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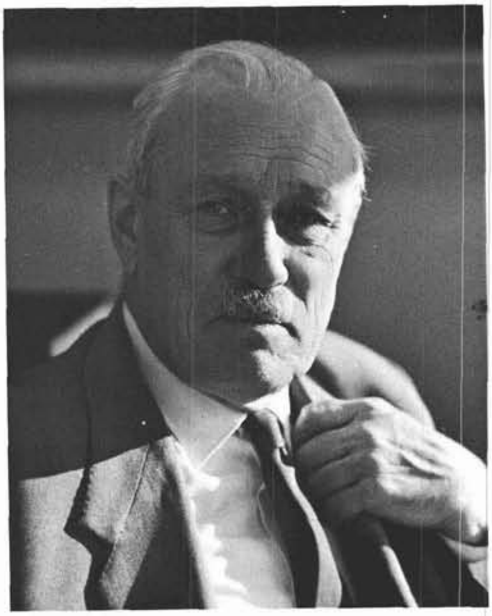

Martin Hotine

Martin Hotine Friend and Pro

Memorial Lecture

"I hold every man a debtor to his profession; from the which as men of course do seek to receive countenance and profit so ought they of duty to endeavor themselves by way of amends to be a help and ornament there unto."—Bacon.

Martin Hotine used this introductory paragraph from Francis Bacon's pen to preface a paper on "Professional Organization" which he presented in London at the 1947 Conference of the Commonwealth Survey Officers. I selected the same paragraph for this memorial lecture because of the insight it provides of Hotine's philosophy on professionalism—whether it be surveyor, photogrammetrist, geodesist, mathematician, administrator, or statesman. His talents were great and he shared his tremendous enthusiasm with friends and colleagues throughout his entire life wherever he might be and whatever the responsibility he faced. All of us who were privileged to be associated with him in any way can recall many exciting incidents—some of action, some of discussion, some of debate—each in a very special way identifying this outstanding man as a true professional.

In his associations with friends and coworkers, he requested that titles of rank or distinction not be used; he much preferred the use of surnames for professional colleagues and reserved the first name or familiar nickname for his closer friends. Therefore, whenever I mention any of his colleagues, I will endeavor to follow this informal yet fully respectful pattern.

A playwright might describe Hotine's life as a continuous and logically planned series of episodes. Whether Hotine was preparing the script, setting the stage, leading the action, or greeting the guests after the performance, his keen sense of timing and his natural appreciation of the dramatic have made the story of his life unique for the international surveying and mapping fellowship.

Prologue

Early Life—First World War—Education—Family

We may consider the first third of his life as a fitting prologue to a full career of service to his government plus all the other governments associated with Great Britain. Born June 17, 1898, he received his early education at Southend High School in Essex and was graduated from the Royal Military Academy at Woolwich on June 6, 1917, being commissioned in the Corps of Royal Engineers, the "top cadet of his batch." In the First World War, following additional training at the School of Military Engineering at Chatham, he was sent to India for service in the Queen Victoria's Own Bombay Sappers and Miners. His company moved up to the Northwest frontier where there was incessant guerilla fighting with German-trained hill

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tribes. Later his company moved on into Persia at the invitation of the Persian Government to suppress some unruly tribesmen. Along with the skirmishing, his company was accomplishing some of the engineering requirements—building roads and railways, placing telegraph lines, and, of course, supplying the supporting surveying and mapping.

His mental challenge during those years was the mastery of unmasterable languages. He learned to read, write, and speak Urdu, the language of the Moslems in India, and also Persian. In 1920, his company was sent into Mesopotamia, now Iraq, where sporadic fighting with Arab guerillas was still going on along the banks of the Euphrates. Peace was slow in coming, but, finally, in 1922 he was ordered back to England for post-war courses at Magdalene College, Cambridge University, and advanced studies at Chatham.

The prologue must also include his marriage to Kate Amelia Pearson on August 9, 1924. I remember sitting under the stars in St. Mark's Square in Venice with Kate and Martin along with other friends listening to them recall their courtship days when they were participating in amateur theatricals. They told us that in 1916 Martin's school had decided to put on Shakespeare's "Merchant of Venice." Kate had been chosen from a neighboring girls' school to play Portia and, of course, Martin was playing Bassanio. At the dress rehearsal, before a mixed audience from both schools, Martin went beyond the action indicated in the lines and planted a kiss on Kate's cheek, leaving a tell-tale mark from his, at that time, grease paint mustache, much to her embarrassment, so she said, but, needless to say, to the general amusement of the others.

They could not have selected a better time and place for sharing their memories with friends. Those of you who have known these two, realize that they could have been tremendously successful as professionals in the theatre. However, the story unfolded in the more traditional way: military service, advanced education, home, family, profession. They had been engaged before his long tour of duty in India and Persia, but waited until he had completed his post-war training and education to be married.

Even though the family is basic to the whole drama of life, I should introduce them at this point in the prologue. The Hotines were blessed with three daughters: Margaret has devoted her life to theatrical work, Janet has given her life in service to the church, and Bridget has made a home for a family of her own. Religious faith was a tremendous force in their lives. They were devout Christians and active in their support of the Catholic Church.

Act I

AIR SURVEY COMMITTEE—RESEARCH OFFICER—PHOTOGRAMMETRY—METHODS—TEXTS

In 1925 Hotine was appointed to the Air Survey Committee of the British War Office serving as its Research Officer. Here he used the opportunity to devise practical methods of using aerial photographs for topographic mapping. His mathematical ability, his experimental aptitude, his tremendous energy, and his special gift of writing were all combined in producing four professional papers, each of book length, and finally, in 1931, a textbook, *Surveying from Air Photographs.* The analytical procedures and graphic methods he devised became the basis for all mapping, civilian and military, and as we shall see later, for economic development. The concepts became identified as the *Arundel* Method. Generally, the *proper noun identifier* relates to a person, but in this case *Arundel* is the place where the method was first used. Arundel is a small village in Southern England just a few miles north of the Channel. The photogrammetric target would have been Arundel Castle, seat of the Duke of Norfolk, Earl Vice-Marshall of England.

Although this first episode or *Act I* of the Hotine Drama might be titled *Photogrammetry,* it was during this period that the prick of his pen began to be noted in the United States. Bowie and Hayford, working through the International Association of Geodesy, had been able to persuade the countries of the world to adopt a new ellipsoid, and, for greater persuasion and geodetic diplomacy, it was identified as the International Ellipsoid. But Hotine was quick to note that Bowie continued to use Clarke's 1866 Spheroid for North America. Also, Hotine expressed his concern about the use of Laplace azimuths in triangulation networks. In the Empire Survey Review, he wrote of the fact that the error of observation for azimuths was considerably larger than that of horizontal directions in triangulation. Therefore, he reasoned that the use of azimuth observations could distort the more accurate triangulation. Quoting in part, "Personally, I know very little about the subject, but I have an open mind and I can appreciate an argument. If the real geodesists can be induced to fight in the same ring, we may get at the truth. Therefore, I shall endeavor to prove that both sides are wrong." I do not know if any others entered the *ring*, but some months later, Hotine continued his discussion in the Empire Survey Review. He had relaxed somewhat, perhaps realizing that azimuths observed in the latitudes of the United States did not have as large errors as observed in the latitudes of Great Britain.

He also wondered why those responsible for the theoretical applications in the United States seemed to ignore the classical method of defining a datum, in particular, the origin. Bowie has chosen to use the same geographic coordinates for Meades Ranch, the origin of the then new 1927 Datum, as had been calculated from the original New England Datum and later perpetuated into the U.S. Standard Datum. Quoting in part again from Hotine, "The fact that the constants of the Clarke 1866 Spheroid are just right for this purpose, and that the regional attraction varies with closely approximate uniformity from east to west, is probably the most amazing stroke of luck in the history of Geodesy. The Americans are to be congratulated on this; but their sagacity may be doubted when they suggest in effect that the same chance holds everywhere else." Again later when writing about azimuths, "After some thought on the question, my own opinion is that the Americans may conceivably be right in using Laplace azimuths, but I am quite sure they are wrong in suggesting that everyone else should use this system of adjustment."

ACT II

EAST AFRICA—30TH MERIDIAN—GEODETIC ENGINEERING—TECHNIQUES—RIGORS

Hotine's keen knowledge of theoretical geodesy was soon to be applied in the next episode of his career. Late in 1931 he was assigned the task of establishing an arc of triangulation in East Africa along the 30th Meridian from latitude 10° South to 4° South. Now we see his engineering capabilities: the utilization of native manpower, the development of precise base-measuring techniques, the adoption of rigorous observational procedures, and, in fact, the specification of a Laplace azimuth in almost every quadrilateral of the chain of triangulation. The design or strength of the survey was critical. He avoided the use of long lines for the mere purpose of getting from one place to another quickly. I particularly like this sentence of his written in 1933: "The god of least squares, with his unreasoning hatred of small angles and complete ignorance of field conditions, is not a just god and would likely over-favour the long and possibly inaccurate line."

One can reread accounts of this African project in the Empire Survey Review, but I must use one more quotation to show the complexity of geodetic problems in considering different parts of the world, particularly different continents: "for good or evil, the Clarke 1880 Spheroid has come to stay in Africa and will not be replaced anymore than the Clarke 1866 figure has been displaced by Hayford in America."

Extending an arc of triangulation from Rhodesia northward along the east side of Lake Tanganyika through trackless brush and jungle, infested with tsetse flies, was a task that only humans could accomplish. Back-packing food, blankets (for some of the points were at high altitudes), building supplies, surveying equipment, and, of course, rifles, for protection from lions or for acquiring fresh game, required a small army of native porters, sometimes as many as 250. Hotine had the full responsibility. He had one junior officer to assist him with the observing and a few noncommissioned officers to mark stations, post lights, and assist in the training of natives to do some of the work. The task was completed in two years, working through two wet seasons and living under canvas the whole time—really a remarkable achievement!

ACT III

GREAT BRITAIN—RETRIANGULATION—ORGANIZATION—ADJUSTMENT—NATIONAL GRID

The technical aspects of his assignment in East Africa proved to be the basis for the next major role in his service to his country. In the development of urban England after World War I, especially in Northern London, the need for resurvey (as opposed to revision) had become apparent. Any attempt to patch up the existing network to serve as control for the necessary breakdown surveys merely emphasized the inadequacy of the basic framework. In 1935 a decision was made to observe an entirely new primary net and subsequently to reestablish the lower-order networks. Hotine was asked to undertake this project at a time when the resources of the Ordnance Survey had been, to use their words, "pruned to the irreducible minimum." The Great Depression of the 30's covered the globe, with England affected as much as any country, yet Hotine was called upon to accomplish within a few years a task which when done the first time had taken half a century.

The details of how this retriangulation was planned, personnel selected and trained, procedures for reconnaissance and observing established, a special station mark pedestal designed, and the actual work accomplished were well described by Hotine in several issues of the Empire Survey Review. World War II interrupted the work before it was completed. I refer those of you who are interested in reading a vivid account of the total program to a 1966 publication of the Ordnance Survey, "History of the Retriangulation of Great Britain," compiled primarily by John Kelsey.

But the whole story has never been published. The tales that are told by old-timers, when they sometimes meet, do not become part of an official government publication; but they do become part of geodetic legendry. Fortunately for this occasion, I was provided with a bit of the record which must be passed on to you.

Hotine and the observing party had been bogged down by the weather for weeks on the summit of Ben Mac Dui, a grim Scottish mountain and the second highest in Great Britain. Hotine had gone down to the base camp at Braemar, a distance of some 15 miles, and sent one of his men back to the summit with a supply of the finest Scotch whiskey obtainable. Within a short while the weather cleared, the observations were completed, and a triumphant party staggered down the Luibeg Glen to their trucks parked near a lovely spot, the Linn of Dee. The happy triangulators decided that a more extended celebration was in order so they went to a nearby hotel. Too bad, though, it happened to be the Sabbath and the Free Church of Scotland Community objected. A Black Maria provided transportation to the local *jug* for the merrymakers.

Next morning, Hotine, having heard about the incident, hastily made his way to the Court, arriving just at the time when the observer, who had accepted the responsibility for all, was pleading guilty. Hotine asked the Court if the observer was being provided legal counsel. When the Court replied that the defendant was entitled to such, Hotine proposed that inasmuch as he was the defendant's Commanding Officer he was qualified in his military capacity to speak for him. Thereupon, Hotine painted an excellent picture of the hardships of the field men, he emphasized the consequences of delay to the whole operation if the observer should be detained by imprisonment, he stressed the possible loss of rank and even ignominious discharge. Hotine's eloquence was partially effective. The Court ordered a nominal fine of £20. The delighted observer turned to Hotine and asked for a loan of £20 to pay his fine. After completing the transaction, Hotine ordered the man to another nearby and difficult station to do penance and work off his "nominal fine."

A few years before Hotine had been assigned this major task of retriangulation, he had expressed some concern, in fact some criticism, of the methods Hayford, Bowie, and others had used in the United States in devising the 1927 Datum for North America. When Hotine was confronted with a similar task in his own country, we must note that he also recognized that expediency sometimes must have primary consideration. Because of the desire not to disturb the graticule of the existing large-scale maps, many at 1/2,500, the new triangulation was adjusted to fit the scale and orientation of the old. Thus, Laplace azimuths and precise bases were used for after-the-fact studies or investigations. In a practical sense, the distortions to the new observations were negligible, generally less than one part in 100,000, and for the standards of that era, fully acceptable.

In addition to holding overall scale and orientation, the formerly used spheroid of reference, Airy's Figure of the Earth, had to be retained. Airy's parameters had been defined in feet so there was the complex task of deriving the proper conversion ratios for expressing lengths in meters. There is some satisfaction in noting that we in the U.S. are not the only surveying and mapping group that has been subjected to this *numbers game* in the effort to achieve uniformity. A unique feature of the new British network is that all coordinates are expressed in metric units on a National Grid based on a single zone of a transverse Mercator projection. The published geographic coordinates were derived from the National Grid coordinates.

Another point of interest to us is that Hotine had acquired some Bilby towers from the U.S. He instituted a training program for the erection and dismantling of these towers on the grounds of the Ordnance Survey at Southampton—somewhat different from the *on-the-job training* we have followed. Because of the area-type network and unusual requirement for tower heights in some of the Eastern counties, Hotine encountered the problem of needing more towers. Rather than face time delays and the cost factors involved when purchasing more towers from the U.S., he solved the problem with the assistance of the Geodetic Survey of Denmark who generously loaned him two towers of similar design.

Act IV

WORLD WAR II—DUNKIRK—EAST AFRICA—GREECE —MILITARY SURVEY—LOPER-HOTINE AGREEMENT

I mentioned earlier that World War II interrupted the program of retriangulation. At the outbreak of that war, Hotine was assigned to General Headquarters as the Deputy Director of Survey in the British Expeditionary Force. For those who wish to follow his record from Dunkirk to East Africa to Greece and returning to the War Office to serve the rest of the war as Director of Military Surveys, I suggest you read *Maps and Surveys* published by the British War Office in 1952. From that historical report you will sense that Hotine and his colleagues could have used 3M as a trademark: not for Minnesota Mining and Manufacturing Company with its various products, but rather for a symbol of military strength—Men, Munitions, and Maps—the third element being as essential as the other two.

Hotine was with the British forces in Belgium and France when they were fighting their way back to Dunkirk. He saw the acute problems which could develop if maps that did exist were not in the hands of the troops needing them. Years later he referred to the episode as "when many of us were seabathing at Dunkirk" and, no doubt, using his keen sense of humor could reminisce with his colleagues who were with him at the time, many of the little events contributing to this major military miracle.

Hotine was next assigned to Survey operations in East Africa and later sent to Greece with a small survey team as a part of a British Expeditionary Force assisting the Greek Army. This mission failed, and many of the personnel were taken prisoner, Hotine was among those who escaped.

He was then ordered back to London to the War Office to be Director of Military Surveys. In 1939 he must have been frustrated at times, for in one letter home, he wrote, "I'd love to run my own show instead of being an eternally vibrating second string," but now he drew from his experiences of that earlier phase of the war. The requirements for surveys and maps and, in particular, the problems associated with printing and distributing maps were forcefully presented to the General Staff. Hotine came to Washington in May 1942 to discuss the mapping situation with H. B. Loper and members of the Intelligence Branch of the Chief of Engineers, U.S. Army. As a result of this conference, they drew up an agreement, known as the Loper-Hotine Agreement, dealing with the division of responsibility for map production, the exchange of mapping and other survey data, and the selection of military map grids.

Soon afterward, Herb Milwit was ordered to England, to serve as the Chief of the Engineer Intelligence Division, U.S. Army for the European Theatre of Operations. Hotine and Milwit worked closely and effectively throughout the war. Hotine's earlier experiences in aerial mapping, geodetic surveying, and mathematics of projections provided the technical base that, coupled with his tremendous vitality and dynamic and aggressive leadership, gave outstanding and truly professional direction to the Military Survey Office. Recognizing that in earlier years Hotine had been somewhat critical of survey practices in the United States, his ready acceptance of the U.S. competence in mapping with all of the supporting techniques adds to his professional stature. This spirit of cooperation and good will between the various surveying and mapping groups of Great Britain and the United States continues today. The Hotine-Loper Agreement had set the stage for broader international agreements in programs which would follow World War II.

Act V

OVERSEAS SURVEYS—STATESMAN—ECONOMIST—MATHEMATICIAN

In 1946, after he had retired from the British Army, Hotine became Survey Advisor to their Secretary of State for the Colonies. He was the first director of the newly formed Colonial Surveys, now known as the Directorate of Overseas Surveys. During Hotine's pre-war assignment in East Africa, he sensed the need for such an organization and his close contact during the war years with all British territories as well as many others strengthened his position. In this new endeavor, he was to be statesman and economist, using his energy and ability to assist in the development of the Commonwealth. He organized a staff and provided the leadership in applying photogrammetric, geodetic, and mathematical techniques to surveying and mapping. Before he retired in 1963, his organization had mapped nearly two million square miles, mostly at a scale of 1/50,000.

Even though his administrative responsibilities were great, he continued his mathematical research. He published a series of papers in the Empire Survey Review, giving special treatment to various projections of the spheroid. This work has become a basic reference for all later writings in the field of mathematics dealing with projections. His development of the oblique Mercator projection of the spheroid is particularly unique. Sometimes this projection has been named *skew* or *diagonal*. In Hotine's original work, where it was applied to Malaya and Borneo, it is called *rectified skew orthomorphic*. The same technique was used for the State Plane Coordinate System in Southeast Alaska. Fortunately, the user of the plane coordinates in that part of Alaska has only to know that x and y are in Zone I. More recently, Ralph Berry has proposed the use of these skew projections for each of the Great Lakes, simplifying the cartographic operations where geodetic, photogrammetric, and hydrographic surveys must be combined.

Off Stage

CONFERENCES OF COMMONWEALTH SURVEY OFFICERS—SYMPOSIA AND ASSEMBLIES OF INT. ASSN. GEODESY

Also, during that same time, Hotine was taking an active part in international organizations, giving unselfishly of his time and talent in planning and conducting conferences, even joining in hearty and friendly debate either in formal session or in the privacy of *after session places*. This was the Martin we remember as friend and colleague.

As organizer and leader of several of the Commonwealth Survey Officers Conferences, he set standards which have been followed by many other groups. He enforced discipline on those who prepared papers, he insisted on open discussion, and he maintained a spirit of good will among all participants. At the 1963 Conference, while Sam Gamble was presiding, J. N. C. Rogers from Australia presented a motion "that this Conference of Commonwealth Survey Officers place on record its profound appreciation of the work of Martin Hotine for the distinguished service he has given as President of this Conference and of the previous Conferences of the Commonwealth Survey Officers in Cambridge in 1955 and 1959, and for the stimulation, encouragement, and leadership he has given to surveyors during a long and very distinguished career." The United States has been very fortunate to have been invited to participate in these conferences even though we withdrew from the Commonwealth almost two hundred years ago.

It was through his participation in and contributions to the programs of the International Association of Geodesy that many of us in the United States learned to know him, grasp some inspiration from him, and join in hearty fellowship with him. I first met him at Oslo in 1948 at the General Assembly of I.A.G. It was at this first post World War II Assembly that Antonio Marussi presented his classical paper on the differential geometry of the potential field of the earth. This modern treatment of the science of geodesy was appealing to the mathematically attuned Hotine. These two, Hotine and Marussi, initiated a series of symposia on mathematical geodesy—the two of them co-planning and co-leading with Marussi hosting small groups for intimate discussion at such places as San Georgio in Venice, Cortina d'Ampezzo and Turin, to be followed by others at Trieste and Florence honoring Hotine. Marussi and Hotine seemed to challenge and inspire each other, and in turn the same for those who had the good fortune to have been participants in these symposia. To show Hotine's personal appreciation for this association, I quote from his book, *Mathematical Geodesy*: "The author's main source of inspiration in the subject of this book has been Professor Antonio Marussi of the University of Trieste, not only for the range and originality of his ideas, but also for continual advice and encouragement." Marussi holds the same respect for Hotine. You can grasp the full sincerity of this friendship by reading for yourself Antonio's tribute to Martin reprinted from *The Survey Review*, No. 152, April 1969.

In Memory of Martin Hotine

by Prof. Antonio Marussi, his friend, President of the International Association of Geodesy.

I feel inadequate to write the biography of Martin Hotine because I met him late in my life. I know little of his early professional activity, which I am sure was intensive; but in the past two decades through our connection with the International Association of Geodesy I have come to know him as a man, and as a man of science. On first meeting, I understood many of his thoughts and feelings. Later I studied his work. Then he honoured me with a friendship which I reciprocated with admiration and affection.

Our friendship was born on the advanced frontier of the discipline dear to us, Geodesy. I remember our first meeting at the General Assembly of the U.G.G.I. in 1948. It was there that the intrinsic and three-dimensional geodesy began to develop, anticipating the oncoming space age which was then knocking at the door. When a report on this subject was read, Martin said that he understood only very little about it, but that it broke with crystallized tradition and that it must therefore be important.

Later I came to understand that in this thought was all of Martin. He was attracted to the new ideas because they challenged the scholastic framework of the time. Such ideas were perfectly congenial to his non-comformist and politely rebellious temperament.

I did not meet him again for four years. When we did meet it was at the Assembly of the Association in Brussels. In the interim he had mastered tensor calculus, which he later used with rare insight and elegance, finding in it the instrument which permitted him to materialize his intuition of the fundamental problems of modern geodesy, giving life and substance to the creations of his vivid fantasy.

His first work on the metric properties of the Earth's gravitational field, and on three-dimensional systems of geodetic coordinates appeared at the Toronto Assembly in 1957. Here, through the initiative of President Baeschlin, was born the idea of dedicating a special symposium to three-dimensional geodesy which had already anticipated the use of electromagnetic methods for the measurement of distances in space, and was now anticipating the launching of the first artificial Earth satellites.

I considered Martin's proposal that this symposium should take place in my country, Italy, to be a token of his great friendship. Italy was very happy to host this symposium at Venice in 1959, and offered Martin its chairmanship. Later, two other symposia were held in Italy, at Cortina in 1963 and in Turin in 1965. The fourth symposium will also be held in Italy at Trieste in 1969, and will be dedicated to his memory.

At Venice Martin introduced his *Primer of Non-Classical Geodesy,* a work whose title is decorously provocative. It is written in a style which makes it difficult to know which to admire most: its rigor, its conciseness, or its elegance.

He thought that in the same way as in classical geodesy a clearer vision of many problems could be reached by representing the surface of the ellipsoid on the plane, if three instead of two dimensions were involved one could similarly represent with advantage the three-dimensional space on another three-dimensional space, not necessarily Euclidean, in order to make clearer and more immediate some aspects of the Earth's gravitational field. As in classical geodesy, conformal representations appeared to be the most promising. These ideas were gradually brought to perfection by Martin, and presented by him at Turin in 1965 at the third symposium held on the occasion of the celebration of the 100th anniversary of the Italian Geodetic Commission. In 1967 at Lucerne, Martin introduced new ideas about the downward continuation of the terrestrial potential field. That was the last time we had the pleasure of enjoying his incomparable personality.

We would have expected that Martin, whose background was in the sphere of practical activity and whose career was anchored in the most deeply rooted traditional habits, would have contributed to geodesy by following the most classical and orthodox trends. However, the truth is exactly contrary, since he was particularly anti-scholastic in facing the problems of speculative geodesy. This attitude originated in his deep dissatisfaction with compromises by which classical geodesy, burdened by prejudices accumulated during centuries, presented its own problems, managing a way between the rigor of the theoretical approach and the empiricism involved in its practical applications. At the same time this attitude came from his innate horror for everything that was not simple and rational and, therefore, aesthetically satisfying.

On this point Martin was intransigent. He detested any compromise whose purpose was to avoid conceptual difficulties if even to the least extent it impaired the rigour of the logical process. He hated approximations, reductions, corrections, or badly-defined, unfounded, accommodating hypotheses. He was an aesthete and a purist.

We must be grateful to Martin for the impetuous vigour with which he always defended his viewpoints, even when they clashed with the deepest-rooted convictions. We must be grateful to him for this courage, since even science sometimes needs courageous men in order to progress.

Perhaps it is too early to assess how much his work has influenced modern thought concerning our discipline. It is probably too early because we have not had the privilege of reading his book on *Mathematical Geodesy* which synthesizes the twenty years of thought and creative work with which Martin concluded his earthly spell. This book represents the last and most dignified satisfaction of a man whose work and family were his only reasons for life.

If I am permitted to express my opinion, perhaps prematurely, I believe his influence will not be found in any particular results of immediate application but, rather, in his effectiveness in changing convictions which, because of their venerableness, were removed from critical attack; in clearing away difficulties which hampered the free progress of ideas; and in showing how to get rid of the heavy superstructure heaped up in the long history of our discipline. Martin's spiritual heritage is for this reason embedded in our subconscious by the ways he demonstrated to us for researching the truth through the simplicity of the origin and the elegance of rational thinking.

Of course Hotine's interest extended to all aspects of geodetic work. He naturally had a keen interest in the coordination and improvement of the geodetic networks of Europe. The geographic location of the British Isles and the separation from the continent meant that the geometric impact on the continental networks might not be great, but his contributions to the development of the overall specifications were significant. When he was the leader, he was a strict disciplinarian as we well know, but I must tell you of an incident I will always remember. Back in 1962 we were meeting in Munich, working on the plans for the readjustment of the European triangulation networks. At the middle of one morning session, a break was taken—not the customary coffee break—but a *beer break*, Munich's best along with open-faced sandwiches. We had relaxed for at least a half hour when I, who happened to be chairing that particular session, suggested we resume our work. Martin boomed out in his sonorous tone, "Whitten, I thought Abraham Lincoln had freed the slaves!" We did continue our work in good spirit, properly relaxed physically and mentally.

Thus it was that Hotine, through his spirit and vitality, supported with his engineering and scientific ability, enlivened the symposia and assemblies of the Geodetic Association, always supporting and encouraging the officers of that association in their various activities.

Epilogue

USC&GS—RESEARCH SCIENTIST—"MATHEMATICAL GEODESY"—RETURN TO WEYBRIDGE—HONORS———

The year was the one that Hotine's own government had established as the point in his life when he should begin to enjoy the rewards of retirement. In that year he was fittingly honored by his colleagues and countrymen for his long and distinguished service to his country, but he did not seek "the rocking chair." He accepted the invitation of Arnold Karo, the Director of the Coast and Geodetic Survey, to come to Washington and join the ranks of the Survey as a research scientist. I have referred to Hotine's numerous contributions to geodesy. These papers had been in the form of mimeographed reports—somewhat in sequence, all logically interrelated—yet all on the distinctive legal-size paper which would not conform to the standard U.S. notebook, file case, or bookshelf. Karo persuaded Hotine to combine, refine, and extend his work and produce a *hardback* monograph that would fit in our bookshelves.

For the next five years, Hotine worked toward this goal of producing a text which, in his words, would be "an attempt to free geodesy from its centuries-long bondage in two dimensions." Of course, those same five years were those in which geodesists were entering a new era of experimentation and development through the use of artificial satellites. Hotine's interest in and contributions to these developments were just as keen as all of his thinking had been throughout his whole life. Wherever activities of this type were going on, Hotine's advice was sought, so there were excursions from his main thrust. There were even administrative excursions involving agency reorganization. The Hotines accepted with pleasure the physical move to Boulder. He and Kate, with their love of nature and hiking, could explore the trails in the foothills of the Rockies. I was told that the photographic collection they made of Colorado wild flowers is probably equal to that of any ever compiled by the best of American naturalists.

I always noticed that Hotine never hesitated to use a familiar quotation if it helped to emphasize a particular point of interest. I do not think he would have objected to my use of another quote from Francis Bacon: "Reading maketh a full man, conference a ready man, and writing an exact man." All of these phrases apply to the man we honor and, in particular, to his preparation of the manuscript for his text, *Mathematical Geodesy*. Hotine's plan, which he followed explicitly, was to use the methods and notation of tensor calculus for the derivation of theorems and formulae which apply to all of mathematical geodesy. He included geometrical and physical, terrestrial and spheroidal, and, in his words, "internal adjustments" and "external adjustments" of geodetic networks. I urge you to read two outstanding reviews of this text. One is by Bernard Chovitz published in 1970 by the Italian Geodetic Commission in the Proceedings of the Fourth Symposium on Mathematical Geodesy, Trieste, Italy, May 28-30, 1969. The other was written by Paul Thomas and published in the International Hydrographic Review, January 1971. They were close friends and associates of Martin, had worked with him on many sections during the development stages, and Chovitz, in particular, during the final editing and printing.

Early in 1968, while the manuscript was

nearing completion, Martin underwent a serious surgical operation. His friends in Boulder told me that he did some of his most effective writing after he returned to his office from the hospital. His friends around the world were concerned and Joe Edge has permitted me to quote from a personally penned letter Martin sent him in July of 1968: "I progress slowly after the extensive revisions, as the tailors might say and do say. It is an up-hill job, but according to the Medicos I have to work at it. If they would only let me off eating and let me concentrate on drinking, I should feel fine, but unfortunately they will do neither."

Martin and Kate Hotine had made their plans to return to England in August of '68. The manuscript had been sent to the printer and now only the tedious task of checking the galley proof remained. Soon after the Hotines had returned to their apartment in Weybridge in Surrey, Martin wrote in his usual keen manner to Bernie Chovitz, "We have been struggling to get the place straight and in effect start a new life. It would be easier to do this in America; we have forgotten where the ropes are here, even what to do in the absence of yellow pages."

His interest in his work and his love and consideration for others never diminished, but his physical energy and strength, of which he had been blessed in abundance, left him. He died on November 12, 1968. Those who knew him mourned his passing, but gave thanks for the privilege of having known him and having been associated with him. The encouragement and inspiration he gave to others cannot be taken from them.

Governments, national engineering and scientific societies, and other groups recognize the honored individuals of high distinction. Martin Hotine, modest and unassuming, yet forceful and energetic through his brilliant personality, was an example of true professionalism. Numerous awards were given him at various times throughout his career and significant memorials established after his death.

He was awarded the O.B.E., Commander of the Order of the British Empire in 1945, and the C.M.G., Companion of St. Michael and St. George in 1949.

Also, the Royal Geographical Society awarded him its Founders Medal in 1947 and in 1955 he was the first recipient of the President's Medal of the British Photogrammetric Society. The Gold Medal of the Institution of Royal Engineers was awarded to him in 1964.

The United States Army made him an officer of the Legion of Merit in 1947 and in 1969, the U.S. Department of Commerce conferred, posthumously, on him its highest honor award, the Gold Medal.

During the 1971 Conference of Commonwealth Survey Officers, a tree, a Norway Maple, was planted on the grounds of the Ordnance Survey at Southampton as a living memorial. Kate Hotine assisted in the ceremony and her daughters and grandchildren were also present. Gifts, which had been received from friends in 31 countries, have been used to create in his honor a Scholarship Fund for graduate study at University College in London. I believe that this method of encouraging and helping young students would have pleased him the most.

Notice to Contributors

1. Manuscripts should be typed, double-spaced on $8\frac{1}{2} \times 11$ or $8 \times 10\frac{1}{2}$ white bond, on *one* side only. References, footnotes, captions—everything should be double-spaced. Margins should be $1\frac{1}{2}$ inches.
2. Ordinarily *two* copies of the manuscript and two sets of illustrations should be submitted where the second set of illustrations need not be prime quality; EXCEPT that *five* copies of papers on Remote Sensing and Photointerpretation are needed, all with prime quality illustrations to facilitate the review process.
3. Each article should include an abstract, which is a *digest* of the article. An abstract should be 100 to 150 words in length.
4. Tables should be designed to fit into a width no more than five inches.
5. Illustrations should not be more than twice the final print size: *glossy* prints of photos should be submitted. Lettering should be neat, and designed for the reduction anticipated. Please include a separate list of captions.
6. Formulas should be expressed as simply as possible, keeping in mind the difficulties and limitations encountered in setting type.