed that my Committee would arrange to secure a number of papers to round out the few already on hand. Those of you who have received your January Surveyor will agree that my Committee was successful in getting sufficient material, although we approached the problem in a rather round-about manner.

The members of the Education Committee felt that survey education was of sufficient importance to Canadian survey associations to warrant a full-scale meeting. It was also apparent that there was little merit in telling one another about the need for more attention to surveying in Canadian universities. When it was suggested to the Council of the Institute that we hold a meeting with representatives from sister associations and universities, along with a few surveyors representing industry and government, our President, Mr. Armand Dumas, heartily endorsed the proposal, and we were authorized to approach the provincial survey associations. We then consulted Dr. L. E. Howlett, Director of Applied Physics of the National Research Council and Dr. W. E. van Sterenburgh Director General of Scientific Services, Department of Mines and Technical Surveys, since we knew they would give us sound advice. Needless to say, they were most helpful and gave us much encouragement.

The proceedings of the Colloquium on Survey Education are fully covered in the January isssue of The Canadian Surveyor. Our editor, Mr. E. J. Jones, has gone to a great deal of trouble to make this a useful and interesting number, and I am sure it will be widely read.

The total number of registrations was 85, somewhat larger than the Committee expected, which indicated a keen interest in survey education. We were particularly pleased that 13 Canadian universities saw fit to have representatives at the meeting. We were also pleased to have with us Professor Thompson, of University College, London, England, Professor Arthur McNair, of Cornell University, Professor Fred Doyle of Ohio State University, Mr. Phillip Bill, Chairman of the Property Survey Division of the American Congress on Surveying and Mapping, and Mr. Louis Dickerson of Watertown, New York, of the American Society of Photogrammetry.

Despite what some may think, the Colloquium was not sponsored for the sole purpose of encouraging universities to train survey scientists for government service. Ours is a national Institute, and I believe we are primarily interested, or if not should be, in the larger problem of survey education for all surveyors rather than for any one particular field.

Despite the fact that Institute representatives were in the majority at the meeting we had comparatively little to say and let our guests do most of the talking. I think you will find that the little that Institute representatives did say indicated a reasonable approach to the problem of survey education.

Our first objective was to investigate the annual Canadian intake of surveyors and the type of work on which they would be engaged. It was felt that this was important since it would show the dimensions of the problem. The second objective was to examine current survey education in Canadian universities and ascertain whether it was of a type to produce the required surveyors. I believe it was clearly demonstrated to the satisfaction of most of the delegates that the current situation was unsatisfactory.

Our final objective was to interest universities in improving education in surveying. Whether we were successful in this or not remains to be seen. Certainly it will require more than any single action by our Institute to persuade universities to improve survey education; continual persuasion by all survey associations and those in positions of prominence in our profession is also necessary.

Our Institute is facing a major challenge, and if it is to be worthy of the name of the Canadian Institute of Surveying, and pay more than lip service to the objects stated in our Constitution, it must do all it can to promote good survey education, and the best place to carry our professional education is surely in our universities.

Our Committee is convinced that immediate attention must be given to the education of surveyors, including emphasis on the development of a professional outlook.

In conclusion I would like to thank the members of my Committee, Mr. Angus Hamilton, Mr. Lou Gale, Mr. Ted Bachut, Mr. Ted Lawson and Mr. Al Stewart for their wholehearted support this past year.

In a few moments I shall be calling upon Mr. Hamilton to give his views on the organization of the 1960 committee that will continue the study of surveying education.

I wish the new committee every success and trust they will find 1960 as interesting as 1959 has been.

Comments by Professor deJong

(Extracted from a letter to Mr. Gamble)

I have had a few thoughts since the closing of the conference. They are not really new but are a sort of recapitulation. I will try to put them down here coherently and you may use them as you wish.

1. Every effort must be made to have all surveying organizations recognize education as such. Any candidate with a university degree should be given preference over the non-university man and from whatsoever subjects he has passed with adequate standing he should be exempted in any professional examination. Recognition of university standing will go a long way to convincing the universities that we mean what we say.

I first expressed this publicly in my paper in 1958. Cy Smith expressed it very capably at the Colloquium but it will need to be said often.

2. There is a great deal of pertinent subject matter available at all universities and the interested candidates should be able to select curricula that would allow finishing up in a short time at institutions which specialize. The surveying organizations should interest their candidates in carefully selected programs "at home" with support offered for the period in the specialized school for finishing.

3. Arising out of the latter point, I should like to see the Committee on Educa-

tion consider setting up an advisory council to guide young men who wish to get into surveying via the university. The chairman of such a council would preferably be the "director of surveying education" at a university offering a degree in surveying or an adequate surveying option. There should be one member on the council for every university. The function of the council would be to correlate the offerings and special curricula at the universities for intending surveyors so that they might most effectively take advantage of whatever specialized courses are offered to produce the best qualified graduates in the most efficient manner. The representatives at the participating institutions would be student advisers helping students select curricula and the chairman would need to review the curricula to assure their adequacy.

Plans To Continue The Work
OF THE COMMITTEE ON SURVEY EDUCATION

By ANGUS C. HAMILTON

The Colloquium on Survey Education was planned primarily to stimulate thoughts and interest in education. We on the committee, are vain enough to hope it has been successful in this respect. It was not our intention to solve the problems of survey education nor even to find a magic formula that could be applied ever after. Education is and ever will be a continuing and continuous process.

Individually, we learned a great deal and formed conclusions of our own from the colloquium but as a committee we are reluctant to draw conclusions or even state any findings that would purport to have the full endorsement of the delegates. Any action that may result from it will come from an individual or group of individuals who got sufficient inspiration to go home and do something. Pious resolutions on our part will not add significantly to individual inspirations and could in fact lead to quibbling that would do more harm than good. As Mr. Gamble has mentioned there are several points on which for the present there has been ample discussion, but still no topic can be considered closed.

Even a casual review of the proceedings reveals that the recent technological explosion in instruments and methods and increased land and resource values call for a corresponding upgrading of the educational opportunities available for students in surveying. Herein there is nothing new or original. This has all been said before but now it has been lucidly and forcefully expressed by men of outstanding reputation.

It would be very easy to go through the proceedings and list a few points on which unanimous, though half-hearted, agreement could be reached. In this age of mass-communications and predigested news and views, the casual reader has come to expect predigested conclusions. We are going to disappoint him; we are offering instead a think-it-yourself project. The comments of Prof. Thompson, Dr. Howlett, Mr. Pierce and others are excellent raw material for such a project.

If we acknowledge that education for surveyors should be upgraded, then something should be done. But what and by whom?

Let us consider the interested groups.

First and foremost are the universities—faculty members, deans and boards of governors. Ultimately this is the only group that has the resources to act on the problem. It would be presumptuous on the part of any other group to attempt to tell them what they ought to do.

Second in line of responsibility are the provincial associations empowered to license surveyors in each province. By the standards that they set and by the qualifications that they honor they can have a strong influence on the entire education setup.

A third group that can affect the picture is the government agencies employing surveyors. They, also, by their recruitment policy and by the remunerative rewards for education achievements, can have an indirect but appreciable influence on the general level of survey education.

For very good reasons the Canadian Institute of surveying has not been included with these groups. It has negligible financial resources, no teaching facilities, no licensing authority and no employment to offer. What can the C.I.S. do? It can be a catalyst; it can bring reagents together; it can stimulate a useful reaction; to put it more bluntly it can apply the heat. We hope that the colloquium has already started some reactions in motion, or accelerated the motion of some that were already started. This, we think, is and should be the primary function of the Institute.

Now we would like to think for a moment about how the Institute can best achieve this end. As a start we are proposing some changes in the format of the education committee. In the past the education committee has consisted of a chairman who did what he could to further the interests of survey education. Now we propose to make use of the talents of all who are interested. We intend to create an Advisory Group consisting of all those from the colloquium who registered a desire to pursue the subject further and of those who by their position or interest wish to be included. The functions of this group cannot be denied explicitly until the group is formed. Whether activity is limited to a bit of spasmodic correspondence or whether it is extended to several very active subcommittees will depend on the amount of interest shown by the members. Instead of getting involved in details of organization let us look at a couple of projects that could be undertaken. At the colloquium, representatives of the University of New Brunswick mentioned that proposals for a survey course at Fredericton were being considered. Obviously most of the problems that will arise can and will be handled by faculty members working closely with the N.B. Land Surveyors' Association. But many other groups stand to benefit if U.N.B. goes ahead with these plans and it is just possible that the Faculty could benefit from meetings with representatives of these other groups. At the very least I'm quite certain that the Advisory Group will be extremely interested in receiving an informal review of progress at U.N.B. each year.

Another proposal from the colloquium was for an institute to do research and graduate training. This is an exciting proposal and one which I know several members are anxious to investigate further. There are at least four other proposals, mainly on a regional basis, that I know of.

As you know, ideas come from individuals, not from groups. All we wish to do is to create the machinery whereby an individual can exploit his ideas and sound them out on his colleagues from other parts of the country. Many of the obstacles and hurdles that are due to inertia can be removed by a good prod; we think the Advisory Group, and through it the Institute, can be used as the prod.

A PAPER ON

The Nova Scotia Land Survey Institute

Prepared by W. D. MILLS for reading at the Annual Meeting of the Association of Land Surveyors of Nova Scotia on November 17, 1959

Introduction

Mr. Chairman, ladies and gentlemen, I felt a considered sense of honor when I received the kind invitation to present a paper to your Association in annual meeting and it is with even greater sense of honor that I find myself before you with the opportunity to explain the establishment and the planned operation of Nova Scotia's new and recently opened Land Survey Institute. Not only does it give the Government of Nova Scotia, through one of its officials, the opportunity to display some discreet and modest, but nonetheless intentional, pride in a relatively small but important educational effort, but also it gives that official an opportunity publicly to thank many who have assisted in making the plans of the new Institute.

This new Institute represents my first sizable administrative "baby" and, I am sure you can realize that there has been more than administrative duty involved in the part I played in the development of this school. I must hasten to assure you that there has been the most willing and useful assistance from many people and organizations; from officials of the federal Department of Mines and Technical Surveys including Mr. S. G. Gamble, as Chief Inpographical Engineer, and Brigadier Baldock, as Chief Cartographer, from officials in the Nova Scotia Departments of Lands and Forests, Mines, Highways, Public Works and Education, from many members of the Association of Provincial Land Surveyors of Nova Scotia, from members of the Advisory Committee for the school, all of whom are members of the Nova Scotia Association and last, but by no means least, and no doubt the presiding genius of it all, Major James A. H. Church.

Major Church, has from time to time described the school and its operation. I did not hear him, but I have every confidence that, along with the factual description, he presented hopes for a better program and a better building. He described the school to you through the eyes of a surveyor and a teacher of surveying. I have no alternative but to present my paper to you as the observations of an educational administrator.

The Nova Scotia Land Survey Institute is a new government school administered by the Vocational Education Division of the Nova Scotia Department of Education. Perhaps the new Institute can best be described against its administrative background and its historical background.

Vocational Educational Division

As with most functions of Government, the Vocational Education Division has terms of reference which in this case are set forth rather definitely in the definition of "vocational education" in the Vocational Education Act (Nova Scotia 1947, 1949, 1956). "Vocational Education" is defined there as

> ". . . any form of instruction below that of university level, the purpose of which is to fit any person for gainful employment or to increase his skill or efficiency therein and without restricting the generality of the foregoing, includes instruction to fit any person for employment in agriculture, forestry, mining, fishing, construction, manufacturing, commerce, or in any other primary or secondary industry in Canada."

That definition was admittedly borrowed almost word for word from the definition of "vocational training" in the Vocational Training Co-ordination Act (Canada 1942). Briefly, the function of the Division is to teach people to work more efficiently in certain occupations by acquiring the necessary skill, knowledge and attitudes.

To accomplish our function, we have adopted, and we use, certain practices which in the briefest of terms are:

(1) to establish and operate vocational courses, each of which is specific to an occupation and is based on an analysis of that occupation.
(2) to select the instructor for a vocational course from amongst those who have highly regarded competency in the occupation concerned and to superimpose the necessary teacher training on that occupational competency.
(3) to arrange, as nearly as possible, to have the student learn under the same condition and use the same equipment that he will meet and use in the occupation concerned,
(4) to select students who wish to prepare for the occupation concerned, who will likely be able to acquire the skills, knowledge and attitudes required in the occupation concerned and who will likely work at the occupation concerned, and
(5) to operate a course as long as the graduates can find employment in the occupation concerned.

It is not my purpose to explain at length our modus operandi but this much more I think you should know: we stress tne acquiring of occupation competency in terms of skills, knowledge and attitudes to a degree that enables the students to enter and make progress in his chosen occupation. The matter of passing "outside" examinations, admittedly important, is in our view secondary as far as purpose and administration is concerned. We judge the effectiveness of a vocational course in terms of the occupational success of the graduates during employment as shown by their individual progress and by their employers' opinions of them, rather than in terms of the results of the examinations or marks at graduation.

History

The Institute has had a series of contributory antecedents.

First, there has been a land survey school of one kind or another in Nova Scotia since 1943. In order, the school, the period, the operators, and the nature of the students were:

School	Period	Operator	Students
No. 6 Vocational Training School	1943-45	Department of National Defence (Canada)	Army-Engineers and Artillery
Land Survey School	1945-48	Departments of Labor (Nova Scotia and Canada)	War Veterans
Land Survey School	1949-58	Department of Education (Nova Scotia)	Public

All three "schools" had Major James A. H. Church as instructor. The school has been operated in several centers in Nova Scotia but for the last ten years it has been located in Lawrencetown, Annapolis County. The selection of Lawrencetown as a site has been a happy one. There is no preponderance of reflection of artificial lighting, there are excellent opportunities to set up permanent monuments; the residents have liked the students, and there are not too many distractions for the students.

The record of the graduates of the School has been most satisfactory. They have been practically 100% successful in their first attempt at the P.L.S. examinations and have had good employment placement and records. They have been enrolled from most provinces in Canada and from the British West Indies. They have been employed principally by private firms or surveyors, by departments of federal government and by department of provincial government.

As soon as the school came under the jurisdiction of the Vocational Education

Division, an official Advisory Committee was appointed to advise the Director of Vocational Education, Mr. E. K. Ford, on the technical aspects of operating such a School. It must not be inferred that there was any lack of confidence in the Instructor, Major Church. It would be impossible for officials of the Division to administer courses concerning so many occupations without the valuable asssistance of advisory committees composed of people who are active and competent in each of the occupations for which we operate vocational courses. Appointing an advisory committee for this school was normal practice and this particular committee has certainly been most useful. It is composed of Messrs. Reg Dickie, P.L.S., J. A. Russell, D.L.S., V. J. Harrison, P.L.S., and Walter E. Servant, P.L.S.

Second, in 1929, a Dr. J. B. Hall, a native of Lawrencetown, left a considerable bequest to be used in the establishment and operation of a vocational school in Annapolis County. This was a generous, far-sighted bequest on the part of an educator who worked wholly in the field of academic education in a province which had, in his day particularly, a profound academic tradition and practically no knowledge of vocational schools.

Third, in 1957 the Lawrencetown Branch No. 112 of the Canadian Legion, generously donated a parcel of land to be used by the Government if it established a land survey school.

Fourth, over several years, there have been the vision and the efforts of Major Church for a school to provide a high standard of instruction in all land survey subjects to be housed in a suitable building. Major Church's contribution must be regarded as useful, generous and contributory gifts along with the more material gifts of Dr. Hall and the Legion. Major Church's efforts were made in the direction of the Department of Education through the Vocational Division with a series of submissions and recommendations for the better teaching of land surveying and associated courses and in the direction of the Department of Lands and Forests through the Association of Provincial Land Surveyors of Nova Scotia for higher professional standards in entrance requirements, in training requirements, and in certification requirements.

Fifth, as a result of the offers of the Association of Provincial Land Surveyors of Nova Scotia, there is every likelihood of legislation providing, amongst other provisions, that those wishing to become professional land surveyors should serve three years apprenticeship indentured to a certified Provincial land Surveyor or Surveyors.

Sixth, in addition to advocating more and better instruction in land survey, Major Church called to our administrative attention the demonstrably growing need for technicians trained in photogrammetry and for technicians trained in map drafting. We found on investigation, that his view was more than shared by officials of the Department of Mines and Technical Surveys and the Department of National Defence and others.

So, the success of Major Church's School down through the years, the generosity of Dr. Hall and the Legion, the persistent and admirable efforts of Major Church for a better program and building, the proposed legislation relative to professional land surveyors, and the opportunities for trained photogrammetry technicians and map drafting technicians, and efforts of our provincial department of Education, Lands and Forests, Mines, and Highways have combined to bring about the establishment of the Nova Scotia Land Survey Institute.

Program

It was decided that, initially, the program of the Institute would be an expanded land survey course, a photogrammetry course and a map drafting course.

The plans for the new and expanded land survey course, as set forth below, were made primarily to effect an improvement in the course. It must be admitted that the provisions of the proposed legislation referred to above, particularly in reference to apprenticeship, influenced the planning but, I think, that the new course will be a most effective one even if, by some remote chance, the proposed legislation does not come to pass or is changed, even drastically, during consideration in the legislature.

It was assumed that the condition of apprenticeship would permit an apprentice, providing he could arrange the necessary indenture or indentures, to serve his three years with a P.L.S. or a succession of P.L.S.'s and that such P.L.S.'s could be

(a) in Private practise
(b) in or with a firm in private practice
(c) with a firm to do land survey work for that firm only.
(d) with a Department of the Province or the Dominion doing land survey work, and
(e) employed as an instructor in the Nova Scotia Land Survey Institute.

With the apprenticeship and other factors in mind, it was planned

(1) to provide a "first year" land survey course and a "second year" land survey course each beginning in September of one year and ending in May of the next year, providing approximately 1000 hours of instruction;
(2) to include the following subjects with the allotted time, at least on a tentative basis:

1st Year		2nd Year	
Subject	**Hours**	**Subject**	**Hours**
Drafting	36		
Mathematics	168	Mathematics II	168
English	60		
Photogrammetry I	126	Photogrammetry II	126
Instruments	158		
Field Astronomy I	162	Field Astronomy II	162
Survey Methods I	162	Survey Methods II	162
		Legal	60
Professional Practice	126	Professional Practice	320
	998		998

(It should be known that the addition of Drafting and Photogrammetry I and II represents a decided improvement over the syllabus we have been following for some years. It should also be known that Major Church has been able to make arrangements through officials of our Provincial Attorney- General's office to have the Dalhousie Law School gather together the Nova Scotia laws pertaining to land survey, to provide copies of same for the Institute, and to give some lectures in conjunction with the Legal subject in the Second Year Course.);

(3) to provide under the auspices of the Institute and under the conditions of indenture a summer period of professional practice between May and September each year for those who for one reason or another wish such practice for approximately 500 hours of practice per summer; and
(4) to provide a classroom for each course and to provide for a maximum enrolment of fifteen in each course.

It should be noted here, and not only in relation to the land survey courses, that the entrance requirements must remain a matter of control by the Institute always subject to the approval of the Minister. As in the past a certain standard of accomplishment will be required in English, mathematics and science at matriculation or higher level. Undoubtedly, the Institute will recognize and accept apprentices who have met the requirements of any entrance examinations set for candidates for apprenticeship, but because the Institute is a government school and because the Institute will be accepting students from outside Nova Scotia, it must maintain control over standards of admissions to the Institute.

The Photogrammetry course was planned for those who wish to become technicians in Photogrammetry with particular reference to the use of photogrammetric equipment. It is emphasized that this course is at the technician level and not at the professional level in the university graduate sense. It was decided to provide facilities for a maximum enrolment of 12 students.

Further plans for this course have not been concluded but it can be stated that the course will be based on an analysis of the occupation of technicians of Photogrammetry, and that the entrance requirements will likely be junior matriculation, that the length of the course will be approximately one academic year. Our initial information is that this course will call for a great deal of individual instruction, hence our tentative plans to limit the enrolment at any time to 12. As a matter of interest, we think we can turn out a very useful technician for approximately $600 which is much less than can be done by a firm or Government department that is in production, photogrammetrically speaking.

The same facilities will be used for a somewhat lesser course for the land survey students both in their first year and in their second year.

It has also been decided to have facilities for the teaching of Map Drafting and this, too, at the technician's level. As with the photogrammetry facilities, the map drafting facilities have been planned to serve two groups: a short course for the land survey students and approximately a year's course for students who wish to become technicians in map drafting and associated skills. The course has as yet not been constructed but it was decided to provide facilities for a maximum enrolment of 20.

To repeat, the prime purpose of the program is to prepare students to enter and make progress in employment, that is to have students to acquire occupational competence. The courses are terminal. There has not been and there is no intention to provide courses for university credit. If any university wishes to give credit to any of the graduates for any course he has taken at the Institute, that is a matter between University and the graduate. On no account, however, will we alter a vocational course at the request of a university to make it more acceptable for university credit; that is, on no account will we construct and operate a vocational course for other than its prime purpose. A vocational course, like man, cannot serve two masters.

It will be quickly admitted that the Institute courses, although terminal, do not include all the skills and knowledge used in the occupations concerned, but our effort will be to give good basic courses so that each graduate will be useful to his employer immediately on entering employment both production-wise and potential-wise.

We shall continue, as much as possible both physically and financially, to have the student acquire his skills, knowledge and attitudes by doing actual occupational work. We shall continue to require the land survey students to do actual surveys which will be used in one form or another. This represents the essence of our vocational education methods. We are of the opinion that a student will be much better prepared for employment if he has learned under "employment" conditions and that he will actually learn more about making surveys if he knows his survey is a real survey and not a survey which is going to be used for learning purposes only and then discarded.

The same methods will be used in the Photogrammetry Course and the Map Drafting Course. Having the photogrammetry students do actual work which will be actually used presents somewhat of a difficulty but we hope to be able to do it, at least to a degree. It seems much more possible to arrange to do actual work in map drafting and considerable progress has been made towards making such arrangements.

Having planned the program we made plans to house it, to equip it and to staff it. We now have a steel and masonry building 80 feet long and 50 feet wide designed and constructed to accept another floor. The building contains four classrooms each approximately fifty feet long and thirty feet wide. The upper floor, slightly above street level has two classrooms, one for map drafting and one (divided) for photogrammetry. The lower floor, at ground level at the rear, has two classrooms each for land survey. There is a dark room on the lower floor for teaching some photographic development techniques. The building is set on a parcel of land which in time will be nicely landscaped. We think it is a nice appearing and functional building. As stated at the beginning, it is our plan to have available the equipment used in the respective occupations. With the purchase of some new land survey equipment recently, we consider that the land survey classes are fairly well equipped. Plans for adequate and appropriate equipment for the photogrammetry course and the map drafting class are being made. We expect to have four full-time instructors, two for land survey, one for photogrammetry and one for map drafting. There is a full-time secretary and a full-time caretaker.

Conclusion

Physically this plant is not large but educationally it is and will be of considerable size. Reference has been made to Major Church and his efforts, both professional and educational. We now have a building which, he says, surpasses his wildest dreams and a program which, if nurtured wisely, will perhaps approach his dreams but never surpass his desires. We have tablets to commemorate the gifts of Dr. Hall and the Legion, but to commemorate the priceless gifts of Major Church, we have a building which will endure, a program which, we think, will produce better and better land surveyors and technicians, and students who have been and will be successful.

Officially it will be the Nova Scotia Land Survey Institute but, in most conversations, it will be referred to, even in its new clothes, as "Major Church's School". I, for one. will be glad to have it so.

Vocational Education Division
November 17, 1959.

New Approach In Power Site Survey

On foot, by boat and plane, survey teams worked on locating potential hydro sites for N. B. Electrical Power Commission

"New approaches have been used in an investigation of potential hydro sites on the Saint John River, for the New Brunswick Electric Power Commission.

Methods used in two preliminary surveys included:

"Application of the underwater seismic profiler known as Sparker to study the sub-surface formations under the river bottom.

Supplementing the Sparker survey with spot determinations by the portable MD-1 seismograph (known as the "Magic Hammer") along river banks and on islands.

"Use of a tellurometer to measure distance electronically for ground control, in production of topographic mapping of the area.

"Employment of two scales of aerial photography for the topographic mapping, to reduce ground control to a minimum.

The Sparker and Magic Hammer were employed in a survey by Hunting Technical & Exploration Services Limited, carried out for consulting engineers H. G. Acres & Company.

HTES was requested to locate impervious layers suitable for dam sites and bedrock capable of supporting spillways, along selected stretches of the Saint John, totaling approximately 30 miles, between Fredericton and Aroostock, N. B.

Positioning themselves by aerial mosaics, Sparker operators traversed the river from bank to bank in a converted scow, using both ancient and modern sources of power — a horse pulled the boat Volga-style through one shallow stretch and five outboard motors pushed in through the more turbulent water. Three full runs were made in this manner in 15 days, zig-zagging up and down the river.

At the same time, MD-1 operators made determinations along the banks and on river islands, providing results which (a) calibrated and identified horizons revealed by the Sparker and (b) provided data on underground formations not accessible to the waterborne instrument.

The HTES survey extended over two summers—the Sparker operation was completed in the summer of 1958, while the MD-1 seismic work continued and was completed in September, 1959.

The topographic mapping was produced by PSC at a scale of 200 ft. to 1 inch with 5-ft. contours. For this assignment, photography was flown at two different scales—high-level and low-level. In the map-making process horizontal and vertical control was extended from the highlevel to the low-level photography, through photogrammetric "bridging" that involved simultaneous use of two Wild mapping machines.

Use of the tellurometer — which measures distance electronically between two stations provided the minimum amount of ground control which was required.

Adult Education

The October, 1957, issue (Vol. XIII, No. 10) of The Canadian Surveyor carried an article by Mr. T. J. Blachut entitled "What should an Academic Education for Survey Engineers Be and Why?" In a preface to this article, we invited comments from readers, especially in relation to four questions of particular interest, listed in the preface. Early in 1958, we received letters commenting on these points from Professor S. H. deJong, Department of Civil Engineering, University of British Columbia, and from Mr. J. F. Doig, Provincial Land Surveyor, Paradise, Nova Scotia. By a most unfortunate accident, these letters, which the Editorial Committee had intended publishing in April 1958, were placed in the wrong file and forgotten temporarily. They were rediscovered during a recent review of the files. We apologize to Prof. deJong and Mr. Doig for this occurrence. Since their comments have lost none of their point with the passage of time, we publish them below. Prof. deJong's comments were given in the body of his letter, while Mr. Doig's were given as a separate document.

PROFESSOR DEJONG'S LETTER

Dear Sir:

In the preface to Mr. T. J. Blachut's second article, "What Should an Academic Education for Survey Engineers Be and Why?", you invited discussion on education for land surveyors. The following are my answers to the questions you raise.

(1) There ought to be university education for land surveyors. Land surveying is a profession requiring the acquisition of a body of knowledge at an advanced level. It also requires exercise of judgement in the performance of professional duty. The land surveyor is, or should be, motivated by a desire for service. He must maintain relations of confidence with his client. He must accept responsibility for his work. He is bound by a code of ethics. He should take part in the advancement of knowledge in his profession. He has a responsibility to society to enhance the value of his profession to the public. To achieve these things the standards of the profession must be set at the highest level.

This is not to say that the common means of entry into the profession by service under articles and examinations should be closed. Far from it. Too many of our respected surveyors have entered the profession by this avenue and many more will continue to do so. However, the standards of comparison must be set