ENGINEERING FOR NATIONAL SECURITY

BY MAJOR GENERAL EMERSON C. ITSCHNER*

Read by BRIGADIER GENERAL ALDEN K. SIBLEY,** *Member*

(Presented at a joint meeting of the Boston Society of Civil Engineers and the Boston Post, Society of Military Engineers, held on January 21, 1959.)

THE engineer has played a more significant role in national security and advancement in the United States than perhaps in any other nation. That has been due to the peculiar circumstances of our national origin and the availability of a large, rich frontier suddenly opened for development by an aggressive people who were ready for it.

The engineer was a key figure in winning our national independence. His skills hastened the settlement of the frontier. His work in constructing roads, canals, harbors, waterways and railroads made possible the economic integration of this vast land within a single century and helped to build our modern industrial society.

The engineer's role in defense from the earliest days to the present time has been equally fundamental and dynamic. In the United States, the engineering profession originated with military necessity and grew out of the establishment of the Army's Corps of Engineers and the U. S. Military Academy at West Point for the training of engineers and other military leaders. There has been a close community of interest between the military and the civil engineer from that period to our own time.

Thus, in addition to his modern technological skills, the American engineer has an excellent background of tradition for meeting the requirements of our present military and economic emergency. For the primary problems of national security today are basically military and economic, and the two are closely integrated.

Many people are so appalled by the prospects of nuclear war that they tend to overlook the risk that we could lose the world conflict by failure to counter Soviet efforts for economic penetration and political domination of the undecided nations outside the Iron Curtain. While we must be prepared to fight a hot war and marshal

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military strength to deter it, we are already fighting an economic and political war. To lose it would be as disastrous as to lose a military war.

Both types of conflict present new, difficult and important tasks for the engineer. Primary among these are the technological aspects of how to cope with two of the most formidable forces known. These have been loosed upon the world by Science opening the Pandora's box of technological advancement before we were morally and spiritually ready for it. They are:

> The inter-continental missile, with its nuclear blast that could devastate a nation in a single, concentrated attack, within a few minutes time; and
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> The pressure of the world's explosive population growth on the limited natural resources of this already crowded planet.

Two recent events highlight the imminence of these threats as problems demanding immediate action:

In mid-December, the world's largest and best equipped missile facility was put in service at Vandenberg Air Force Base in California. Here men are being trained to fire the new inter-continental missile. Bases for actual deployment of the weapon are already under construction in the United States. The enemy too, has advanced far, and either has or soon will have the capability for sending nuclear destruction over the great Polar arc to destroy wide areas of our country. The problem of how to survive the availability of such a weapon is upon us.

Last November, Dr. Philip M. Hauser, Head of the University of Chicago's Population Research Center, announced that the United States may grow to as much as a billion people in less than a century, if current trends continue. He thinks we may number almost a quarter billion people just sixteen years from now.

Even though the growth may fall short of that predicted, it will certainly be extremely large. Moreover, it is part of a global trend. Great Britain's leading soil scientists a few weeks ago warned that the world would need to support six billion people in the next century. That is three times the present population.

This problem, too, will soon be upon us in full force. We see its advance effects in world-wide social, economic and political turbulence upon which the Soviets seek to capitalize. At home, we already feel the repercussions. And we are beginning to feel the pressure of our own population growth: in urban expansion, the overcrowding of our schools and thoroughfares, the increasing problems of water supply, flood protection, stream pollution and soil depletion, and in many other ways.

So, on the one hand, we must be prepared to fight an intercontinental nuclear war, if necessary, and to repel country-by-country "installment plan" aggression whether it be military, economic or political, or a combination thereof.

On the other hand, we must support the phenomenal growth of our own population, and help friendly or undecided nations to find ways to support theirs.

These tasks call upon us to exercise the utmost of engineering ingenuity in military advancement and in keeping our country strong and dynamic. They hold special significance for engineers of all kinds—military and civilian. For we must literally, as well as figuratively build our way to security, military and economic. All aspects of technological warfare and military construction to support it, as well as economic activity such as water resources development, the highway program, schools, housing, utilities, industrial expansion—all must move ahead—at an accelerating rate.

Scientists and engineers are in a very real sense ultimate weapons in our struggle for suvival in the nuclear age. Before the plans for a new weapon or a new piece of equipment are off the research and development drawing board, the construction engineer must plan its installation. Many of his designs will be unprecedented, requiring pattern-making engineering solutions, such as the Arctic airbases using ice and snow as materials; snow tunnels in lieu of roads on the ice cap, and for crack-proof rigid pavements to carry 240,000-pound gear loadings on frost-susceptible, glacial till material. The construction engineer is among the first to come to grips with realization of the national strategic concept. Construction capabilities frequently dictate the feasibility of military plans and operations. Meticulous design, careful supervision and inspection must produce the high standard of construction for which the Army Corps of Engineers is reputed.

Our revitalized military defense program is now and will continue to be costly. The Corps of Engineers is concerned, of course, with the military construction, combat engineering and other technological support aspects of the program. The Corps' military construction program in recent years has amounted to about $1½ billion per year in Continental United States and overseas. Under our unified defense system, the Corps performs construction for the Army, Air Force, National Guard and some construction for the Navy.

The Air Force is our biggest client. Although most of the construction for the Air Force is still conventional, consisting of modification and expansion of existing facilities and bases, construction of missile installations is rapidly coming to the fore. This year missiles account for 15 percent of the Corps' military construction. In Fiscal Year 1959 however, we expect support of missiles to amount to about 40 percent of our military construction.

New England has a big stake in the military construction program. This strategic, northeast corner of the United States is now in the front lines of potential inter-continental warfare. The shortest air route from Moscow to Washington would pass over Maine, Vermont, New Hampshire, western Massachusetts and on to Washington. A Soviet jet bomber flying that route would be within 15 minutes of any New England city. An inter-continental missile could span the whole distance in little more than 30 minutes. Thus New England, by virtue of its geography, its industrial targets and population concentration, is indeed of critical strategic importance.

What does this mean to New England? The U. S. Army Engineer Division, New England, has constructed and is now adding to one of the most concentrated centers of defense in the nation. We have the multi-million-dollar Strategic Air Command bomber bases like Loring, Dow, Westover and Portsmouth. We have our warning facilities dotting the area and the Texas towers ever watchful off the coast. We have a complex system of aircraft control and warning, and we are now building inter-continental missile facilities at Presque Isle in Maine. We are building such weapons systems as these in strategic areas throughout the nation. With their development and the sure knowledge of their retaliatory capability comes one of our greatest deterrents to war and therefore one of our greaters powers for peace.

The industrial and air-base complexes of New England are now defended by the Army's NIKE AJAX missile batteries designed to spell the doom of the piloted bomber. These facilities are now being modified to accommodate the longer range NIKE HERCULES missiles. These deadly air-defense missiles are being supplemented in New England by the Air Force's BOMARC IM–99 missile, a long range ground-to-air interceptor missile designed to operate at high altitudes and supersonic speeds. Launched by a liquid-fuel rocket engine, the BOMARC is a weapon 47 feet long with a wing span of 18 feet. In Presque Isle, Maine, the first operational SNARK missile base in the United States is now under construction. This missile, not to be confused with a ballistic missile, is a surface-to-surface intercontinental cruise (subsonic) missile with a range of over 6,000 miles.

Besides construction, another missile responsibility held by the Corps is Engineer support for Army deployment of the weapon. The Redstone Missile, for example, which uses great quantities of liquid oxygen (called LOX) as a propellant, requires refrigeration at minus 296 degrees (F) in order to avoid excessive loss in storage and transportation. Already five and 20-ton transportable manufacturing plants have been developed for operation by Engineer troops close to launching sites, and a 50-ton plant is under development. Nine-ton tractor-trailer LOX units are being procured in New England to equip IRBM units deployed overseas.

In support of ground and airborne forces in the missile age, the Corps has devised airborne construction equipment, tank-mounted bridges, mechanical minelayers, jeep-mounted mine detectors, and tank-mounted mine-clearing devices that will help troops move more rapidly and fight more effectively. We have infra-red equipment to help them see at night. We are helping meet problems of supply to small, fast-moving groups. We can quickly provide large numbers of accurate maps, which contain more information about trafficability than ever before. Meanwhile we are cooperating with 63 other nations to establish a unified international mapping grid system for use in missile operations and strategic planning.

I have given you only the highlights of what engineering is contributing to military defense through the Corps of Engineers. And now, what are we doing about the second aspect of engineering for national security—the problem of population growth?

One of the most essential elements to a strong and growing economy, to support both military defense and national growth, is water resources development. The Corps of Engineers holds a large share of the national responsibility for this activity. We are pushing forward a nation-wide $800-million annual program of investigations, construction and operations of flood control, navigation, hydro-electric power, water conservation, and related activities. Our investigations and construction programs are proceeding on the basis that we shall ultimately need full use of our water resources to meet the seemingly insatiable demands being placed upon this vital resource. We shall need greater flood protection as the centers of production along our rivers expand. Our inland waterways have become virtually floating mass-production lines as heavy, bulk materials are carried from plant to plant in the various stages of processing. Barge traffic has about doubled over the past decade and will grow considerably. Our harbors are becoming increasingly important as we look more to the importation of essential raw materials.

Just three short years ago the flood control program in New England was given added impetus as the result of one of the worst floods in the history of the northeast. In an effort to prevent the recurrence of a similar major economic dislocation in one of the most highly industrialized areas of our country, the Corps of Engineers has made rapid progress in the construction of the New England flood control system. In fact, the progress we have made in the past three years in planning and constructing protective facilities in this area has been truly remarkable. I know of no other area in the country where so much has been accomplished in such a short time following a flood disaster.

Under this accelerated planning and construction program, seven new flood control projects have been completed at a cost of $10 million, 12 projects at a cost of $104 million are now under construction (many of which will be completed within a year) and six more projects aggregating about $11 million in cost are now being designed. This is a total of 25 flood control projects which will be completed soon at a total Federal cost of over $125 million.

The significance of this accomplishment is evident when we compare this three-year record with the total history of flood control construction in New England prior to August 1955. In the more than 30 years following the major flood of 1927, 23 flood control projects were built. This represents about 20 percent of the comprehensive program recommended by the Corps of Engineers and authorized by Congress before 1955. In other words, when our present program is completed, we will have done more to provide flood protection in the few years since the 1955 flood than was accomplished in the whole previous history of New England.

This is only part of the picture. With the aid of their Congressional delegations, the people of New England have gained a greatly augmented flood control program, in addition to the millions of dollars appropriated for projects already authorized. The Northeast Flood Studies and Hurricane Studies have thus far resulted in the authorization of two major hurricane protective works on Narragansett Bay and in New Bedford Harbor.

The task of engineering for national security demands that we preserve a sound and healthy domestic economy to support our military defense programs. We must not sacrifice one on the altar of the other. We must never lose sight of the fact that the Soviets have declared and are fighting the economic "cold" war. As Kruschev challenged: "We declare war upon you in the peaceful field of trade. We declare war. We will win over the United States. . . . We are relentless in this, and it will prove the superiority of our system."

To face this challenge with success, while at the same time deterring the Communist bloc from open military aggression, will require more than the taxpayer's dollar, more than national determination and fortitude. It will require national brains!

We must remain acutely conscious that the greatest power on earth is and always will be the human mind—the thoroughly trained and highly educated mind. The real war of today and tomorrow is the war of men's minds. We can no longer afford to rely upon the scientists of Europe to provide us with the basic scientific knowledge on which our great technology rests. As engineers we can help improve the lot of the small and devoted group of pure scientists in the United States by understanding them and applying the fruits of their basic research to technological development. The military engineer today can no more afford to ignore the methods and achievements of pure science than can the statesman ignore the intercontinental missile and the Pentomic Army.

We must feed our strong and virile technology with solid scientific nourishment, and the engineering profession must digest this nourishment and put it to use building national growth and strength as rapidly as it emerges from the laboratory. Herein lies our profession's great challenge.

SURVEYS IN CONNECTION WITH THE PREPARATION OF CONSTRUCTION PLANS FOR SEWERS IN DERRY, N. H.

By Harry R. Feldman,* *Member*

(Presented at a meeting of the Surveying and Mapping Section, B.S.C.E., held on January 28, 1959.)

Those of you who have driven through Derry, N. H. have done so perhaps by way of the Londonderry Turnpike (Bypass 28) and think of it as being simply a route junction with two service stations and an ice cream stand. The main portion of Derry is about one mile west of the above mentioned intersection, called West Derry, and is actually a picturesque modern community with a population of about 6,000. It has several successful industries among which is the original Harvey Perley Hood Milk Farm.

As in so many other similar towns, however, it had failed to develop a satisfactory sewage disposal system. The present Board of Selectmen realized the need for urgent action on this problem, "because of the increasing deterioration of Derry's water supply and the antiquated and unsanitary method of the town's sewage disposal system—" and engaged Camp, Dresser and McKee, consulting engineers, to propose and follow through a satisfactory solution.

After making sufficient preliminary studies, the consulting engineers engaged Harry R. Feldman, Inc. to make the surveys from which contract drawings could be made. It is with this phase that this paper is concerned.

The survey requirements were these:

(1) Plans of all streets to be drawn at a scale of 1″ = 40′ showing buildings, trees, utilities, travelled ways, and other pertinent topographic features.

(2) Profile data along all streets with sill elevations to 0.1′ or better.

(3) Topography of two cross-country strips (for interceptors) to be plotted at forty scale and with two-foot contours or better.

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(4) Research and field work in regard to land takings or easements.

From an existing small scale map of the town, it was estimated that there were about one hundred streets averaging 1,000 feet in length or approximately twenty miles of streets to be mapped. Also, through this area of about three square miles, were two brooks which met at a "Y" intersection in the south west part of the town close to the area of the proposed sewage stabilation ponds. It was felt that these brooks were suitably located and, with their natural gradients, would be ideal along which to place the trunk line interceptor sewers. These were the two cross-country strips to be surveyed as mentioned above and were each about 7,000 feet long.

Realizing the relative magnitude of the job, the question arose of how best to make the necessary surveys keeping in mind the usual parameters, for the least cost in the shortest time. Aerial methods were immediately considered. Although aerial photogrammetry is more than one hundred years old, it has only been in the past decade that it has made its greatest advances and then thought of mostly in terms of large highway projects. Then too, the elevation requirements were, for the most part, too fine for standard photogrammetric methods.

An estimate of time and cost, therefore, was made up in two ways:

(1) Complete conventional ground survey.

(2) An aerial survey for planimetric data with conventional methods for elevations. The results indicated that the combination aerial and ground method would be better in that the cost would be about 30% less and would take only half the time of the conventional method. Needless to say, the job was flown.

The U. S. G. S. "quad sheet" (Fig. 1) was delineated and the area flown by Lockwood, Kessler and Bartlett, Inc. in the early Spring before the foliage appeared. In the interim, surveys were started along the banks of the two brooks keeping in mind to have the survey lines as close as possible to satisfactory interceptor sewer locations.

The aerial photographs were delivered with requests to locate and coordinate 18 horizontal control points. Since there were no geodetic coordinated points in the area concerned, it was decided to

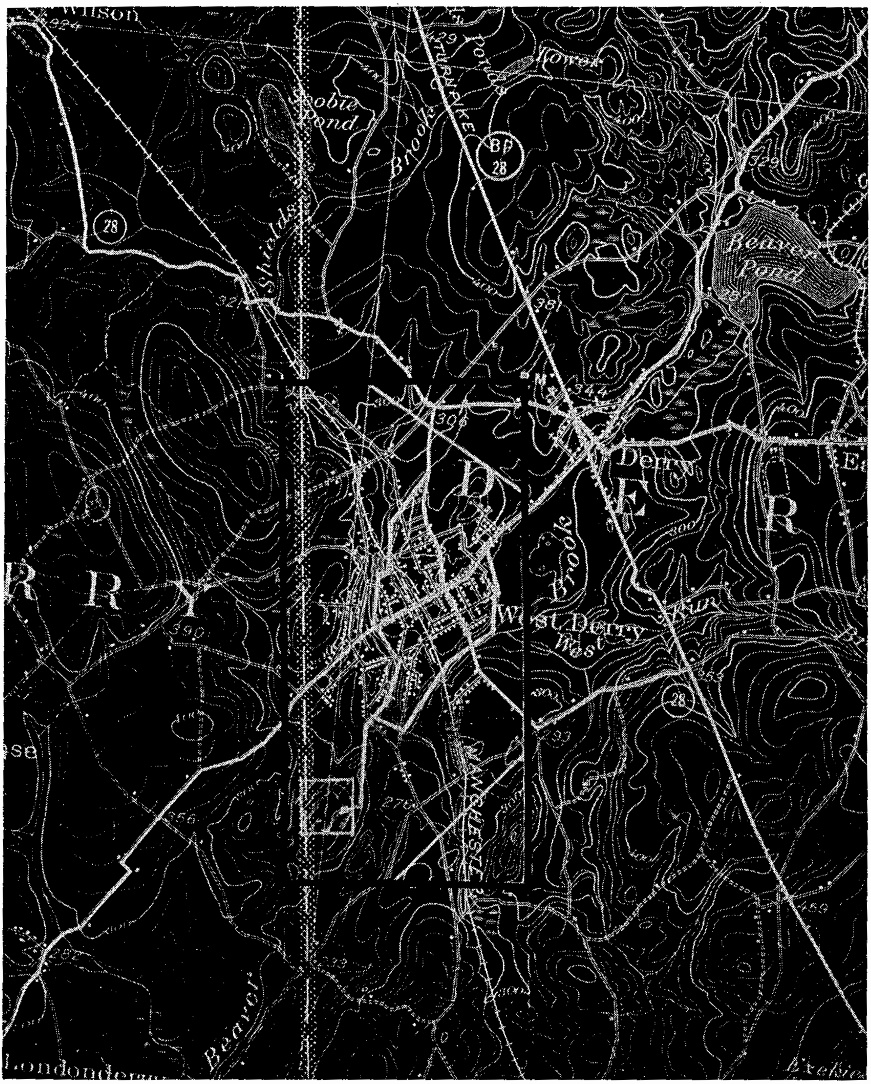
Scobie Pond
Brook
Lower
Beaver Pond
Derry
West Derry
Beaver

Fig. 1.

use an arbitrary coordinate system with a value of N 10,000, E 10,000 in the center of town at the intersection of the main street (Broadway) and the B & M R. R. Broadway and the railroad made an "X" intersection and it was along these that the main control traverses were run with closing sides to make two loops called the "A & B" traverses. The bearing system used was based on the R. R. baselines. The closures of the loops were of second order accuracy. The traverse points were of a semi-permanent nature, painted for future reference.

The cross-country trunk line surveys, which were originally random traverses, were tied into the aerial control lines to give a check on these and create additional loops with a minimum of work.

As soon as the traverses were run and checked out, the coordinates of the ground control points were calculated and noted on the $9'' \times 9''$ aerial contact prints. They were returned to Lockwood, Kessler and Bartlett, Inc. with these instructions:

(1) Provide working drawings only, at a scale of $1'' = 40'$.

(2) Show streets, buildings, poles, large trees, travelled ways, ponds and brooks.

(3) Indicate any other planimetric data which may be helpful for determining property lines such as walls, fences and cultivated fields.

Briefly, the essence of photogrammetry is the creation of a measurable spatial model, the basic principle being similar to the manner in which our brains perceive a three dimensional scene with depth provided by superimposed images from our two eyes. In one method, light rays which originally went from the object (in this case, the ground surface) to the camera are reversed. The reversal of the light rays is done by pairs of projectors which are closer than were the original adjacent camera positions during flight and thus making a "model" which is smaller than the object. For planimetric data, the operator traces the desired details such as buildings, roads, and the outline of wooded areas. If contours were needed, the operator would follow a "floating point" over the model which had been preset with identifiable points of known elevation. As the operator moves over the model a plan is created by means of suitable linkage arms not unlike a pantograph.

While the aerial photographs were being processed through the plotting machines, the vertical control points were established on the ground. The U. S. Geological Survey provided bench mark information on the Seal Level Datum of 1929. Three bench marks were found to be useable, two along the B & M R. R. and the third at the town fire station on Broadway. Several level loops were made from these and the turning points and temporary bench marks were located, painted, and described to facilitate the profiling of each of the streets to be done later.

A field office was set up and a procedure was arranged for profiling each of the streets. Stations were marked off with a cloth tape from L to L of travelled ways. Using the pre-established T. P's, elevations were taken at 50 ft. intervals and at the sills of the buildings on each side of the street. This data was turned into the field office where it was checked and plotted on the photogrammetric work prints. The stationing on the ground and the scaling on the plans between streets checked out very well. Also added in colored pencil were underground utilities as observed in the field and as indicated by the various town departments.

All of this work was accomplished and turned over to Camp, Dresser and McKee in less than three months. The key point in this whole process, we believe, was that duplication of work was eliminated by following through with working plans from the outset to the final contract plans. This was accomplished by close cooperation between Lockwood, Kessler and Bartlett, Inc., Harry R. Feldman, Inc., and Camp, Dresser and McKee. It was found also that the aerial method provided at all times a "bird's eye view" of the project and the photogrammetric plans gave infinitely more details than would be economically feasible by ground surveys.

There remained only to obtain property owners and lines for easements and taking plans. Although, from our point of view, the assessors' records were incomplete, the town officials were extremely cooperative and helpful. The work involved with property lines will not be detailed here, but a few points will be mentioned. Here again the photogrammetric plans were exceedingly helpful in that they showed walls, fences and hedges which were excellent clues to the property lines. For the most part, it was a matter of going from door to door to obtain the owners' names and other information.

In this regard, it may be of interest to quote here verbatim a small portion of the report by one of the men working on this phase of the project. "Horne Brook Easement—Owners unknown—Land north of Maple Street, between the Derry Dressed Poultry Company's land, and that of the Derry Fibre Mills, Inc., including a gravel drive and a small wooden building. The abuttors believe that this parcel belongs to the Boston and Maine R.R. The Boston office of the B & M denies ownership. The Selectmen's Clerk believes that it is owned by the Derry Fibre Mills. There was no one around the small building, nor was there any identifying name on it. A January 1955 plan of the area, by a local surveyor, has the building labeled 'Marr Scaffolding Co.' This plan was made for land taking purposes for a proposed street, but the Selectmen dropped the project when a question over land ownership developed." Possibly, had the researcher scrutinized the little wooden building more closely he may have discovered a design cut in the door—a crescent shaped moon.

DISCUSSION

By Darrell A. Root,* *Member*

The results of the survey work performed by Harry R. Feldman, Inc. were turned over to us in the form of two sets of photogrammetric sheets. The work sheets covered the whole area in which sewers, interceptors, pumping station and treatment facilities were to be constructed. These sheets showed all the necessary topographical features, and in addition the surveyors had plotted the elevations of the centerline of the streets at every 50 ft, or at shorter intervals where necessary, the elevations of the sills of all the buildings, and the rim and invert elevations of all manholes, catch basins, and culverts. The underground utilities as observed in the field and the information furnished by town officials were also shown on the work sheets. We were furnished a set of aerial photographs which were used occasionally to check the photogrammetry, and in some cases used to check topography by the use of stereoscopic glasses.

Before the field surveying was undertaken, we advised the Surveyor that we would need detailed topographical surveys along the interceptor routes. This work was included with the base line survey work, and the details were placed on the photogrammetric work sheets. In addition to the street profiles, we required some profiles cross-lots which had been selected with the initial sewer layout. These profiles were taken at the time the street profiles were made. This information was also included on the photogrammetric work sheets.

Previous to the receipt of the photogrammetric work sheets, we had laid out a map of the proposed sewer system on a street map with the scale of 1″ = 400 ft. By using the photogrammetric work sheets, we first checked the locations of various sewer lines and the ends of the various sewer lines and corrected the proposed layout to agree with the details furnished on the work sheets. Construction plans on plan and profile sheets were then laid out to cover the proposed system, and these plans were started by tracing the plan information from the work sheets. Prints were made from the con-

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struction drawings after the plan material had been completed, and these prints were then used as work sheets for designing the sewer system.

The first step in preparing the design work sheets was to plot the ground profile from the information on the photogrammetric work sheets. After the ground profile was plotted and the utilities shown on the profile, the size and location of the sewers was established and placed on the work sheets. At this time the information to be added to the plan was also included on each work sheet, such as the location of sewer line, manholes, and other information which was required to be added to the plan.

After a work sheet was completed, it was set aside until the work sheets that were tied into the sheet in question were completed. Such sheets covered upstream sewers, downstream sewers, and all lateral sewers which might come into any particular work sheet. All of the work sheets were then rechecked to ascertain that all the necessary and related changes were completed. The work sheet information was then transferred onto the construction drawing. This final construction drawing was the first time that a drawing, as such, had been prepared, because up to this time all the information was contained on either the photogrammetric work sheets or the sewer design work sheets.

During the development of the design sheets, it became apparent that minor changes were required in the overall layout. For example, a few lateral sewers were taken cross lots instead of around the block, and it was necessary to sewer a few additional streets. Because the photogrammetric work sheets contained information between the streets as well as along the streets, and because they showed all of the existing buildings, it was a simple matter to make adjustments in the sewer design work sheets because the information was available.

Before the preparation of the construction drawings was started, it had been decided that these plan and profile sheets would be reduced by half, so that the plans issued to the bidders for bidding purposes would be approximately 11″ x 18″. Considerable thought was given to the size, spacing of lettering, the weight of lines, and the presentation of material on the final drawing, so that when the sheet was reduced, we would have a legible, workable drawing on which contractors could base their bids. We also planned to use these same reduced drawings in the field for construction purposes.

A total of 93 plan and profile construction drawings, divided into two contracts, was prepared to cover the work on which bids were received. A total of 82,130 ft, or about 15.5 miles of intercepting and street sewers was laid out on these drawings. In addition to the sewers, these contracts called for the installation of 16,180 ft of house connections which were built within the street lines.

Low bid on the first contract was in the amount of $372,000, and low bid on the second contract was in the amount of $572,000.

We were particularly pleased with this method of developing the construction plans from the survey data furnished to us. The advantages to us were that the data was presented in a relatively short time from the date we authorized Harry Feldman, Inc. to proceed with this work, the photogrammetric work sheets contained more information than would have been developed from street surveys, we were furnished aerial photos of the area in which we were working, and that the cost of the survey work was reduced and we were able to pass this saving on to our client.

Mr. Chester C. Pease, Jr. was the Engineer in charge of the preparation of the construction plans on this project, and he is now Resident Engineer in charge of the construction. His principal assistant on both of these assignments is Manning S. Chellis.